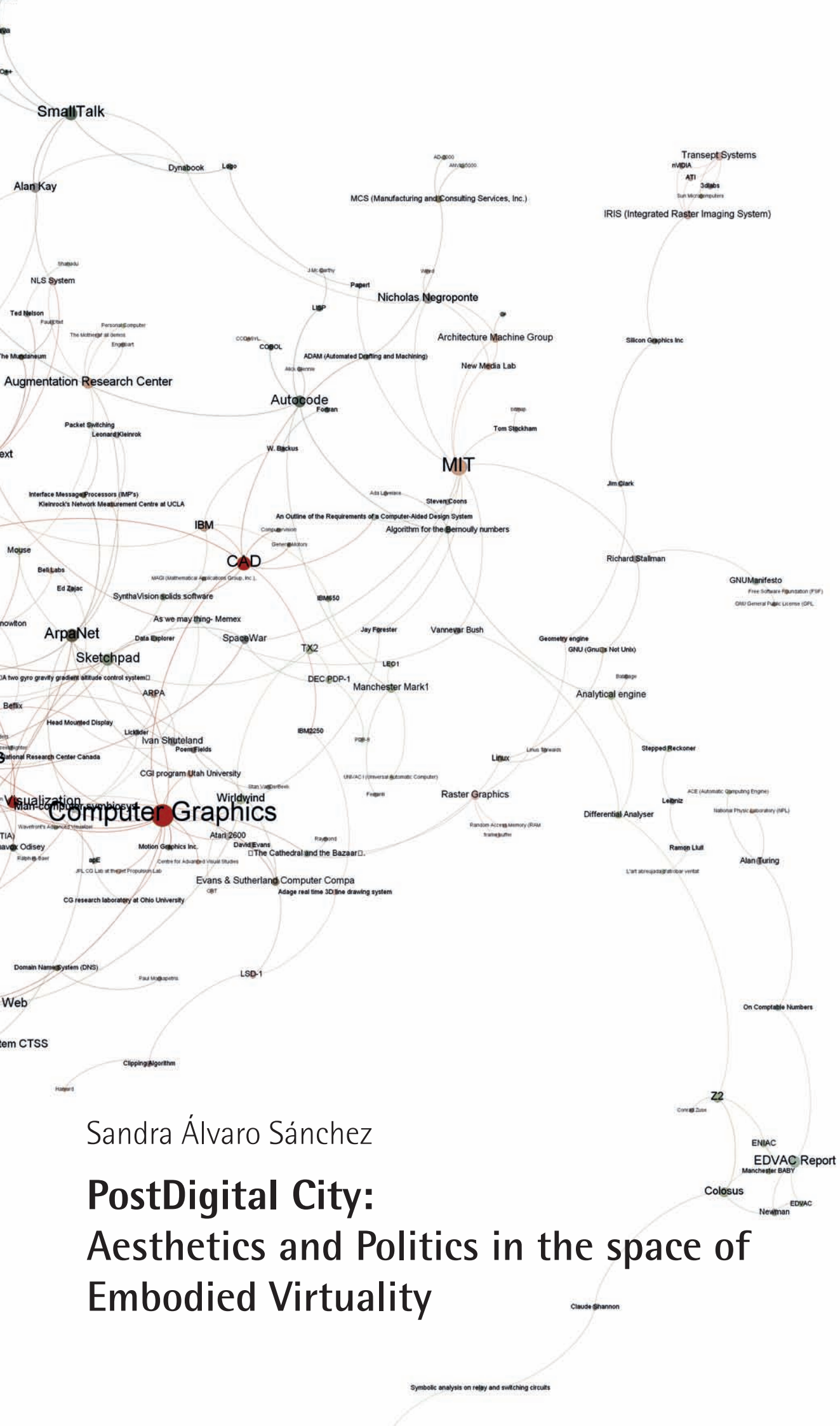
Universitat Autònoma de Barcelona

PostDigital City: Aesthetics and Politics in the space of Embodied Virtuality

Sandra Álvaro Sánchez



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The Assemblage of Embodied Virtuality (2016)
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PostDigital City:
Aesthetics and Politics in the space of Embodied Virtuality

La Ciudad PostDigital. Estética y Política en el espacio de la Virtualidad Encarnada

Sandra Álvaro Sánchez

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Klee dit qu'on «exerce un effort par poussées pour décoller de la terre» qu'on s'élève au-dessus d'elle sous l'empire de forces centrifuges qui triomphent de la pesanteur. Il ajoute que l'artiste commence par regarder autour de lui, dans touts les milieux, mais pour saisir la trace de la création dans le créé, de la nature naturante dans la nature naturée; et puis s'installant «dans les limites de la terre», il s'intéresse au microscope, aux cristaux, aux molécules, aux atomes et particules, non pas pour la conformité scientifique, mais pour le mouvement, rien que pour le mouvement immanent; l'artiste se dit que ce monde a eu des aspects différents, qu'il y en aura d'autres encore, et qu'il y en a déjà d'autres sur autres planètes; en fin il s'ouvre au Cosmos pour en capter les forces dans une «œuvre» (sans quoi l'ouverture au Cosmos ne serait qu'une rêverie incapable d'élargir les limites de la terre), et pur une telle œuvre il faut des moyens très simples, très purs, presque infantiles, mais il faut aussi les forces d'un peuple, et c'est cela qui manque encore, «il nous manque cette dernière force, nous cherchons ce soutien populaire...»

Gilles Deleuze, Félix Guattari (1980)
Capitalisme et schizophrénie 2. Mille Plateaux

"Les ouvres acquerront une sorte d'ubiquité. Leur présence immédiate ou leur restitution à toute époque obéiront à notre appel".

Paul Valery (1928)
La conquête de l'ubiquité

ABSTRACT

Deleuze and Guattari quote Paul Klee to characterize modern art as research engaged in the mobilization of the creative potentialities of matter. Art gives up mimesis or Representation and assumes an aesthetic and political compromise: to express how things reach existence. The Modern Artist becomes an artisan engaged in the experimentation with matter, which is understood as multidimensional, active, complex, and counter-intuitive. After having abandoned the repetition of tradition and the codifications of power, art explores noise, the unactualized possibilities of the Virtual, and unfolds new channels of communication, new Transductions towards the creation of new territories or spaces of dwelling. Art becomes ecology and claims for a population, called on to be the oscillators that make these starting points and new temporalities resonate. The collective engagement in the creation of our surrounding reality will reach philosophy and science, this resulting in a new understanding of Ontology; our reality becomes an ongoing collective project, not populated by static objects but by the immanent process of producing complex assemblages.

The Deleuzian concept of Art stems from a materialistic ontology that unfolded from the postcartesian philosophy of Leibniz and Spinoza and the conception of a processual reality proposed by Whitehead, and followed by authors such as Bergson, Simondon, Deleuze and Serres, that was later elaborated by Delambda and Latour and more recently by currents such as Software Studies, Media Archaeology, the Ecology of Media, and others that have considered the agency of matter in relation to the digital ground. The research presented here navigates these theories, their relation to and influence on to theories about urbanism, especially in Lefebvre, and contemporary artistic production to propose a series of concepts: 'Space of Transformation', 'Embodied Virtuality' and 'PostDigital' are the points of accumulation where all the previous conceptual elaborations converge; the nodes of a constellation that will allow a navigable map towards the understanding of the conformation of our technological milieu to be built.

The Postdigital designates a situation shaped by the ubiquity of a big assemblage that has spread computation to all the spaces of knowledge and practice until reaching our daily routines and the physical space by means of the new connected devices of Ubiquitous Computing and the associated phenomena of Big Data, the Internet of Things and Smartcities, that are territorializing all the spaces of our life, all of them flattened under the politics of a representation where everything becomes computable data and modelled by new cartographies, which are aimed at the efficient management of these spaces. Under these circumstances, computers are not tools, but a new techno-social Apparatus changing the practiced, conceived and lived space.

This research is aimed at the proposal of a productive relation with the new non-human agents populating our environment, by means of the consideration of the creative potential of Making, understood as a transductive process from where things emerge as Embodied Spaces of Transformation. That is to say, the result of a communicative encounter by virtue of which things are produced at the same time as the subjectivities and territories of the Collectives involved in them. As Valéry predicts art is becoming ubiquitous, the creations and techniques developed in the experimentation with new media pervade our environment from the facades of our buildings to the small communicative devices we stock in our pockets and the design of consumer products. In it, art and design encounter with technology and engineering. What is proposed here is a set of strategies arising from the free and playful activity developed on the intersections between art, engineering, architecture and social intervention, the Postdigital Strategies are rooted in the space of Embodied Virtuality and directed at the elaboration of a new poetics of the city, which is concerned with the speculative construction of programmable space. It becomes not an unrooted, homogenized and fragmented nowhere, jeopardized by the fuzzy relational systems of an imperceptible Apparatus, but a space rooted in the specifics of the local and able to embrace difference, populated by open systems that foster participation and empowers citizens, able to be appropriated for new uses and where everybody can be engaged in its social production; the seeds for the new citizenship that Lefebvre claims in the Right of the City.

ACKNOWLEDGMENTS

The realization of a thesis is a long journey starting with a first proposal that grows and evolves through its passage by multiple spaces and encounters. This short text is to thank some of the people and places that have collaborated to keep this research open and growing.

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INTRODUCTION

POSTDIGITAL RESEARCH: TOWARDS A POETICS OF EMBODIED VIRTUALITY

> *"Like air and drinking water, being digital will be noticed only by its absence, not its presence...- the Digital Revolution is over"*[1]

This sentence by Nicholas Negroponte –published in the magazine Wired in 1989 – establishes the end of the Digital Revolution and the beginning of the postdesktop era. The fascination for the interface and personal computers being substituted by the realization of the dream of Weiser: the vanishing of computation in the background of daily life.[2] Ubiquitous Computing is a new phase of technological evolution. In it, new advances such as the proliferation of bandwidth; the exponential growth of processor's capacity; the progressive miniaturization of electromechanical devices and the realization of Moore's law, towards the access to an increasing capacity of information storage makes it possible to embed computation capacity in the devices we interact with in our daily lives.[3] In his text, Negroponte speculates with some examples such as auto-washing t-shirts, driverless cars or therapeutic dolls that nowadays have been surpassed by the projects developed in new fields of research related to Wearables, Big Data, and Artificial Intelligence. To quote some well-known projects: the artificial skin developed by Donghee Son in the Institute of the Basic Science of South Korea, an imperceptible patch that could retrieve data of our vital signs, process them and administrate medication according to the results. The driverless car Stanley created in Stanford by Sebastain Thurn's team, who is now developing it in the Google labs. Alternatively, the recent acquisition by big information companies such as Google, Amazon and Facebook of *drones*, or its engagement in the development of neural networks and machine learning algorithms.[4] These examples illustrate some of the trends that lead to the development of an environment where computation is becoming pervasive. From the proliferation of smartphones, increasing our perception of space means the delivering of geolocalized information on demand, to the dissemination of networked devices equipped with sensors and actuators able to retrieve information, process it and start a reaction. Adam Greenfield calls this new situation "Everyware" (in all things), a new interaction paradigm giving birth to a fuzzy and highly relational system that is blending in our daily routines until becoming imperceptible.[5] This new interaction between humans and a reactive environment populated by new intelligent agents is changing our way of perceiving and acting on the environment, as well as our notions of space and time.

In 1998, when digital technologies were realized and became stabilized, Negroponte pointed out that the important changes we must focus on are those affecting our way of life, the changes that the intrinsic characteristics of digital technologies produced in our way of relating to our environment and others. The internet framework decentralizes and flattens, and is at the same time both small and big, and composed of matter, the bit that can be easily personalized and replicated. This system, open, delocalized and non-hierarchically organized, globalized our communication and externalised our intellectual capacities.

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1 Nicholas Negroponte (1998) "Beyond Digital", *Wired*

2 Mark Weiser (1991) "The Computer for the 21ts Century"

3 Pew Research Center Report "Digital Life in 2025. The Internet of things will thrive in 2025"

4 The author had compiled those and other examples in the application for curating Internet Scoop.it. See on-line: <http://www.scoop.it/t/data-and-algorithms-everyday-life-and-culture>

5 Adam Greenfield (2006) *Everyware. The dawning age of ubiquitous computing*

Our perceived macroscopic and microscopic reality became increased thanks to the affordance of shared knowledge beyond geographical boundaries and clusters of experts. It was the realization of a virtualization process[6] towards the augmentation of our Collective Intelligence and the spring of a planetary consciousness. Nevertheless, this world *"all close at hand at any time"* (*maintenant tenant en main le monde*)[7], as pointed out by Serres in his latest book, bears important changes to our way of life, our relations and the way we experience and build our environment.

This technologically enhanced environment is becoming a new Apparatus[8], which evolves into a relational, modular and emergent system in which we are engaged without being real users, where we are integrated into a process of which we are unaware, and where we could lose our freedom and agency. This fact leads us to rethink what are the conditions of an aware intervention, by virtue of which human beings can be actively engaged in the construction of their environment.

This new situation involves risks that are being criticised beyond the specialized fields and spreading to the public sphere. Among them, we can highlight the following: the loss of control produced when the imperceptible agents of pervasive computing, able to anticipate our needs, assist us; the resulting dependence of the automatized process of a modular system, from which in the case of failure, nobody has total knowledge; the capacity of surveillance and control of a system that works retrieving and processing massive data. Our interactions with the services offered by the social web and the devices of Ubiquitous Computing produce data that is retrieved and processed algorithmically. This new algorithmic medium[9] becomes a techno-social device, in which the capacity of personalization of the net becomes a means to control demand, and our interest and relations are registered and used to filter the information we have access to, releasing us from the overload of information of these media, but however, segregating us in a highly efficient way. In relation to this issue, what has been known as the post-Snowden era has highlighted the problematic of who has access and manages massive personal data that can be used as a tool of hyper-surveillance.

Finally, the materiality of the Net is becoming apparent thanks to the smart objects integrating this Apparatus. The illusion of the virtual space having vanished, we are confronted with server farms that centralize information and to a proprietary net of communications managed by regional sovereignties and telecommunication corporations with the power of threatening net neutrality, offering faster connexions to big corporations able to pay higher prices, as an example.

Cyberspace, considered as an anthropological space emerging from the crisscross of human communication, mediated by networked computing machines known as fast growth such as personal computers spread from labs to enterprises and institutions until reaching domestic space, and computers became increasingly connected to the Net. The Internet has become the defining technology of our epoch. It has changed the way we constitute knowledge, the modes of production and leisure and the ways we relate to one another and conduct our actions in our daily lives. As more computers are connected and our cultural production is digitized and produced online, contents and relations are converted into data and the archive of documents, conceived as a hypertext aimed at the augmentation of intellect, becoming a complex system of data production and tracking that is unreachable by unaided human capacities and managed by new learning algorithms. To this data deluge, produced in human interaction, we must add the data produced from the sensing of the environment by the networked objects of Ubiquitous Computing and its globalization to constitute the Internet of Things. Big Data is feeding the long-time dormant machinery of Artificial Intelligence towards the

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6 Pierre Lévy (1995) *Sur les chemins du virtuel*

7 Michel Serres (2012) *Petite poucette*

8 The term Apparatus is used here as it was developed by Agamben in G. Agamben: *What is an apparatus?* For a more exhaustive discussion about this concept see the section: *"The Apparatus and the relationship between human beings and their environment"*. On the first chapter of this essay.

9 Pierre Lévy (2013) "Le médium algorithmique"

production of generative algorithms able to infer knowledge from its environment and convey a reaction. In this way, the symbolic layer of the internet becomes operative, data producing and processing becomes able to actuate on the environment by means of connected devices and according to a pre-emptive system, with the capacity to calculate probabilities until the exhaustion of uncertainty and adapt itself to foreclose the possibility of change. However, at the same time, the networking of computers has produced a diagrammatic space open to hackability, a virtual machine of simulation able to produce operative models for speculative research and production. The capacity of abstracting all reality to data makes this machine able to submit collective bottom-up actions and produce cross-fertilization between fields of research and materials towards a bigger composability of matter by design, that is materializing in new objects able to process information without losing their materiality such as tangible interfaces, sentient robots, geolocated games, intelligent buildings shaped with previously impossible morphologies, and so on, which are spreading new affordances on the environment.

The development of the contemporary technological milieu runs simultaneously with the Ontological Turn, a turn of thought consisting of a change from metaphysics to ontology and from semantics to pragmatics.

The Ontological Turn starts with North Whitehead[10] and the processual conception of reality and with Bergson, who considered its relational nature, and proposed the concept of the Virtual, afterwards developed by Deleuze. Knowing the new conception of multiple spaces, which is derived from the theory of relativity, the theory of open systems and the new theories of communication, Deleuze develops the Virtual as an intensive space, a manifold holding the structure of the space of possibilities. This diagrammatic and multidimensional space enables a new conception of creation, harnessing the poetic capacity of both individuals and matter. This is attained after the substitution of representation and transcendentalism by the immanence of an expressive matter and Becoming. In it, entities encounter by virtue of their Affects and start processes of differentiation towards the constitution of new assemblages. The communicative encounter towards the increase of reality is elaborated after the theory of Individuation and the substitution of form by information in the process of Transduction between systems proposed by Simondon, who elaborates it as a process at the same time ontological – producing new systems-, epistemological –producing knowledge- and social –producing transindividuation-. Delanda reinterprets the Deleuzian Virtual towards the proposition of a flat ontology and a syncretic realism, based on a speculative epistemology that does not aim at the discovery of the regular laws of nature, but to the experimentation and setting up of models that allow differentiating between the important and the ordinary. In other words, localize the degrees of freedom of a system from where change can emerge.

Latour reinterprets the concepts of communication and network elaborated by Serres to develop the Actor-Network theory and dissolve the modern distinction between Nature and Culture towards a constructivist ontology, from where knowledge is the result of a traceable cascade of transformations supported by a net of Collectives, constituted by human and non-human agents, Things resulting from a process of composition by virtue of which they can be judged according to their convenience and the relations and possibilities they enable. In this conception, politics will be the collective involvement on the composition of our world.

All these theories share the overcoming of the traditional division between subject and object or culture and nature by means of a new conception of what a thing is. Things become events, assemblages that result in the unfolding of the complex ecological systems shaping our environment.

The work of Deleuze influences contemporary thinkers situated in the hyper-mediated world produced by new technologies of computation and communication. These bred a new materialism and an augmented empiricism cultivated in transversal fields, where philosophy meets with studies of science, technology, mathematics, informatics, new media, sociology, politics, anthropology, cultural studies, and urbanism.

10 Alfred North Whitehead (1978) *Process and reality. An essay in cosmology*

Among them, the Affect Theory practiced by authors such as Massumi, Media Archaeology started by Kittler and developed by authors such as Jussi Parika, the Ecology of Media started by Mac Luhan and followed by Neil Postman, Software Studies with representatives such as Mathew Fuller and David Berry, involved in the material turn in Digital Humanities and urbanists involved in the analysis of programmable space such as Batty, Thrift or Kitchin. All these theorists have in common the consideration of technology as an assemblage produced from the situated encounter of multiple agents and with transformative power, a techno-social Apparatus shaping our milieu and our affordances.

> *"Unlike the posthuman turn, the nonhuman turn does not make a claim about teleology or progress in which we begin with the human and see a transformation from the human to the posthuman. Rather, the nonhuman turn insists (paraphrasing Bruno Latour) that "we have never been human," that the human has always coevolved, coexisted, or collaborated with the nonhuman—and that the human is identified precisely by this indistinction from the nonhuman"*[11]

This theoretical background is explored here to develop three concepts – Space of Transformation, Embodied Virtuality, and the Postdigital- that work as points of accumulation, multiplicities connecting other concepts and their possible relations. The capacity of concepts to enrich themselves transferring between differentiated domains enable us to build a map and navigate it towards the understanding of the constitution of our technological milieu and the new epistemologies, aesthetics, and capacities of intervention emerging inside the complex assemblage mediating our contemporaneous space.

The three concepts proposed here stem from the Deleuzian ontology considered as an ontology of the Embodiment and Encounter, defining a space where things exist as being physically in the world, and always in communication with other things, by means of which they persist in its existence or evolve to new configurations.

The first concept introduced here is the Space of Transformation, a concept aimed at the understanding of things in the broader sense. Things are assemblages produced in the communication between systems in a process of Transduction that lead to the emergence of new things that cannot be deduced from the addition of its parts. In the production of the assemblage Collectives of human and non-human agents, materials, processes, norms and social interests are weaved together, merged in a multidimensional space, where time is not linear progress but the provisional result of the union of beings. This conception of things links the aesthetics-of-matters-of-concern proposed by Latour and a new theory of action related to the ontological theory of information developed by Simondon. Simondon considers Technicity as the creative relation with technology, the operative knowledge of a system and the capacity to couple it with other systems to produce a new thing. From this standpoint, Making will be considered here as the capacity to participate in the poiesis of our world, laying new processes of Transduction, at the same time, an ontological and epistemological operation. Making is a process able to open a Space of Transformation, a node where to converge multiple relations towards the production of a new thing charged with Affects that in turn will open up new possibilities. Participating in the Spaces of Transformation humans relate to reality being actively engaged in the acquisition of knowledge and the production of their environment, at the same time as their subjectivities.

In a world without transcendent immutable entities, where reality is mobile and changeable, that is to say, actively produced by processes that lead to assemblages, which must be collectively maintained, the epistemology becomes experimentation and aesthetics the theory of forms of Becoming. Art becomes a

11 Richard Grusin (ed) (2015) *The Non-Human Turn*

revolutionary activity able to produce the System of Simulacra, the deterritorialization of the codified and the Ontological Game able to produce new forms of life. The Ontological Game of art will be developed here towards the proposition of a poetics, understood as the exploration and speculative experimentation towards the discovery of all the potentialities emerging from the relations between human and non-human agents.

The Spaces of Transformation will be analysed in the emergence of new spaces where people meet around the collective production of things, spaces fostering the formation of new Collectives, in which Participation arises as a situated Collective Intelligence that produces new things and that appropriate the technologies related to Ubiquitous Computing for the commons and from where a new conception of education, design and production will emerge, and the speculation about a new social system.

Embodied Virtuality is the concept that designates the space produced by our technological milieu, a complex assemblage of nested technologies that has spread throughout our world. This system is considered here from the point of view of its material ground and traced across the multiple nets that converge towards its constitution. Embodied Virtuality is the product of the convergence of three big assemblages. Computation is the oldest of them and started with the origins of the algorithm in the 9th century, the works aimed at mechanization conducted by Babbage, who projected the Analytical Engine in 1833; the proposition of the Universal Machine by Turing in 1936, and the Turing-Newman Architecture exemplified in the first mainframes. It evolved between the production of military weaponry, scientific research, and industry; they were assembled in the Iron Triangle, an institution that continued during the Cold War and the related Space Race. In this situation, researchers and practitioners from diverse fields met around the production of a machine able to automatize the processing of complex data sets and to distribute its resources to improve collaboration. New assemblages encountered this machine as the integrated circuit that allows the production of increasingly smaller machines, able to leave the big research centres and spread to offices, institutions and finally to private houses. In addition, the development of the high-level languages, allowing the separation between content and expression, and the abstraction of any entity of our world to a list of programmable objects. The second big assemblage came from communication and produced the Internet. Starting after the Second World War and during the cold war and the related world race, it was first aimed at fostering research by means of sharing computing resources and information and meshed with the development of new information retrieval systems, such as the hypertext aimed at the augmentation of intellect and constructionist theories of education. The Internet came from mainframes supporting time-sharing systems, and evolved into personal computers and the cloud, which moved data processing and storage from computers to the Net. During its evolution, it became a social system occupied by BBS systems, mailing lists and independent service providers, as well as the basis of a new system of production involved in globalization. The Net evolved into the platforms of the web 2.0, where participation encounters with algorithmic control and reaches physical space, first by means of GPS and RFDI tags that allow the identification of objects in physical space, and finally with the connected devices of the Internet of Things. The third assemblage comes from the technical reproduction of the audio-visual, a system that evolved towards the high-definition simulation of our reality inside a data-space navigable and populated by manipulable objects. This assemblage started when the first oscilloscope was attached to a mainframe, which evolved towards the development of the direct manipulation on the *Sketchpad* by Sutherland. This principle produced the GUI and the field of Human Computer Interaction, at the same time as the first Computer Assisted Design systems and Scientific Visualization evolved towards the immersion of the human being inside screened data-space in Virtual Reality. *Spacewar!* simultaneously appeared, the first computer game, and the starting point of a wealthy industry that would foster the development of computer graphics and the spread of personal computers. As computers became able to reproduce our reality by means of manipulable data structures they became able to read any image of our reality, therefore, our space will be augmented with geolocalized information projected on the screens of our portable devices, this changing the way we perceive and orientate inside urban space. In addition, it will lead to a new epistemology based on diagrammatic models from where all the relations described by entities and our interactions can be visualized and computed, and that will spread all the spaces of knowledge and practice from the understanding of complex natural systems and our cultural production to the control of

social interactions. Finally, data became objects and objects data, transportable on the Net. The data structures of synthesis image led to the culmination of the Internet of Things, objects designed on a screen or scanned became data able to travel across the Net and be materialized anywhere by anybody thanks to the procedure of additive fabrication.

The development of these assemblages encountered a varied set of fields of research theories and practitioners from all steps of life, among them engineers and technologists, as well as scientists, psychologists, artists, and designers. This software-based medium is a space of convergence for liberals in favour of a new economy based on knowledge production; philosophers of the virtual realm and sociologists of a new public sphere; post-colonialist anthropologists on the lookout for the Other; cyberpunks fuelling the techno-utopia of an open, autonomous space that conceived as the seeds of a new society; 'new agers' who believe in new transpersonal ecologies; artists developing shared authorship environments and new interactive processes; hackers ready to bend the medium and elude control by keeping it open; activists who see it as a tool for civic gatherings and citizen empowerment, and educators promoting digital literacy and a medium accessible to all. These interdisciplinary groups have contributed to developing the software that in turn has become a techno-social device, and has shaped new forms of interaction and sociability. From the early mailing lists for non-profit projects with cultural or social aims, to open source co-creation platforms and databases or archives that have generated Collective Intelligence and communal action, all of these uses have helped to mold the logarithmic medium in which our everyday reality has become immersed. This has made the Internet a living medium, in which there is always tension between the reductive vision of our predictable and computable world and the creative capacities of a virtualized medium, where multiple systems are modulated and hybridized towards new potentialities.

Focusing attention on the material processes that produced the evolution of this big assemblage will allow a reflexive criticism about how the technologies producing this system intermingle, translating it from one field to another until becoming spread in all our spaces of knowledge and practice. Alternatively, it will allow going beyond the interfaces and their acceptance as correlates of our actions to understand them as situated constructs shaping our affordances inside the screened environment and constraining the programmability of the Universal Machine.

Embodied Virtuality spread a new system of inscription in which all becomes programmable by means of virtualizing our reality, which is abstracted to discrete data and modulated towards its co-functioning inside a diagrammatic and auto-generative space. This transforms this space in a meta-model able to reproduce all the possible Becomings of matter. This deterritorializing machine can be used in both directions, towards the computing of probabilities and the programmability of space to attain its control, in contrast to the hackability and the speculation of new possibilities.

The appropriation of computing systems can only be attained as Disruption; this is understood as the revelation of hidden mechanisms commanding their functions and the production of new couplings producing new Transductions and the emergence of novelty.

The emergence of new Spaces of Transformation runs simultaneously with the development of new technological procedures that allow the creative capacities of data to spread to non-experts and apply it to the production of everyday objects and urban interventions. Physical Computing, Visualization, and Digital fabrication will foster the development of participatory urbanism, community building, Hackerism, citizens' science, open data and other movements related to the spread of Participation to the production of space.

Finally, the Postdigital is the concept proposed to define our contemporary situation, in which digital technologies have become stabilized and integrated into all the fields of life, and a turn of attitude from the fascination for the interface and the cyber heterotopias at the beginning of an epoch of critical reflexion about how the new agents and protocols of this new Apparatus affect our material environment and our capacities of action in it.

Postdigital is a concept borrowed from the Artistic practice, which designates a shift of focus from pixels to particles and from the interface to circuits, concretized in artistic works that make computing processes apparent, making systems that work out of its frame of application and hybridizing them with traditional methodologies and unexpected couplings. This first definition will be extended here to the proposal of three Postdigital Strategies that will be developed through the analysis of the work of a set of artists that appropriates the technologies emerging from Embodied Virtuality to question the digital Apparatus we are immersed in with different methodologies and purposes. This set of artists follows a tradition developed concurrently to the development of the technological milieu, starting on the constitution of the EAT in 1966 and following with the exhibition *"Software"* curated by Burnham in 1970, and more recently we encounter the works by the developer of Processing, Cassey Reas, the criticism of digital mediations by Aram Bartholl, the inclusion of new agents in the environment accomplished by Nathalie Jeremijenko and the social urban intervention of Usman Haque, among others.

All these artists work in the intensification of space by technology and the unveiling of the systems conforming our ecological milieu appropriating it and approaching the concept of Profanation developed by Agamben and the understanding of Art as an Ontological Game by Deleuze, the unveiling of mediations and the speculation towards the increase of reality. Among these practices developed here are: the deciphering of models, the criticism of the new cartographies, commanding the understanding and management of the city; the embodiment of social processes; collective initiatives that lead to the engagement in the social production of space; and the intensification of space and the Speculative Production, including projects that explore all the potentialities of modal space to produce new dispositions of the same, leading to the development of new possibilities.

These strategies are developed with the aim of the discovery of a poetics and pragmatics of data, useful for the development of a Critical Theory of Prototyping, based on the poetics and open experimentation with the potentialities of Embodied Virtuality towards the composition of our spaces of dwelling rather than on the application and testing of social theories on the development of prototypes.

The philosophers of everyday life Lefebvre and De Certeau stressed the act of walking in the streets as a performative practice, an act of resistance able to create its own space. The Situationists will use this everyday practice as a way of disrupting the mediations imposed by the structures of power towards the appropriation of public space for culture production. Locative Media used the internet platforms and geographical position systems to add new layers to the base map increasing the potentialities of represented space. The multi-layered networked systems of Ubiquitous Computing and its functioning guided by protocols, where any content can be added as long as it works using the same protocols, allow a new way of active intervention that is not concerned with discursivity or representation but with the active building of our space, the branching of new objects from the network able to start new Transductions and spread new possibilities.

SUMMARY OF CHAPTERS

The constellation produced by the translations of the three proposed concepts across the Apparatus of our epoch and its Disruption will be traced in three chapters, which will evolve the theoretical tools that lead to the proposal presented in the conclusion. The first one is dedicated to ontology leading to the materialistic conception of reality, from where the main concepts applied to the understanding of our contemporary milieu and our relations and possibilities of action in it will be defined. In the second chapter the conformation of the assemblage of Embodied Virtuality and its consequences in daily life, knowledge, and politics will be tracked. The third chapter explores the las upgrade of Embodied Virtuality and the Spaces of Transformation arising from the appropriation of the technologies related to Ubiquitous Computing. Finally, in the conclusion the Postdigital Strategies and the poetics of data towards a new form of collective intervention in space production will be developed.

The first chapter, *"Ontology as the creation of the Common World"*, navigates the Virtual and the Ontology of Becoming proposed by Deleuze and reinterpreted by Delanda in relation to the theory of Individuation and the concept of Transduction proposed by Simondon and the Actor Network theory and the matters-of-concern by Latour towards a new definition of what is a thing. The Space of Transformation is laid out in the relation to a definition of aesthetics, epistemology and politics emerging from the reinterpretation of the work of these authors and the definition of power and common space by Agamben. The conclusion of this chapter *"The Apparatus and the relationship between human beings and their environment"* summarizes the social reception of the new epistemology and ontology emerging from the Ontological Turn in relation to the emergence of the new technological Apparatus that in the next chapter will be developed as Embodied Virtuality. This reception is laid out by means of the analysis of relevant exhibitions and the introduction of the Society of Control by Deleuze and the Post Media epoch by Guattari.

The second chapter, *"The Embodied Virtuality"*, traces the net from where our technological milieu emerged from the point of view of Software Studies. It explores the complex net of agents and Collectives involved in its production and spread to all fields of practice and knowledge as well as the cultural transformations it has produced. This net is traced from the convergence of three main nodes: the development of computing, the communication technologies producing the Internet and the automatic processes of inscription producing Computer Graphics. In the conclusion, *"The Algorithmic Management of Data"*, the evolution of this Apparatus towards the algorithmic management of data, which nowadays characterises our relation with the same, and the laying out of a diagrammatic space characterized by its capacity for both pre-emptive control and hackability will be reviewed.

In the third chapter *"PostDigital Space. The world after the Digital Revolution"* Ubiquitous Computing as the latest upgrade of Embodied Virtuality and the changes this new Apparatus is producing in our urban space from the standpoint of the Unitarian Theory of Space by Lefebvre is analysed in how it has affected the practiced, the conceived and the lived. Then the technological procedures developed towards the collective appropriation of the Ubiquitous Computing for the Commons will be introduced: the Physical Computing, Visualization and Digital Fabrication and the Spaces of Transformation that are emerging around these procedures as Hackerspaces and Fab Labs. The conclusion, *"The New Techno-social Apparatus and its discontents. Towards a playful interaction between human and non-human agents"*, exposes the concerns associated with the Apparatus produced by Embodied Virtuality. At the same time that introduces the new forms of urban intervention and design arising from the practices produced in the new spaces of transformation as Critical Making, DiY, Community building, Hackerism...

The conclusion, *"PostDigital Strategies"*, develops the poetics of Embodied Virtuality by means of the analysis of three strategies – the deciphering of models, the embodiment of social processes and the Speculative Production- arising from the contemporaneous art practice. *"The poetics of PostDigital space: From streetwalkers to city builders"* is the conclusion of this chapter, the proposal of a Critical Theory of Prototyping consisting of the collective participation in the design of the agents populating our environment.

1. THE ONTOLOGY AS THE CREATION OF THE COMMON WORLD

"The conception, the construction, the production of rapports, of relations, of transports-communication in general evolve so fast that they continually construct a new world, in real time. We still live in a century or a universe of concepts, beings, objects, archaic statues, or even operators, while we continually produce an environment of fluctuating interferences, which in return produce us".

M. Serres and B. Latour, B. (1995)
Conversations on Science, Culture, and Time, pp. 114

INTRODUCTION: SPACE-TIME

Space-time is the common substrate of an intersubjective reality, the settlement of the ongoing interactions that are shaping our world. This conception of space-time relates to worldliness, which is the human capacity to fill the openness of the world, creating a shareable reality populated by things that endure.[12] The worldliness in which humans become engaged in the creation of their environment and their subjectivity is in debasement after the process of proletarianization characterizing modernity and the accomplishment of industrialization, a process that is less based on the alienation of product and the atomization of productive processes rather than on the division between space and time, which produces the dissolution of places and the loss of affective values fostering intervention.

Our understanding of space and time has mutated throughout history, changing at the same pace as the way we organize our dwelling spaces. They have been considered cosmic entities, organizing dwelling from an unreachable and eternal outside - as the transcendental principles incarnated in divinities, the founders of the ancient closed cities, which reproduced the cosmic order- or general principles such as Roman law, which was capable of reproducing the eternal city, Rome abroad. Another transcendental move from the unreachable outside to the inner subject was operated on Modernity, where space-time becomes mental entities, the Kantian a priori conditions of our knowledge, running away from material reality, which becomes appearance and the correlate of a subject.

Modernity began with Descartes and his division between the *res extensa* and the *res cogitans*, the body and the mind. Space separated from time becomes the Euclidean absolute, an emptiness where Galilean objects translate without suffering transformation. Space becomes a flattered plane, static and fragmented, the grid of coordinates of the Cartesian System, where position becomes a principle of classification; the position on this grid identifying subjects and objects according to the hierarchies of the dominant social order. The empty places and big boulevards, shaped according to the imperative of visualization and linearity and exemplified by Haussmann's renovation of Paris, define the construction of this emptied space, where public life was evacuated of streets, which become space of circulation for the efficient transport of merchandise and workers of the new Industrial system. The mechanistic space becomes the place for the repetition of the same, in any of its places, the system of production, which attaches individuals to the monotonous repetition of the assembly line or the spaces of leisure dominated by the spectacle, with the unified movements and bodies of the chorus line. It is a dominated space with an operative character that subdues bodies to a self-maintaining system.

This fragmentation translates to the study of space, which becomes fragmented into standpoints of separated disciplines such as the space managed by architecture, the political space of geography or the mental space of mathematics.

In 1974, Lefebvre proposed the Unitarian Theory of Space.[13] Lefebvre was a philosopher and sociologist, himself assigned to the tradition of thought engaged in life. Considering the performative capacity of the body and its everyday practices, Lefebvre oversteps the modernist division between time and space. The Unitarian Theory considers space as the ongoing product of the interactions, these analysed in three related fields. The space of practice -the daily-perceived environment where our actions take place, according to a codified system of norms-; the conceived space -the theories and forms of knowledge that shape the forms of production and management-. And finally, the lived space or space of representation, from where the

12 Hannah Arendt (1958) *The Human Condition*

13 Henri Lefebvre (1991) *The Production of Space*

codes shaping our culture arise, the space performed by the rhythms of the bodies inhabiting it and where certain forms of art can emerge; three fields interacting where the codified is constantly challenged by the movements of the lived and their capacity for appropriation.

Space is practiced and conceived according to an Apparatus[14] that codifies it; the set of relations, discourses, institutions, laws, police measures and philosophical propositions supported by certain forms of knowledge and supporting the relations of power; a space dominated and segregated in static functional parts. However, at the same time, it is the lived space, appropriated by its inhabitants and the rhythms of their bodies, giving birth to new usages capable of producing an excess of meaning towards the conformation of new territories. These three standpoints reunited, considering the relations between them, enable reincorporating Time into Space. Space recovers its movement and the linearity of progress shifts to a multiplicity of events actualizing an intensive space, where the abstract truths are substituted by the truth of bodies, senses and desires. In reunited Time and Space reappears the historicity of space and the rhythms producing it becomes apparent, the lived space emerges from the repetition and fragmentation under which it was concealed, thus allowing space to be understood as a social production.

To visualize how a flattered static shape can be put into movement becoming multidimensional, we can imagine the most common of our public places, the Square. We start looking at the represented shape on a map, the vision from outside. We perceive the grid as it is shaped by urbanism, the fabric of streets around, and the codified areas presented by the building facades embodying power, the city hall, and institutions around; their banners, effectuating identity; the monuments, souvenirs of the official history; the nameplates of the events, added to the official history. All this sited around the benches and garden patches, reminiscence of a domesticated nature and indicators of authorized transit and behaviour. If we go inside and undertake a more detailed close-up look, beyond this mapped space we can find the marks of transitory uses, such as the hopscotch drawn on the floor, the parallel stones indicating an improvised football goal, the remains of the market stall of a street vendor; the footprints on the official monument, left behind by the children using it as improvised attraction and the selfies remembering the encounters in front of this improvised meeting point. A multiplicity of times monopolizes the marks left on trees and walls, souvenirs of personal stories attached to this place. Next to the advertising billboards the more or less elaborated graffiti, the claims left by the usurpers of a non-authorized, but effective space of enunciation. Then there are the multiple playful or political ephemeral concerns, multitudinous manifestations, changing the space's structure and purpose. Finally, we look down, and we find the underground entrance and the different metallic plates giving access to the sewage, electrical and other communication systems, we discover the hidden geographies of the systems affecting the maintenance of this space. These multiple standpoints take into account space becoming a texture, the encounter and historic precipitate of multiple movements and events. In the in-betweens of this texture appear the interstices available for new concerns and unexpected encounters. Now imagine we are moving across to the snapshot we have just taken of this full space and you can trace a line from each one of the multiple marks -nodes of meaning- extending it towards every one of the non-actual events linking with it. The graffiti attached to the system of signs deployed, transmitted by a community of practitioners, the spray-paint coming from a productive system, extended across different countries, the encounter between writers and readers, with the cleaning services and the municipal ordinances banning this practice. Our line extends from node to node unfolding a complex net that intersects and overlaps with the considered node of our actual plane. The space represented as static grid becomes a Rhizome, a diagram with multiple entrances extending in all directions. The quantitative space becomes intensive, charged with the qualitative marks, Effects that are able to start movements of actualization. The intensive space increases its dimensions with each new intervention towards a progressive differentiation that challenges the static plane of domination towards a complex self-organized system drawing infinite cartographies. Space is no more a medium dominating our relations, but the medium embracing all the possible mediums.

14 Giorgio Agamben (2009) *What is an apparatus?*

In contemporaneity, the visual privilege and linearity imposed by modern space explode in all directions. The conceived space was struck by the theory of relativity that restrains the field of application of classic mechanics. The modal space becomes multidimensional and intensive but remains as an abstract entity inside the dedicated field of mathematics. In the space of representation, art loses its object, at the same time as it attempts to overstep the univocal vision of perspective. The image captures the object in multiple perspectives in cubism or dissolves the object in a revalorized environment in the works by Paul Klee. The New Media bursts into art putting the image on movement. The cinema begins with first static planes of flat characters standing up in front of artificial stages. However, experimentation soon disrupts. The view is enlarged to include actions on the second plane, in the films by Orwell, or focusing on little indices, charged with meaning but falling outside of the main plot, as can be seen in *"Mon Oncle"* by Jacques Tati. This filmmaker also produces works deconstructing the homogeneity and repetition of the globalized contemporaneous space, in works such as *"Playtime"* or the series portraying the holiday of M. Hulot and the absurdity of the controlled spaces of leisure. In the seventies, action-cinema irrupts and the environment is no longer a stage of action but the changing space around moving bodies. In addition to the techniques of montage, new chronologies will emerge, disrupting the linearity of plots. In another field, the moving image will turn into a real-time image. The mass media reunites people around the unidirectional transmission of an ever-changing message. This contributes to the creation of a passive audience without stable referents to subdue the projection of their subjectivities. The mass media will be interpreted as the realization of post-modernity, what Baudrillard calls the *succession of simulacra, preceding the desert of the real.*[15]

To understand space as a social morphology - the set of relations and shapes resulting from the creative capacity of the Collective- a new ontology is needed that substitutes the missed transcendent truths with the realities of bodies, the starting rhythms that resonate towards the emergence of new dispositions of the real. Intensive space and its potentialities remain enclosed in the field of mathematics considered as a mental entity and separated from the superabundance of the lived space. Deleuze turns metaphysics into ontology and develops a new thought capable of translating the complexity and potentiality of topological space into social practices. This activates the potentiality of matter, recovering the openness of the world and its capacity to embrace creativity. This new Ontology has led to the ethical commitment of increasing potentiality by means of following all the intensive lines that rise from a complex space as ever-divergent regimes of action and Expression. This evolves towards the multiplication of powers of existence by the creative intervention of all the individuals in a collectively performed matter. This creative intervention fosters communicative encounters capable of going beyond what is mapped and to think about all the ongoing realities pictured in our multidimensional Square. Summarizing, it is the proposal of a reality not reducible by power by means of the empowerment of every individual and every molecule of matter, all of them becoming communicative entities, where information is not transmission and perpetuation of a codified message but *negentropy*, the irruption of the emergent capacity of noise.

15 Jean Baudrillard (1977) *La précession des simulacres*

1.1 THOUGHT AND CREATION IN DELEUZE AND GUATTARI

> *"The genious of a phylosophy is first measured according to the new distributions that it imposes to beings and concepts"* [16]

The collaboration between Deleuze and Guattari matures into a new metaphysics that will overcome the acosmism, the timeless succession of simulacra, characterizing postmodernity. This is achieved by means of the formulation of a constructivist and open ontology capable of recovering the world giving a material content to the thought in motion and its creative capacity. This ontology sutures the fringe separating Object and Subject. The Subject is no longer a static entity facing a world, which is the object of knowledge, but a mobile body immersed in the process of a Becoming reality. Individuals will subjectivize by means of involving themselves in their environment and relating to the manifold of agents populating it. This world is no longer the realization, or imperfect copy of any superior or transcendental reality, but immanence and open process, where all matter holds some degree of freedom and agency. In this space open to embrace creation and change, thought becomes a nomadology. The nomadology is a mode of creation that brings philosophy closer to the other activities engaged in the production of the world, art, and science. The world becomes a creative process operating in a continuum of infinite potentialities, which are moving towards rhizomatic unions, where meaning is not inherited from any transcendental entity but an event, the result of a communicative encounter between differentiated entities producing new assemblages.

This ontology begins with a redefinition of what is philosophy and how it relates to science and art, the other activities of thought. Philosophy is no longer a reflexive or critic activity, but a creative practice implied on the creation of concepts. Deleuze defines this activity in the work *What is philosophy?*,[17] and in the talk *What is the creative act?*

> In the speech: *What is the creative act?* pronounced in 1987, included in the program the *Tuesdays of the Femi foundation*, he gives this definition:
>
> *[...]; philosophy is not made to think about whatever else. It is not made to think about any other thing. I would say that addressing philosophy as the power to reflect on, it looks like we are giving it a lot but in fact, we are removing it from everything.*
>
> *If we are asking-. What is the content of philosophy? This is easy. Philosophy is a discipline as creative and inventive as any other discipline. Philosophy consists of the creation or invention of concepts..*[18]

The creative task of philosophy arises from its confrontation with the Virtual, the original chaos where all possible particles and forms spring out only to disappear immediately. Philosophy retains the infinite speed of birth and disappearance that characterizes this uninformed matter to establish what can be thought. In this metaphysical fluid, always in motion from where reality arises, the concept becomes a Multiplicity, a point of accumulation, the connector between other concepts drawing every possible relation. Science and Art also confront the Virtual, establishing respectively the matters of fact and the Affects, the expressive qualities of matter. Wandering across the Virtual, thought confronts the complexity of an ever-changing reality and captures the emergence of matter.

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16 G.Deleuze(1969) L*ógique du sens*, pp. 15. Translation by the author

17 Gilles Deleuze and Félix Guattari (1994) *What is Philosophy?*

18 On-line: https://www.youtube.com/watch?v=a_hifamdISs. Translation by the author

Deleuze develops the Virtual from the works by Bergson. Bergson interrogates himself about the possibility of novelty and creation. The world is perceived as constant evolution and change. Things are perceived in their duration as a constant elaboration of novelty: *"Reality is global and indivisible growth, gradual invention, and duration: as an elastic balloon, which expands little by little, taking unexpected forms at every instant".* [19] Bergson considers perception as impersonal and coinciding with the perceived object. The perception situates us in matter, duration is not a psychological entity but an immediate datum of our consciousness, leaving our consciousness to be captured in things themselves. The method of Intuition is directed to problematize -focuses on the creation of problems as an invention, not in their solutions-, differentiates –looking for authentic differences dissimulated under differences of grade- and temporizes reality –it apprehends time-. These are the criticisms elaborated by this author to deconstruct all the immobilizing abstractions and get back the heterogeneity of duration to the homogeneous space, thus liberating it for creation.

1.1.1 THE VIRTUAL

> *"Chaos is defined not so much by its disorder as by the infinite speed with which every form taking shape in it vanishes. It is a void that is not a nothingness but a virtual, containing all possible particles and drawing out all possible forms, which spring up only to disappear immediately, without consistency or reference, without consequence. Chaos is an infinite speed of birth and disappearance."*[20]

The Virtual is a positive act towards an increase of our reality, as a result of the processes of actualization: difference, divergence, and creation.

Bergson develops the Virtual from the conception of an absolute space-time. Space-time is qualitative and undetermined and only becomes extensive retroactively. That is, it is as quantifiable as the chronology of our calendars and the timing of our clocks, the areas of our countryside and the graded distances of our roads. Before being stopped for the pragmatic needs of everyday life and the logics, time and space are qualitative, they are not homogeneous and not divisible, changing at every moment and at every point, a source of differences. Bergson exemplifies duration as a pure memory. This past is not a personal chronology, a linear collection of experiences, but an undetermined gathering of all our memories that coexist with the present and which can be actualized in infinite different stories. This deep memory remains unconscious being actualized on fragments selected by perception according to the needs of daily life.

The Virtual is not the possible; a logical category conformed according to the rules of limitation and resemblance and containing the program of its realization, where the real only adds existence without any difference from the concept. On the contrary, the Virtual is emergence, an increasing of reality, creating its own lines of actualization. It is not the solution to a problem rather than a problematizing action; a positive act, a differentiating movement that slides across the multiplicities, the heterogeneous entities existing in a continuous space-time, resulting in a diverse reality and in evolution. The Identity as a logical abstraction leads us to the confusion of considering the being as more than the not-being, the real as more than the possible, order as more than chaos. However, chaos is the original reality containing all possible order, which must be actively produced. The Virtual enables a shift from the abstract entities, shaping a stable world under the tyranny of identity, to the immanence of the difference, and the vital impulse towards creation.

Deleuze develops a metaphorical construct to think about the complexity and productivity of the Virtual. The Plane of Immanence is an abstract machine, a deterritorializing surface that spreads over land and connects it to the infinite. This diagrammatic plane is the fruitful ground where thought takes root and

19 H. Bergson (1938) "Le possible et le réel", at *La pensée et le mouvant*, pp. 105. Translated by the author

20 Gilles Deleuze and Félix Guattari (1994) *What is Philosophy?*, pp. 118

cannot escape to either the transcendental height or foundational depth. It is not an abstract model, the Cartesian System that renders the space homogeneous and subdued to its coordinates, but a locally constituted space, multidimensional, intensive and embracing the potential of difference. This is the space for the transportation of nomadic thought, a shift from the abstract map, stabilising reality towards the orgiastic rhizome, establishing connections between differences, divergences that can resonate raising new dispositions of the real.

Delanda deciphers the plane of immanence by means of putting it in relation to the mathematical fields of differential geometry, group theory, and dynamical systems theory. This is summed up in an explanation of how the Virtual embraces not only a nomadic creative thought but also a nomadic creative reality. The processes of actualization are the processes of morphogenesis. Quoting Deleuze: *"thinking and being are the same thing." It is in this sense that thinking and being are said to be one and the same. Or rather, movement is not the image of thought without being also the substance of being".*[21]

To summarize Delambda's proposal we will begin elucidating the concept of Multiplicity as a concrete universal that avoids essentialism. *"Unlike essences which assume that matter is a passive receptacle for external forms, multiplicities are immanent to material processes, defining their spontaneous capacity to generate pattern without external intervention"*. [22]

The plane of immanence is populated by Multiplicities. This concept first appeared in Deleuze's philosophy in his work about Bergson[23]. Multiplicities are what cannot be divided without changing their nature, a multidimensional unfolding space. Bergson reinterprets the Multiplicities from the Manifold developed by Riemann, a surface without any reference to a global embedding space or supplementary higher dimension imposing an extrinsic coordinator or extrinsically defined unity. This space is continuous and only determinable according to its dimensions or independent variables, contrary to the metric or extensive space, which can be measured. Manifolds are only determinable by the events that occur and differentiate it. Multiplicities are a constant concept in all of Deleuze's philosophy, who develops it through close concepts such as *disparate series, ideal events, nomadic singularities, becomings,* and *concepts.*

As far as Multiplicities are understood as Manifolds these are the structures of the space of possibilities, containing as many dimensions as possible State Spaces, which are the possible changes of any entity contained in it. These geometrical spaces arise from the differential geometry by Friederich Gauss and Bernhard Riemann. The analytical geometry developed by Descartes and Fermat solves geometrical problems embedding it in a plane divided by coordinates. In this way, they become algebraic relations between numbers. However, differential geometry studies dynamical processes, expressing not positions but rates of change. In it, geometrical objects become determined by the rate at which some of its characteristics change. Gauss realized that the differential calculus focuses on infinitesimal points sited in the surface itself. As a result, it can be studied without any reference to a global embedding space. This locally constituted plane is the Manifold that assisted by the theory of groups and the property of *enclosure*, allows to consider symmetry as the number of transformations in a group that leave a property invariant. This space differentiates itself by symmetry-breaking transitions, a process that converts one of the entities contained in another by losing or gaining symmetry.

The Manifold becomes a model of physical processes, the space of all possible states that the physical system can have. Each dimension of this topological space harbours each one of the possible states that the physical system can arise from according to the system's degrees of freedom, which are the number of relevant ways in which such an object can change. The state of the object at any given instant of time becomes a

21 Gilles Deleuze and Félix Guattari (1994) *What is Philosophy?,* pp. 38

22 Manuel Delamda (1994) *Intensive science and virtual philosophy,* pp. 28

23 Gilles Deleuze (1991) *Bergsonism*

single point in the Manifold, which is now called State Space. The possible changes of state are defined by singularities. These model the behaviour of the system describing trajectories following the Attractors, which are the inherent or intrinsic long-term tendencies of a system, the states that the system will spontaneously tend to adopt in the long run as long as it is not constrained by other forces.

Singularities act in a recurrent manner independently of the mechanisms where the physical process or system are involved and are presented in sets not given all at once but unfolding progressively following recurrent sequences that specify the nature of the Multiplicity progressively. The singularities may undergo a symmetry-breaking transition and be converted into another one. These transitions are called bifurcations since they unfold a new recurrent trajectory specifying the system. Transitions are events, which take place at critical values of some parameters, switching a physical system from one state to another, like the critical points of temperature at which water changes from ice into liquid, or from a liquid into steam. Transitions are due to external perturbations, a differentiating operator that generates a velocity vector, which reunited on a field can result in a new manifold of trajectories determining the system.

Populated by multiplicities space becomes intensive. Intensive is a space that differentiates itself progressively giving rise to extensive structures. The space is not a static emptiness where objects translate, but the product of differentiating operators affecting matter. It changes concurrently to the systems occupying it. In this sense, the Deleuzian space is close to the space postulated by Leibniz, the indiscernible, only perceived in the transformations of objects populating it. The division of space and time operated in modernity shifts to a processual reality produced by Becoming matter, space, and time.

Space is at the same time the uninformed infinite speed, allowing the transformation of matter and the product of the processes of this matter. The Plane of Immanence, also named Plane of Consistence, is what allows the philosophy to become a fractal thought able to capture a transformative reality. Philosophy gains consistency without losing infinitude. The plane operates a transversal section of chaos, the infinite speed of birth and vanishing, which is the Virtual. This plane spreads out the diagrammatic features, allowing movement, transformation, linkage with increasing connections. In the plane, concepts act as intensive features, that projects the velocity vector field, and selects the variable curves that retain infinite movements, towards stratification. Nevertheless, at the same time due to the coexistence of divergent lines in the vector field, it is able to foster new connections, opening the Bodies Without Organs. This is the non-stratified, new line of actualization. This inherent uncertainty will allow for the creation of new connections or Transductions between planes towards new creative Becomings. *"The plane of consistency is the abolition of all metaphor; all that consists is Real".*[24]

Opening the space to embrace the movements of a Becoming reality allows the Difference to surface from the concealment of the codified or stratified. This operation will dissipate the illusion of objectivity and lineal causality, reality becomes emergence. This leads to a new conception of what is a thing. Things become aggregates, historical assemblages that cannot be deduced from their components. Representation will be replaced, for Deleuze, by the expression of how things become, reaching existence, and the epistemology will no longer be knowledge of the regular laws of matter but engaged experimentation with a reality that cannot be apprehended from outside.

> *"Philosophy does not consist in knowing and is not inspired by truth. Rather, it is categories like Interesting, Remarkable, or important that determine success or failure. Now, this cannot be known before being constructed"*[25]

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24 Gilles Deleuze and Félix Guattari (2005) *A thousand Plateaus,* pp. 69

25 Gilles Deleuze and Félix Guattari (1994) *What is Philosophy?,* pp. 82

1.1.2 BECOMING AND TRANSDUCTION

The plane of immanence allows an understanding of the intensive space. Space becomes a continuum of heterogeneous, where the intensive is a productive difference. The process of differentiation occurs at phase transitions. These are changes in the symmetry of a system produced when an intensive quality reaches a threshold due to a contribution of energy from the outside. This process describes a Becoming without being, where all possible transcendental preconditions are substituted by the communicative encounter among intensities. The actualization of matter is not the realization of a program, but the constitution of a channel between two heterogeneous series of singularities, by virtue of which these series are coupled, changing probability distributions. These series resonate, leading to a change or forced movement. The communication becomes a difference of the difference, the contribution of new energy that overloads the series determining the system and produces a divergence that changes it. Delanda focuses on the process of ontogenesis to explain the process of differentiation and Becoming of the extensive and qualitative qualities of matter.[26] It considers ontogenesis associated to the population's thinking. This is a way of considering evolution and the distribution of species related to ecology, where populations and rate differentials substitute the types and ideal norms. This shift gives birth to a Flat Ontology based on the equal agency of matter, where entities and systems communicate by virtue of the space of uncertainty laid out by the Virtual, not in a hierarchical manner.

As the goal of this work is to examine the agency of Collectives and their potentiality to intervene in the conformation of their environment by means of laying out differentiating disruptions, this text will focus on the process of communication as a productive encounter, the process of assembly that keeps the world ongoing.

The next paragraph by Serres points out communication not as a human capacity but as a process that living and inert matter shares:

> *"Our body listens, yells and remembers. Bacteria, seaweed, mushrooms, plants, and animals signal their presence and perceive the environment, each one in its way; without changes of energy and information any organism survives. Before becoming human, communication characterises the living as an open system: the cells into bodies, communicate between them in the same way that bodies communicate with their ecological niche. In the small scale, the chemical reactions, and in the big one the storms and the galaxies. All they exchange energy and information in the blossom of the inert matter".*[27]

Communication is the mechanism of a process of assembly by virtue of which singularities differentiate themselves. The process of communication involves intensities in the machines or systems emerging from the plane of consistency. This plane is diagrammatic, without a centre, like an infinite network of automata in which all individuals are interchangeable and only defined by their state at a given moment. There are no pre-existing channels among them, and communication runs from any neighbour to another. Deleuze severs communication of language, the redundant transmission of order-words, related to representation and politics, linking it with rhythm. Communication does not translate from code to code and does not transmit messages; instead, it starts new rhythms by means of making resonate, disparate series. The transmission of information occurs due to the capacity of making resonant a surplus value of code affecting and integrating

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26 Manuel Delanda (1994) *Intensive science and virtual philosophy*

27 Michel Serres (2002) "Les nouvelles technologies" (The new technologies) translation by the author

two separate series or systems. This process of amplification –being physical, biological, mental or social- in which activity gradually sets itself in motion, propagates within a given domain and bases this propagation on a structuration carried out from close to close areas in such a way that each region of the constituted structure serves as a constituting principle for the following one. It is what we know as Transduction. Deleuze develops this conception of communication following the works of Simondon and his Theory of Individuation. In his text, *Difference and Repetition*[28], Deleuze characterizes Individuation as the act of solution of a problem, or discordance that arises between two metastable systems. A metastable system or quasi-system (also called open system) is a system which localizes its critical points and becomes able to receive energy from the outside. The Individuation arises as the actualization of the singularities localized in these critical points after the setting in communication of disparate elements. The act of Individuation consists not of the suppression of the problem, but the integration of the elements of the discordance in a state of coupling that assures their internal resonance. The critical points arise from what Deleuze refers as a pre-individual state, understanding it as the reservoir of singularities of the system. In other words, the margin of uncertainty set up by the Virtual that gives to the system the potentiality to transmute. Individuation is an Ontological Theory of Information different from the abstract theory of communication developed by Shannon and sustained by cybernetics, which considers information as quantifiable. In contrast, Simondon considers communication not as an object, but as an event not reducible to any cause. Communication is not the transmission of forms or messages as determinable objects. Thus, Information is not a given reality, a unique term we can transport, as much as the result of a disappearance. So it is the dimension where two disparate reals can become a system, the result of a process of assembly that is not guided by filiation or evolution but rather by alliance and sympathy that produces a meaning, which is the transformation arising from the encounter between a body and its associated milieu. The milieu is not defined by spatial boundaries, but by frequency and resonance. Communication is not an act of power, but a mediation between different systems or between the subsystems inside a body.

Simondon differentiates between two behaviours of information.[29] Information is not only what can be infinitely modified but also, what must reduce its randomness to be transmitted. This reduction is executed by means of producing a regularity, a localization, a defined dominium or determinate stereotype that distinguishes information from pure randomness. In this way, the form is not a quality of information, but a precondition imposed on the system; it reduces the probability of the occurrence of an event, which may trigger a series of unforeseeable states. *"In the beginning was the noise"*.[30] These two behaviours of information correlate to two different modes of amplification.[31] On the one hand, the Transduction that is able to create new structures, and on the other hand, the modulating amplification, The latter being a domestication of Transduction, consisting of the separation of the fundamental levels of Transduction -the energy supply, the way-in and the way-out- and the imposition of a form directed to manage and subdue to control the regime of state changes of a system. This form is based on the layout of a structure of relays, which determines the gradients of energy accepted by the system and limits the possible activity of the system. In this situation, information is no more the production of novelty and inventiveness, but the energy of a task of maintenance that conducts the system to a situation of homeostasis or self-regulation. This modulation distinguishes information of noise; information becomes what can be determined by a code, a relative homogenization that reduces indeterminacy. The combination of Transduction and modulation can lead to organisational amplification, addressed to the solution of a problem or the accomplishment of a given task. These differentiated forms of amplifications will determine the possibilities of intervention in the composition of our reality, from the disruptive emergence of noise to the modulation and coupling of disparate systems.

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28 Gilles Deleuze (1994) *Difference and Repetition,* pp. 365

29 Gilbert Simondon (2012) "Du mode d'existence des objets techniques", pp.187

30 Michel Serres (1982) *The parasite,* pp. 13

31 Gilbert Simondon (1962) "L'amplification dans les processus d'information" at (2010) *Communication et Information*

1.1.3 THE ECOLOGY OF AFFECTS

> *"The creative capacity allways belongs to a community or collective, to a group, to an active social division, to an agent or and actor".*[32]

Although we have been describing communication as a process among systems, we have already quoted how Individuation is a process between a body and its associated milieu. Systems or machines and milieus are all assemblages. The difference, which I will outline here, is that a milieu is a system or an assemblage of systems becoming expressive. Deleuze characterizes Expression as an *"operation of amplifying structuration carrying the active properties of the originally microphysical discontinuity to the macrophysical".*[33] A system contains the multiplicities, which are actualizing themselves towards possible state spaces. The milieu adds to these multiplicities the Affects leading the systems to co-function in an ecology of differentiated functional structures. Deleuze elaborates the Affect after the post-Cartesian philosophy developed by Spinoza and Leibniz, where Expression becomes meaning, understood as the immanence of matter; in other words, the result of Becoming. In addition, this materialism is complemented by the Bergson's outline, who considers affection as taking part of the method of intuition, from where the body cannot be a point or a mathematical abstraction, but has to be considered as having a volume and a space by virtue of which it becomes a producer of differences.[34] In this re-embodied reality, Affect (Spinoza's Affectus) is an ability to affect and be affected, the motor for the communicative encounters with other bodies, which implies an increase or decrease in that body's capacity to act. Delanda calls Affects quasi-operators and identifies them as capacities. Every system or body exhibits properties (extensive and qualitative) as a result of the process of differentiation, and an infinite list of capacities, differences of the differences. The definition of capacity is close to the term Affordance, meaning the opportunity for action, which was elaborated by the psychologist Gibson to explain ecological interactions. Every action (physical or mental) of a body emerges from the capacity to communicate with the milieu in which it is immersed. Capacities are relational and symmetric, as a movement of Transduction where the body Affects the milieu at the same time as the milieu Affects the body. Affects are opportunities for the productive encounter of communication, they increase the dimensions of multiplicities, adding new degrees of freedom or new possible state changes to the assembled bodies.

The Affects are the starters of movements leading to form new assemblages. These must be understood as emergent aggregates, whose identity is produced historically, being initiated and sustained by the interactions between its constituent parts. Being reunited by relations of sympathy and co-function they are wholes that cannot be deduced from the addition of their parts. Assemblages as systems, bodies and milieus are the way that matter emerges from the Virtual to conform the meshwork in which we are immersed as our reality. The role that Affects play in the assemblages leads Deleuze to realize the key movement for the formulation of his open and constructivist Ontology. Affects separate content of Expression.

Deleuze distinguishes between matter, content and Expression. The matter is the plane of consistency or the abstract machine (Body Without Organs). In other words, the unformed, unorganized, non-stratified, or de-stratified body and all its flows: subatomic and submolecular particles, pure intensities, prevital and prephysical free singularities. Content refers to formed matters, which would now have to be considered from two points of view: substance, insofar as these matters are "chosen", and form, insofar as they are chosen in a certain order (substance and form of content). Finally, Expression designates functional structures, which would also have to be considered from two points of view: the organization of their own specific forms and substances insofar as they form compounds (form and content of expression).[35]

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32 Heri Lefebvre (2000) *La production de l'espace,* pp. 137. Translation by the author

33 Gilles Deleuze and Félix Guattari (2005) *A thousand Plateaus,* pp. 57

34 Gilles Deleuze (1991) *Bergsonism*

35 Gilles Deleuze and Félix Guattari (2005) *A thousand Plateaus,* pp. 43

Regarding this distinction, assemblages are set up on two axes. On a first horizontal axis, an assemblage comprises two segments: one of content, the other of expression. On the one hand, it is a machinic assemblage of bodies, actions, and passions, an intermingling of bodies reacting to one another. On the other hand, it is a collective assemblage of enunciation, acts and statements, incorporeal transformations attributed to bodies. Then on a vertical axis, the assemblage has both territorial sides and reterritorialized sides, which stabilize it, and cutting edges of deterritorialization, which carry it away.[36]

On the one hand, Assemblages comprise of the horizontal free movement of contents and expression, the Becoming of matter. On the other hand its superimposed vertical axis strives between codification and de-codification or territorialization and deterritorialization, which is the space where abstractions, social rules, and power arise. To understand the relevance of this disposition we will examine the case of a specific kind of assemblage: language. Deleuze considers communication independent of language. Discursiveness is one of the fourth illusions dismantled by the Plane of Immanence, conjointly with the illusion of transcendence, illusion of universals, and the illusion of the eternal. Language is not communicational or informational either, but the transmission of order-words. On the vertical axis, language is indirect discourse, the redundancy of order-words based on implicit presuppositions and directed to maintain the collective of enunciation codified. On the horizontal axis, we find the collective of enunciation, the abstract machine constantly subject to transformation. This is constituted by all the immaterial transformations, juridical acts or equivalent of juridical acts, which far from depending on subjectivation proceedings or assignations of subjects in language, in fact, determine their distribution. The Expression of all the possible incorporeal transformations, where contents are not signifiers, but variables of the assemblage, laid out on the plane of immanence as a collective of enunciation, is not based on language having a syntax and logics, but diagrammatic and superlinear. Language does not represent matters of fact, we are never presented with an interlinkage of order-words and a causality of contents each one in its own right, nor do we see one represent the other, with the second serving as a referent. The independence of the two kinds of forms, forms of expression and forms of content is not contradicted but confirmed by the fact that the expressions are inserted into or intervene in contents, in order not to represent them, but to anticipate them or move them back, slow them down or speed them up, separate or combine them in a different way. In this sense, language is always pragmatics, a speech act giving birth to a concrete state of things. The scientific enterprise of extracting constants and constant relations is always coupled with the political enterprise of imposing it on speakers and transmitting order-words. There is a primacy of the collective assemblage of enunciation over language and words. This collective assemblage of enunciation is the ecological milieu constituted by bodies and the Affects, which put them in movement laying out the interactions that form the Collective; a precise state of the intermingling of bodies in a society, including all the attractions and repulsions, sympathies and antipathies, amalgamations, penetrations and expansions that affect bodies of all kinds in their relations to one another.

The Ontology set out by Deleuze and Guattari translates the processes of matter - the differentiation process actualizing matter and producing the extensive space- to the macroscopic level of societies of any kind. It is an Ontology based on Embodiment and Encounter. The assemblages are always embodied in physical entities, this being bodies, machines or cities, which are affective in relation with their movements, needs or desires; movements that lead them to form new assemblages towards the production of new dispositions of the real. This Metaphysics replaces filiation and logic necessity with the alliances and cooperation originated from the confrontation with new problems.

At this point, we can point out some of the consequences of the thought initiated by Deleuze and Guattari. The former refers to science and is suggested by Delanda and his criticism of the essentialist conception of science. According to this author, the normal laws of science and linear causality – given a particular cause the same effect was bound to be produced- comes to subordinate mathematical models to logic relations between linguistic statements. In contrast, Delanda proposes a problematic approach to scientific research.

36 Gilles Deleuze and Félix Guattari (2005) *A thousand Plateaus,* pp. 88

Deleuze stresses the role of correctly posed problems rather than their true solutions, a problem being well set out if it captures an objective distribution of the important and the unimportant, or more mathematically, of the singular and the ordinary. In this way, problems can replace fundamental law statements and science will be the research of the critical points leading to changes. That is to say, what the degrees of freedom of a system are and which disturbances may or may not make a difference. These extrapropositional and subrepresentative distributions replace law statements and essences. The laboratory must be viewed not as a place of discovery of fundamental laws but as a place for experimentation, where heterogeneous assemblages form, assemblages that are isomorphic with real intensive processes. We learn from electrons or other entities making them part of heterogeneous assemblages where they affect and are affected, and it is this causal know-how which gives us confidence that these individuals actually exist. Science encounters philosophy and becomes a Speculative activity. It is no more a contemplative attitude, but a pragmatic engagement with the Becoming of our reality. The researcher engaged in the experimentation becomes part of new assemblages that explores all the possible Becomings of matter.

The second conclusion we reach, which will be extended in the next chapters, is that Transduction is an ontogenetic operation implied on knowledge and the adequate representation of reality. Knowledge and representation are forms of Transduction, we learn and represent our world forming and being engaged in assemblages. As an example, to learn to swim you have to be immersed in water, become one with this milieu, the movements of our body becoming movements of the particles of the liquid. Following this, I will elaborate how the Poiesis is a fundamental mode of being; this means that knowledge as experimentation emerges concurrently to the production of our world.

Our third conclusion follows the overcoming of the separation between object and subject, nature and culture, the immutable pre-existing exterior and the result of human actions and knowledge. They all become assemblages. Our milieu, the extensive spaces we inhabit shaped and codified according to cultural rules such as our cities, or the more recently discovered wildling lands, are all the result of the same material processes, without any relation to primacy or progress of one over other. The Populations of Delanda's Flat Ontology substitute culture and society, understood as totalities defining our relations and behaviour. These become a set of molecular individuals interacting in a non-hierarchical manner, only defined by their relative positions and the assemblages they are taking part in at a precise moment. I will use the term Collectives to refer to societies and communities of any kind, a molar assemblage of molecular individuals reunited by expressive functional structures, but exhibiting the same indeterminacy as the molecular structures allowing them to translate and extend to new assemblages towards a productive and creative activity.

1.1.4 ART AND THE CRITIQUE OF REPRESENTATION

> *"We lack creation. We lack resistance to the present. The creation of concepts in itself calls for a future form, for a new earth and people that do not yet exist. Europeanization does not constitute a becoming but merely the history of capitalism, which prevents the becoming of subjected peoples. Art and philosophy converge at this point: the constitution of an earth and a people that are lacking as the correlate of creation".*[37]

Deleuze and Guattari describe the engagement of philosophy, science and art with the Virtual to define how these different movements of thought create consistence by means of their specific contents and procedures.[38] Hence, philosophy wanders around the Virtual to set up the concepts, the variables expressing all possible

37 Gilles Deleuze and Félix Guattari (1994) *What is Philosophy?*, pp. 108

38 Gilles Deleuze and Félix Guattari (1994) *What is Philosophy?*, pp. 108

connections, which establishes the possibility of everything that can be thought –in other words, in this case, taken from Serres: ontology is what is concerned with the whole set of relations–.Science is also the creation of prospects, which actualize matters of fact. Finally, art is concerned with Expression; it embodies the Virtual and makes it affective. This schema concedes a relevant role to art that becomes the field from where arises the socio-political thought of these authors. Inside art, thought becomes an ecology. That is to say, art is the procedural field engaged with the understanding and intervention in the creation of our territories or spaces of dwelling, our Collectives, and our subjectivities. Deleuze says that art is the establishment of the first territory, a first composition or assemblage, whose components become appropriative. Aesthetic qualities exhibit a value and a direction, by virtue of which they foster the communicative encounters towards assembly, as they have a meaning, they codify or territorialise the space, setting the frame of our movements and Becomings. However, at the same time, art connects this territory with the infinitude of the Virtual. The Affects may escape the codified and trace *lines-of-flight* towards new encounters or Transductions, transmuting the space. This becomes a movement of deterritorialization-reterritorialization, the setting up of the Body Without Organs, the non-stratified and the exploration of new communicative encounters actualizing new modes of existence. As a result, art is the free experimentation with the lines of Becoming, a way of being always setting on the edge, the moment when this assembled Being begins to transmute into something else. The experimentation on the borders of what is stratified or codified convert art into a revolutionary activity engaged with politics. Art is free experimentation directed at overthrowing all the orders and representations in order to establish difference – the intensive constitution of matter – as a condition of permanent revolution. In contrast to politics, which consists of the maintenance of what is established by means of the negation of everything that differs from it, art is engaged in a molecular politics, the fostering of the Expression of the Collectives by means of exploring all that can Become. Art shifts from the mono-centred vision of a unique perspective – the fake deepness that mediatizes everything without mobilising anything- to the molecular movement, characterized by a plurality of centres, the superposition of perspectives and the coexistence of different unfolding times. The field of art is the struggle, set on the vertical axis of the assemblage, between the frozen monuments of power and its desire for permanence and the always-on movement of an intensive space-time, the Infinite Now, which is the Virtual. Instead of the immobilizing codification of a normative superimposed from a transcendental outside, it is a pragmatics arising from the problematic, the assembly procedure leading to the formation of collective forces, which are producing the intermingling that characterizes our ecological space at a given moment. Politics is before Being. Art makes rhizome, it spreads the diagrammatic features of the plane of consistency and creates new spaces of interference, which will allow the increase of our reality and affordances.

The political engagement of Art is only feasible after the criticism of representation. The movement of the difference towards the Speculative Production cannot be thought as long as it is subjected to the requirements of representation. Representation is the place of the transcendental illusion.[39] By means of their four operations: the identity in the concept, the resemblance in perception, the opposition in predicate and the analogy in judgement, representation is a mediation that reduces all the existent to the repetition of the same. What is the same, an organic force that reduces everything to the proposition, this considered as the only thing that can be thought. This illusion is sustained by the preconceptions framing thought, sensibility, idea and Being. The identity in the concept is sustained by common sense, the identity of a thinking subject that imposes their conditions on the concept. Together with this, resemblance is an application of the identity of the concept to the perceived as an assimilation of diversity operated by good sense. The difference necessarily tends to be cancelled in the quality, which covers it, while at the same time inequality tends to be equalised within the extension in which it is distributed. This is a transcendental illusion because the nature of the intensive is not in the quality or in the extension. However, in what is implied, the matrix from where these qualities arise, intensity is not the sensible but its mode of Being. The third illusion is concerned with the negative and the manner in which it subordinates the difference itself in the form of both limitation and

39 Gilles Deleuze (1994) *Difference and Repetition*

opposition. Deleuze conceives ideas not as propositions, but as Problems-Ideas, which are extra-propositional and sub-representative. These are positive multiplicities, full and differentiated positivities described by the process of complete and reciprocal determination, which relates problems to their conditions. Problems give rise to prepositions, which can be represented as affirmations or solutions that cancel the problem. Otherwise, the affirmation must be understood as an affirmation of the difference and negativity not as the incorrect answers to the problem, but as the other possibilities arising from a persistent problem. Persistent problems, as we will see later, are the procedure of knowledge that from a pragmatic point of view is engagement and creation, in place of recognition of transcendental entities and regular laws. Finally, the analogy in judgement relates to the consideration of Being as a founding principle of the concept. Concepts acquire identity being analogous of Being. In this way, representation divides reality between the primary determinable concepts (a priori) and the derived determined concepts. This analogical, hierarchical determination cancels the collective and relational nature of Being and its distribution, which is not dependent, but the product of the free nomadology of thought. The understanding of Being as a grounding, immutable entity, outside of our world reduces our reality to the repetition of what has only a derivative existence. It reduces to the darkness all that is not positively determined by common sense. Grounding becomes a moral movement that distinguishes between the true and the false, the good copy and the bad one. All that does not go through the filter of representation is considered simulacra, as a not well-formed image without reality or permanence.

Deleuze opposes the organic force of Representation to the System of Simulacra.[40] This system gives birth to the possibility of a nomadic thought: a thought without image that is able to express a multiple and productive reality. It is developed through the substitution of the filters imposed by representation of the entities of an ontological list that in later works of this author will populate the Plane of Immanence. In summary: (1) the depth darkness of ground is substituted by the intensive space and its multiplicities. (2) The unconnected series of repetition from model to copy by the field of Individuation is the encounter between singularities as Individuation factors. (3) The principle of sufficient reason, by the "dark precursor", quasi-operators that are the Affects. (4) The logical filiation and causality imposed by analogy by the movements of Transduction, the linkages of internal resonances and the forced movements as a result of them. (5) The identity of the thinking subject by the constitution of '*larval subjects*': the individuals shaped by a process of differentiation, centres of convergence of the spatiotemporal dynamism that characterises the movement of difference. (6) The delimited, well-known and determinable object or categories, as accomplished by the qualities and extensions by the independent movement of content and Expression. (7) The reductive mediation operated by representation by the centres of envelopment, which nevertheless, testify to the persistence of these factors in the developing world of qualities and extensities.

The system of simulacra is the diagrammatic abstract machine that affirms divergence and decentring. Simulacra are not false and do not exhibit a lack of reality. On the contrary, they are the actualized temporal states arising from an uninformed chaos and its speed of appearance and vanishing. The nomadic thought and its combinatory movement towards the communicative encounters and progressive determination (Transduction) that is the Becoming, substitute the hierarchies and sedentary distributions of representation.

Art is the fostering of the System of Simulacra and since it engages with the free movement of thought it becomes a free Play. Play without pre-existent instructions that gives itself its own rule, in which every play places on the agenda all the fate, all the possibilities, and randomness, without having a necessity, which subtracts the difference. The play branches into all possible consequences, where successive changes are not distinguished numerically -the ongoing progression-, but formally, each one being an ontological chance, a new movement of the components of the ontological list towards the actualization of a new state of the world, a change of dimension. It is a pure game not fragmented by the labour of men. Art is an Ontological

40 *"Systems in which different relates to different through difference itself are systems of simulacra. Such systems are intensive; they rest ultimately upon the nature of intensive quantities, which precisely communicate through their differences":* Gilles Deleuze (1994) *Difference and Repetition*, pp. 277

game, which is able to appropriate the milieu and intervene in it producing new things, which in its turn will foster new relations and encounters. This free play is also developed by Lefebvre, who names it Enjoyment ('jouissance')[41] and by Agamben as the concept of Profanation.[42]

After the critique of representation, which is considered the long history of a mistake, aesthetics becomes the theory of forms of Becoming and the work of art becomes experimentation. This experimentation is developed through three procedures that will be explained in this essay. First, art is experimentation as un-concealment. The world tends to be presented as a set of unconnected objects or as a set of systems in a thermodynamic equilibrium. The Expression of how things Become is related to the opening of the black boxes we are confronted with in our daily life. The understanding of the things around us such as assemblages of active matter, which are the result of historical procedures and that in turn, can take part in new assemblages, not being determined and isolated objects, but agents. The second procedure concerns the fostering of new Collectives. Art captures intensities and activates Affects mobilizing the molecular forces of populations towards the conformation of new Collectives. Deleuze quotes Paul Klee[43] when he claims that art lacks a population, the molecules of an amplifying resonance towards transformation and an increasing reality. Agamben describes it as the coming of a community without presuppositions.[44] The Collectives are assemblages of individuals (human beings), things and codified behaviours and procedures among them that become the places of a productive communication. They open Spaces of Transformation by means of removing the filters that power and representation put in the intersections of our ecological systems and replace them by noise, which is the mesh of points of view and actions. They become the fostering of new ecologies populated by human and non-human agents. Finally, we have the modulation of the existent.

Deleuze signals the synthesizer as the functional assamblage of the Plane of Consistence.

If this machine must have an assemblage, it is the synthesizer. By assembling modules, source elements, and elements for treating sound (oscillators, generators, and transformers), by arranging microintervals, the synthesizer makes audible the sound process itself, the production of that process, and puts us in contact with still other elements beyond sound matter. It unites disparate elements in the material, and transposes the parameters from one formula to another. The synthesizer, with its operation of consistency, has taken the place of the ground in a priori synthetic judgment: its synthesis is of the molecular and the cosmic, material and force, not form and matter, Grund and territory. Philosophy is no longer synthetic judgment; it is like a thought synthesizer functioning to make thought travel, make it mobile, make it a force of the Cosmos (in the same way as one makes sound travel[45]

The Synthesizer holds heterogeneities together without ceasing to be heterogeneous. It synchronises the rhythm of disparate elements and places them in continuous variation until they become a common matter, until the point in which they reach the abstract machine, the diagrammatic communication towards new Transductions. As a synthesizer, art modulates and puts together disparate realities to foster the speculative capacity of matter towards the exploration of all the possible assemblages.

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41 Henri Lefebvre (2000) *La production de l'espac*e, pp. 471

42 Giorgio Agamben (2007) "In praise of profanation" at *Profanations*

43 Gilles Deleuze and Félix Guattari (2005) *A thousand Plateaus*, pp. 416

44 Giorgio Agamben (1993) *The comunity that comes*

45 Gilles Deleuze and Félix Guattari (2005) *A thousand Plateaus*, pp. 343

Finally, I would like to introduce the fourth conclusion of the ontological thought developed by Deleuze and Guattari: Poiesis becomes a privileged mode of Being. That is to say, the knowledge of our world only arises by means of the engagement with its production what is mentioned in the introduction of this text as worldliness. This epistemological turn is related to the speculative thinking and the consideration of Transduction as an ontogenetic operation. After the removal of transcendence and its theological implications, we find ourselves living among things; things that do not become objects anymore, but circulating matter or what Serres calls quasi-objects.[45]

46 Michael Serres (1982) "Theory of the Quasi-Object" at *The Parasite*, pp. 235-246

1.2 WHAT IS A THING: THE EMBODIED SPACE OF TRANSFORMATION

> *"Reality is not defined by matters of fact. Matters of fact are not all that is given in experience. Matters of fact are only very partial and, I would argue, very polemical, very political renderings of matters of concern and only a subset of what could also be called states of affairs. It is this second empiricism, this return to the realist attitude, that I'd like to offer as the next task for the critically minded."*[47]

An object is a false thing, a thing which obfuscates its potentialities and the set of relations from where it results. After the division operated on Modernity that severs space and time, object and subject, space appears as the emptiness where objects translate without suffering any transformation except position. Objects are understood as individual instances of a transcendental idea, accomplished, independent and fully determined by a knowable set of characteristics. After Deleuze, we know that this understanding of our world is the product of a transcendental illusion. Things are not the persistence of matter in front of the subject, but the temporary result of the process of differentiation of matter, a process of Individuation, where things communicate with their environment by means of movements of Transduction, which produce the change of things themselves that become part of new assemblages, the emergent wholes that cannot be deduced from the addition of their constituent parts.

Heidegger wonders about the essence of things in his book *The Thing* [48].Even if his phenomenological solution does not agree with the proposal here in development, in his characterization we can find a change in the understanding of essence that advances the differentiation between objects and things and the participatory involvement of human beings in the production of their world.

The condition that differentiates things from objects, according to Heidegger, is that they are self-sustained –stand on their own- and self-supported –independent-. Things are not mere objects grounded in representation and do not exist only in front of the subject. Things are the result of a process of *setting forth* that liberates them as constitutive parts of our world. That is to say, they are produced as a result of a process of making. Self-support is what the making aims at. The standing of produced things follows a twofold condition. On the one hand, things stem from somewhere, as they are made. On the other hand, things are the *unconcealedness* of what is already present, a nature that makes the things stay for something, a function or purpose. In the case of the vessel discussed in Heidegger's text, it stays due to its holding nature as the creation of a closed emptiness that is allowing the vessel to be a container. Making is the process of openness of the world, the process by virtue of which we are sited in the world among things. For example, in worldliness. There is an important point to outline in this second condition; it is the consideration of openness as the *unconcealedness* of the nature of things. Even if Heidegger goes beyond the critique of representation, when he considers the nature or essence of things as already present, Heidegger still stays on the transcendental illusion. According to the ontology exposed here, the openness of the world is not the *unconcealedness* of a veiled true, but the emergence of a new affordance. The function of holding is not something already there to be unveiled, but a relational capacity emerging from the encounter among the thirsty, the vessel, the liquid...

It is the openness of our world as a result of the making, what was allowing Heidegger to give an explanation about the anxiety about the progress of techno-science. This is shown in his work on "*the question concerning technology*".[49] Technology differs from the technique of artisanship in that the first is *provoking*

47 Bruno Latour (2004) "Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern"

48 Martin Heidegger (1971) "The thing"

unconcealedness. The implementation of Apparatus out of our control that makes nature appear as a constant, or what is already arranged. That is due to the instrumental conception of techno-science, where it is considered as a neutral tool of domination. The poietic potential of making falls apart and human beings lose their freedom, which stems from the Participation in the production of their world. By setting up the technologies towards the conquest of all distances, the nearest remains absent. The world of things is substituted by a self-regulated system that is not *settled forth* by the encounter of new affordances, but for the self-reproduction of the constant. Carrying out the dominion of our world, man becomes the dominated being.

Serres develops the relation between humans and technology to show that the only instances or systems are black-boxes. *"When we do not understand, when we defer our knowledge to a later date, when the thing is too complex for the means at hand, when we put everything in a temporary black box, we prejudge the existence of a system. The system is the other side of non-knowledge"*.[50] Non-Knowledge has two sides, the first one is chaos, the multiplicities of the Virtual not reachable until their actualization; the second one is the concealment of the system. Knowledge is a Space of Transformation, the experimental activity that builds a bridge between the unformed matter embracing all the possible and the Becoming systems. Serres proposes the quasi-object as a means to attain knowledge outside representation.

The quasi-object is circulating matter. If we consider the Heideggerian Jug. Heidegger characterises it as the result of four causes or modes of being-responsible-for: the material cause – the material where the jug is embodied-, the formal cause –the shape the jug takes -, the final cause – the goal of the jug, containing a liquid-, finally, the efficient cause –that produces the effect, this is the jug. Now, let us substitute causes by Becoming: we have the ability of our hands, their concavity and the encounter with a malleable material they can shape. The encounter of the shaped material with fire and the process of baking that makes it stable. The encounter with cooking and the need for containers that can resist high temperatures. The existence of a human aggrupation that repeats this productive operation for ages and generations. The jug becomes part of multiple assemblages, tracing a network of complex relations where the production of multiple times and spaces meet. The jug becomes a quasi-object, which traces or makes visible the relations that constitute the group through which it passes, like the token in a children's game.

Serres characterizes the quasi-object as follows:

> *"This quasi-object is not an object, but it is one nevertheless, since it is not a subject, since it is in the world; it is also a quasi-subject, since it marks or designates a subject who, without it, would not be a subject. He who is not discovered with the furet in his hand is anonymous, part of a monotonous chain where he remains undistinguished. He is not an individual; he is not recognized, discovered, cut; he is off the chain and in the chain. He runs, like the furet, in the collective. The thread in his hands is our simple relation, the absence of the furet; its path makes our indivision. Who are we? Those who pass the furet; those who don't have it. This quasi-object, when being passed, makes the collective, if it stops, it makes the individual. If he is discovered, he is "it" [mort]. Who is the subject, who is an "I," or who am I? The moving furet weaves the "we," the collective; if it stops, it marks the "I." in the Copernican world objects are slaves. As a ball in game. The ball is the centre of the referential, for the moving game. This quasi-object that is a marker of the subject is an astonishing constructor of intersubjectivity".*[51]

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49 Martin Heidegger (1997) "The Question Concerning Technology"

50 Michel Serres (1982) *The Parasite*, pp. 73

51 Michel Serres: *ibid*, pp. 225

Production is a communicative activity, which is always setting inside a Collective, where object and subject continuously change its positions always in relation to the considered matter of circulation. Participating is to take part in this Collective weaved by the movements of the quasi-object, where we are not sovereign but involved parts.

In the weaving-together of the Collective nature and culture are not differentiated, as the movement of the socially constructed in front of the immutability of the already given. As the subject-object, the determination of nature and culture moves and changes its positions accordingly to the movement of the circulating matter. The lack of freedom and agency that Heidegger claims to be the danger of techno-science emerges from the constitution of nature and culture as separated domains.

1.2.1 NATURE AS A COMMON PLACE

> *"Nature is not a physical place to which one can go, nor a treasure to fence in or bank, nor as essence to be saved or violated. Nature is not hidden and so does not need to be unveiled. Nature is not a text to be read in the codes of mathematics and biomedicine. It is not the "other" who offers origin, replenishment, and service. Neither mother, nurse, nor slave, nature is not matrix, resource, or tool for the reproduction of man. Nature is, however, a topos, a place, in the sense of a rhetorician's place or topic for consideration of common themes; nature is, strictly, a commonplace".*[52]

Donna Haraway names Commonplace a re-articulation of the relations between Nature and Culture. This re-articulation pushes away the limits between human and animal, organism and machine, the physical and the spiritual, it refuses the totalizing theories that always left fractions of the reality outside, and overcomes the predominance of a metaphysics anti-science.

The consideration of the common processes of Becoming of all matter and our world as composed by assemblages leads to: on the hand, the Collectives to be aware and responsible of the productive relations between the two hitherto separated domains of society and science. And on the other hand, it leads to a redefinition of communication and knowledge towards the overthrow of the mechanisms of control that are subjecting our postmodern society. Nature is no more a space to be known and dominated by culture but rather it becoming a common ground for the action of Collectives. In other words, the ongoing composition of a public space that is the result of the communication processes between human and non-human agents, where the creation of matter and meaning arises as a result of this communication.

In order to afford the construction of the commonplace we need to overthrow the modern division between Nature and Culture towards a new relational understanding that allows interpreting the numerous hybrids or quasi-objects populating our environment. The distribution of electric energy into our homes, the voyages to outer-space, the atomic bomb, the cloning of life and the advances in Artificial Intelligence are some examples of new phenomena that cannot be only attributed to technological progress, these developments have been affected by political decisions, social events, economic needs and moral changes and have affected our world beyond labs and scientific research. Thus, these hybrid objects have produced changes in the way we use public space, the composition of the air we breathe, the way we communicate within us, even the definition of life. These hybrid-objects question the division between a natural transcendent world in which humans can only establish a relation of knowledge and disclosure and an artificial world, immanent, which is the result of human actions.

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52 Donna Haraway (1992) "The Promises of Monsters: A Regenerative Politics for Inappropriate/d Others"

Bruno Latour establishes the origin of this fracture in a double division occurred in modernity and that will separate the world of non-humans –Nature- and the world of humans, Society.[53] This author proposes the Modern Constitution as an historical event that can be traced for the purpose of explaining the mechanisms producing this division.

The Modern Constitution began in a double movement of translation and depuration. According to this author, Translation is the movement of mediation – a movement implying Transduction and codification- that establishes relations between heterogeneous entities creating hybrids of Nature and Culture. The Translation is a process that leads to the symmetrical creation of the matters of fact - the objects of science - and the political body, constituted by the legal personalities. The movement of Depuration is the second step that consists of stopping the movement of Translation to stabilize the result and close it in a black-box.

The matters of fact were produced in the lab, by means of the displacements produced after the creation of tools such as Boyle's air pump. This was the proposition of a new instrumental procedure that substituted apodicticity for doxa. In other words, the deductive reasoning of regular laws by the reproduction of facts in a controlled space –the experiment performed in the laboratory- in the face of the trustable witness. This instrumentalized observation that left behind the discussion of causes is the mechanism that from now on will give voice to natural forces. Symmetrically, the same shift is produced in society; the creation, in this case, after the rational calculus, of the union of the political body in the figure of the Leviathan. This shift was effectuated by Hobbes after his consideration of the *bare life* and the social contract, in virtue of which human beings delegated their power to a unique sovereign. These two parallel processes lead to the representation of the objects as Matters of Fact, which are able to speak by themselves by means of instrumentalization, and the representation of the legal personalities by the sovereign, by means of the constitution of a social contract. At the same time, these processes show how even nature, epistemology, politics or power are not composed of trans-historical entities.

The movement of Depuration followed the Translation and was accomplished by means of a process of discussion. In the case of Boyle, this discussion was directed to maintain the influence of politics outside the field of science. In the case of Hobbes, it was directed to maintain any transcendent entity outside the social construction that can give man any argument to oppose the contract and the unified power of the sovereign. Depuration is a movement aimed to hide the processes and controversies involved in the creation of these assemblages, matters of fact and the social contract, which after being stabilized by this process, appear as independent substances and immutable.

These two movements do not eliminate transcendence but use it as an immobilizing force in a concealed way. They create a world of matters of fact, the objects of science that even if they are produced in the lab, by means of the Participation of multiple actors, appear as transcendent entities. They pre-exist any human intervention and may speak by themselves –the researcher becomes considered as just an enabler-. At the same time, a unique delegate of power is produced, a transcendental entity beyond the will and power of other human beings that is considered as the immanent result of the relations between the legal personalities. This double shift that obfuscates the process of Translation to show the fracture produced during Depuration gives birth to the Modern world: *"A world where the representation of things by means of the lab is dissociated of the representation of citizens by means of the social contract".* [54] That is to say, a world constituted by a transcendent Nature, but that can be mobilized in the lab by means of the processes of instrumentalization and a Society created freely, but that can turn to transcendental entities to secure its continuity. This dissociation allowed the concealment of the complex assemblages formed between science

53 Bruno Latour (1993) *We have never been modern*

54 Bruno Latour: *ibid*

and politics, the social intermingling and codification that keeps the speculative labour of science away and makes it go forward in one way. Once the process of mediation was hidden and science was moved away from the interference of social events, science became able to progress towards the big productivity and innovation that characterizes modernity. In this way, the work of Depuration that was avoiding the conception of hybrid objects was fostering its proliferation at the same time. A situation that Latour summarizes by telling us that actually *we have never been modern*.

Collectives have been defined here as the places for productive communication; the assemblages of molecular individuals –populations- reunited by expressive functional structures that, at the same time, maintain the agency and creative capacity that allow the uncertainty of the Virtual, the places of transformation described by the movement of the Serre's quasi-object. Latour uses the term Collectives to refer to aggregates of culture and nature, human and non-human agents. These are considered not as mere mediators, but as actors or mediators having the capacity to translate the things they are transporting whatever they are: the political body or the empty space. In this Translation, they can redefine, unfold, curve and betray these entities. The matters of fact do not have a different statute of social events, they look like this because they are pacified Collectives, depurated and stabilized in black-boxes. They are assemblages that maintain themselves in its repetition becoming codified strata.

Latour focuses on the proliferation of hybrid-objects occurring in modernity after the scission between nature and culture to understand the conformation of Collectives and the role that humans and non-humans play in the constitution of our reality. The study of the hybrid-objects turns the radical division into a gradation that we can follow. This study will enable banishing the appearance of the inhumanity of techno-science towards a new productive relation between the techno-science and the social, the Participation in the collective composition of our world.

1.2.2 BRUNO LATOUR AND THE ACTOR-NETWORK THEORY

Latour rearticulates the nature-culture pairing by means of his research into the studies of science.[55] In his investigation, he descends into the laboratory as the place of production of scientific knowledge. From there he can show the realistic foundation of the process of representation implied in the elaboration of scientific knowledge. In particular, he follows the process of mediation that leads to the constitution of scientific facts to show how the observation and experience from where to derive the scientific knowledge are processes of metonymy. In these processes, an element is translated through different processes of inscription: from the open air to the table of samples, to the archive, to the map, to the chart, to the document. The resulting inscriptions are two-dimensional, capable of being superimposed and combinable. They allow an actor to maintain his true substance across the cascade of transformations. Thanks to the shape received from inscriptions the actor becomes a circulating reference or an immutable mobile that can be translated and re-elaborated. An example is, the inscription of a jungle on a map or the orthogonal projection on a blueprint of a monument. The cascade of translations allows shaping matter by means of the enchainment of reversible processes, from where it is always possible to recuperate the origin as a guarantee of the process. These processes occur one after another until they become an Institution, which stabilizes and gives substance to the newly produced scientific fact. The Institution is the wrapping of the scientific fact, a set of actions that stabilises the circulating reference, a complex node produced in the crossing among different relations, processes of translation and inscription, recruitments and movement. In it, we can find the experiment

55 Bruno Latour (1999) *Pandora's Hope. Essays on the Reality of Science Studies*

understood as an event and the creation of tools and instruments that mobilize the world. In addition is public communication, the formation of alliances and groups of research sharing the same facts. In this way, the existence of a scientific fact or substance is always relative to the existence and maintenance of the Institution, as a spatiotemporal assemblage, which allows their concretion.

The Circulating Reference and the information produced during its translation can be traced, that substitute the unreachable correspondence between subject and object for the articulation of propositions. The representation of our world is no more a mortal leap between two dissociated realities, but a process of articulation of propositions by means of the viability of the circulation of the reference. Representation is an immobilizing force, but not based on the transcendental illusion of an identic subject of knowledge imposing the reductive preconditions of common sense and the common reason but on a collective process, where human and non-human agents are involved, producing a result that is neither static nor univocal. It is a process where the processes of Transduction and the Affects implied in an ongoing negotiation that can always be re-elaborated are involved, giving back to the origin, pushed up towards new limits, new dispositions or propositions emerging from a world mobilized and constructed which at the same time is autonomous.

The propositions resulting from this process have ontological meaning; they are *Actants* –non-human actors- they can be connected among them and change its definition, as they become part of new events. The system of reference becomes mobile and subjected to a continuous process of composition. What determines the reality of an actor is the several propositions or assemblages it is taking part in. The action becomes relational and pragmatic. The action is what makes an actor emerge, the chain of relations that makes-make an actor or what is the same, the actualized capacities emerging of the environment where this actor is immersed in a given moment. Actors are only determinable by their realizations in the space-time, what Latour calls its wrapping.

We live involved in Collectives -not only constituted by human beings- and submitted to a constant process of negotiation, from where they can go beyond their limits changing their sphere of action. Following the work of mediation -the transductive events from where the information that constitutes the Collectives emerges- we can attain the political process that reunites the world in an inhabited territory. The process of articulation can be traced. The mutations of the *actant* along the cascade of translations is conducted by the process of inscription producing data that can be traced reproducing the history of this process. This will be the task of the Actor-Network Theory.

On the contrary, the process of depuration developed in the Modern Constitution maintains the facts, the power, and the discourse as separated entities. The Net is at the same time collective and discursive. The Net is the result of considering non-humans as *actants*, -not the simple transporters of a symbolic projection- and follow them on the process of mediation producing the Collective. Tracking the Net will allow us to understand the relation between the human being with their technical environment. The theory of Actor-Network starts from the premise *"we must follow the actors themselves"*[56] and describes the process of the ontological movement of the *Actant- Rhizome.*

The methodology of the Actor-Network follows the actors in their process of establishing relations across the diverse controversies and the fragile links that lead to the formation of groups and conglomerates of agencies that determine the action the *make make*. These associations cannot be described ostensibly, but only in a performative way. They are constituted by the different modes that are said to exist and only remain meanwhile they are actuated. In this way, the Net is a concept or instrument, the result of the following of an enchainment of Mediators, in which everyone actuates thoroughly. The Net shows reality in its movement of assembly before this movement becomes stopped and concealed in the black-box of social or scientific facts.

56 Bruno Latour (2005) *Reassembling the Social. An Introduction to Actor-Network-Theory*

The Net unfolded by Latour relates to the Rhizome spread by Deleuze. Both are the instruments of an open and constructivist pluralistic ontology. Deleuze elaborated the Rhizome as the embodiment of the diagrammatic nature of the plane of consistency and the process of Becoming that matter follows in it. The Rhizome describes the movement traced by the thought of difference as an immanent process far away from the hierarchized path traced by the rooted thought of metaphysics. The thought of difference is able to raise multiplicity, to go inside the structures of the stratified strata and make them go beyond their borders, tracing the *lines-of-flight* that put heterogeneous elements in communication. The rhizomatic multiplicities are flat, multidimensional and without a centre, unity or outlined nodes. They are only constituted by the lines looking for the new connections of a permanent field of Transduction. The Rhizome can never be stopped and does not lose its nature after being catted or fragmented, as it is always generating new lines or potentialities towards new connections. Not being able to be reproduced in a map it is a principle of cartography, a movement not reproducing or representing the structure of the world but producing it in a speculative way, exploring all the possible configurations in a performative movement. The Rhizome is the space traced by nomadology and its revolutionary movements challenging the codifications of power, the contrary to a history where filiation and hierarchy are substituted for alliances, sympathies and cooperation in an intensive space that never exhaust its variations. The Net traced by Latour can be understood as a partial cartography of the Rhizome when it results in temporary stable and codified assemblages. The Net is an instrument of representation. A map conceived as an instrument for navigation rather than as a calque.[57] It being able to embrace heterogeneous elements related to multiple determinations and affected by spatiotemporal evolution. Latour develops the Net after Serres[58], who characterizes it as a space of representation able to shape any possible state of a mobile situation and in evolution. Summarizing the definition by Serres, the Net is a multidimensional diagram in constant evolution, being conformed by paths and nodes – crossroads-, where every node can receive multiple determinations at the same time all of them coming from different nodes and being different in their entity and intensity. It is a poly-determined diagram, where it is not possible to find an origin and where the plural differentiation and the irregular spatial distribution of the paths and nodes lead to the appearance of local associations. Every net is a set in constant evolution that can be maximized in its internal difference, shaping a diagram as irregular as possible. Henceforth, the Net enables following the nomadic evolution of actors involved in the process of composition of the commonplace. It breaks definitively with the linearity and necessity of traditional concepts. Complexity becomes the best chance for knowledge and experience rather than an obstacle for knowledge or a descriptive judgement.

What interests us here of the Actor-Network Theory as a methodology to follow the processes of articulation of the Actor that make it actuate and Become is that it describes it in a net that allows us to understand and make apparent the processes involved in the composition of our world. Especially where representation is substituted by the process of the inscription and allowing to highlight some points that will be further elaborated here: The actors implied in the process are embodied and having an ontological and political meaning, which will be a starting point for the elaboration of the aesthetics of matters-of-concern. The nets constitute their own space–time, which will be elaborated as a reformulation of the commonplace and its politics. Summarizing, the nets are a configuration that makes understandable the collectively constructed nature of our environment without renouncing the autonomy and agency of matter.

The agents involved in the net are never abstract entities but bodies fitted with Affects. The cascade of the process of inscription produces new objects with its Affects that in turn lead to new relations. They can be translated to new assemblages where they can start new Transductions. As an example, we can take *the sample of ground in the Amazonia jungle*[59] studied by Latour. In this net, we can find the jungle, this large ecosystem full of live assemblages from where the expedition will focus on a very small part. Secondly, we

57 Bruno Latour (2010) "Entering a risk Territory. Space in the age of digital navigation"

58 Michel Serres (1968) *Hermes I, La communication*

59 Bruno Latour (1999) *Pandora's Hope. Essays on the Reality of Science Studies*

have the expedition, the three scientists coming from different institutions, featuring different traditions of knowledge. They meet together towards a common goal, in which considerations about cooperative development, botany, sustainability and economics intermingle. Thirdly, we have the map, and the aerial pictures, that the researchers use to orientate inside the jungle and establish their field of research. Maps elaborated a long time ago, involving data banks, the work of designers, printers, and now being renegotiated in contrast with the pictures, the result of a long net starting with the launch of the Ariadne Rocket and the satellites orbiting the earth. Fourthly, the different kinds of trees studied, as indicators of the richness of ground, each one the result of its biological evolution and shaped by the conditions of their environment. Following, we have the archive, not only a set of data but an institution, to be contrasted and studied for new purposes. Finally, the scientific text, which will travel to institutions and conferences becoming part of new controversies and quotations. These new things may move to new spatiotemporal distributions, showing a new topography where the territory rather than a delimitated and dominated space is a temporal conjunction of heterogeneous elements. This new conception allows us to re-elaborate the notions of the global and the local. The global structures can be traced towards the local places where they are produced. The globalization as a culmination of the deterritorialization and homogenization that characterizes the postmodern space can be overstepped by means of tracing the quasi-objects that circulate in a global scale towards their origin and through their successive stages and points of distribution. At the same time, the local understood as closed space unconnected becomes redistributed, by means of the articulations and localizers that translates references from one frame to the next one. That which is the same, which translates the embodied inscriptions from one place to another. Every net can be extended and followed until reaching the global. Following the characterization of net featured by Serres, the local can be sited on a space of bigger density inside the irregular distribution of nodes, a localized space of temporal association of points and connections that form a family with more defined determinations. In this way, space or territory is defined by the translations between places, not by the places themselves; to be small is to be unconnected, and to be big to be linked. None place features enough dominance to be global and anyone is enough self-sufficient to be local. The places do not differ in shape or size but in the direction of the movements coming and going of what is translated inside. In addition, there is always a plurality of nets, diverse modes of being and connected systems that are produced simultaneously. From the net on the underground we are traveling, which only has a metropolitan range, to the speech we are hearing in our mobile phone streamed from the United States, which connects us to a more global net. Our space becomes a multiverse with a variable topography, where it becomes possible to draw multiple cartographies, partial nets that can be interconnected or not, but that never reach all the potential space. The partial nets constitute Oligopticons. These are described by Latour to oppose the framing vision of the Panorama, in spite of panorama, which reduces reality to a completely coherent snapshot. A totalizing image showing a misleading zoom vision from where the small part are contained and explained by the big whole, the Oligopticons result from a close vision following the paths traced by relations, always partial and only visualizing a small part of reality, but visualizing it very well. They are the vision from inside the Net, showing the lack of control and weakness of connections, the ephemeral territorializations of what is temporary actualized. This vision is a result of our positions in relation to nets. We can fix or build a tool, but we can never switch networks, we can only attach ourselves to the network, adapt to it, participate in it. The relation between humans and networks is Participation, an interaction in which we subjectivate ourselves becoming involved in the multiple nets conforming our ecosystem. The network contains and dominates the human actions, spreading out our affordances and a collective normativeness, which stems from the standardization accomplished by the of the inscription processes.

The project *Paris invisible city*[60] features this cartographic network, it confronts the panoramic vision of Paris with the multiple nets emerging from localized centres of control and shaping and sustaining this big city; a territory shaped by services and urban furniture that indicates the possible movements of the citizens, the

60 Bruno Latour (text). Emilie Hermant (Photo), Patricia Reed (Screen Design) Online Project launched in 2004 Included in Airs de Paris Exhibition, Centre Pompidou. On-line: http://www.bruno-latour.fr/virtual/EN/index.html

circulating subjects that construct their identity attaching themselves to the multiple partial nets that allow them to communicate and produce meaning. Inter-subjectivity and inter-objectivity become the result of a mesh of perspectives, overlapping spaces, and temporalities.

The moving citizens participating and tracing their own nets become interchangers of time. The Nets informs reality along its composition through multiple agencies and relations among heterogeneous elements distributed discontinuously and running simultaneously. In this way, they change our conception of space, becoming a multiverse -or the multiple expressions of the intensive space- and our conception of time. The nets dismantle the arrow of time, the idea of an absolute linear time, which annuls the entire past in its progress forward. This revolutionary time arises from the dismissal of all the details leading to the emergence of things, its apparition a sort of miracle that produces an epistemological leap, and a new epistemic totality subsuming the entire reality. Serres does not consider time as a frame, but the provisional result of the union of beings, the extensive determination of the intensive. A temporality is an ordering system aimed to relate elements if we change the principle of classification we can obtain a different temporality stemming from the same events. Time follows a recursive schema. It is not distributed along a line but in a spiral in which the future does not overcome the past, but expands itself, resuming the past, reinterpreting and meshing it in new combinations. The Nets are poli-temporal. They select elements coming from different temporalities, from different histories and systems.

The Nets reunite processes of Transduction -the communicative encounters between different systems that resonate producing information- and the process of codification -the processes of the inscription, metrology, and standardization that allow the translation of references from one place to another. Although on the contrary of surfaces that fill all the space extended, the nets have interstices. These are the in-betweens where the uninformed matter sits, what has not yet being actualized or known, the space that is needed for the emergence of new communicative processes, which allow the persistence of the movement of thought and its creative processes. Latour calls this uninformed matter Plasma. Serres call it Noise. Both are manifestations of the Virtual we have already explored here.

The Nets show things arising from the nodes where disparate realities intersect, where things appear as the result of the communication inside Collectives. Things become Open Spaces for Transformation, the problematic encounter from where the Collectives emerge. The Collectives must be composed. Deleuze identifies Composition as the procedure of Art, the procedure by means of which art assembles heterogeneous things, starting new procedures of Transduction towards the creation of new dispositions of the real. This procedure involves art on politics. The aesthetics of matters-of-concern will be a new form of considering things, valorizing its Affects and involvement on the Nets towards the responsible involvement of Collectives in the design of the commonplace.

1.3 COMMUNICATION, KNOWLEDGE AND CREATION

The inscription process described by Latour can be related with Technicity[61] characterized by Simondon as the relation between men and machines based on creation. After Bergson creativity is based on Duration, the living being endures. Simondon explains the special relation of living beings with time through the Individuation process. Individuation does not occur on the borders of humans toward the encounter with the milieu and stops after the concretization in a new thing. In living beings, Transduction is interior and continuous. Humans are at the same time the agents and the theatre of Individuation. That is to say, humans are individuating themselves continuously, at the same time as they individuate their milieu. Life is sustained in a permanent transductive relation with the milieu. This characteristic will be the place from where I will develop the conclusions stemming from the previous chapters: Transduction as a process simultaneously ontogenetic and epistemological, the poiesis as a fundamental mode of existence and Participation as the process of formation of Collectives.

1.3.1 PARTICIPATION AND THE FORMATION OF COLLECTIVES

The Collective is a molar assemblage of molecular individuals reunited by expressive functional structures, but exhibiting the same indeterminacy as the molecular structures, allowing them to translate and extend to new assemblages towards a productive and creative activity, now populated by human and non-human agents interacting to produce their milieu. The interaction between the entities populating Collectives is performed as a communication based on Transduction and will be characterized here as Participation.

The conclusions numbered here stem from the understanding of Participation as a creative engagement in the production of a shared and ongoing world. Henceforth, Participation is opposed to alienation. Alienation has been discussed as a result of the process of industrialization and the consequent proletarianization of human beings. Marx was the artificer of the most quoted schema of alienation, the economic system equalizing and absorbing human work as *surplus value*. In contrast, Hanna Arendt pushed alienation backward in time, situating its origins on the rise up of *vita contemplativa*, the activity of the theoretical knowledge based on the contemplation of transcendental ideas and completely split from praxis. The split between theory and praxis translates to the division between project and execution and consequently to the loss of the object as a meaningful result of work. The workers remain attached to a meaningless and unceasing process. Simondon turns to the hylomorphic schema – things becoming as a concretization of a pre-existing idea- that has been dominating traditional thought to explain the division of work and alienation. Meanwhile, alienation is not the nostalgia of the work of the artisan as owner of a process of production of things, but the lack of the operative knowledge of the systems due to the division between theory and praxis, knowledge kept away from the pragmatics and operability of how things work. Thus, assembly produces functional systems, whose human beings are subjected to the process of production. Without an aware knowledge of the operative processes carried out by the system, the workers become subdued to machines. They are not real users. It will be useful here turn to the distinction laid out by Lefebvre between "*utilisateur*" and "*usageur*",[62] even if it is referred to as public space it can be applied to any milieu, in this case to the technical milieu of production. *"Utilisateur"* refers to a subject whose use is subdued to the codified norms and spaces, the normative behaviour to which subjects adhere passively. "*Usageur*" in contrast, refers to the engaged user, the user making an appropriative use of the space, in this case, the system. The appropriative use is characterized by

61 Gilbert Simondon (2009) "Technical Mentality"

62 Henri Lefebvre (1991) *The Production of Space*

its relation with creation, a free use in which the user can disrupt the modulating amplification and establish a communicative encounter producing new information. That is to say, a change of phase-estate and the correspondent new produced meaning. In addition, it is an action where the user becomes involved, being at the same time agent and theatre of action, a communicative encounter based on Transduction, where the subject of the action is modified, becoming subjectivated at the same time as it modifies the milieu. Agamben defines use as the affection that a body receives inasmuch as it is in relation to another body.[63] Therefore, the aware Participation of the workers into self-regulating becoming of technical objects can become a source of new affordances increasing the potentialities of subjects. Thus, it can overcome the alienation of the operator.

Contrary to alienated use, appropriate use is characterized by the aware involvement of the user on the system. This active involvement is produced as Transduction, which at the same time is both an ontogenetic and epistemological process. It is ontogenetic as it is able to invent and produce new things. In addition it is epistemological as is the relation by means of which the user acquires knowledge about the milieu they are engaged in. The conception of knowledge and Becoming as Transduction is based on the conception of the human being as Duration. Beings do not possess a unity of identity, which is that of the stable state in which no transformation is possible; the being possesses a transductive unity, it can dephase itself in relation to itself. The nature of the being is Becoming not the accomplishment of a primitive given substance but the continuous movement towards communicating and individuating in relation to the milieu. Transduction is a vital operation, not only the process of information of matter but also a psychic procedure. In the domain of knowledge, it is the discovery of the dimensions according to which a problematic can be defined, where the veritable process of the invention resides, as a speculative activity.

The problematic, unachieved and temporal character of the living being is the principle of the transindividual[64]. Beings are problematic in nature; they have a preindividual dimension, a side always immersed in the Virtual as the infinite unactualized singularities. Participation, for the individual, is the fact of being an element in a greater Individuation, via the intermediary of the charge of preindividual reality that the individual contains, that is, via the potentials that the individual contains. Both, psychic and collective Individuation is a continuation of physical Individuation. In order to resolve its own problematic, the individuals must participate as an element of the problem by its action, an active Participation by virtue of which beings actualize themselves as subjects taking part of a Collective, an affective implication in which individuals must make use of new dimensions or potentialities arising from the preindividual. The Individuation of new potentialities arises from the transductive encounters among the individuals involved in the group, the union with the preindividual realities of other individuals leading to the Individuation of the collective unity in which the individual is linked becoming a group-individual. Participation is a condition of the Individuation of the group at the same time as the psychic Individuation –subjectivation-of the assembled individuals.

1.3.2 KNOWLEDGE AS TRANSDUCTION

We have already seen how the ontological theory of information replaces form with information. Information is never a unique term but the signification that springs from the transductive process between two metastable systems that resonates becoming reunited in a new system. Transduction is an ontological process that designates the process of thought itself, that only occurs with the encounter with matter and the process of concretization. According to this, knowledge becomes an analogy between two operations, a certain mode of communication.[65] Knowledge arises from a disparity between two regimes of activity:

63 Giorgio Agamben (2014) "What is a destituent power?"

64 Gilbert Simondon (2009) "The Position of the Problem of Ontogenesis"

the functioning of the system, without an ontological presupposition that is relative to the nature of what enters into activity, and a perceptual disparity. The preindividual field of thought guides an experimentation or speculative activity with the system components, when the system reaches operational solidarity thought passes a threshold towards a well formed cognitive schema, where the mechanism producing a given effect can be traced from its anticipatory emergence back from the future from which it came, strategically guiding the setting in place of elements towards the emergence of a new system. This well-formed schema can be standardized, codified in inscriptions that can be shared and repeated inside a Collective.

1.3.3 TO MAKE: ENGAGING WITH THE WORLD

In this way Individuation, the encounter between disparate entities and their resonance towards the production of information, accounts for the formation of matter, knowledge and the human Collectives. What is lacking in the system laid out by Simondon is the Participation of things in Collectives. Thinking about systems Simondon misses the things as agents. Technicity is not only the operative knowledge and Transduction between systems from where information arises but the creation of things that become new mediators and integrators of the Collectives themselves. They embody the systems that are producing our milieu or worldliness. Things are incorporated in our daily understanding of the world and agency, not only as tools and instruments but also in numerous occasions, becoming the centre of the problematic giving rise to the transindividual and the formation of Collectives. It is at this point where the methodology of Latour can assist in the understanding of Participation. In our contemporary situation where technologies become ubiquitous, we are transduced in technical mediations. Participation is not only social, but becomes engaged in the matter. That is to say, Collectives encounter around the setting up of the things that will integrate their milieu. Spreading out the nets that link the Collectives we will encounter the separated domains of production and use, at the same time as the recuperation of the affectivity now hijacked by consumerism. Throughout the next chapters of this essay, we will find projects and movements such as Critical Making[66], Critical Engineering[67], Participatory Urbanism[68] and so on, which engage in the collective production of new things and the Disruption of the existent ones towards the promotion of new assemblies and forms-of-life.

We are engaged in the things we can change. These Collectives encounter around a reflexive analysis encompassing not only the devices and their functioning but also the processes, social relations, and politics in which they are merged. With this aim, their practitioners refuse general-standardized solutions to focus on situated issues arising from local communities. They do not accept information as a fact to be consumed passively and appropriate the spaces of knowledge and production for the common space. Reunited around a shared problematic arising from a common milieu, these Collectives overstep the separation between production and use. The problems become recursive being a source of creation. Things produced inside a Collective are tested continuously and modified to accomplish new uses, needs, and desires.

The activities held in these Collectives reach the speculative and pragmatic research that characterises Art. They produce things that embody information and its processes, Things capable of invading the public space producing unexpected results and transforming the programmable space in writable information, where it becomes an interpretative experience open to creative intervention. They produce their own codes and norms of behaviour arising from the communication directed to solve the shared problematic. Finally, they

65 Brian Massumi with Arne De Boever, Alex Murray and Jon Roffe (2009) "Technical Mentality revisited: Brian Massumi on Gilbert Simondon"

66 Garnet Hertz (ed) (2012) *Critical Making*

67 OLIVER, J., Savicic, G., Vasiliev, D. (2011-2014) "The Critical Engineering Manifesto (2011-14)"

68 Eric Paulos, Ian Smith, RJ Honicky "Participatory Urbanism", Web: http://www.urban-atmospheres.net/ParticipatoryUrbanism/

assemble heterogeneous realities, modulating them to foster the speculative capacity of matter towards the production of new complex assemblages capable of producing unexpected results.

Not being alienated is not to be freed of material constraints, but becoming well linked. It consists of the aware intervention and proposition of new Transductions that will produce our transindividual reality, the Collectives of human and non-human agents we are involved in and where we communicate, producing our subjectivities at the same time as our physical reality.

This change in the definition of Participation and Things requires a new aesthetic that can foster the aware intervention in the shared production of our milieu. This aesthetic must embrace the System of Simulacra proposed by Deleuze in his critique of representation, not showing the Things as accomplished objects but in his process of Becoming and the production of new Affects and intensities. The aesthetics I am proposing here is related to Latour's distinction between the aesthetics of matters-of-fact and the aesthetics of matters-of-concern.

1.4 THE AESTHETICS OF MATTERS-OF-CONCERN

Objects are false things, what Latour calls matters-of-fact. The result of a process of depuration, which hides their composition's history in a black box and the net of encounters through which they gained existence. Matters-of-fact are partial, polemic and political renderings of what Latour names matters-of-concern. On the contrary, matters-of-concern are trustworthy and engaging things, things that can be followed in their process of assembly, such as the quasi-object by Serres, but at the same time, things charged with Affects. Matters-of-concern must be liked, appreciated, mounted, experienced and proved. They are temporal assemblages, moving in all directions and spilling over their boundaries, unveiling the fragile grid that gives them existence. As they are part of our Collectives, they have to matter. They are not pure and indifferent, the accomplished realization of a pre-existent substance, but an integrating part of the problematic gathering a Collective. They have to be liked; they are the preferred result of the discussions and controversies going on during their problematic existence. At the same time, they are the things we are engaged with during the ongoing communication that sustains life, the embodiment wearing our affordances. They have to be populated; they are assemblages where diverse agents meet; they circulate assembling the agents producing them, the social stage where they appear and their users. Finally, they have to be durable, as the emergent result of historical processes, they must be maintained. Endurance is the terminus of a process of concretization, not what is already given by some substrate, or some substance. Things can always be disrupted, tergiversated, become obsolete and enter into new assemblages that may change their nature.

Matters-of-fact is not what is given in experience, but the result of a process of codification where aesthetics and politics encounter: the recruited members of an Apparatus[69], which Agamben defines as the set of relations, discourses, institutions, laws, police measures and philosophical propositions supported by certain forms of knowledge and supporting the relations of power; the result of a process started in modernity that divided Nature and Culture, giving birth to a world of real objects defined by their magnitudes, but without meaning and a meaningful world of discursiveness, but having a derived existence. The bare objects of the aesthetics of representation perceived according to the visual predominance and the linear narration that characterizes the Apparatus shaping modern age. The result of the division between space and time and the political will of creating a world where non-humans can proliferate without the interference of human issues.

Latour proposes returning the things to the arena of parliament, not considering it as independent objects, but agents involved in our ecological environment as a result of our pragmatic actions and, at the same time support of our affordances. Things must be allowed to speak for themselves, with this aim an aesthetic is necessary which goes out of representation and follows things in their Becoming. Latour takes the first steps towards this aesthetics with the exhibition *"Iconoclash: Beyond the Image-Wars in Science, Religion and Art"*,[70] held in the ZKM in May 2002. This exhibition is a cabinet of curiosities assembling artifacts, documentation and contemporary artworks aimed at substituting The Iconoclash by Iconophilia. It shows the necessity of images, but rejecting their neutrality. The image wars demonstrate the political meaning of images, their relation with power and the freezing operation of representation, which extracts the image of the flow as if it was sufficient, the operation of a power that struggles to endure, eliminating any difference that can activate the movement towards the actualization of new possibilities. In contrast, Iconophilia is the renewing of image movement across the cascade of inscriptions that produces the accepted facts inside an Institution, the acknowledgment of the hands at work in the production of mediators and the multiplication of them as the unique way to grasp reality. The second step towards this aesthetic can be summarized in a

69 Giorgio Agamben (2009) "What is an Apparatus?"

70 Bruno Latour (2002) "What is Iconoclash? Or is there a world beyond the image wars?"

second exhibition curated by Latour in the same centre. *"Making things public"*[71] was held between March and August 2005. This exhibition was aimed at a renewal of politics by means of the inclusion of things in the democratic process. It was the development of an object-oriented democracy towards the redefinition of the *res publica* that allows recognizing the role that things play in the process of assembly of the public. The exhibition shows things conjointly with the nets described by its entanglements with scientific and political issues, becoming an exploration of the hidden geographies of assemblages. Substituting bared objects –matters-of-fact- by things –matters-of-concern- the material conditions of our existence become assembled again and returned to the forum of human discussion, the social cannot being put aside from the natural.

The aesthetic of matters-of-concern is the aesthetics concerned with assemblages, not objects and the frozen images of the representation. It substitutes the critique with care. The critique is used to consider the relation between humans and things, the perception and agency of our world from two contrasted points of view. On the one hand, there is the standpoint from where things are the screen for the projection of power, the determinants of our behaviour by powerful causalities coming from an unreachable objective reality. On the other hand, objects are considered as the projection of our wills and desires, an illusion produced by the subject. From the standpoint of aesthetics of matters-of-concern, things reclaim materiality, they must be designed and maintained, they are engaged in our Collectives. Returned to the arena of human forums they become the social material from where we compose our world. The Actor-Network theory substitutes the representation of an immediate world by the network projection of a mediated world, translated and transformed, where every node or *actant* is a matter-of-concern. They are defined as things we are concerned with and we take care of. Things that are active participants in the composition of our world, no longer pre-existent and indifferent objects but gatherings of Affects and forces, undetermined things that can be questioned as they are real agencies; things that can be liked and disliked and that above all we are interested in. They are things that we can decide about their convenience to take part in the composition of our shared world, things that we can always make a political decision about. After the return of things to the political arena by means of the proposition of a new form of representation, Latour passes on to the discussion about plural institutions.

What I am proposing here is to extend Participation to all the societal agents towards an activation of the molecular forces that can diversify the Collectives. That is to say, the spreading of epistemologies that can generalize Participation in the processes of matter towards the fostering of an active Participation of all citizens in the formation of their territories and their subjectivities. The aesthetic laid out here is poietic, going beyond representation to be engaged with the material production. Poietic is not only the creation of something that was not there before, but the creative process always pushing out the limits of the existent towards a re-articulation embracing new possibilities of existence. This can be accomplished by the liberation of the mediations, deactivating them and making them available for new uses. This use is able to deactivate the codified use of things, it is what Agamben characterizes as Profanation[72]. Profanation is related to the Ontological Game that Deleuze attributes to Art and its unexpected creativity. It is a use freed of utilitarian goals, the free experimentation that can start the System of Simulacra. Employing things beyond their purpose and connecting them to unexpected fields of Transduction we activate the intensive space and its singularities towards new individualizations. New things are produced that sow the space with new Affects, affordances that become opportunities to increase our possibilities to subjectivate ourselves and produce our space, at the same time.

Things become Spaces of Transformation. They are able to embrace the noise produced by Collectives towards the emergence of always-renewed assemblages. The places for the experimentation that characterizes the Speculative Production of our reality, where we cannot know the convenience of our results in advance, but we are always open to making a new attempt.

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71 Bruno Latour (2005) "From Realpolitik to Dingpolitik or How to Make Things Public"

72 Giorgio Agamben (2007) "In Praise of profanation", pp. 73-93

1.5 THE POLITICS OF THE COMMONPLACE

> *"The transformation of society implies the collective possession and management of space by means of a continuous intervention of the "interested", conjointly their multiple interests diverse and even contradictory. Then the confrontation... this will be at the end, in the limit of the possibilities for producing the space of the human kind as a collective work of this specie in the manner of what we called and still call "art", which has not sense in the scale of the isolated "object" for and by the individual...*
>
> *Nothing but an orientation. What is call: a meaning, in other words, a perceiving organ, a conceived direction, a lived movement that opens up its path towards the horizon. Nothing looking as a system"*[73]

The social contract that gives birth to modern legal personalities is based on the presupposition of a *bare life*, a definition of life detached from the preindividual as a condition for the communication with its ecological milieu and its duration as creation. Detached from its potentiality and form-of-life, life is reduced to the self-regulated activity of the organism, it being administered according to the imperatives of efficiency. Bodies are not only subjected to organic subsistence, there are sites of complication, intersection and heterogeneous collective processes. There is no sense in considering humans without entering into commerce with what authorizes and enables them to have an active existence. Bodies are assemblages merged in socio-technical negotiations and artifacts. Being human is always an encounter with enabling others. After the ontological propositions that have been exposed here, the social body is substituted by the Collective as a result of a permanent Composition. The Composition is the process that allows things to be put together, maintaining their heterogeneity, a term that in his manifesto[74] Latour relates to the processes of Art and with a commitment to the world that our collective actions are composing. This process allows is to realize the world is not already given, so all that is composed can be decomposed and judged according to whether it is well or badly composed. Latour defines politics as the progressive composition of a common world. Composition withstands universality as it responds to the purpose and necessity to construct a common world. However, at the same time, it maintains the relativism as what is constructed can never be considered as an accomplished whole, but a fragile assemblage of the heterogeneous. Assemblages are gatherings of intensive differences that can always activate new dimensions from the multiplicities that form their attached pre-individual. Latour explains political commitment as the promotion of new entities to the assemblages, entities that until now were not reunited and were not considered as social matter. This relates to proposals such as the Cosmopolitic laid out by Stengers[75], where Gaia is incorporated as a participant into the democratic forums and other proposals related to the Anthropocene, the geological age characterized by the incorporation of all that was considered natural in the productive actions of human societies. These proposals confront the emergency of reconsidering our actions in this world. How we will see these proposals conjointly with the crisis of capitalism has become a fostering factor in the spreading of participation.

The commonplace has been defined here as the intensive space for the emergence of Collectives, the assemblages of human and non-human agents linked by Participation, the place of the commons, which Agamben defines as the point of indifference between the appropriated and the non-appropriated, something that can never be grasped in the terms of appropriation or expropriation but only as usage.[76] It is the place

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73 Henri Lefebvre (2000) *La Production de l'espace*, pp. 484-485. Translated by the author

74 Bruno Latour (2010) "Steps toward the writing of a Compositionist Manifesto"

75 Isabel Stengers (2005) "The Cosmopolitical Proposal"

76 Giorgio Agamben (1992) "Le commun comme en faire usage"

from where our pre-individual part emerges, which connects us to the Virtual and its infinite possibilities. The pre-individual only emerges in the communicative encounter, the use as Transduction, where we become agents and place, where we become at the same time as our milieu. The fundamental problem of politics is how to make use of the commons. How to promote a plural Participation that connects the pre-individual with the transindividual and the collective promotion of new forms-of-life, the continuous challenging of the Apparatus of domination towards the promotion of a freed collective usage.

The inclusion of things as participants in the Collective and the conception of Participation as Transduction is the key point to include not only things in the discussions of democracy but to engage humans in the processes of matter, to overcome the discursiveness of the codified towards collective engagement in the creation of an emergent ever-changing world. That is to say, the collective involvement in the experimentation with the matter that shapes our form-of-life. Agamben defines form-of-life, as a life not separated from its form, for which in its way of living what is at stake is living itself, in which the single way acts and processes of living are never simply facts, but above all possibilities of life.[77] The life considered as potentiality, not focused on the question of identity –what I am- , but in modality –How I am what I am. In politics, it is equivalent to the dissolution of the political body as constituted to put it in movement. Movement is the acceptance of the imperfection and lack of definition of all politics towards the substitution of the proposition of goals by the progressive promotion of potentialities or forms-of-life. The politic engaged on the promotion of forms-of-life is possible after the deactivation of the dispositive of the exception, by virtue of which; life assumes the form of *bare life*. It is in this sense that Agamben considers politics as a destituent power: the deactivation of the Apparatus by means of the liberation of the mediations. Apparatus are not mere accidents in which humans are caught by chance, but rather are rooted in the process of humanization. The Apparatus is the set of rules, processes, and instruments with which the human beings fill the openness of the world. Deactivating the Apparatus and rendering the power inoperative is a way to render visible the pure mediation as the field of agency and thought, to change production and praxis by inoperativity and use. Politics becomes linked to the Virtual or the pre-individual and its creative productivity. It becomes the collective project to maintain the space open for the proposition of always renovated forms-of-life. The use maintains the openness of the world producing a world never imposed but emerging from its citizens, whereby they are engaged with the production of their space as an opportunity to increase their knowledge and define their identities.

We have already seen how individuals can individuate themselves participating in a Collective, becoming an individual-group. Collective Intelligence is what arises when a group of individuals organises themselves to affront a common problematic. In the next chapters, we will discuss how technology can be an opportunity to enhance Collective Intelligence towards the appropriative use of our spaces of dwelling and knowledge.

77 Giorgio Agamben (2014) "What is a destituent power?"

1.6 THE APPARATUS AND THE RELATIONSHIP BETWEEN THE HUMAN BEING AND THEIR ENVIRONMENT

> *"The conjunction of circulation with production finds analogies with contemporary economy, the monetary international system, the linguist's interest in the pragmatics of the 'acts of language'. The writer-artist as an ennobled artisan leaves traces of his labour in his manuscripts. Crossing outs, erasures, additions and inserts are useful to him and the ones working in the deciphering of his work as signage from where recompose the process followed towards the achievement of the text, potentially also to reach a better understanding of the same. Sited in front the automatized world processor, the writer experiences how good or badly these signposts -recourse of the neglected- become steal and him may present himself ready in the net. The text becomes caught and becomes readable for others as soon as written. He exposed, like this misses the intimacy of the hitherto private space."*[78]

In 1985 Jean François Lyotard in collaboration with Thierry Chaput was commissioned for the exhibition *"Les immateriaux"* (the immaterial), held at the Pompidou Centre in Paris. This exhibition occupied the entire fifth floor of the cultural centre, becoming the most expensive held until then and the first with a philosopher as curator. Planned to be called "New materials and creation", it was aimed at exploring the change in our relation with our world after the implantation of techno-science. The definitive title, *the Immaterial* refers to the loss of our identities and the state of uncertainty that characterizes the postmodern age. This is produced by the crisis of traditional metaphysics and the decline in the capacity it may have to create wide-ranging global systems that include the great and final issues for which we feel a need. Techno-science and its applications had promoted the appearance of new hybrids, complex assemblages that challenge the categories implied in the mediation of our world. What is at stake is not the loss of materiality, but the disappearance of the accomplished objects that we use to categorize our world. They becoming replaced by the rising of a matter imbued with agency, the Becoming of matter that challenges the traditional notions of Being, space and time.

Les immateriaux[79], was conceived as a philosophical artifact, a wandering starting on the theatre of not-body -the absence of the world hitherto secured by the transcendental- and going across the stages linking five differentiated nodes in multiple paths. These five nodes intermingle art, science and philosophy to show the five dissolutions of the postmodern age. (1) The loss of body – the material stuff: the nostalgia for artisanship and the value attached to work in front of the emergence of the calculus and experimentation. (2) The loss of the word – the matrix: the substitution of the message by the structure as the disposition of the entities emerging from a matrix. (3) The loss of the other – material: loss of the filtering realized by the material in the transmission of messages and the technologic enhancement of our insight. (4) The loss of History – matter: the loss of the referent as the object of which the message delivers information, nowadays missed in the progression of simulacra. (5) The loss of the "I" as identity – Maternity: the source of the message, its guarantee as authority now vanished. These five dislocations of the traditional schema of communication: source-emitter-message-receptor, guaranteed by the correspondence between the referent and a material entity existing outside communication, made to vanish by the proliferation of the Virtual. Henceforth, uncertainty is attached to our bodies, our borders, our identities, our time, our language, our

78 J. François Lyotard (1985) "Post-scriptum" at Epreuves d'écriture. Text published in occasion of the exhibition *"Les Immateriaux"*, held at The Centre national d'art et de culture Georges Pompidou, from Mars 28 To July 15, 1985, pp. 260. Translated by the author

79 J. François Lyotard (1985) *Les Immateriaux. Inventaire*

perception, our images, our habits and our spaces of dwelling. Among the manifold of traceable paths, we find the synthesis of artificial skin redefining the limits of our body, being linked to the ambiguity of our identities under the functional undifferentiation of the change of roles we play in our society, represented as a change of clothes. It is linked to the functional administration of our habitats reduced to spaces for resting rather than the places for intimacy. Finally, it is linked to the continuous renewal of fashion as a matrix from where an ever-changing pret-a-porter identity emerges. In another possible path, we can find the human body bearer of identity dissolved in its constituent molecules, functional associations repeated in all living organisms. It is linked to the reduction of processes of life to the feedback from cybernetic communication. It is linked to the reciprocal space of the mathematical representations where the properties of matter are explained. It is linked to the determination of our body due to the combination of genetic information. We can follow this labyrinthine structure to find the changes in our routines of alimentation, our economic system, our schedules, in the system of production of goods and in the planning of our architectural projects. What this exhibition showed with clairvoyance was the formation of a new Apparatus that would define our contemporary world, spreading new potentialities as new ways of domination.

The Apparatus is the net linking the technical assemblages with the discourses, institutions, buildings, norms, policy measures and philosophical conceptions. It constitutes a form of government, which is not based on the being, but on the submission of each and every one of the beings subjected to this heterogeneous set of norms and agencies, which emerge from the process of humanization. The Apparatus constitutes the ecological milieu where we are immersed, the stratification of the Virtual by virtue of which the movement of Individuation is stabilized stopping communication as creation and subjecting individuals to the processes of self-sustained systems. The Apparatus shaping our contemporary society is sustained in the new capacities of computation and communication that give birth to a new form of domination that Deleuze characterizes as Society of Control.

Deleuze considers the implications of the new communication media in the "*Postscript on the Societies of Control*", first appearing in *L'Autre Journal* in 1990.[80] This text describes the shift from the disciplinary societies described by Foucault to a new society. Namely, the Society of Control as the culmination of the deterritorialization process accomplished by the regime of capitalism. Foucault characterizes disciplinary societies as an evolution of the sovereign society.[81] In this the panoptic – the architectonic accomplishment of the perfect prison system, designed by Bentham at the end of the XVIII century- becomes the paradigm of a new technology of power based on the segregation and constant vigilance of the members of society. This is a biopolitics where the submission to a sovereign is substituted by the successive submission to diverse systems of incarceration: the family, the school, the factory, the prison or the hospital. These are institutionalized systems of control, where the individuals are segregated and submitted to constant surveillance to ensure they repeat the behaviours they have been instructed for. This leads to a fierce centralization of knowledge that divides society into functional parts. This becomes a kind of surveillance in which the individuals are constantly watched at the same time, that they are never seeing, which transforms the individuals into objects of information without ever becoming subjects of communication. It is a situation that dissolves the Collectives and their capacity of multiple associations and productive interchange. What is produced is a society made up of separate functional parts, where the individuals themselves become the principle of their submission, power becoming relational and multiple. The Control Society is produced by a technological evolution that turns the capitalism of concentration into market capitalism, exemplified by big corporations. The new economic system assisted by the new computer machines changes the disciplinary control by means of a new kind of modular control. The modular control is able to spread beyond the closed spaces of the institutions -nowadays, in crisis- towards the entire space-time. This form of control identifies and positions the individuals among the mass by means of an attached code that unifies all the values making

80 Gilles Deleuze (1992) "Postscript on the Societies of Control"

81 Michel Foucault (1995) "Panopticism"

them interchangeable and reprogrammable. This code regulates the access of individuals to information and to the physical spaces. The modular power of Control Society can change its program at any moment, redefining their actions, goals, and behaviours. It substitutes the functional training of individuals by a state of permanent formation and competence training of all of them. This means fierce territorialization and antinomadism that characterizes the disciplinary society being substituted by the absolute deterritorialization, where subjectivation is not possible anymore. As a result, the individuals lack an identity from where they can communicate and appropriate their milieu.

In contrast, Guattari considers the new media as enhancers of communication, a chance to facilitate the access of all individuals to the systems of Transduction. Thus, they foster Participation and the creation of Collectives. A short time before the generalization of Internet, this author considered the New Media as the opportunity to overcome the one-way communication of the mass media towards the beginning of a new epoch, the Postmedia.

In the words of Guattari:

> *"From now, we can expect that a reorganization of the power of mass-media flattening contemporary subjectivity is operated towards the begging of a Postmedia epoch, it consisting of the collective individual appropriation of the machines of information, communication, intelligence, art and culture and its interactive use."*[82]

The space of postmodernity is characterized by the deterritorialization produced by a homogeneous and timeless space subdued to the interchange of merchandise, the split between the use and production and the repetition of the standardized goods, the vain variation of the mass media and the dissolution of places, these being substituted by the functional fragmentation of space. In this situation, the new communication media appears as a new space for gathering individuals towards a productive communication. The appropriation of these new systems to promote creation and freedom stems from its technical characteristics.

The new media is produced in a conjunction of the screened emission that characterizes mass media, telematics or the capacity to communicate through distance and informatics or processing of information. This convergence of diverse functions in a unique audio-visual medium re-articulates the traditional communication schema, shown in Lyotard's exhibition, towards the active Participation of the receiver. The individual sited in front of a screen is not more submitted to the seduction of a unique discourse, but they has the freedom to choose and navigate among the large quantity of contents offered by the multiplication of digitized channels, data banks and collections of text and images. This capacity will increase progressively with the implementation of Internet that will allow the creation and sharing of contents by their users. The capacity of storage and data retrieval of this media allows the externalization of memory that becomes shareable and accessible at any time from any place. In addition, it promotes the active access to knowledge. These characteristics will be the seeds of an increased Collective Intelligence. In addition, Guattari points out another characteristic of this media towards their appropriation. The digital media are a way of immaterial production by means of the assembly of heterogeneous elements. The images produced in a computer are not univocal representations, but the result of the montage of diverse elements. This capacity of assembly can be appropriated towards the recuperation of the social experimentation. These two characteristics are what will determine the Internet as a place of assembly, a new Space of Transformation where individuals can meet across distances, leading to new ephemeral Collectives and re-elaborating new assemblages with the material

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82 Félix Guattari (2004) "Vers une ére Postmédia" (Towards the Postmedia epoch). Translated by the author

stored, which can be released to the net, becoming accessible for new re-elaborations. The transmission of a unique message-substance is substituted by the movement of assembly, a generalized communication between humans and machines that produces new Collectives of Enunciation.

> *"The question is to know if we have promoted a transcendent computer object. What is to say, if we are taking as starting point an already done discursiveness serving as infrastructure of all existential elements. Alternatively, if we are taking as starting point, the immanence of the event that will mean to an object do not apprehended in the coordinates of the discursiveness, the time, the space and the energy but inserted in the intensive ordinates generating temporality, specialization and differences of potential".*[83]

The separation between content and expression, the data and the software –the set of syntactic rules for the assembling of these data- and not its supposed immateriality is what brings this new technical assemblage closer to the Virtual. On the Internet the paradigm -the set of relations between words that designate all the possible words that can occupy a determined position in a sentence- becomes implicit and stored in a database. Meanwhile, the syntagm -the set of norms to determine the structure of a sentence- becomes the explicit program. The Internet is a space for the storage of a molecular content free to assemble in multiple undetermined ways. These assemblages are always ephemeral and never exhaust the content that remains available for new uses. This characteristic is what determines the appropriative use of this medium and its poetic capacity.

The Internet has been the battlefield where to confront control and free creativity from its inception. The enabler of the control linked to a fierce deterritorialization and the Space of Transformation of a collective creativity, at the same time. The alienating dystopia of a globalized nowhere and the space of a utopia extended everywhere. The Postdigital situation is characterized by the standardization of this medium, which has extended its application to all the fields of daily life and its progressive embodiment in the physical space by means of new networked devices, which translates the capacities to store, process and retrieve data to an increasing number of things that conforms our milieu and which we interact on a daily basis.

This technical assemblage has become ubiquitous and has vanished in the background of our interactions. Data has become massive getting out of the reach of human capacities and being processed by the generative algorithms of Artificial Intelligence. The explicit syntagm that has allowed the appropriation of this medium is being substituted by the hidden processes of a highly relational and complex system from which we are not aware. This system is shaping new ways of seeing and relating to our environment. The software has left cyberspace to spread itself into our urban environments becoming a socio-technical Apparatus and a space producer. The aim that guides the research explained in the next chapters is to respond to how individuals can be engaged in this Apparatus, how to promote Participation towards the new Transductions from where knowledge and active intervention can emerge in the production of the environment of the Embodied Virtuality. What are the poetics of this new Apparatus, their internal constitution and the relations it is creating?

What is the Embodied Virtuality, in which Collectives have emerged and what are their possibilities of Encounter and Embodiment will be the subject developed in the next chapter.

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83 Félix Guattari (1992) "Vers une auto poétique de la communication" (Towards an auto-poetics of communication). Translated by the author

2. THE SPACE OF EMBODIED VIRTUALITY

"A fundamental data processing has been at play whenever ontological thought or mathematical writing changed the course of cultural history. Instead of still subjecting humans, beings, and machines to the dichotomy of form and matter, we could learn to spell out, at least for the time being, this new trinity made up of commands, addresses, and data. It would be an ontology of media under the twofold conditions of silicon solid-state physics and von Neumann architecture which are, as you may know, intricately interwoven."

KITTLER, F. (2009)
"Towards an Ontology of Media"

INTRODUCTION: THE APPARATUS OF THE DIGITAL AGE

Things are Embodied Spaces of Transformation, the result of an ongoing process where Collectives meet and communicate in a mishmash of differentiated practices, interests, and systems that transduce them producing new information, which afterwards can be codified, standardized and put in a black box. This process of concretization changes the associated milieu that the system is coupled with. As a result, this milieu is imbued with new affordances, new capacities to establish new communications that can spread across other systems that become interlinked in an ongoing ecology. Sometimes we attend to the emergence of assemblages that produce significant changes in the ontology and epistemology of their ecological milieus. Boyle's vacuum pump, as we have already discussed here, changed the way in which scientific research was performed into the modern experimental scientific method. The Social contract supposed the redistribution of social relations, such as starting representative democracy. The steam engine changed the production milieu; it became the agent engaged in the production of big factories and the standardized way of production. Thus, it becomes the Apparatus of the mechanist age. Some of these technological assemblages become ubiquitous. They are new processes of inscription, new mediations that intervene in all the processes of translation that codify our reality. Among these, we can quote phonetic language, writing, and the mechanical movable type printing that started the printing revolution towards the standardization of a shareable knowledge that homogenized language, ideologies, and nations. The Internet is one of these ubiquitous processes of inscription. It is the Apparatus of our Digital Age.

The Internet is a complex assemblage of nested technologies that has spread throughout our world. This has produced significant changes in all our ecology. It has changed our productive and economic system, delocalizing production, command, and distribution, and has led to the Globalization that defines our contemporary world. It has changed our epistemology and the way we codify knowledge. The way we produce data has also changed the way these are processed and circulated. This produced a new form of knowledge based on the collective access to information rather than on authority and transmission. New techniques and procedures have emerged related to digitation, visualization, and simulation. These developed in new research fields that emerged in the encounter between hitherto separated disciplines. Finally, it has embedded in our daily life. Social networks changed the way we relate to each other. At the same time, new ways of organizing work and new offers of leisure related to video games, geolocalization, urban screens, and interactive storytelling have appeared. Screens, the flat terminals of computation procedures are everywhere around us: in the electrical appliances of our houses, medical centres, war command posts, commodity shops and in between our belongings. They become the black mirrors of an efficient dystopia at the same time as the chance of a new sociability.

The Net of this assemblage spreads across a big range of times and spaces: starting from the origins of algorithm in the 9th century,[84] the works aimed at mechanization conducted by Babbage, who projected the Analytical Engine in 1833; the proposition of the Universal Machine by Turing in 1936, the first computer network in 1969 and including the last I-pad model and the first printed anatomic organ. It connects the entrepreneurs working in garages and meeting at the Homebrew Computer Club in Silicon Valley, with governmental and scientific institutions such as the Defence Advanced Research Projects Agency (DARPA) in Virginia, the MIT in Massachusetts, the CERN in France and with the hackerspaces emerged in Europe and the Chinese Shanzhai -the alternative production system emerging in Shenzhen.[85] It is the result of a big Collective, where new tools and instruments such as calculating and cryptographic machines, missile guidance system, satellites, integrated circuits, sensors and printers meet, at the same time as the practitioners of a variegated set

84 The term 'algorithm' comes from the name of the 9th century Persian mathematician al-Khwarizmi, and originally referred to the set of rules used to perform arithmetic operations with Arabic numerals

85 Sandra Álvaro (2015) "The Maker Culture in China (I) (II) (III)"

of disciplines such as mathematics, engineering, neuroscience, biology, and chemistry, but also art, design and soft architecture. Thus, during its concretization process new hybridized disciplines such as computer sciences, artificial intelligence, and digital humanities, among others, have emerged.

Here, only a partial small part of this Net will be traced. The questions I am addressing are what computers are and how they become interconnected to form the background architecture of our milieu. How can this technology be addressed from the point of view of the aesthetics, epistemology and ontology it is generating? In other words, how is this new Apparatus produced and what are the dominated and appropriated spaces emerging from it? What are the aesthetics and politics stemming from the codification and translation process it is supporting? What are the new capacities of control and the new chances for Participation it is shaping, i.e., from the announcement of the Postmedia era to the bottom-up organization of the Arab spring through social networks as Twitter and the appropriation of production procedures by the Maker Community? The standpoint adopted here is that despite the compelling dreams laid out by different kinds of cyber-utopias, the internet is not and must not be an autonomous space from where to escape from the constraints of daily life and enjoy a simulated freedom. On the contrary, it is the technological assemblage shaping our material milieu, in which we inhabit and act on a daily basis.

Behind the black mirror, there is not the emptiness of the cyberspace, but the Transductions between the potential differentials of a whole machine, switching between relays that are obfuscated by software and interfaces. Regarding the material basis of computation Kittler, whose theories inspired Media Archaeology and other neo-materialistic approaches, points out how the value of messages inside this milieu shift to automation, which stems from programmability: automation defined as 'logical deep'; the amount of mathematical or other work plausibly done by its originator, which the receiver is saved from having to repeat. While programmability is the capacity demonstrated by Shannon according to whom the connections between simple telegraph switching relays can implement the whole of Boolean algebra.[86] After eliminating noise and chaos, the programmability of matter takes command. As Kittler says: *"there is no software"*.[87]

Following the Ontology of Deleuze and the reformulation of information and communication by Simondon and the new empiricism by Latour, new thinkers emerged from the hyper-mediated space of the Apparatus, whose emergence is traced here. New ways of thought such as Media Ecology, Software Studies, Media Archaeology and New Media Aesthetics all have a common way to consider computers as a milieu rather than as a tool. This approach began in the works of McLuhan about New Media.

McLuhan considers New Media as the new communicative capacities of the electric era.[88] Carried by electricity, the medium becomes the message. New Media are means for transmission that are able to connect our entire world and to disturb the traditional expansive schema from centre to periphery. This multi-centred implosion contracts our world which becomes a global village, where we wear all humankind as a second skin that increases our perception and knowledge. The printing produced a homogenization that led to the Nation State. Opposite the electronic era is a focus of diversification that fosters new communities, from where new centres emerge that challenge the specialized fragmentation of our highly civilised culture. On the contrary of the hot medium of mass-media and its high resolution New Media is a cold medium that asks for involvement, fostering new chances of Participation. The new technologies associated with electricity are modifying our milieu at the same time as the human sensorium.

New Media has become a usual tag to denominate the encounter between older cultural conventions for representation, access and manipulation of data and the new procedures of inscription associated with computation and networking, an expression especially used to refer to the new artistic procedures experimenting

86 Claude Shannon (1936) *A symbolical analysis of relay and switching circuits*

87 Friedrich Kittler (1995) "There is No Software"

88 Marshall McLuhan (2001) *Understanding Media. The extensions of man*

with these technologies. At the same time, the capacity for global distribution underlined by McLuhan has led to the convergence of all techniques related to communication towards a new Ecology of Media. Neil Postman founded the Media Ecology program at the New York University in 1971. Media Ecology theory considers that technology not only profoundly influences society, but also controls virtually all walks of life.

According to Postman: Media ecology *"is concerned with understanding how technologies and techniques of communication control the form, quantity, speed, distribution, and direction of information; and how, in turn, such informational configurations or biases affect people's perceptions, values, and attitudes . . . such information forms as the alphabet, the printed word, and television images are not mere instruments which make things easier for us. They are environments-like language itself, symbolic environments with in which we discover, fashion, and express humanity in particular ways".*[89] In other words, technology defines the Apparatus shaping the politics, social organization and habitual ways of thinking inside a Collective. Related to this discipline is the work of Harold Innis, Walter Ong, Lewis Mumford, Jacques Ellul, Eric Havelock, Susanne Langer, Erving Goffman, Edward T. Hall, George Herbert Mead, Margaret Mead, Claude Lévi-Strauss, Benjamin Lee Whorf, and Gregory Bateson. Between the approaches closer to the Deleuzian Ontology is Manuel De Lambda and his Flat Ontology, Matthew Fuller, who is also a founder thinker of Software Studies, Brian Massumi, and the theory of Affects, Adrian McKenzie Wark, and Jussi Parika practicing Media Archaeology. They all also related to this field of research.

Another important branch of the study of the technological assemblage defining our ecological milieu is New Media Art. New Media Art has become a place for encountering between the experimentation with the capacities of these new technologies and its societal reception. It has assembled a variegated group of practitioners with unequal backgrounds and new Institutions. Among them we can quote Peter Weibel and Jeffrey Shaw from the ZKM in Karlsruhe (1989); Alex Adriaansens from the V2_Institute for the Unstable Media, founded in Rotterdam in 1981; Frank Malina founder of the publication Leonardo in 1968 in Paris, which after 1981 became the non-profit organization Leonardo/The International Society for the Arts, Sciences, and Technology (Leonardo/ISAST); SIGGRAPH in the US, which emerged as a special interest group of the Association for Computing Machinery (ACM) in 1974 in the U.S.; Arts Electronica started in 1979 in Linz; New Media Institute in Frankfurt (1990); ISEA (Inter-Society for the Electronic Arts) in the Netherlands (1990) and Art Futura in Spain (1990). These institutions, among others, are important meeting places as art centres, labs, festivals, conferences and publications that have assembled an interdisciplinary and international community, which contributed to extending the net of this assemblage and its concretization processes. Despite some theorists trying to fence Media Art into a specific assemblage or process such as interaction, the interface, the hypertext or specific software, I will consider art in a broader sense. Following Deleuze, I will consider art as the deterritorializing activity that sows *lines-of-flight* in the codified strata of this Apparatus towards new possibilities. Thus, art is a revolutionary activity engaged in the promotion of new forms of life, and therefore politics.

Another Collective of thinkers and practitioners that will be included in this net are those related to Cyberculture. Cyberculture is differentiated from New Media as it is more related to politics and epistemology. It focuses less on computation and more on networks and the sociability of the new public sphere. It frames assemblages as mailing lists, wikis and social networks and questions such as digital identity or the ethnography of e-mail usage. As these things are sustained in the same technological assemblage as interfaces in all interactive devices, this distinction will be not sustained here. At the same time, the artistic projects studied in the next chapters will be projects based on the questioning of the material capacities of networks and the Collectives they assemble. They respond at the same time to aesthetic and political aims. For this reason, and even if they do not share a materialistic approach in their theories, the work of theorists such as Pierre Levy and Manuel Castells will be considered as part of the net traced here.

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89 Neil Postman (1979) "Teaching as a conserving activity"

Finally, we encounter Postdigital Research. This is a new theoretical approach stemming from art practice that has been exposed in encounters such as the CAC3 (Computer Art Congress) held in Paris in 2012[90] and the research/Ph.D. workshop organized by Aarhus University and Transmediale in Berlin in August 2013.[91] It is inspired by the works of authors from different standpoints such as David Berry from the new wave of Digital Humanities, Alexander Galloway, engaged in the politics of networks, Katherine Hayles working in posthumanism, Lev Manovich, more focused on aesthetics, Adrian Mckenzie, and Jussi Parika. I will consider the Postdigital as the result of a historical situation stemming from the codification of our lived space by the processes of inscription of this technological assemblage that has been stabilized and put in a black box, a situation that can be summarized as the realization of Weiser's dream. Computing has become ubiquitous, our space disseminated by networked devices that are embedding computation into the daily environment, quoting Ted Nelson: *"we live in media, as fish live in water"*[92]. Post-Digital research is involved in the unveiling of the material basis of the new responsive space. It is a reflexive criticism emerging from the experimentation with its material components addressed to understanding the epistemology and ontology that this situation is producing towards a productive engagement with the new non-human agents that are populating our environment, considering it not matters-of-fact but matters-of-concern. The above-mentioned authors, despite their differentiated standpoints, all have in common that they focus beyond the interface, looking for the material processes that produce this new situation. In this way, Berry considers the shift of digital humanities from remediation to the interest in computation, especially software, towards a qualitative, interpretive, experimental, emotive and generative approach. He proposes to look at the digital component of digital humanities in the light of its medium specificity, as a way of thinking about how medial changes produce epistemic changes.

Summarizing the content of this chapter, I will lay out here the Net of the technological assemblage producing the Apparatus of the Digital age as an Embodied Space of Transformation and considering it from a materialistic approach. This Net will be composed after the tracing of different events that lead to the three characteristics that defines it as a Virtual Space. Among them, (1) the division between content and Expression, this based on the development of computation and computers. Programmable machines that have become multipurpose machines, enabling them to foster new forms of knowledge and action. (2) The Network originated in the sharing of computational resources. The Internet as a space shaped by the struggle between Participation and control. (3) The definition of a new navigable space that mediates our access to this milieu and that linked to reality can be traced as emerging from bottom-up actions, the evolution of computer graphics and human-computer interaction. This first journey through the history of these three events will elucidate how something that started as the development of automation -that is to say, the reduction of processes to a discrete-state-machine, the behaviour of which can be determined and predicted- becomes interlinked with other technologies until being disseminated to all the fields of knowledge and practice. From this process will emerge a diagrammatic space, dominated by the corporate companies that own the opaque algorithms that manage its complexity, and at the same time, appropriated by the Collectives emerging from communicative encounters that are engaged in the sharing of knowledge and the speculative experimentation with data towards the promotion of new systems of simulacra. This net will allow us to define the technological assemblage shaping the Apparatus of the Postdigital Age as the Space of Embodied Virtuality. After summarizing the history and the encounters leading to this technological milieu, in the next chapter, I will trace the new technologies embodying this space in our daily environment, the urban space. These technologies spread through the networks of the Internet where they can be appropriated by different Collectives for the production of new things, which become capable of producing meaningful changes in our ecology.

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90 http://www.computer-art-congress.org/index.php/previous-editions/

91 http://www.aprja.net/?page_id=1327

92 Ted Nelson (1974) *Computer lib/ dream machines*

2.1 THE CONSTITUTION OF VIRTUAL SPACE

In 1990, a bored spectator stood up from his sofa, and decided to get rid of his TV. Once he arrived at the dumping site, he encountered a virtual agent who would introduce him to the new virtual world of Hyperland.[93] This scene tags the realization of the Postmedia epoch announced by Guattari: the end of an epoch of passive reception in which spectators stay in front of the monitor like *stewed potatoes*. Afterwards, spectators will become engaged in a new interactive medium. Hyperland introduces this new medium from the standpoint of the user. The flat screen becomes an interface, a point of encounter between the machine and the spectator, who now can interact with the displayed contents thanks to the intervention of the virtual agent. This agent is an application running on the computer, a simulated and customizable assistant who works in the background in order to take care of the user and respond to their demands. The virtual agent can provide the user access to any piece of information from any place in the world such as text, music, pictures, films, statistics, and so on. This film shows the beginning of the internet introducing the most relevant characteristics of a new-born medium called to change the way we interact with information. These characteristics can be deduced from the first names given to this medium, all compiled on the film. Dynabook, intelligent TV, interactive TV, hypertext, interactive multimedia, Cyberia or Infinite Virtual refer to different approaches to a dynamic medium able to respond to the queries of the user, where all previous media converge and the linearity is substituted by rhizomatic navigation. A new space not defined by specialized places of concentration, but for the fast transmission of disseminated contents on demand. The Internet is a set of relations, where addresses do not designate places, but contents that can be accessed from anywhere without considering where they are stored.

Pierre Levy[94] defines virtualization as the fundamental procedure of humanization: a vector towards creation emerging from the augmentation of potentialities. Virtualization is a problematizing action by virtue of which, what is codified is not only objects but also processes, so these processes become detached from the here and now and embodied in a new system that can encounter the otherness. Thus, it activates new differences and increases heterogeneity. Computers embody the cognitive processes of human beings in a transductive machine, where digitation modulates diverse contents and the programs codify processes. This separation between content and Expression makes the machine intensive and confers on it a degree of uncertainty by virtue of which it becomes able to actualize multiple events. All reading in a computer is an edition or singular montage of the contents linked inside a hypetextual space, where meaning emerges from a chain of Transductions started by the user who starts the software and ends in the reordering of data. This multidimensional space will deterritorialize itself and increase its complexity when computers become networked. Networking will open the space to an increasing quantity of contents from different sources and to new generative processes. On the Internet, space becomes interconnection and time synchronicity. Data produced at different times and spaces encounter inside a programed multidimensional space towards the constitution of a collectivized memory that each time is accessed can be actualized differently.

Levy says that the most virtualized systems are the ones that codify the space in a more powerful and violent way. The Internet and its deterritorializing power will codify our spaces and our bodies. It will change our understanding of what intelligence and sociability are. Behind the interface, giving access to the hypertext where the users can navigate information, there is a big technological assemblage, a big system of connected machines and the software that controls the transmission of data among them. 'Hello world!' is the call of a new inscription process that operates reducing ambiguity and noise towards the constitution of a set of repeatable simple instructions. This assemblage will grow in a specific historical frame and spread to different fields assembling new systems and increasing its complexity until becoming a new ecology managed by algorithmic processes.

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93 *Hyperland* (1990) [film]

94 Pierre Levy (1995) *Qu'est-ce que le virtuel?*

In this logarithmic space, innovation and creation will become Disruption, the mobilization of the molecular forces of the Collective towards new encounters and Transductions. It is the place of the inception of a new creative class, the hackers. Hackers emerge with the Digital Revolution when computers become commodified and the Internet is provided as a service, the processes of which are obfuscated by the interface and the ready to use software. Hackers will struggle to maintain the project of the first pioneers of this medium. The New Media as a space of a new literacy based on engaged knowledge and free access to a public space that is produced collectively and changed in its process of becoming. In this appropriated space, the gathering together of diverse forms of knowledge that couple software with other systems is a way of enlarging the capacity of hackability.

2.1.1 THE DEVELOPMENT OF COMPUTERS: AUTOMATION AND CONTROL

> *"Computing is any goal-oriented activity requiring, benefiting from, or creating algorithmic processes. The discipline of computing is the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application. The fundamental question underlying all computing is "What can be (efficiently) automated?"* [95]

Computers are machines capable of implementing algorithms. An Algorithm is the set of instructions to be carried out for the accomplishment of a task. For instance, Euclid's algorithm specifies the operations to be carried out for calculating the greatest common divisor of two numbers 'a' and 'b', stored in the positions 'A' and 'B', by means of two loop subtractions. Algorithms result from a process of discretization that reduces a process to its most simple operations being recursively related. In the example, the algorithm proceeds by successive subtractions in two loops: IF 'the test B ≥ A' yields "yes" (or true), (more accurately the number 'b' in location 'B' is greater than or equal to the number 'a' in location 'A') THEN, the algorithm specifies 'B ⟵ B – A' (meaning the number 'b – a' replaces the old 'b'). Similarly, IF 'A > B, THEN A ⟵ A – B'. The process ends when the content of 'B' is 0, yielding the g.c.d. in 'A'. This procedure automates reasoning, increasing accuracy.

In the virtualized space of digital computers, algorithms trace a process within the software, having an autonomous existence independent of what computer scientists refer to as implementation details. That is, its embodiment in a particular programming language for a particular machine architecture. Nowadays, computers are involved in the processing of all that can be reduced to data, algorithms have become logical functions so fundamental that they may be imperceptible to most users; they prescribe ways of thinking and doing that leak out of the domain of logic and into everyday life. As Mathew Fuller says on the introduction of Software Studies *"...the judgments of value and aesthetics that are built into computing programming's own subcultures and it's implicit or explicit politics; or the tightly formulated building blocks working to make, name, multiply, control, and interrelate reality".*[96]

Algorithms result from the addition of abstraction and control. They are the formal expression of a know-how acquired during the construction of machines, which are able to carry out automated process. This expression is isolated from the machinic process that it is translating and becomes part of a syntax with a pragmatic dimension, a set of expressions embodying command structures that can be wrapped in modules, which can be assembled to do things. *"Code makes things happen"* as the well-known sentence attributed to Steve Jobs goes.

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95 Allen Tucker, A. Joe Turner and Paul R. Young. (1989) "Computing as a discipline" *ACM* report January 1989 Volume 32 Number 1

96 Mathew Fuller (2008) "Introduction" at *Software Studies*, pp. 1-14

2.1.1.1 THE DEVELOPMENT OF COMPUTING

The assemblage of machines that model the behaviour of known systems, aimed to predict their performance for pragmatic purposes is as old as human civilization. The Antikyteria mechanism is a complex assemblage of gears, a model of the known astrological bodies that simulates their movement -it was designed to predict astronomical positions and eclipses for calendrical and astrological purposes- was found in 1901 on Antikyteria Island, and dated from 100 BC. The observation of regular processes and their quantification as producers of extensive space leads to the development of a universal science based on the combination of abstract entities. In the 17th century, Leibniz developed calculus being inspired by the Llullian Circles, an artifact aimed at demonstrating the existence of God through the algebraic notation of its attributes and their combination by means of mechanical figures. Leibniz changed the Llullian symbols into numbers, convinced that all questions can be reduced to mathematical problems and any problem can be solved by calculating. Leibniz also proposed the binary code and created the Stepped Reckoner. Being developed between 1672-1694, this was the first calculating machine that could execute all four arithmetical operations. It was based on a gear mechanism, nowadays called the Leibniz wheel, which performs repeated additions or subtractions, they being counted on a dial and the results accumulated in an attached mechanism. In 1679, while he was mulling over his binary arithmetic, Leibniz imagined a machine in which binary numbers were represented by marbles, governed by a rudimentary sort of punched cards.

It was in the early 19th century when Babbage realized that by breaking operations into simple stages, which are restricted to addition and subtraction, computation could be automatized and performed by machinery quickly and more reliably than human computers. After working on his unfinished Differential Engine, in 1833 Babbage conceived the Analytical Engine. This was the first programmable machine, where the input of programs and data could be provided to the machine by punched cards, a method being used at that time to control mechanical looms such as the jacquard loom. For output, the machine had to have a printer, a curve plotter, and a bell. The machine also had to be able to punch numbers onto cards to be read later. The engine had to incorporate an arithmetic logic unit, control flow in the form of conditional branching and loops and integrated memory, making it the first design for a general-purpose computer that could be described in modern terms as Turing-complete. Meanwhile, Ada Lovelace wrote the first algorithm to be implemented in the machine and become the first computer programmer. The "*Diagram for the computation by the engine of the numbers of Bernoulli*" is included in the *note G* of the translation of the memoir on Babbage's Analytical Engine by the Italian mathematician Luigi Menabrea's that Ada wrote. This diagram consisted of a table indicating the variables, operations and places of storage for the transformed variables. Later on, at the end of 19th century, Gottlob Frege developed the language of formal logic, characterized by a formal notation, using variables and symbols to represent the different logical propositions and operations, the first step towards the developing of programming languages.

The project by Babbage was taken up in the 20th century when Alan Turing theorized the Universal Machine, a machine that could be programmed by an algorithm to accomplish any computational task.

Turing proposed his machine in the paper *On computable numbers*, published in 1936.[97] This paper was a response to David Hilbert's project of formally deciding whether or not any mathematical proposition can be proved true. In it, Turing envisioned a computer machine, according to a mathematical proposition coming true if it can be described algorithmically and computed by the machine. The Turing machine was an automatic machine, which consisted of a tape -analogue of the paper that a human computer uses to note its operations. It was divided into squares, each square containing symbols. In addition it had an operative unit that ran along the tape, scanning one square at each stop. This machine was a discrete machine, a machine that jumped from one state to another, being defined by the configuration of the machine, which is defined

97 Alan Turing (1936) "On Computable Numbers, with an application to the Entscheidungsproblem"

by the scanned square conjointly with the initial configuration. This configuration is what determines the behaviour of the machine at any moment. According to this configuration, the machine can erase a symbol, write a new one and move to the next square to change its configuration. These are all the operations used in the computation of a number.

During World War 2nd, Turing was working at the British Bletchley Park in the electro-mechanical bombes aimed at breaking the encryption machine Enigma. After of War, he worked in the ACE (Automatic Computing Engine) at the National Physical Laboratory (NPL). These experiences led him to publish "*Computing Machinery and Intelligence*"[98], where he proposed the Imitation Game as a solution to the question: can machines think? The Imitation Game consisted of a test aimed at determining if a machine was intelligent. This meant that the machine was indistinguishable from a human being. The machine able to succeed in this game is a Universal Machine, a digital computer that can mimic any discrete state machine. The machine described above becomes programmable when the store tape becomes the controller of the machine. With this aim, part of the store is Random Access Memory and part of the store is the 'Book of rules', the program commanding the machine. The squares of the tape not only contain symbols, but packages of information specifying the processes to be carried out and these squares denominated by numbers, in some systematic way, that allow the operative unit to jump from the scanned position to the next one referred to in the package of information. This paper describes modern computers as multi-purpose machines, not only aimed at calculating numbers, but to process any kind of information, the reason why it is considered the foundational document of theoretical computer science and Artificial Intelligence.

2.1.1.2. THE MAINFRAME COMPUTER

The Second World War saw the fostering of the development of computers; these new machines were involved in the research directed at the development of more accurate weapons and the deciphering of German communications. The Office of Scientific Research and Development (OSRD) was an agency of the United States federal government created to coordinate scientific research for military purposes during the war. Created in 1941 by Franklin Delano Roosevelt and under the direction of Vannevar Bush, it was characterized to establish a cooperative relationship among the military, industry, and academic research. Once the war ended, this remained as the 'military-industrial complex', widely known as the 'Iron Triangle'. The development of computers was framed inside a variegated research devoted to new and more accurate bombs, reliable detonators, guided missiles, radar and early warning systems, lighter and more accurate hand weapons and so on. In this way, the Colossus, the first electronic digital computer was developed in 1943 to crack the German military communications, which are encrypted by the Lorenz SZ 40/42 machine. The Colossus was built upon circuit design based on relays, an innovation that emerged from the field of communications. In 1937, Claude Shannon published his thesis: "*A symbol analysis on relay and circuit systems*".[99] In it, Shannon proved that Boolean algebra and binary arithmetic could be used to simplify the arrangement of electronic relays that were used in telephoning call routing switches. Next, he expanded this concept proving that it would be possible to use arrangements of relays to solve problems in Boolean algebra. In this way, computation evolved to become the result of the Transductions between relays.

After the Colossus appeared the ENIAC (Electronic Numerical Integrator and Computer)[100], developed in 1946. ENIAC was the first programmable computer built in the US, similar to Colossus but faster and more flexible. It was a huge machine, weighing 30 tons, using 200 kilowatts of electric power and containing over

98 Alan Turing (1950) "Computing machinery and Intelligence"

99 Claude Shannon (1936) *A symbolical analysis of relay and switching circuits*

100 About the History of computer https://en.wikibooks.org/wiki/The_Computer_Revolution/Timeline; http://ei.cs.vt.edu/~history/machines.html; http://www.thocp.net/

18,000 vacuum tubes, 1,500 relays and hundreds of thousands of resistors, capacitors, and inductors. As in the Colossus, a program in the ENIAC was defined by the states of its patch cables and switches. Once a program was written, it had to be mechanically set in the machine with the manual resetting of plugs and wires. In 1945, Von Newman, while working on the development of the EDVAC (Electronic Discrete Variable Automatic Computer), established the logical design of the computer using the stored program concept. This was published in the incomplete "*First Draft of a Report on the EDVAC*".[101] The design on the First Draft is known as Newman Architecture and is based on the Turing proposal of a uniform memory containing both numbers (data) and commands (instructions). This machine is divided into six major subdivisions: a central arithmetic part, CA, a central control part, CC, memory, M, input, I, output, O, and (slow) external memory, R, such as punched cards, Teletype tape, or magnetic wire or steel tape.

The EDVAC established the architecture of modern computers. However, it was a huge and complex machine only affordable by big corporations and operable by professional staff. The access to the computational capacity of these machines was a long process, in which researchers sent their programs and waited for long periods for their results after they were prioritized and queued to be set on the machine by the operators. The first steps towards the wide access to computers came after the development of programming languages and time-sharing.

2.1.1.3. PROGRAMMING LANGUAGES

The Manchester Mark 1 was developed in 1951, becoming the model of the first commercially available general-purpose computer and the first one for which a code and a compiler was developed. Alick Glennie developed Autocode, a generic name for early programming languages characterized by using a compiler to convert the language into machine code. The Autocode from Manchester University had later versions and is considered the first compiled high-level programming language.

High-level programming languages are characterized by their independence of machine code. Machine code is the language that the machine can understand directly. Thus, it is dependent on the computer architecture, which consists of the holes in the punched cards of the first computers or the sequences of binary digits in the later ones. Low-level languages are very close to the machine's native language; they are based on a strong correspondence - generally one-to-one- with the architecture of the machine code instructions. The most common low-level language is Assembly code. Another example is SQL that is a basic set of instructions to build and operate a database. High-level languages are independent of the machine architecture by virtue of a Compiler that translates the high-level English-like language to machine code. In high-level languages, algorithms become virtualized and severed from the implementation of the machinic processes they describe. They become a form of logic reasoning that shifts from the arrangement of the operation of relays in a concrete mechanical assemblage to the processing of any entity in the world that can be abstracted in a datum. In this way, software becomes independent of hardware and can be developed between communities framed in differentiated research fields. At the same time, programming languages became a basic step towards the spread of the use of computers, where independent individuals could write their programs to be implemented on mainframe computers thanks to the technique of time-sharing and later on, in personal computers. Time-sharing was a technique developed to allow several batched processes to execute simultaneously. It works giving each of several processes time on the CPU, then pauses it and switches to another; each process behaves as if it had full use of the computer, although the time to complete its operation increases. This system also allowed multiple users to share use of the CPU and memory. They could access from a terminal with keyboard and teletype printer, later on also screens, and submit their own programs to the computer

101 John von Neumann (1945) *First Draft of a Report on the EDVAC*

for execution. The CTSS (Compatible Time-Sharing System) was demonstrated in the College of Dartmouth in November 1961 and remained in use until 1973. Another well-known time-sharing system was PLATO II created by Donald Bitzer.

After being virtualized, programming languages were developed outside the machine and within communities who shared and used them extending their potentialities. In this way, the historic high-level languages were developed for different purposes and according to different ways to formalize the world. Fortran (Formula Translating System) was developed by W. Backus in 1953 at IBM, one of the first enterprises aimed at producing commercial machines. It was suited for scientific and engineering applications, especially to numeric computation and scientific computing. Lisp, specified in 1958, is the second oldest high-level language. It was originally created as a practical mathematical notation for computer programs, influenced by the notation of Alonzo Church's lambda calculus. It quickly became the favoured programming language for artificial intelligence (AI) research. As one of the earliest programming languages, Lisp pioneered many ideas in computer science, including tree data structures, automatic storage management, dynamic typing, conditionals, higher-order functions, recursion, and the self-hosting compiler. The name LISP derives from "LISt Processing". Linked lists are one of Lisp language's major data structures, and Lisp source code is itself made up of lists. As a result, Lisp programs can manipulate source code as a data structure, giving rise to the macro systems that allow programmers to create new syntax or new domain-specific languages embedded in Lisp. COBOL, an acronym for common business-oriented language, was designed in 1959 by the Conference on Data Systems Language (CODASYL) for business use. It was created as part of a US Department of Defence effort to create a portable programming language for data processing. Intended as a temporary stopgap, the Department of Defence promptly forced computer manufacturers to provide it, resulting in its widespread adoption. COBOL is primarily used in business, finance, and administrative systems for companies and governments, it is deployed on mainframe computers, such as large-scale batch and transaction processing jobs. ALGOL (ALGOrithmic Language) is a family of imperative computer programming languages, which greatly influenced many other languages and was the standard method for algorithm description used by the ACM in textbooks and academic sources for more than thirty years. ALGOL was the first language implementing nested function definitions with lexical scope. Moreover, it was the first programming language that gave detailed attention to formal language definition. It eventually gave rise to many other programming languages, including BCPL, B, Pascal, PL/I, Simula and C. The modern languages are algol-like.

The Mark 1 quickly became the prototype for the Ferranti Mark 1, the world's first commercially available general-purpose computer. Built by Ferranti, it was delivered to the University of Manchester in February 1951. The new market of commercial computers developed quickly. The LEO I computer became operational in April 1951 and ran the world's first regular routine office computer job. In June 1951, the Remington Rand sold the UNIVAC I (Universal Automatic Computer) to the U.S. Census Bureau. The UNIVAC was the first "mass produced" computer. In 1954, IBM introduced the IBM 650 a smaller, more affordable computer that proved very popular.

The bipolar transistor was invented in 1947 and the Integrated Circuit in 1955. Geoffrey W.A. Dummer conceived the idea of the integrated circuit when working as a radar scientist for the Royal Radar Establishment of the British Ministry of Defence. It was described as a set of electronic circuits condensed in a small plate, called a chip. Kilby at Texas Instruments produced the first IC and half a year later Noyce produced the currently used silicon chip. Chips progressed quickly, becoming smaller and cheaper to produce. They allowed the standardization of circuitry, which replaced the design using discrete transistors and became mass-produced. The availability and cheap production of chips would allow embedding computation in variegated devices and the production of mini and microcomputers, which were the predecessors of personal computers. Microcomputers become popular during the 70s and 80s, usually sold as kits to be assembled by the consumer, and were the first computers available to individuals. The language popularized in these computers was BASIC (Beginner's All-purpose Symbolic Instructions Code). G. Kemeny and Thomas E. Kurtz developed BASIC in

1964 at Dartmouth College in New Hampshire with the purpose of enabling students from fields other that science and mathematics to use computers. Based on Fortran II and ALGOL 60 it concentrated on supporting straightforward mathematical work, with matrix arithmetic support from its initial implementation as a batch language, and character string functionality being added by 1965. BASIC allowed people to develop custom software on computers they could afford and reach great popularity after being used in the design of the first arcade games.

Simultaneously to the popularization of BASIC as a way of making computation affordable to everybody, the industry started the path towards the commodification of software. In 1968, IBM split its software section off from its hardware section. The software was no longer to be bundled as a service or gratuity conjointly with the machines. Afterwards, software would become a product in itself developed as an application to fulfill different functions and demands and commercialized independently.

As viewed through the optic of applied logic, software exists as a result of a process of virtualization that severed it from its implementation in a machine and now exists only in terms devoid of any reference other than itself. However, even if software now is assembled independently from the Transduction and differential potentials of the machine where it is compiled, it is still involved in Collectives. As we have seen programming languages had been developed to operate machines, but inside the Collectives from where they emerged there were different practitioners and artefacts involved in complex situations from where different goals arose - implied in scientific knowledge and engineering, but also in education and the understanding of biological processes- and visions of the world. In this encounter, the software produces spaces of knowledge and sociability, becoming a Space of Transformation. The software is the place of a dichotomy, which comes from its capacity to categorize and manipulate any world entity. As a commodity, it is technologizing senses and structuring relations, which are enabling certain kinds of programmability or use. However, it is produced inside communities from where new problematics arise, leading to new formalizations that are compiled in libraries to be reused and that extend the capabilities of a programming language. These ready-to-use building blocks, even if they obfuscate the program by enclosing it in black boxes, make a language more affordable extending its use to new communities, and to new problematics that exceed the preformatted needs. In this encounter, software is modified to produce new unexpected events, cross-platform portability and easy ways of sharing and distributing contents. Across artifacts and the Internet, events can occur at the levels of user subjectivity or forms of computational power that exceed those of pre-existing social formatting or demand new figures of knowledge.

Nowadays, the most used programming languages are Java, C, C++, Objective-C, C#, Javascript, PHP, and Phyton.[102] All these programs stem from C. Python and PHP are written in C, meanwhile, C++, C#, and Java are object-oriented versions of C. The success of C stems from the fact it is the language in which Unix was written, an operative system characterized by a new philosophy. In turn, Object-Oriented languages stem from smallTalk, a new language that features a new understanding of the world. Both have in common the fact that they introduce another of the main characteristics of actual computation, modularity.

Dennis Ritchie originally developed C between 1969 and 1973 at AT&T Bell Labs. Its formal specification appeared in 1978 in the book by Ritchie and Brian Kernighan *The C programming Language*. This book known as the K&R contains the canonical example "Hello world!"

The fast dissemination of C stems from the fact it was used to write Unix. Unix was the first operative system not written in Assembly, but in a cross-platform language, becoming the first portable operating system. It was a multitasking multiuser system created to sustain time-sharing. Its most relevant characteristic is its modular design based on the "Unix Philosophy". This philosophy consists of the fact that complexity and

102 Paul Ford (2015) *What is Code?*

performance do not stem from programs but from the relations between them. In this way, the operating system provides a set of simple tools, each one performing a limited well-defined function, with a filesystem as the main means of communication and a shell scripting and command language to combine the tools to perform complex workflows. The kernel or master-work program provides services to start and stop programs, handles the file system and other common 'low-level' tasks that most programs share, and schedules access to avoid conflicts when programs try to access the same resource or device simultaneously. To mediate such access, the kernel has special rights, reflected in the division between user space and kernel space.

The modular architecture of Unix follows an inverse procedure that is carried out by in the automation of computing. Complex tasks emerge from the combination of the procedures carried out by simple programs. The advantages of this system stem from these programs being independent from one another, allowing them to be reused in other systems and to be substituted and updated easily. The system can increase in complexity and performance adding new modules without altering its configuration.

Object-oriented languages follow a similar approach and benefits from the same advantages, whereby functions can be classified in classes and methods, ready to reuse. This improves the language affordances and accessibility. It becomes possible to create highly complex programs assembling and applying predefined methods. However, at the same time, Object-oriented languages shift the object of computing from the computation to the world. C works as an abstraction over the computer that makes it easier to do computer things. In contrast, Object-Oriented language was developed as an abstraction of the world to make it easier to do human things.

The archetypical object-oriented language is SmallTalk written by Alan Kay at Xerox Parc in 1972 as part of the effort towards the development of Personal Computer. Thus, it is influenced by the NLS system of Engelbart, who sees computers as a means for the increase in knowledge, the theories by Papert about machine-assisted learning and the developments in direct manipulation attained by Sutherland. The things form the assemblage of Personal Computer that will be traced in the next chapter.

At a technical level, object-oriented languages work as a file system, giving the programmers a way to name things and build a library class. These things are not only numbers or logical functions but also abstractions of the entire world, now hierarchized in classes and methods. Programming becomes a way of simulating and manipulating things in the world that can respond either to the aim to control it or to conduct speculative research towards the increasing of potentialities and increasing hackability.

2.1.2. THE COMPUTER AS A MULTIPURPOSE MACHINE

Nowadays using a computer has become as common as making a phone call, writing a note or listening to music. The computer as a multipurpose machine has pervaded all fields of our daily life. Ted Nelson wrote *"In such a world, computers are not a tool but a way of life. The computer is toy, pet, checkerboard, music box and TV. Computers are for making music, computers are for getting people together via community memory, computers are for letter-writing, computers are for art and movie making and the animated decoration of the home".*[103] This sentence was framed in the launch of the Altair 8800. Created by Micro Instrumentation and Telemetry Systems or MIST, a young firm from Albuquerque, the Altair was a microcomputer based on the microprocessor Intel 8080. It was sold for 400 dollars as a kit in a box not much bigger than a typewriter, and its standard language was BASIC. This machine tags the starting point of the Digital Revolution.

103 Ted Nelson (1974) *Computer lib/ dream machines*, pp. DM3

The crystallization of an underground movement, which claimed: *"Computers belong to all humankind (mankind)".*[104] in which new small companies such as general Turtle Inc. or The Sphere and Loving Grace Cybernetics; new publications with a more hobbyist approach as Bit, PCC or Creative Computing, and new communities that saw in free access to information provided by computers the chance for a revitalization of society, had the leading role. *Computer Lib/Dream Machines* is a mapping of this revolution leading to the assemblage of Personal Computer, a bi-faceted pamphlet that contrasts the new technical artifacts concerning computation with the new uses and societal changes fostered by these machines. Among the things listed in this foundational document of New Media we can find the Hypertext – a term coined by Ted Nelson- as a new form of knowledge; the encounter between art and technology in the interface design, the multimedia, and the machine assisted graphic design and the new experimental fields of Information Retrieval, Artificial Intelligence and Machine assisted learning. New things claimed to convert computers in extensions of our mental life and enhancements of our creativity. That is to say, Dream Machines.

2.1.2.1. THE AUGMENTATION OF INTELLECT

The vision of computers as tools for a new literacy was envisioned a short time after Turing described a computer processing text in the Imitation Game. In 1945, Vannevar Bush projected the Memex system in the article *"As we may think"*, published in the Atlantic Monthly.[105] The Memex was conceived as a way of improving collaborative knowledge after considering technology as an extension of the mind. It was a system for storage and information retrieval, which took account of the technoscientific advances attained in the processes of inscription as photography, movie cameras, voice registering, and microfilm, during the World War 2nd. The products of these processes become considered as documents, pieces of information capable of being stored and processed in an automated way. In this way, the Memex was a mechanized device where an individual can store all his books, records and communications converted to pieces of information, an extension of his memory that can be accessed according to a positional indexing system that mimics the associative functioning of the mind. The basic idea is that a provision whereby any item may be called on at will to select immediately and automatically another. These contents are linked as in the mind trails carried by the cells of the brain.

Extending the collaboration that started during the World War with the assistance of machines was also the goal pursued by Licklider, who was one of the pioneers of the network that would later give way to the Internet. In his paper *"Man-Computer Symbiosis"*[106], he explains that for a real man-machine symbiosis to be attained it was necessary for computers to assist in formulative thinking as they now facilitate the solution of formulated problems. In other words, to enable man and computers to cooperate in making decisions and controlling situations without inflexible dependence on predetermined programs. The achievement of this cooperative association includes developments in computer time-sharing, in memory components, in programming languages, memory organization and in input-output equipment.

The predictions of Licklider led to the Apparatus of our Digital Age. Time-sharing would evolve into the network of networks that is the Internet. Memory storage would increase its capacity, according to Moore's law, until reaching the magnitude of yottabytes (1000^8). The management of this big quantity of data has led to a new epistemological model that we will discuss in the next chapter. The programming languages would be virtualized until attaining the abstraction of the entire world and its modulation, which would allow the

104 Ted Nelson (1974) *Computer lib/ dream machines*, pp. DM3

105 Vannevar Bush (1945) "As we may think"

106 J.C.R. Licklider (1960) "Man-Computer Symbiosis"

intersection between different systems that would give it its creative capacity. Memory organization would develop towards the creation of the hypertext, and other data structures that conjointly to input-output equipment would be the basis for human-computer interaction.

These goals were first developed at the research centre for Augmenting Human Intellect (AHI) founded by Engelbart at the Stanford Research Institute in 1962.[107] The developments attained in this centre will be considered as pioneering the development of the personal computer. This centre focused on the design of tools to increase the capability of human beings to approach complex problem situations. Engelbart's team worked on the development of the NLS system and the experimental research around an interactive multi-console computer display system. The NLS system followed Vannevar Bush's project Memex for information indexing and retrieval but displayed in a network of terminals in such a way that from a terminal, you could read anything you or others have written and modify it. To attain this aim, the working documents were organized into highly structured files in its internal information; in such a way that they make explicit the various types of network relationships among concepts, and the system disposes of flexible means for users to set up indices and directories that allow hopping from file to file.

The interactive console was a terminal from where to access the time-sharing computer, for it was developed in several peripherals allowing input and output information such as keyboards, screens, and the *mouse*. The mouse-screen pairing would start a new approach in human-machine interaction. The *mouse* was meant to spatialize the interface, being mapped in x y coordinates, where each point can be pointed to by the user via the tracking of the movements of his hand on the table top. It was a hand-held transducer with two wheels, which when rotated produced two analogue voltages. The rotation of the two wheels changed in proportion to the x or y movement over the table-top. These voltages control, via an analogue/digital converter, the memory of the computer and the display generator. The terminals, peripherals and systems developed at the Centre for Augmenting Human Intellect were demonstrated at what was called the "mother of all demos" exhibition that took place at the Fall Joint Computer Conference in San Francisco in 1968.[108]

The *mouse* benefitted from a previous development. The sketchpad was created in 1963 by Ivan Sutherland[109] and it inaugurated the human-computer interaction, becoming the first conversational interface. Sketchpad was created to assist in design. It used a lightpen that allowed drawing on the screen, where the graphical shapes became considered as objects, in a way that it could be manipulated, constrained, instantiated, represented iconically, copied and recursively operated upon, even recursively merged. Some of these graphical objects that would become common were the 'rubber-band line', a straight line on the screen, one end of which follows your lightpen while the other remains fixed, and the 'instance', a graphic item stored in the core memory that could be called on to be displayed numerous times in a larger picture. The strategy of considering images as operable objects would not only be the starter point of human-computer interaction and New Media; it would also lay the foundation of object-oriented programming languages.

We have already seen the virtualization of programming languages and its ambiguous relation with control and creation; at the same time, the development of languages would foster a new way of understanding knowledge and education. The first object-oriented language, SmallTalk was created to be implemented in the Dynabook,[110] an affordable computer for the education of children which became involved in the project *One Laptop Per Child* initiated by Nicholas Negroponte, the founder of the MIT Architecture Machine Group (Later the MIT Media Lab), and where Engelbart, the Xerox PARC and Seymour Papert also took part. The Dynabook had to provide a user-empowering environment where children could learn in an operational way.

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107 Douglas Engelbart (1962) "Augmenting Human Intellect. A conceptual framework"

108 Douglas Engelbart (1968) "A Research Centre for Augmenting Human Intellect"

109 Ivan E. Sutherland (1963) "Sketchpad. A man-machine graphical communication system"

110 Alan Kay (2007) "The Real Computer Revolution Hasn't Happened Yet"

In it, Knowledge became a speculative activity involved in the production of things. The precedent of this aim was the learning theories of constructionism and the LOGO Language developed by Papert at the MIT Architecture Machine Group.

Papert developed Constructionism[111] after genetic epistemology, and the constructivist learning theories laid out by Piaget of whom who he was one of his protégés. Constructivism argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas. Constructionism takes ideas from Piaget as *consciously engaged* and *public entity*, but it looks closely at the idea of mental construction, considering computers as an enhancing environment where children can interact and create their learning structures. Papert's position shifts from the consideration of the computer as a machine training, the computers programming children - thus pushing them through their training by means of providing exercises of an appropriate level of difficulty, providing feedback, and dispensing information- to the children taking control and programming computers. Instead of considering computers as a place to transmit and adapt children to the codified space, they become considered as an empowering space where children can learn how to codify their own environment. In this way, computers support the children as they build their own intellectual structures with materials drawn from the surrounding culture that is explored in its potentialities until the emergence of the pursued goal. Constructionism is not just learning-by-doing, but engaging reflexively and socially in the task, both the creation process and the produced artifacts set aside to be socially shared.

> *"In this model, educational intervention means changing the culture, planting new constructive elements in it and eliminating noxious ones".*[112]

Programming allows children to learn powerful ideas via constructing them. The child becomes more active and self-directed; the knowledge is acquired for a recognizable personal purpose. The child does something with it and knowledge is experienced as a source of power from the moment it begins to form in the child's mind. LOGO in contrast to BASIC was not an easy language to learn, with a short list of commands to apply for the obtaining of already implemented results. However, it is an enabling set of tools operating in a playful environment, populated by a small mobile robot the 'Logo turtle', which can be programmed to accomplish simple tasks by means of formulating them as problems.

Constructionism and the Dynabook saw the process of virtualization accomplished by computation as laying out an empowering space for the proposition of new potentialities and tried to make it affordable, thus opposing traditional education and the process of commodification of industry. Traditional education as transmission of the codified and conservation of power is a way of training consumers, difficult access to formulative thinking ensures a high quantity of targets to buy ready-to-go products. Alan Kay says that *"the real computer revolution hasn't happened yet"*. However, some of these ideas have remained in the underground movements leading to the open-source software and hackerism.

2.1.2.2. THE HYPERTEXT

Referring to the developments in memory organization, the information management system started by the Memex and Englebart led to the development of the Hypertext. The Hypertext would provide the basic

111 Seymour Papert and Idit Harel (1991) "Situating Constructionism"

112 Seymour Papert (1980) "From Mindstorms. Children, Computers, and Powerful Ideas"

structure of the web and conjointly with the interface and man-machine interaction be one of the main concepts explored by New Media. Englebart already quoted hypertext, but its definition is attributed to Ted Nelson, who characterizes it as non-sequential writing able to better represent the structures of ideas. Thus, it became what he calls a *thinkertoy*, an object to think with, that allows visualizing complexity.

"Everything is deeply intertwingled"

> *"In an important sense, there are no 'subjects' at all; there is only all knowledge since the cross-connections among the myriad topics of this world simply cannot be divided up neatly. Hypertext, at last, offers the possibility of representing and exploring it all without carving it up destructively".*[113]

Hypertext and Hypermedia are branching representational systems, multidimensional media systems that link contents that can be delivered to the user automatically depending on what they do. Ted Nelson developed it as an environment for the common access to a shared heritage and self-directed education, where students can follow their own paths and inquiries trough information avoiding the *dirty looks* of authoritarian teachers. *Xanadu* started in 1965, aimed at being the structure for the open access repository of all human information after being digitized. It is considered as the never fulfilled project of what we nowadays know as the Web. This incorporates elements of already existent data structures that link diverse materials in a collateral way such as JOT, Carmody's system, Parallel Textface and Th3, the latter also developed by Nelson. These systems would operate the shift from the computer as a programming environment to the computer as a media system. The design of this flat environment would start New Media, which would forget the machinery and Transduction producing operativeness to focus on the new immaterial world displayed on the surface of screens.

Ted Nelson follows McLuhan who pointed out how New Media were changing our perception and awareness of the world and considers that responsive computer display systems can, should and will restructure and light up the mental life of humankind, and assigns to artists, as experts in sensorial perception and the hybridization among different media, the task of designing these interfaces.

In his Minifesto:

> *"My work is concerned principally with the theory and execution of systems useful to the mind and the creative imagination. This has polemical and practical aspects: I claim that the precepts of designing systems that touch people's minds, or contents to be shown in them, are simple and universal: making things look good, feel right and come across clearly. I claim that to design systems that involve both machines and people's minds is art first, technology second, and in no way a derivative specialty off in some branch of computer science".*[114]

In this way, aesthetics burst into technology in what Nelson calls *fantics*. This neologism derives from the Greek words *"phainein"* (show) and its derivative *"phantastein"* (present to the eye or mind) and he describes it as the art and science of getting ideas across, both emotionally and cognitively. "Presentation" could be a general word for It. *Fantics* are concerned with the design of the *fantic space* emerging on the computer

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113 Ted Nelson (1974) *Computer lib/dream machines*, pp. DM45

114 Ted Nelson (1974) *Computer lib/dream machines*, pp. DM58

displays, later on called GUI. It includes the art and science of presentation, the analysis and design of media systems, data structures and interaction, all this taking account of the psychological and sociological effects of new standardized ways of representation. That is, by organizing data in particular ways and by making it possible to access it in particular ways, they privilege particular models of the world and of the human subject.

2.1.2.3. THE USER-FRIENDLY PARADIGM

After the "mother of all demos", Bob Taylor, who while in government had been central to the funding of the Engelbart's projects was eventually hired by Xerox to establish the Palo Alto Research Centre (PARC), the research at the Augmentation Research Centre slowed and the project was sold by the Stanford Research Institute to a commercial company. Many ARC staffers went to PARC, where Engelbart's inventions were deployed towards different goals. The new goals were defined by Xerox, redefined by Apple, and then adopted by Microsoft to become today's dominant computing environment. This environment shifts from the creation of conceptual structures to the WYSIWYG (what you see is what you get) tools, from the literacy of how computers work to the user friendly systems, from the engagement of users able to create their own tools to the commodified software as a service and to the focus on collaboration among people to the personal computer as a private space.

The user-friendly media environment of the personal computer will be the graphical user interface (GUI), which would be developed after an encounter with the third assemblage, here developed, Computer Graphics. GUI stems from the text-based hyperlinks manipulated with a *mouse* for the On-Line System by Engelbart. The concept of the hyperlink was further redefined and extended by Alan Kay at Xerox PARC, who went beyond text-based hyperlinks and used a GUI as the primary interface for the Xerox Alto Computer released in 1973. Following PARC, the first GUI-centric computer operating model was the Xerox 8010 Start Information System in 1981, followed by the Apple, Lisa, which introduced the menu bar and the window controls, in 1983, the Apple Macintosh 128k in 1984, and the Atari ST and Commodore Amiga in 1985. The Visi On was released in 1983 for the IBM PC compatible computers; although it did not become popular it was a crucial influence on the development of Microsoft Windows.

2.1.2.4. OPEN-SOFTWARE

In 1982, Time Magazine named the computer as its 'man of the year'. The Personal Computer became a successful commercial product called to revolutionize the everyday life of all the consumers. During the 80s, the personal computer would spread to all homes, offices and institutions at the same time as the software they ran on became privatized. In 1984, the AT&T announced that the operative system Unix would no longer be free. At this moment, Richard Stallman was working at The MIT Artificial Intelligence Lab, where he and his colleagues used to develop their own tools, the software of which was shared and open for modifications. After the closure of the Unix source code, the activity of modifying it for improvements and the accomplishment of specific needs became illegal, the reason why Stallman decided to leave his job at MIT and start the GNU project (Gnu's Not Unix), an open source operating system. GNU had to be created collaboratively. Stallman wrote the GNU Manifesto[115] to ask for collaboration, considering creativity as a social contribution and the social advantages of the collaborative work, even for technological development. After this document, Stallman established the foundation of the open source movement. He defines what is *free software and copyleft* and established the Free Software Foundation (FSF) and the GNU General Public License (GPL).

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115 Richard Stallman (1985) *The GNU Manifesto*

A program is free software if the program's users have the four essential freedoms:[116]

- *The freedom to run the program as you wish, for any purpose (freedom 0).*
- *The freedom to study how the program work, and change it so it does your computing as you wish (freedom 1). Access to the source code is a precondition for this.*
- *The freedom to redistribute copies so you can help your neighbour (freedom 2).*
- *The freedom to distribute copies of your modified versions to others (freedom 3). By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.*

The open source software, and the community of hackers reunited around it recovered some of the principles and goals of the computer pioneers, the computer as a programming environment and programming as a socially engaged speculative activity that modifies the established codes and produces its own culture. Working in an open environment suitable for collaboration, the hackers opened the space behind the screen and disrupted the created systems showing their arbitrariness. They recuperated the Virtual and its possibilities towards new assemblages and ways of involvement and relation with our world. Software became the result of a live process of engagement between thinking and working with the software materials and the problem space that emerges, which activates the molecular forces of the Collective that can access multiple universes of reference. Programming occurs in a virtualized world, showing their potentialities, where the Transduction between the empowered subjects and the abstracted materials modifies the produced objects at the same time as the subjects. Promoting new relations, this collective movement creates their own culture beyond the self-sufficiency and technicality of software components. *"Through the production of new forms of abstraction, the hacker class produces the possibility of the future - not just 'the' future, but an infinite possible array of futures, the future itself as virtuality."*[117]

By 1990, Stallman and the GNU's contributors had everything in place to create a system that could replace Unix except the kernel and had created a large number of tools in broad use within Unix. Among these featured the text editor, *emacs*, a compiler and a shell. It was the lack of an operating kernel that motivated Linus Torvalds to start a new Unix-like free operating system in 1991. Linux would also be assembled under the model of free and open-source software started with GNU. This system was originally created to work in personal computers based on the intel x86 architecture but has been exported to more computer hardware platforms than any other operating system. Linux is the leading operating system on servers and other big iron systems such as mainframe computers and supercomputers and in embedded systems running on mobile phones, tablet computers, network routers, facility automation controls, televisions, video game consoles and smartwatches. Concretely, its dominance on smartphones is because Android is built on top the Linux Kernel, making it the most installed base of all general-purpose operating systems.

The big success of Linux led Raymond to test its model of production and characterize it as a 'bazaar system' differentiating it from the development model of its predecessor GNU, the 'cathedral system'. The main principle laid for Raymond to characterize this model is *"Given enough eyeballs, all bugs are shallow"*[118], which stems from the fact of extending the engaged Collective in software production to embrace not only the developers but also all the potential users. Unlike the 'cathedral system' that delivers a high performing product developed by experts, the 'bazaar system' applied on the production of Linux was characterized by

116 GNU.org *The free software definition*

117 McKenzie Wark (2004) *A Hacker Manifesto*

118 Eric S. Raymond (1998) "The Cathedral and the Bazaar"

a continuous process of improvement based on collaboration. In this way, it did not start from scratch, but from an existing project -The MINIX created by Andrew S. Tanenbaum- that was improved until becoming something new, by means of rapid prototyping and the release of beta versions to be continuously tested by a community of potential users actively engaged in the process of production. These new peers aided the process of debugging and contributed to the continuous rebuilding with fresh ideas, new needs emerging from different perspectives and the elaboration of patches. The increase in the engaged Collective that characterizes this model of production was possible thanks to a new system fostering networks and community building, the Internet.

2.1.3. THE ENCOUNTER BETWEEN COMPUTATION AND NEW COMMUNICATION TECHNOLOGIES: THE INTERNET

> *"The Internet is at once a world-wide broadcasting capability, a mechanism for information dissemination, and a medium for collaboration and interaction between individuals and their computers without regard for geographic location."*[119]

With the Internet the computer reaches a new process of virtualization, overstepping the space assigned on desktops to be disseminated in a global net. The screen will become the surface where the intensive nature of Cyberspace is actualized, this newly disseminated space, where fast transmission substitutes concentration. Thus, it becomes a Big Here and Long Now, where addresses do not designate places anymore but data packets, which can refer to any entity in the world. Internet had been one of the fastest-spreading technologies in our history. It started as a research utility, shared among a few hundred scientist and engineers, but nowadays has reached the 40% of connected users all over the world.[120] It has spread from specialized research centres to enterprises and big institutions until reaching, first, our homes, where it has become a usual commodity and later on, our pockets by means of the smartphones. This process achieved our Postdigital situation, where computation has been embedded in quotidian physical objects. The Internet has become the defining Apparatus of our epoch. It has reshaped our way of perceiving and relating to our environment, at the same time as the management and shaping of our cities and houses.

Even if the inception of personal computers in the market was revolutionary, the domestic use of these green screens was barely defined. Two other assemblages would encounter personal computers, becoming influential factors in its spread to homes. The first one was the video games, which will be briefly introduced later. These would not only play a leading role in the acquisition of domestic computers, but would also shape a generation, -navigators of a new virtual world- that from then on, would grow in front of the screen. The second one was the Internet and the web. These technological assemblages would convert the black mirror into a window to a borderless and reconfigurable world. The integration of the TCP/IP protocol into Unix connected the computers to a global network that accomplished some of the aims of Licklider and Ted Nelson towards the constitution of a shared space for collaborative knowledge and a universal archive. The Networked computers would start the Postmedia epoch theorized by Guattari, the empowerment of humans by means of the free equal access to the technologies of communication that overcame the mass-communication towards the many-to-many communication, and the constitution of an augmented Collective Intelligence in a navigable space open to experimental collectivism. It is assisted by the apps of the social web and the increasing affordance of editing tools, to remix, actualize and share the disseminated contents

119 Barry M. Leiner, Vinton G. Cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff *Brief history of the Internet*. On-line http://www.internetsociety.org/internet/what-internet/history-internet/brief-history-internet

120 Data from the http://www.worldbank.org/ http://datos.bancomundial.org/indicador/IT.NET.USER.P2/countries?display=graph

that integrate this space accessible from everywhere. At the same time, the internet will reconfigure the systems that conform our environment. Information will become a prominent resource in a new economy and production system based on the reticular logics of this Apparatus and the constant innovation. The Net will globalize our world, deterritorializing our space. From now on, the Internet will be an ambiguous machine of deterritorialization, the battlefield where the creative forces of newly assembled Collectives struggle against the increased capacity of the Society of Control.

2.1.3.1 THE ASSEMBLAGE OF INTERNET

The Internet emerges from a complex assemblage of technologies such as computers, time-sharing systems, and packet switching, as well as from institutions and historical events such as the Cold War. It follows a process of virtualization from where it started as a system to share computation resources to assist in research, in time-sharing machines until becoming the ubiquitous net of transmission, where the disseminated human knowledge circulates.

After WW2, the U.S. found themselves armed with a big capital made up of human resources and cutting-edge technology. These resources were deployed in the conquest of a new milestone, outer space – sown into the hearts and minds of young Americans by popular culture- and against a new ideological enemy, the USSR. It was the beginning of the Cold War and the Space Race. On October 4th 1957, Russia launched the Sputnik, the first satellite orbiting around the earth and a banner waving above American heads, showing that Russia was not a backward country. The Defence Advanced Research Projects Agency (DARPA) was created in 1958 by the president Dwight D. Eisenhower as a reaction to this potential threat and to ensure the superiority of the US's military technology. DARPA put the Explorer in orbit in February 1958. In October 1962, Licklider was appointed the head of the Information Processing Techniques Office (IPTO) at DARPA. The same year he addressed a memo to a group called *"Members and affiliates of the Intergalactic Computer Network"*[121], where he explained its ideas about time-sharing –a technology he was pioneering– and the advantages for research of sharing resources through networked computers. Although he left DARPA in 1964, he convinced his successors Ivan Sutherland, Bob Taylor and the MIT researcher Lawrence G. Roberts, of the importance of this concept, which in 1969 materialized as ARPAnet. The feasibility of using programs at a remote location was demonstrated in 1965 when the AN/FSQ-32 computer at Systems Development Corporation in Santa Monica, California was linked with the TX-2 computer across the continent at the Lincoln Laboratory in Lexington, Massachusetts, using a low-speed dial-up telephone line. A person at the TX-2 graphic console was making use of a unique list of processing programs at the SDC. However, the phone line proved not to be useful to connect several computers. The realization of the network would only be possible after the encounter with another technological assemblage, the Packet Switching. Leonard Kleinrock did his Ph.D. thesis at MIT in queueing theory, which became the mathematical background to Packet Switching, in 1961.[122] Packet Switching was a new theory allowing information to be delocalised, substituting circuits with packets. In this way, the network would not connect remote places, but information, irregardless of where it was located. The transmission between circuits is an end-to-end communication, where once a communication is started, a net of connections links the origin with the destination terminals. In Packet Switching, this is substituted by a datagram constituted by several layers of information in which, one of them contains the destination address. This packet information is transmitted to a networked link from where it can be accessed by different connected machines. At the same time, as the packets are enrooted independently, the system allows the same postbox to store messages for different targets. The first ARPAnet was connected in 1968, after the development of the packet switches called Interface Message Processors (IMP's). It connected four Honeywell

121 J.C.R. Licklider (1963) "Memorandum for Members and Affiliates of the Intergalactic Computer Network" Originally distributed as a memorandum April 23, 1963. Published on KurzweilAI.net December 11, 2001.

122 L. Kleinrock (1961) "Information Flow in Large Communication Nets"

microcomputers, these nodes located at four separate universities. The first IMP was installed at the Kleinrock's Network Measurement Centre at UCLA (University of California at Los Angeles). The second node provided an early hypertext system, the one elaborated by Engelbart's group and the Network Information Centre, located at SRI at Stanford. After the first host-to-host message was sent from Network Measurement Group to the SRI, two more nodes were added, the University of California at Santa Barbara and the University of Utah. These last two nodes incorporated visualization projects. In December 1970, the Network Working Group (NWG), working under S. Crocker finished the initial ARPAnet Host-to-Host protocol, called the Network Control Protocol (NCP), at the same time as the number of connected computers increased. In October 1972, Khan organized a successful demonstration of ARPAnet at the International Communication Conference (ICCC). The same year, Ray Tomlinson at BBN wrote the basic software for the e-mail, the killer Internet Application. The ARPAnet began as a system to share computing resources; the email proved that the Net would be useful for human-to-human communication and to improve the tasks of coordination among researchers.

Internet evolved from the Packet Switching network of ARPAnet after Khan developed the idea of "open architecture internetworking" in 1972. This new concept stems from the capacity of Packet Switching to provide arrangement between networks. The Internet would be a decentralised net of networks that could be of a different kind such as packet satellite networks, ground-based packet radio networks and others. These were designed independently, according to their environments. The development of Internet would follow four rules: first, each distinct network would have to stand on its own and no internal changes could be required to any such network to connect it to the Internet. Second, communications would be on a best effort basis. If a packet did not make it to the final destination, it would shortly be retransmitted from the source. Third, black boxes would be used to connect the networks; these would later be called gateways and routers. There would be no information retained by the gateways about the individual flows of packets passing through them, thereby keeping them simple and avoiding complicated adaptation and recovery from various failure modes. Finally, there would be no global control at the operations level. NCP proved ineffective for this purpose and Khan conjointly with Vin Cerf designed the Transmission Control Protocol/Internet Protocol (TCP/IP).[123] This was a protocol of communication rather than a device driver, the TCP providing for services such as control flow and the IP for addressing of individual packets. Initially, a 32 bit IP address was used of which the first 8 bits signified the network and the remaining 24 bits designated the host on that network. This would prove insufficient for the unexpected growth of connected computers by means of other technologies such as LAN's (Local Area Networks). The TCP/IP would be distributed at a conference at Sussex University in September 1973. The early implementation of TCP was done for large time-sharing systems. When personal computers appeared David Clark and his research group at MIT produced an implementation, first for the Xerox Alto and then for the IBM PC operable with other TCP's, but tailored to the application suite and performance objectives of personal computers. Later on, the new transmission protocol would be integrated into the kernel of Unix in the BSD (Berkeley Software Distribution) Unix, the fact that increased the spread of connectivity that all personal computers would soon attain. This was improved by the development of Ethernet technology by Bob Metcalfe, and nowadays Ethernet networks are the most common. In addition, the fast spread of the network, after the personal computer joined it, proved impossible to maintain in a single table of all the hosts and their associated names and addresses, the reason why Domain Name System (DNS) was invented by Paul Mockapetris in 1983 to automate the translation and hierarchy of the domain names to IP addresses.

In the spreading of the Net, NSFNET played an important role, the first net that was available for multiple users and purposes and where the change from institutional to private providers would be operated. Other networks flourished while Internet technology was being experimentally validated. These early networks were purpose-built, intended for and restricted to close communities of Scholars. In 1985, the NSFNET program was aimed at providing service to the general academic and research community. This program launched several policy decisions such as the foundation of the Federal Networking Council and operated the transition

123 Vinton G. Cerf and Robert E. Kahn (1974) "A Protocol For Packet Network Intercommunication"

from the federally funded backbone to a commercial one, this leading to a new architecture supported by commercial equipment in 1995. During the 80s the Internet traffic, now supported by commercially operated networks where the clients pay for access, exploded. It soared from a few thousand hosts to about 200,000 in 1989. At the same time, connection speed increased, while the first T-1 line offered speeds of 1.5 Mbps, by the end of the decade T-3 line was in the works and when it was finally implemented in 1991, it allowed for data transfer speeds of 45 Mbps.

In 1991, senator Al Gore, later vice president, circulated the High-Performance Computing and Communication act, where he coined the expression "Information Superhighway" and stressed the importance of building the information infrastructure of a global village to give access to all Americans to this transformative technology.[124] The Internet Society was created the same, under the auspices of Kahn's Corporation for National Research Initiatives (CNRI) and the leadership of Cerf, then with CNRI to give community support to the development of Internet.

2.1.3.2 NAVIGATING THE NETWORKED SPACE: THE WWW

Meanwhile, the other assemblage that led to our digital culture was emerging across the Atlantic. Tim Berners-Lee developed The World Wide Web at the CERN, located in France. If Internet was providing the system to allow computers to communicate with each other, the www would become the interface allowing humans to communicate in the new space produced by the interchange of information between these machines. At this moment, the CERN (*Conseil Européen pour la Recherche Nucléaire*, later called *Organisation Européenne pour la Recherche Nucléaire*/ European Organization for Nuclear Research) was populated by a critical mass of researchers that were producing a large amount of data and documentation. The www born as a proposal to provide easy access through a single interface to this documentation. In 1989, Tim Berners-Lee circulated the *"Information management proposal"* for comments, which produced the back text *"Hypertext and CERN".* The first proposal with description and technical specifications for the implementation of the WWW was presented on the 12th November 1990 in the document *"World Wide Web: proposal for a hypertext project"*[125] The World Wide Web was a simple hypertext system, integrated by a net of links, which can be followed to a node or piece of stored information.

The first definition by Tem Berners-Lee:

> *"HyperText is a way to link and access information of various kinds as a web of nodes in which the user can browse at will. It provides a single user-interface to large classes of information (reports, notes, data-bases, computer documentation and on-line help)".*

The www must provide a common interface to access existing information with different formats and stored remotely on different machines. With this aim, it provided a common simple protocol for requesting human readable information stored on remote systems using networks. The basic architecture of this system consists of servers, where data are stored and clients performing processes.

The server is a native application program running on the server machine that stores the web of nodes. Each node is a piece of information that can be text or other media such as diagrams, pictures, sound, animation, collected in a non-hierarchical way. The net of nodes is accessed through a browser via a native application

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124 Robert Kahn and Vinton Cerf (2000) "Al Gore and the Internet"

125 T. Berners-Lee/CN, R. Cailliau/ECP (1990) "WorldWideWeb: Proposal for a HyperText Project"

program that operates on the client machine. It performs the display of the hypertext or list of links, which when pointed, follows the referred to node that is displayed on the screen, using the client hardware and software environment. In addition, it traces and remembers the visited links, and as such allows going back and forth and negotiates the display format with the server.

The World Wide Web was a simple hypertext system aimed at navigating collections of information, where documents are linked among them as a net of nodes. This simple structure contrasts with the unrealized project by Ted Nelson. Xanadu[126] was a universal publishing system and archive, providing methods for indexing information, and where the net can evolve by means of incorporating new relations and annotations stored in a dated multi-versioning system, where modifications are attributed to their authors. In contrast, the www is a simple and open system with a minimal structure allowing multiple uses and standpoints that will evolve through the creation of applications.

The team at CERN directed by Sir Tim Berners-Lee, Sir Sam Walker, and Robert Caillau, introduced the www publicly in 1991 and distributed it as freeware in 1992. In addition, they developed the Hypertext Transfer Protocol (HTTP), the Hypertext Markup Language (HTML), rather than a language in a list of tags to format hypertext pages (i.e. <a>this is a link<a>), and the Uniform Resource Locator (URL), which names the web pages. However, the big hypertext was not fully deployed until Marc Andersen created the first web browser. Mosaic was a graphical web browser, easy to use and install that, later on, would evolve into the popular Netscape Navigator and its competitor the Internet Explorer, which was widely distributed after being bundled into the Windows operating system. During the 90s, Internet grew fast, increasing from 130,000 hosts in 89 to 37 million hosts, 4 million 3 hundred thousand domains and more that 4 million pages in 98, this traffic increasing at the end of the decade by the implementation of new technologies such as the cable modem and the DSL. This growth made it hard to keep track of what was on-line until the Search Engine appeared. The first Search Engine was Archie (the name stands for archive without the 'v'). Alan Emtage, Bill Heelan and J. Peter Deutsch, computer science students at McGill University in Montreal, created Archie in 1990. It consisted of a program that downloaded the directory listings of all the files located on public anonymous FTP sites (File Transfer Protocol), thus creating a searchable database of file names. In 1993, Jonathon Fletcher created Jump Station. It used a web robot to find web pages that are ordered in an index and a web form as an interface for a query program. In 1994 WebCrawler appeared, similar to Jump Station, but allowing users to search for any word in any webpage and not only among titles. This becomes the standard for all major search engines. After that appeared Lycos, Magellan, Excite, Infoseek, Inktomi, Northern Light and AltaVista. Yahoo! was one of the most popular ways to search for web pages, but at the beginning, it was a directory until it bought Inktomi in 2002. Yahoo is still one of the most well-known Internet Services Provider (ISP), a platform providing multiple applications to the users free of charge, such as e-mail, forums, chats and so on. The first popular ISP was AOL (America on Line), providing access to on-line games, chat environments, and email services. Focusing on non-technical users, it offered a non-technical way to experience the web and Internet.

2.1.3.3. THE INFORMATION SOCIETY

All that described above, hard and soft technologies, come together to form a big assemblage that will encounter all the systems of our environment and led to a new ecology that Manuel Castells would characterize at the end of the 90's as Information Society.[127] The networks embedded in our daily environment and reshaped the systems of production and power at the same time as our notions of space and time. They resulted in a new cybercapitalism and cyber power, both deterritorializing forces that would create a new global space at the

126 Ted Nelson (1987) *Literary Machines*. Edition 87.1 *The Report on, and of, project Xanadu. Concerning word processing, electronic publishing, Hypertext, Thinkertoys, Tomorrow's Intellectual Revolution, and certain other topics including knowledge, education and freedom.*

127 Manuel Castells (1996) *The Rise of the Network Society, The Information Age: Economy, Society and Culture* Vol. I.

same time as dissolving the places of dwelling. In contrast, the capacity for the encounter of this medium would lead to new Collectives able to appropriate the space and promote new territories by means of artistic and political actions.

The Information Society refers to a new way of social organization in which the production, processing and transmission of information become the main sources of power and production. The spread of new technological infrastructures including advanced telecommunication systems, interactive information systems, and computers with an increased capacity to compute at high velocities the complex models required to manage complex transactions would result in a new global economy. It interlinked and sustained in networks that were capable of working at a planetary scale in a unitary way and in real time. The new economic and productive systems operate beyond the screens in a new space of fluxes, which are constituted and managed accordingly to a reticular logic that hides its material conditions. This space becomes highly integrated and disseminated. It is characterized by its interconnection and flexibility and evolution towards constant innovation. These characteristics confer to this space a big capacity of deterritorialization. It deterritorializes processes. The process of production becomes modular and highly integrated into a seamless system. The involved agents only take part in coupled fragments that can be easily changed and relocated, even it can get rid of the whole, from which anybody has a complete knowledge. It deterritorializes time. The productive and economic systems are sustained by a continuous innovation. It is fuelled by a continuous feedback loop between production and consumption, in which consumers are reduced and standardized, converted to computable data. As innovation it is aimed at maintaining a constant demand, producing a constant flux of standardized goods, which are laid out without regarding local and temporary needs and that lack duration. These are not suitable for appropriative use leading to creation. In addition, the major flexibility of the system, given its modularity, to move and adapt itself to incorporate new chances of profit, makes it highly exclusive, when the more cutting-edge a technology is, the more people are left behind in its evolution. It deterritorializes value. Value is severed of product and based on speculation. Finally, it deterritorializes space. Production becomes disseminated to a planetary scale thanks to the capacity to transmit information to remote places in real time. Command, development, production, and distribution are dispersed to remote nodes, which can be easily disconnected and replaced in an ever mutating and borderless system. This Affects urban space, the centres of big cities become hubs harboring the centres of command, while the rest of urban space becomes fragmented and dissolved. The complex nets of these systems are populated by a cosmopolite elite that moves transnationally and that can take part in the coordination, management, and innovation of the crisscrossed activities of corporate nets. Meanwhile, the disarticulated mass remains in an impoverished space that is organized according to unhistorical fluxes, these becoming non-places deprived of meaning. This situation alters the dynamics of the local and separates knowledge from experience. Thus, it gives birth to a lack of subjectivation and a spatial schizophrenia, where the channels of communication are not able to produce shared cultural codes that can give birth to territories.

At the beginning of the 90s artistic groups emerged such as Critical Art Ensemble[128] that in front of the impoverishment of public space proposed Electronic Resistance as the only way to oppose the Nomadic Power that characterizes the Society of Control. The cultural activist (before, artist) may disrupt the diffuse power field by means of cutting off the fluxes of information from where it arises. These guerrilla tactics directed at sabotaging the information technologies share the cyberspace with the dwellers of a new public sphere. The openness and accessibility of Internet could turn it into a technology of freedom. Cyberspace is the place for the accomplishment of the Postmedia epoch. The turn from mass communication, characterized by the collective and passive reception of a unique message, into auto-mas-communication, the plural access to a horizontal space that escapes from any centralized control, where digitalization can support any kind of message, which can wander in a global space as data packets. People encountering in this medium promote

128 See information about Critical Art Ensemble's projects and publications at http://www.critical-art.net/

the production of new contents that proliferate beyond the filter of traditional authorities towards a new Collective Intelligence. At the same time, they can form a critical mass, which later on would be able to reach the streets and reterritorialize urban space towards social change.

2.1.3.4. THE SOCIAL APPROPRIATION OF THE WWW

The appropriation of networks for personal communication, leading to the formation of new Collectives has evolved simultaneously with the development of these technologies. Early initiatives were the Bulletin Board System (BBS), the mailing lists and the Digital City.

The Bulletin Board System appeared at the end of the 70s, as soon as the first modems become available, disappearing when Mosaic became popular, offering the www as an alternative. This system consisted of a computer server running custom software, in which users could connect from a terminal and perform actions such as uploading and downloading software and data, read news and bulletins, and exchange messages with other users via email or on public message boards. These systems evolved from a previous initiative, the *Community Memory*,[129] a time-sharing system initiated at Berkeley in 1973. *Community Memory* allowed its users, after inserting a coin, to type a message into a terminal that could be tagged with keywords. These messages could be searched and displayed publicly. Despite its simplicity, this system was appropriated as a form of expression for its users who found the way to use the tags as assemblers from where they spontaneously created histories and poetry. The system closed in 1975 after its host machine became unavailable. One of the best-known BBS was *The Thing*.[130] It was started in 1991 by Wolfgang Staehle, to provide services to an international net community of artists. It is considered as the first project that emerged from the conceptually-oriented art scene into the data-nets realm of communication, distribution, and production. In 1995, *The Thing* was transformed into a web page.

The Mailing list is a list of mail addresses administered by a moderator, and subscribers can send messages that are redirected to all the contacts in the list. *NetTime*[131] was proposed in 1995 by Geert Lovink and Pitz Schult at the second meeting of the "Medien Zentral Kommittee" during the Venice Biennale. This list had been largely recognized for its commitment to tactical activism, net art, tactical media and net critique and for pioneering collaborative practices as collaborative filtering. It had relevant contributors and it remains available on the web as a valuable source of documentation.

Finally, *The Digital City* (De Digitale Stad)[132] was created in 1993 as a free services provider on the web, when the internet was a popularly accessible technology, characterized by openness, free access, equality and anonymity. It was an interface built around the notion of the square, places for the gathering of diverse people, discussing local issues. These were surrounded by houses, home pages related to the discussed topics. In it, the city was used as a metaphor to show the culture-in-the-making resulting from the interaction between complex community spaces and the conceptual diversity and assembly that we can find in an open medium for general-purpose. *The Digital City* closed in 2003 due to funding problems. Other services, such as *GeoCities*,[133] discontinued in 2009, used similar metaphors to show the internet as a socially produced space.

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129 http://www.neatorama.com/2012/08/07/Community-Memory-Worlds-First-BBS-and-Online-Troll/

130 The original The Thing: http://old.thing.net/, The Thing as a web site: http://thing.net/

131 www.nettime.org

132 http://mediaartnet.org/works/internationale-stadt/

133 https://archive.org/web/geocities.php

Nowadays, social networks, forums and other services related to the Social Web have made these systems obsolete. The media publisher Tim O'Reilly popularized the social web under the denomination Web 2.0 after the crash of the dot.com.[134] The social web will emerge from a new technological procedure, the dynamic web. The dynamic web evolves from the algorithmic management of the database, which will become the new core of the www, and a new architecture based on the users participation, inherited from the open source software. In this way, the Web 2.0 companies are not offering packaged applications, but platforms, where software is delivered as a service. This procedure will lead to a new business model where benefits stem from harnessing Collective Intelligence and where the final product will become the users themselves.

The new platforms of the social web are not characterised by the apps or contents they offer to their users, but by the offer of ongoing services that are continuously updated accordingly to the use and acceptance of the audience. In these free services, publishing is substituted by participation. Users do not only work as a co-developers, establishing preferred and alternative uses of the provided software, they become content providers by means of contributing the database from which the website is generated. In this way, the improvement of the website increments with its use, the reason why it is also called Incremental Web. This use takes advantage of the decentralized structure of the web to reach what Chris Anderson calls the Long Tail.[135] This harnesses the collective power of small contributions, contributions that are not only crowdsourced by the users, but also produced as a side effect of their activity on the web. Monetizing these free services will depend on a change from getting paid for the access to contents to exploit the user-generated data.

The Incremental Web is supported in a new technological procedure, which decentralises the processing of information from mainframes and disseminates it along the network of middle powered personal computers, the Map-reduce, conjointly with the promotion of a new approach in databasing.[136]

Google[137] was one of the earlier examples of this approach. Google started in January 1995 as a research project by Larry Page and Sergey Brin. The conventional search engines index web pages according to meta tags and on-page information and ranks the results accordingly how many times the search terms appeared on the page. Using a different approach that allows them take advantage of the structure of hypertext and not only the characteristics of documents, the developers of Google created PageRank, an algorithm that models user behaviour on a graph, from where web pages are ranked according to the citation link –how many pages are linked to and from the page-. The more a page is correlated with topics, the more relevant a page is and this page will be ranked higher for this specific search. In addition, PageRank is used to create a database of websites, which is managed algorithmically.

Google has evolved to an always-ongoing services provider. The services freely provided on the web by Google had been increasing to include e-mail facilities, Gmail (2004), blogs, Blogger (2003), storing and indexing of images, with the acquisition of Picassa (2004), cartographic and navigational services after the acquisition of Keyhole Inc. in 2004 that became Google Earth and Google Maps (2005); documentation indexing for academic research, Google Scholar (2004), simultaneous translation with Google Translate (2006) and so on. These services allowed the company to increase its database by means of including images, geographic data, user's profiles and other information. In addition, Google set out APIs (Application Programmable Interface) to allow professional and amateur programmers access to its data and programmed functionalities that can be embedded in new applications. In this way, it harnessed collective innovation towards the creation of data mining and data visualization facilities, collaborative work tools, and many other user-friendly services. Nowadays, it is possible to use a fully functional computer without any application stored on it, just connected to Google and working on the Cloud.

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134 Tim O'Reilly (2005) "What is web 2.0"

135 Chris Anderson (2004) "The Long Tail"

136 Paul Dourish (2014) "No SQL: The Shifting Materialities of DatabaseTechnology"

137 More information about PageRank history and functioning can be read at http://infolab.stanford.edu/~backrub/google.html and http://www.google.com/intl/en_us/insidesearch/howsearchworks/thestory/

Cloud technology is another of the material resources that foster the development of the social web. Cloud computing is a set of technologies that allow remotely using resources stored in a datacentre, as storage and software applications. Before the Cloud was popularized, the social web was pioneered by per-to-per services such as Napster and BitTorrent. Napster was released in June 1999 as a pioneering peer-to-peer file sharing internet service, focused on sharing audio files in MP3 format. In this system, users do not only contribute a searchable database but a networked architecture in which every connected computer works as a server, from where the listed files can be downloaded. Napster was shut down for violating copyright in 2001. Meanwhile, it achieved high quotas of popularity, counting on 80 million registered users and it changed the music business forever. BitTorret was the first client of the BitTorrent protocol for the practice of peer-to-peer file sharing. Released in 2001 it enabled users to search for and download torrent files in a built-in search box, which opens the BitTorrent torrent search engine. This system is not freely available anymore.

Another pioneering project that fostered the evolution of the social web is Wikipedia,[138] which in addition is one of the most quoted examples of Collective Intelligence. The Wikipedia is a collaborative generated encyclopaedia that translates the principles elaborated by Raymond to the editorial field. In it, all the contents are elaborated and supervised by their users by means of a Wiki. Wiki engines are another of the inspiring social web technologies, a software that allows the users of a website to modify collaboratively its structure and contents inside of the web browser, using a simplified *markup* language. Ward Cunningham developed the first Wiki software in 1994 inspired by Hypercard from Apple and the ideas of Vannevar Bush and Engelbart to create a system where different documents can be interlinked and modified by a group of collaborators. Cunningham used its software to create WikiWikiWeb released on-line in 1995 and described by its creator as the simplest online database that could possibly work. Wikis are widely used for collaborative documentation and knowledge management. Wikipedia is the most known Wiki, becoming since its creation in 2001 the most consulted encyclopaedia and one of the most visited webs. It has grown rapidly into one of the largest reference websites, attracting 374 million sole visitors monthly as of September 2015. There are more than 70,000 active contributors working on more than 35,000,000 articles in 290 languages. As of today, there are 4,967,244 articles in English.

Another content management system popular inside social webs is the Blog. The Blog is a publishing format inside the web, consisting of chronologically ordered posts produced by a sole author or group of contributors. Blogs are widely used on the web for multiple purposes, such as online diaries, thematic spaces inside newspapers, think tank assemblers... Its popularity grows with the promotion of services such as WordPress and Blogger that offer free publishing tools easy to use for non-technical users and sometimes free hosting. The Blogosphere enters the world of the social web with technologies such as RSS (Really Simple Syndication) that allow people to subscribe to a website, they are notified when it is updated, and the permalink, which allows building bridges between blogs.

Another of the technologies related to the development of the social web was the collaborative tagging or Folksonomy, promoted by services dedicated to sharing contents such as links in del.icio.us, videos in Youtube –nowadays one of the Google services- or pictures on Flickr. Folksonomy is a portmanteau between 'folk' and 'taxonomy' proposed by Thomas Vander Wal in 2004. It refers to a user-generated system to apply tags to online items that give rise to a classification system based on these tags and their frequencies. In contrast to a taxonomic classification specified previously by the owners of the system that immobilizes the contents, Folksonomy results in a lived net, where the tags work as connectors, facilitating the encounter between different entities and producing new meanings. A special case of collaborative tagging is the Hashtag (#), a tag proposed in 2007 by Twitter to connect histories inside the microblogging place and start conversations. The Hashtag has become highly popular, trespassing the bounds of its original site and becoming commonly used in most of the sites of the social web.

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138 https://en.wikipedia.org/wiki/History_of_Wikipedia

Twitter is one of the most successful applications of the social web. After its creation in 2006, Twitter has grown until reaching 316 million monthly active users and more than 500 million tweets per day. It is a microblogging site where subscribers can share any kind of narration that can fit inside 140 characters. In recent years it has extended its utilities to allow sharing pictures and videos. The users of Twitter build a big database of tweets: small stories relating current state of a large amount of subjects. The 'trend topic' tab answers the question 'what is going on?' highlighting the most discussed topics in real-time. To elaborate the content of this list, Twitter makes use of complex algorithms that not only compute the most quoted words, but also the acceleration of their use, if the subject has become trending previously and if it is distributed among different nets or mainly inside a densely connected cluster. To accomplish this task these algorithms makes use of Hashtags, language analysis and the technology used to shorten links. T.co is a software technology developed to allow sharing links inside the frame of 140 characters, It is a data rich structure that is generated each time we share a link on the social web, in addition to saving characters, t.co allows to track about how links are shared along the net, at the same time as creating user profiles. Similar algorithms work inside the system to suggest new contacts to the users, also to elaborate a personalized list of what is being published matching their preferences.

Finally, we find the most characteristic service of the social web, the Social Network. Social networking services have changed our social life and the way we relate to others. These services give everybody the opportunity to narrate a public identity or social profile, and promote themselves by connecting with people who share similar interests. Consisting of a profile, where users share personal data, social links – a list of contacts to share information with- and publishing tools, these web platforms became popular at the end of the 90 with the emergence of SixDegrees.com in 1997, followed by Makeoutclub in 2000, Hub Culture and Friendster in 2002. Facebook was introduced by Zuckerberg in 2004 and was opened to everybody -almost 13 years old and with a valid mail address- on September 2006. The company announced 500 million users in July 2010 and has become the most widely used service all over the world. Facebook manages a database of people, where it include relevant information such as preferences, pictures, locations, contacts, and activities. This database is incremented by means of the creation of new ways to relate people as the button 'like' and is managed by algorithms such as EdgeRank. Inside the overflow of information generated inside this site, EdgeRank removes the boring or iterative stories of the user's 'news feed'. It compiles data about our preferences based on what we publish and which publications we like, the friends we have in common with the emitter of the post and the comments linked to it to determine how relevant this will be for us. It thus hides the stories that do not match in this compound. Other algorithms inside the application trace the graph of our social connections to suggest new acquaintances or traces our history to show targeted ads. In addition, Facebook has linked with other web services to offer access to on-line video games, chats, and news services. At the same time, it makes it easy to share our activities inside the site, such as our location and preferred places, by linking to Foursquare, the music we like, through Spotify, the books we read by means of Amazon... Thus, it has become the main way of access to the World Wide Web for many users.

The social use of the web has evolved, first by means of initiatives started by Collectives. These aimed to adapt the new technologies to their social use resulting in artifacts such as BBS, Mailing List, and the *Digital City*. Second, when the World Wide Web was fully accessible, by means of developing new technologies that enable sharing of contents such as the per-to-per file sharing protocol and the collective management of these contents, such as the Wiki, the Blog and the Folksonomy, which enabled the encounter inside cyberspace of people and contents producing new Transductions and meaning. These technologies fostered Collective Intelligence at the same time as producing an increasing overflow of information that nowadays is being managed algorithmically by companies such as Google, Facebook, and Twitter, whose commodifying these technologies have monopolized the flow of data towards its monetization. The management of this big flow of unstructured data produced as a side effect of the actions of the platform users is possible thanks to the development of a new approach in databasing and a new technology the Map-reduce. It allows to distribute computation from the big data servers of the Cloud to all the net of computers.

Google, which implemented it in 2004 for all its platform services, also developed Map-reduce. Map-reduce is a procedure in two steps. First, it maps a computer task in a set of smaller tasks that can be conducted independently in a grid of computers. The second step reduces the produced results in a single solution. In this way, it allows the parallel processing of large datasets in a cluster of computers. The open sourced version Apache Hadoop is at the core of platforms such as Ebay, Facebook, LinkedIn and Cloud computing.

At the same time, distributed computing promoted a new database paradigm. A database is a set of notational strategies by which aspects of the everyday world are encoded in computer systems in such a way as they can be read and operated by machines. The predominant database system is the Relational model developed by IBM as System R in 1974, which was the basis to develop SQL and SQL query. IBM aimed at hardware design, software production, and bureau computer services. In this framework, System R has developed accordingly the implementation of hardware aimed at providing market services with great accountability.

A relational database organises data in a table consisting of fields, columns, which encodes information of a particular sort and entries or lines, which encodes relations. For example, if in a table we have the fields 'client name', encoding all the names of the clients of a bank office, and the field 'account number', coding the account numbers managed at this office, in this table each line relates a client with its account number. The relational model allows express relations between tables inside a database, for example, the 'client names' on the table can be related to another table with their personal data, and the 'account number' with a table where the fields encode bank transactions. This model separates content (the data) and structure (the schema). The schema is laid out previously to the introduction of data and determining the way the data can be viewed, edited and contributed. This gives the table greater consistency in transactions, which in the relational mode are operated accordingly by the ACID properties of transaction processing Atomicity, Consistency, Isolation, and Durability. These properties assure the consistency of the table through transactions that are operated one by one as isolated operations. The relational database model was aimed at office services provided by mainframe computers that must ensure fast transactions realized with a high level of consistency.

The disseminated contribution of data that empowers Web 2.0 need a less consistent model that privileges the distribution, flexibility and users' interaction. The NoSQL databases are based on network and attribute-value systems. In these systems, links do not have a predefined meaning and there is no separation between content and structure, which is produced at the same time as data is introduced. This system is aimed at the collection of large quantities of unstructured data such as the collection of tagged pictures of a Facebook user. The focus of attention shifts from the schema, which constrains performance, ensuring consistency, to the collected objects. This approach is characterized by granularity –if relational database was operating relations at different scales, the table, the row, the value, attribute-value is only operating in objects-, associability -there is not a predefined pattern of relations to associate objects-, multiplicity -the most instantiated objects can be duplicated without problems-, and convergence –the network of data is able to manage the temporary inconsistencies resulting from different users updating a table. No relational databasing privileges contribute to semantics and information retrieval. If the relational database produces a related set of values aimed at a predefined purpose that are recuperated accordingly as queries, NoSQL databases produce big collections of non-structured data, to be sorted and interpreted a posteriori by algorithms aimed at different purposes. This approach will move programmability from connected computers and data servers to the network, where programs can interact between each other interchanging data and functions by means of technologies such as API's and Ajax.

2.1.3.5. THE WEB OF DATA, LINKING TO THE REAL WORLD

If O'Reilly Media was defining the social web as Web 2.0 in 2005, in the Submit of 2009 they analyse its evolution and propose the Squared Web as a name that summarizes its newly obtained characteristics.[139] That is, the encounter of the web with the world. Our daily activities have converged on the screens of networked computers, where now we communicate with our friends, work and look for entertainment. As Ted Nelson envisioned, computers have become multipurpose-machines.

This evolution has been fostered by the increment of transmission speed, processing and software capabilities. Recently, the advertising of a well-known Operating System read, *"if you have less than 15 tabs open in your browser, you are a coward"*. This exponential increment of the use of the web has produced a large amount of data that is now managed algorithmically. At the same time, the feedback loop between production and use of new software services, conjointly with the proliferation of APIs and the technologies grouped in Ajax (Asynchronous JavaScript and XML) – that allow to send and retrieve data from a server asynchronously, without interfering with the display and behaviour of the existing page- has produced a crisscross between services and the development of new mashups towards the integration of the existing platforms. As a result, the social web has become an integrated system that is now encountering the physical world.

In the evolution of this integrated system, we find the spread of smartphones and its sensors including GPS, the development of learning algorithms and technologies as the Geographic web, which was pioneered by Google Earth. Google Earth is a virtual globe, map, and geographical information program that was originally called EarthViewer 3D and was developed by Keyhole Inc., a Central Intelligence Agency that was acquired by Google in 2004. It maps the earth through the superimposition of images obtained from satellite imagery, aerial photography and geographic information systems (GIS) onto a 3D globe. This artifact and its flat version Google Maps contain multiple layers of information, which can be contributed by the users, among them textual information of highlighted places, pictures, paths, even 3D buildings that can be modelled using SketchUp – an easy to use modelling software freely provided by Google-. The Google base map provides a set of APIs that allow access and reuse of its data and functions and has been embedded in a wide range of applications and websites that use geolocation and navigation tools, for example Foursquare, which at the same time can be linked to Facebook. The spread of smartphones and mobile applications (after Apple implemented the touchscreen in its I-phone in 2007 the dissemination of smartphones has grown until reaching 1.91 million users worldwide) has meant that the situation described below is an everyday event.

Nowadays, it is usual to call your friends together from your mobile using WhatsApp. Once all together, you look for a restaurant in Foursquare that will provide you with a selection of places according to your location, budget and preferences and show you on Google Maps the way to go. On the way, maybe you will need a taxi and Google will link you to Uber. Once in the restaurant, you will rate it in Foursquare, which will publish your 'check-in' in Facebook so your friends can know where you are and who you are with. If you like the 'nice food', you will picture it using Instagram, which again you will share on Facebook. After dinner, you will repeat the process to find a club. Once there, if you like the music you will capture it with Shazam that will connect to Spotify to add the new song to your playlist, which once again will be shared on Facebook to show the update to all your friends and followers. In the course of this normal evening, you have been contributing to a large amount of data to a system that not only stores and shares this information, but at the same time processes it with algorithms that are taking part in your decision process and modifying the whole ecosystem. This integrated system is becoming the main way to experience the World Wide Web for a large number of users. It is becoming a new source of social anxiety. You feel compelled to have a large number of friends, attend interesting events, tag cool places and eat photogenic food. Summarizing, you feel compelled to post in order to become a contributing part of this new socio-technical Apparatus.

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139 Tim O'Reilly and John Battelle (2009) *Web Squared: Web 2.0 Five Years On, Web 2.0* Submit Special Report at web2summit.com

According to Tim O'Reilly, the future of Internet would consist of a series of interoperating data subsystems. A key competence of the Web 2.0 era is to recognise implied data and structure it in a database, around which a related ecology can emerge. This data is not only retrieved from our interactions with web services, new technologies such as RFID and QR codes also allow linking physical objects to the web to obtain additional information. In this way, reality becomes increased by a computing system that by means of the implementation of learning algorithms becomes capable of recognizing physical objects and places and delivering information about them. As an example, we can quote Layar, a browser based on Augmented Reality developed in 2009 by Raimo van der Klein, Claire Boonstra and Maarten Lens-FitzGerald. Using the sensors included in smartphones as the accelerometer, compass, GPS and the camera, this browser can identify the user location and field of view and insert an additional layer of information. Layers are REST web services, serving geo-located points of interest in the vicinity of the user that can be developed and maintained by third parties using a free API. These can include videos, pictures, related tweets or other media objects. To the wearable sensors of our phones sensing our location and movements that can provide data to a big range of applications, we must add the increasingly common sensors sensing the physical world. It is the rise of the Internet of Things, the web as an integrated system is able to recognise the world and manage information about it not only encoded in a previous taxonomy but inferentially. Learning algorithms process large amounts of data to recognise patterns from where to build a structure. This is how Google Translate works, in addition to a dictionary, a structured database, this engine uses an algorithm that looks for the words that usually appear together in a sentence and indexes it in a big database. In this way, the engine learns of its users improving its accuracy at the same pace as its use. Similar procedures are used to develop vision recognition and the new search by images by Google. The increasing use of data-analysis and data-visualization is turning the web sensitive. The bottom-up machine learning applications gradually make more and more sense of the data that is handed to them without the need of explicit metadata.

The web has changed our social life bringing new capacities and activating Affects towards new assemblages and potentialities. The role that social platforms such as Twitter played in the Arab Spring Revolution of 2010, the Spanish 15M in 2011 and the posterior global Occupy movement is well known. Castells explains this phenomenon relating it to the capacity of assembly of this new media. This capacity is due not only to the openness of the system of auto-mass-communication defined by this author but also to the introduction of collaboratively produced digital objects able to work as Spaces of Transformation; as an example the hashtags act as places for the encounter between people sharing similar concerns. These circulate being enriched in an ongoing conversation, leading to a Collective Individuation in which the participating people produce a shared context and identity. As Castells points out, people feel empowered when they realize that they are not alone.[140] These movements that come together in the electronic nets can reach the streets and appropriate the space towards social change. Despite these encouraging examples of the net power of assembly and its potentiating effects, the web of data shows great discontents. The tracking of our actions to build our profile has awakened public opinion about privacy concerns and the exploitation that results in the monetization of this data in the marketing and consumption industry. More importantly, this data is mined and computed towards new capacities of anticipation towards new forms of control. This integral system described here is becoming a new Apparatus. It is producing a protocological space where our potentialities are actualized by complex algorithms, the black boxes of an automatized socio-technical mechanism that define the borders of our space. Establishing walled gardens inside the global space of the net and the processes by which we become involved and obtaining knowledge of this space. The study of the impact of these technologies cannot run independently from the analysis of their architecture. The interfaces from which we access the system are modelling our space and ourselves, at the same time as they hide the mechanical Transductions that generate the system. As we do not know the processes of the system we are involved in, we become subjected to it without being real users. The question is if it can be a real participatory culture when we remain unaware of the processes of Transduction we are involved in. In addition, how to propose technological interventions that become able to re-embody this system and give it back to the creative action of Collectives.

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140 Manule Castells (2012) *Networks of Outrage and Hope*

2.1.4. COMPUTER GRAPHICS: INTERACTIVITY AND IMMERSION

"I leave to the various futures (not to all) my garden of forking paths"[141]

After WW2, we saw the development of a new industrial revolution, where automatization was not fuelled by energy as a primary source, but by the flux of data. This revolution emerged from the convergence of computation – embodied in personal computers- , new communication technologies – embodied in the Internet- and new audio-visual media, which would lead to a new space of representation. These three technological fields merged into a new integrated system that would constitute the defining Apparatus of our era. This new Apparatus would produce a new space, the space of fluxes, where the data packages circulate sustained by a network of networks constituted by wires, antennas, and black boxes as gateways, routers, and data servers. This space characterized as global, disseminated, decentralized and mutant would encounter with the space of places and change the traditional notions of space and time towards the Big Here and Long Now we are immersed in. The accelerated time and contracted space produced during modernity by the spread of new means of transport and the mechanical reproduction of media, is being substituted by the real-time transmissions of the Internet. This new disseminated and navigable space would grow beyond the screen until immersing all society and reaching physical reality.

The new fluctuant space of discretized data has become affordable through a variegated set of metaphors promoted from different fields such as Data Sphere, Matrix, Digital Space, Virtual Realm, Address Space, Hyperreality or Cyberspace, all them trying to make apparent the new intensive space, where any kind of entity is virtualized as discrete programmable data, which can be actualized by different coded processes. This becomes a lattice that only appears before us through the reprogrammable unit of pixels.

Cyberspace has become the preferred term in academic literature. It designates a decentralized, disseminated space emerging from the crisscross of data communication. This is shared by authors that consider the Internet as a new anthropological space where cyberculture or networked culture emerges. The approach to cyberspace focuses on social interactions that emerge in this medium rather than in its technical implementations. It considers the internet as an extension of mental life, the space of shared knowledge and the emergence of a new public sphere, which is only produced by the interactions between the new nomads of subjectivity. In this way, the theorists of cyberspace disregard computation and New Media, which are considered as differentiated fields of research. Indeed, even if cyberspace is positioned in the delocalized and mobile intersection of networks, it still rests in front of the screen. This approach disregards the computational process that codifies inputs to data, enrooting and processing them, at the same time as the physical structure that sustains these Transductions and the visual conventions that interface our access to this space. Embodied Virtuality is the term proposed here to give an account of the convergence of the three assemblages of computation, communication and the technical reproduction of the audio-visual in an integrated system, which is promoting new ways of involvement, perception, and action; a new physical milieu that becomes programmable by means of virtualizing and modulating our reality beyond any totalizing abstraction and the freezing capacity of representation. This is based on a new process of inscription closer to the System of Simulacra proposed by Deleuze and that entails a big capacity of deterritorialization that can be conducted to both control and hackability.

As Ted Nelson pointed out, the crafting of this new space of representation is not only the domain of computer science but also of educators, sociologists and artists. In particular, New Media studies and New Media Art will focus on the design of interfaces. The interface is a mediation space, the plane that harbours the processes,

141 Jorge Luís Borges (1964) *The Garden of Forking Paths*

images, and artifacts that link software with hardware and both with human users.[142] There are interfaces that connect users with hardware by means of input/output devices such as the *mouse*, the keyboard, screens, sensors, and loudspeakers; interfaces that connects hardware with hardware such as network interconnection points, the set of instructions that connects hardware with software; and protocols determining relations between software as APIs. Finally, symbolic handles, which are the spatialized metaphors on the screen that allow communication between users and software as such windows, buttons, folders and so on. Except for the input/output devices, the other interfaces are conducted by software. Computer programs constrain the total use of hardware, abstracting the universal machine to a specialized function. As we have already seen, graphical user interfaces (GUI) are a later development linked to the personal computer. Initially, computers harbour a programming language environment, including a set of commands or control language that allows the users to communicate with the machine. The command sentences entered in a computer are the representation of re-articulation of a process occurring at another scalar layer. In this way, they involve syntactic and symbolic mapping for operations. The graphical user interface maps these sets of instructions to images, events that when clicked, register an input and start a process codified as a function. The graphical user interfaces under the paradigm of 'user-friendliness' hides the codified processes in a way that they are never experienced by users. It also models the user at the same time as they describe every possible use of the computer. The Interface mediates machine functions like any language or instrument still imposes and enhances particular workflows, thought modes, and models of interaction upon or in combination with human users.

As Ted Nelson says:

"If the button is not shaped like the thought, the thought will end up shaped like the button".[143]

Interfaces not only mediate reality but also enable and articulate it, they become space producers; a new space that has increased its power and reach concurrently to the development of computer displays, computer graphics and the increasing spread of computation to more fields of daily life. As this space is becoming ubiquitous its aesthetics is not only concerned as a science of presentation but as a critique of the possibilities of New Media that focus on the Affects that the Expression of this new ecosystem is fostering.

Hayles about the increasing capacities of electronic text or Hypertext says:

"Materiality always matters in some sense, but it matters most to humanists and artists when considered in relation to the practices it embodies and enacts".[144]

The exhibition "*Software*" curated by Jack Burnham was held at the Jewish Museum of New York between September 16 and November 8 of 1970.[145] This exhibition not only proposed a new way to relate to art, but also made progress on the formation of the problematic that will define the relation with this new space: 'What is to live in the new computerized environment?'.

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142 Florian Cramer and Matthew Fuller (2008) "Interface" at M. Fuller (ed.) *Software Studies. A Lexicon*, pp. 149-153

143 Ted Nelson (1974) *Computer lib/Dream machines*, pp. DM 21

144 Katherine Hayles (2004) "Print is Flat, Code is Deep: The importance of Media-Specific Analysis"

145 Jack Burnham (1970) *Notes on Art and Information processing*

According to its curator, the goal of *"Software"* was to *"focus the sensibilities on the fastest growing area in this culture: information processing systems and their devices"*.[146] Following the influence of McLuhan, Burnham considers how these devices will be instrumental in redefining the entire era of aesthetic awareness. Referring to the name of the exhibition, the artist Les Levine, who took part in it, suggested it referred to *"the personal and social sensibilities altered by the digital revolution. Internal relations in the form of new procedures and ways of dealing with physical reality, rather than pure visual responses"*.[147] In this way *"Software"* focuses on how programs structure reality and forms of action, putting the public in programmatic situations structured by artists. *"Software"* does not show technological art but rather points to the information technologies as a pervasive environment and focuses on modes of creativity which had emerged in this new environment and the possibilities of discretization, modulation, and assembly that it carries.

If the labyrinthine structure of "*les immatériaux*" was exposing the relational structure of contemporary reality and the dissolution of the traditional object, *"Software"* confronted a new issue planning the space: the exhibition without art objects. These were substituted by time-sharing terminals, thermofax machines, synthesizers and the sound ambiance they produced. The machines in *"Software"* should not be regarded as art objects; instead, they are merely transducers. The museum is not planned as a space of contemplation. Despite this, the audience must deal with the equipment, wires and artifacts, the light variations and the noise they produce to become involved and interact, to enter into a transductive relation with the machines from where the artwork will emerge as information.

The exhibition showed conjointly the works of renowned conceptual artists such as *Room Situation* by Vito Acconci and the *Cremation Piece* by John Baldessari, a set of projects, some of them working with the time-sharing system PDP-8 by Ned Woodman of Art & Technology, Inc. and headed by the exhibition catalogue, it was conceived by Ted Nelson and called *Labyrinth*. The catalog was a Hypertext, an interactive retrieval system, where the audience could navigate among the documents of the exhibition, going back and forward and following the linking words, signalled by an asterisk. At the end of their drift, the spectators could print the documentation visited during their personal path across this knowledge space, which was attached to the exhibition and augmenting it. In addition to Nelson's catalog, which translates the underlying structure would conform the web in the exhibition, we find projects showing the possible appropriation and participatory nature of this new medium towards the Postmedia. Among them feature the *Conversationalist* by David Antin, a room where the audience could contribute to the composition of a stochastic poem, improvising a narration after hearing a word. The *Giorno Poetry Systems* by Guerrilla Radio was a radio broadcasting system open to being used by invited poets that was broadcast daily. The audience could listen to the poems from various systems distributed around the museum. The *Software films* by D. Schley, *cinéma verité-style* interviews with several artists about their relation with technology broadcast simultaneously and permanently as a set of loops distributed in space. All these projects show meaning as emerging from the encounter of molecular units assembled by the spectators in the concrete situation and moment they encounter with the piece. The discrete composition units of a reality that can resonate ensemble to produce new assemblages are well demonstrated by the work *Composer* by Allen Razdow and Paul Conly. The *Composer* is a synthesizer that modulates the disruptions produced by the spectators to create music. This piece works through an interface, a keyboard where the audience can introduce new inputs to the performed sound. These inputs are modulated through a logarithmic reduction of indiscernibility towards an operation of consistency that put it in continuous variation with the already assembled data. Thus, the disruption is modulated and integrated to the ongoing melody, which is a result of the assembly of multiple contributions. Another work that discretizes inputs to data and modulates them towards a new unexpected assemblage was the *Solar Audio Window Transmission* by Theodosius Victoria. This project transforms the weather variation in off sound with low volume information transmitted in a resonating window. Finally, the *Vision Substitution System* by the

146 Jack Burnham: <*op. cit.*> pp. 10

147 Jack Burnham: <*op. cit.*> pp. 11

Smith-Kettlewell Institute of Visual Sciences translated visual information to tactile inputs with the aim of making images perceptible across the skin. Artists explored this system during the exhibition and used it for creative purposes. In this way, Linda Berris created a *Tactile Film*, where poetic images were used to suggest scientific concepts related to the human sensory system, and William Vaudoris attached his *Electrochrome Light Pattern Box* to the system to improvise new visual patterns to be translated by the machine.

Another important question related to the new computer-mediated space that was explored during the exhibition was the epistemologies emerging from it. Hans Haacke showed *Visitors Profile*, a profile from the visitors that emerges from their own contributed information that reduces them to the statistical processing of data. *Level of Heat* by John Goodyear was a thermal experience after the processing of data measured from the people moving inside the 'thermal zone' of the museum.

Finally, we encounter the most quoted work of the exhibition. *Seek* by the Architecture Machine Group conducted by Nicholas Negroponte, which was conceived as a responsive space. It consisted of a terrarium, where a gerbil's colony cohabitated with heaps of building cubes and an omnipotent robotic arm. The robotic arm was equipped with an electromagnet, several micro-switches, and pressure-sensing devices, all them controlled by the Interdata Model 3 Computer, with 65536 single (yes/no) bits of memory, which are shared by instructions and data. This small general-purpose computer processed the data from the sensors that register movement in the terrarium and computed a response, a set of instructions to be sent to the robotic arm, which moved the building blogs. In this way, the robotic arm affected the environment with the aim of attempting to handle the local unexpected events produced by the movement of the gerbils. The Architecture Group was focusing on the application of new technologies to urban planning. It is known for the development of machine-assisted design, which was developed with the aim of allowing non-experts participating in the design of their environment.[148] This purpose will evolve, leading to participatory urbanism. *Seek*, was not an input/output peripheral but a responsive environment that senses its inhabitants and reacts to their inputs adapting itself, a first attempt of what later on would make way for *smartcities*, a new urban planning paradigm, where aware participation would be substituted by machinic control; two different approaches to urbanism that will be discussed in the next chapter.

The projects exhibited at *"Software"* show the main standpoints from where New Media Art and the exploration of computers and networks towards the constitution of a new space intensified by data processes were developed. The convergence of art and technology addressed the exploration of new ways of interfacing reality by means of the development of hypertext, new transducers, and responsive environments in these developments played a leading role in the simulation of our reality through the manipulable image generated by computer graphics.

2.1.4.1 COMPUTER GRAPHICS AND THE CONSTITUTION OF THE SCREENED SIMULATED WORLD

Computer graphics is the third big assemblage encountered in the constitution of Embodied Virtuality, the place for human-computer interaction and the simulation of our world. The data space and its processes spread on the flat surfaces of our computer's screens. Attached to computers, the CRT display became the device allowing images to be converted into manipulable data structures, these images becoming the symbolic handles interfacing between humans and machines, at the same time as they evolved to configure a new realistic simulated world. It became the space of new fictional narratives, but also of the new processes of inscription linked to a complex reality, which became interpretable by new epistemological procedures and designed in new ways of production assisted by computers.

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148 Nicholas Negroponte (1975) "Intentionalities", pp. 60-63 and "Computer-Aided Participatory Design", pp. 102-123, *Soft Architecture Machines*, ed. MIT Press, 1975. Published at *The Media Reader*

2.1.4.1.1 The GUI

The most common interface by means of which we access the data space inside computers is the Graphical User Interface. Developed first at Xerox PARC, The GUI was one of the main components of the assemblage of personal computers and the result of developments in displays and a mathematical space rendered in computer graphics that led to the simulated world we navigate in our screens.

As we have already seen, the personal computer was mainly developed at Xerox PARC after some of the staff at Engelbart's centre for Augmentation of Intellect moved there. In addition to the Integrated Circuits, the information retrieval system, the network and the input-output peripherals already developed at the AHI, one of the main components of the personal computer was the Graphical User Interface (GUI). If computers opened a new intensive space, we interacted with it by means of synthesized images, whose development was only possible once the first Cathode Ray Tube was attached to computers. Graphics became the symbolic handles for human-machine interaction, who organized information in a bi-dimensional space, now accessible to non-technical users. As the mission of the Research Centre at PARC was to create the office of the future, this space was shaped as a desktop metaphor. Alan Kay and Ed Cheadle developed a first rudimentary GUI at the University of Utah for the Flex computer. In 1970, Kay moved to PARC where he used the technology of Raster Graphics and the display algorithm Bit Blit developed by Dan Ingalls in 1974 to converge the multiple displays composing workstations to a unique screen along with an easier way of issuing commands, the pop-up menus, and icons. Raster Graphics was the technology that democratizes synthesis images, evolving from a long journey in which the developments of display technologies involving different assembled hardware devices and the production of algorithms that allow discretizing images towards operable and transportable data units converged. The Bit Blit was one of these algorithms, a procedure for the movement of whole blocks of bits on the screen, allowing overlapping windows to be quickly shuffled around the screen without overtaxing the processor. These developments started in the middle of the fifties, when the first computer equipped with a display that reproduced real-time text and graphics appeared, and was the space of convergence of a big range of fields of research, as well as the development of new industries such as video games, Computer Assisted Design, and Manufacturing (CAD/CAM) and the military production of training environments, finally culminating in the production of the Kay GUI in the middle of the seventies.

2.1.4.1.2 Human-machine Interaction and Design

The development of graphical user interfaces began with the Sutherland project developed at the TX-2 at MIT as his PhD. thesis in 1961. Sketchpad was the first interactive interface and the first graphics-generator program, which introduced direct manipulation and moved graphics from a military laboratory tool to the world of engineering and design.

The Sketchpad was developed in what is considered the first interactive computer. The TX-2 featured 320 kilobytes of fast memory –about twice the capacity of the biggest commercial computers-, a nine-inch CRT, and a lightpen. This milestone machine was produced at MIT after the Whirlwind and its developer, Forester, moved to the Digital Computer Lab. The Whirlwind, produced in 1945, was the first computer capable of displaying real-time text and graphics on a large oscilloscope screen. It was part of the Navy's Airplane Stability and Control Analyser (ASCA) project. For this purpose, it received positional data related to the aircrafts from a radar station. In addition, it provided a lightpen, which was developed by Robert Everett to allow technicians to point to the aircraft positions and obtain information about them. In the Whirlwind, the screen replaced the monitors used to visualize and control computer processes and became a place from where to control events in the outside world. In the MIT, the Whirlwind and Forester focused on using the computer for graphic display aimed at traffic and gunfire control and become part of the government SAGE (Semiautomatic Ground Environment) program. The SAGE was one of the biggest and most expensive programs developed in the setting of the Cold War, consisting of a computer-generated landscape of the airspace over a wide area, produced by a network of computers, which coordinated data from multiple radar sites.

The other development starting the field of computer graphics was also produced at MIT one year later with the issue of Sketchpad and added a third Collective to the assemblage to be added to the design and military industries. Steve Russell, Martin Graetz, and Wayne Wiitanen created *Spacewar!*, the first video game. It was implemented on the DEC PDP-1 machine, which was created in 1961 by the company founded by Olsen –the Digital Equipment Corporation (DEC) - to extend the capabilities of the TX-2 to commercial machines. This machine evolved to the production of the first minicomputer, the PDP-8, and the already mentioned PDP-11, which became a regular tool to work with interactive graphics. It consisted of a minicomputer working in the Unix environment, featuring 64k address space and allowing time-sharing. *Spacewar!* took part in a series of interactive graphic programs to test the possibilities of the 30 pixels resolution CRT of the PDP-1. With this aim, the producers of *Spacewar!* planned the creation of some kind of graphical object, which could be operated by the user. Under the influence of science-fiction authors such as Edward Elmer and the then popular *Lensman series*, this object took the shape of a starship. The game nowadays exhibited at the Computer History museum[149] was conceived as a two player game, taking advantage of the incorporated time-sharing system and it consisting of two starships, each controlled by a player, trying to destroy each other. At the same time, a star in the centre of the screen pulled on both ships and required manoeuvring to avoid falling into it. *Spacewar!* was fully distributed, to other universities and embedded in the DEC machines.

Spacewar!, in addition to becoming the starting point for a new entertainment industry, was involved in a set of developments that described the characteristics of the new computerized medium as an interactive interface. That is , a new space characterized by its capacity to simulate the physical world and its laws on the screen, where the capacity of computer languages to represent physical entities transferred to images that could be manipulated accordingly to a coded behaviour. This space was produced as a result of developments in displays, controllers, computer graphics, and storage. If computation produced an intensive space, these developments determined the way we perceived and interacted with it, by means of converting images and sound into operable data structures.

2.1.4.1.3 Displays and Input Devices

The development in displays started once the first CRT was attached to the Whirlwind. The first Cathode Ray Tube was invented in 1885. In 1897, Ferdinand Braun introduced a CRT with a fluorescent screen, the Cathode Ray Oscilloscope. The Braun tube made it possible to transform an electrical signal into images. The screen emits a visible light when struck by the beam of electrons. This was deployed in the invention of Television after Philo Farnsworth introduced the image dissector in 1927. The television soon became a common home appliance and one of the most characteristic devices of the New Media epoch signalled by McLuhan. Artists and related Collectives such as Guerrilla Television[150] soon appropriated the space of global communication, claiming a bigger participation. Attached to computers the CRT became the terminal of time-sharing systems that allowed speculation regarding an 'interactive television', not only a space for the passive reception but of communication. At the same time, it converted the computer from a programmable machine into a multimedia environment.

"The computer display screen is the new frontier of our lives"[151]

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149 More information about the game history at the http://www.computerhistory.org/pdp-1/index.php?f=theme&ts=4&tss=3. You can play the game in a Java emulator here: https://archive.org/details/pdp1_spacewar

150 Guerrilla Television was a term coined in 1971 by Michael Shamberg from the Raindance Corporation and defined in his book of the same name. Michael Shamberg (1971) *Guerrilla Television*

151 Ted Nelson (1974) *Computer Lib/Dream Machines*, pp. DM. 21

The graphics deployed in *Spacewar!* and the Sketchpad system were vectors. Vector graphics shape geometrical primitives such as points, lines, curves, and shapes or polygons, all of them based on mathematical expressions, by means of leading through locations called control points or nodes. Each of these nodes points to a definite position on the x and y-axes of the screen space and determines the direction of the electron beam. The first developments towards the assemblage of the simulated space of computers were dedicated to the production of display systems capable of converting the vector data into analogue signals, voltage differentials, which moved the beam of electrons to reproduce the coded images on the screen.

One of the most commonly used graphics displays of the 60s and early 70s was the IBM 2250, a vector device with 1024 x 1024 addressable resolution, a 12x12 inch display screen, and a .0200 inch spot size. It was produced inside the CAD project started by General Motors and IBM. Firstly named as DAC (Design Augmented by Computer), this project was aimed at creating a unified computer assisted environment.

The second big development in vector displays was invented in 1965 by Tektronix. The direct view storage tube (DVST) vector graphic approach solved the main problem of refresh displays. These must redraw the image continuously and fast enough to avoid flickering. The storage tube vector graphics added a memory unit that stores the history of what is drawn on the screen, this way the screen only needs to be refreshed when the image changes. Thus, this new approach freed the computer processor to perform other tasks. Another system improving display capacities was the rear projection. This was used when large quantities of semi-permanent information such as maps had to be combined with the display of variable or dynamic data. One of the systems using it was the Bunker Ramo display, which can project colour or black and white film images onto the screen of the CRT while the dynamic data is drawn by the electron beam.

The development of synthesis image made the development of new displays that were capable of calculating the different views of a 3D wireframe object necessary. The data structure of a wireframe 3D system stores the lines coordinates in trees, containing the end points of lines in a mythical three-dimensional space, where each point location is referred by three numbers. The Adage real-time 3D line drawing system appeared in 1967, the first stand-alone computer-aided design workstation. It had the advantage of extremely high-speed display rates, allowing for the representation of moving objects and flicker free rotations. Later on, The Evans & Sutherland Computer Company -created in 1966 by Ivan Sutherland and David Evans, chairman of computer sciences at the University of Utah-, created the LSD-1, which applied the first clipping algorithm and allowed true perspective calculation. The clipping algorithm was created by Sutherland's group at Harvard and it allowed any part of a synthetic environment that was outside the field of view to be eliminated, making it less computationally intensive to generate a scene on the screen.

The evolution of 3-D images from wireframes to polygons and surfaces required a new kind of graphics to be displayed. Raster Graphics used a standard television CRT that utilized a video controller to scan the image from top to bottom, turning on or off the individually addressable points on the screen, and providing information such as the colour of the points. The video controller obtained its information from a memory array whose contents was represented in a one-to-one match of the points on the screen. This memory was called frame buffer and was significantly larger than the display list memory of vector devices. Each point on a line in a raster system had to be stored, not just the endpoints of the line required by the vector displays. A standard TV had approximately 250,000 addressable points or pixels on the screen, so the memory was rather large, particularly when colour was included, which increased the size by a factor of three. The frame buffer evolved with new storage memory capacities such as the introduction of the Random Access Memory (RAM) chip. Instead of the sequential storage required in the shift register, the RAM allowed the computer or display processor to access any bit at any time - randomly. A 1K (1024) bit RAM chip was available in 1970, allowing for the affordable construction of a frame buffer that could hold all of the screen data for a TV image, which could be updated rapidly because of the access capabilities for each bit.

The first workstations split graphics and commands between three different screens, a vector device for line graphics, a text display for entering commands, and a video or raster graphics screen coupled with a frame buffer to display the rendered result. These three separate technologies were merged into Raster Graphics screen in the personal computer. However, Raster Graphics were first spread in video game consoles that allowed the generation of images into a domestic television. Atari introduced the 2600 VCS in 1977, which is considered the first generator of 8-bits programmable system.

The capacity of our personal computers to display realistic images evolved after Jim Clark of Stanford made one of the most relevant contributions to display technology when he invented the Geometry Engine in 1982. It consisted of a collection of components in a VLSI processor that would accomplish the main operations that were required in the images synthesis pipeline as matrix transforms, clipping, and scaling that provided transformations in the view space. Clark created the company Silicon Graphics Inc. to produce the IRIS (Integrated Raster Imaging System). About the same time, Sun Microcomputers was founded and they introduced the add-on accelerator board produced by Transept Systems, a coprocessor that frees the CPU of the graphic operations. Processor buffers and accelerator boards are now integrated into the computer graphic cards produced by nVIDIA, 3dlabs, and ATI. These communicate by means of an API to the CPU to render the 3D mathematical space to the 2D visual space that is shown on the screen.

In addition to display computer generated data, working with graphics implied input technologies to allow manipulating this data on the screen. Initially, typical input was accomplished with an alphanumeric terminal, function buttons or dials, and the lightpen. In 1957, Tom Diamond patented an approach to handwriting recognition that utilized an innovative tablet, which was able to detect regions of interaction. This led to the graphic tablet. The Rand Tablet consisted of a matrix of crossed conductors. The circuitry of the tablet used switching techniques to apply pulses to the conductors in sequence, thus coding their individual locations. When a stylus touched the surface of the tablet, it picked up pulses capacitively from the closest of the horizontal and vertical conductors which were converted into an (x,y) coordinate value. The tablet was marketed commercially as the Grafacon tablet and was often bundled with early DEC computers. In 1963, Engelbart invented the *mouse* that would be the input device of GUI. While technology has become ubiquitous and portable devices has appeared more tangible, interfaces had been popularized. The first touch screens evolved from Tom Diamond technology. They consisted of transparent pads to be applied on top of screens that react to a pencil, like those included in the Magnavox and Plato IV terminals. The multi-touch technology was started in 1982 at the Input Research Group at the University of Toronto. This technology was first applied to create interactive information stands and points of sale such as the ViewTouch software created by Gene Mosher. However, it would play an important role in the spread of smartphones after a multi-touch screen was developed for the Apple I-phone in 2007.

2.1.4.1.4 The Assemblage of Computer Graphics

The development of displays and input technologies happened in the new convergent field of computer graphics. During the sixties and early seventies a large number of new centres and projects focused on graphics research emerged, these projects involving groups of artists and designers, the military and scientific research and the beginning of the new industry aimed at design and entertainment. These centres developed the hardware -digital and analogue- and the software -interfaces and algorithms- that enabled the creation and manipulation of images on the computer towards an increasing realism, new centres and projects that targeted the fields of research and application of the new capacity of computers to translate images to operable data. Among them featured the development of CAD/CAE/CAM that changed the form of design and production, Data Visualization that fostered a new epistemology and the Virtual Reality that spread graphics beyond the screen towards new immersive environments from where it evolved new ways of interaction.

Among these Collectives[152]: In 1959, General Motors and IBM started the first CAD project. In 1960, John Whitney, pioneered analog computer animation, with its films and established the company Motion Graphics Inc. In 1963, Edward Zajac produced one of the first computer animated films at Bell Labs, where will work artists as Michael Noll and Ken Knowlton. In 1966, Sutherland moved to Harvard, where started research in Virtual Reality. Also in 1966, Marceli Wein moved to the National Research Council of Canada, where scientist Nestor Burtnyk had started the Computer Graphics research project, where they applied evolving computer techniques to animation. In 1967, Gyorgy Kepes founded the Centre for Advanced Visual Studies at MIT. In 1968, David Evans funded the CGI program at Utah University, one of the nodes connected to ARPA. Later on, Evans will join Sutherland to found the Evans & Sutherland Computer Company to develop and market CAD/CAM, design, molecular modelling and flight simulators. At the Lawrence Livermore National Laboratories, Steve Levine and Nelson Max conducted research in 3D scientific visualization. Charles Csuri started the CG research laboratory at Ohio University with founding from the National Science Foundation. Bob Holzman established the JPL CG Lab at the Jet Propulsion Lab in 1977, working on the visualization of the data returned from the NASA missions. These will be some of the centres and pioneers that will meet at the conferences of SIGGRAPH, the dedicated group of the ACM constituted in 1968, to convert data to pictures and define the computer-generated space.

The data structure of images stemmed from another input system, scanning technologies. These allowed images produced by traditional means to be as input data. The DAC-1 design environment included a photo read-out system connected to a projection device aimed at allowing collaboration on the design drawing. The operator could select a view which would be displayed on an auxiliary CRT film recorder, and it would be scanned and quickly processed, and could then be projected onto the screen. This system pioneered the use of photographic reading that evolved towards scanning technology. Tom Stockham conceived the data structure of the scanned material when he was at Lincoln Labs at MIT working on a project to use computers to process photographic material. His technique was to use a facsimile machine to 'digitize' a photograph, converting it into a map of dots or bits. This bitmap was originally black and white, but the same data structure allowed it to code colour by means of augmenting the depth, or the number of bits for a pixel that becomes able to store more information. The bitmap led to image processing, a technique to alter colour and brightness of pixels, applying mathematical techniques, at the same time as the halftone system that allowed recreating photorealistic images. Kenneth Knowlton[153] at Bell Labs developed one of the first popular applications of halftone system when he was experimenting with human perception. He created mosaics of scanned pictures converting the analogue voltages of the camera to binary numbers, which were assigned typographic symbols based on halftone densities. The *Reclining nude of the dancer Deborah Hay* shown at the Museum of Modern Art MOMA from New York in 1968 was a popular example. He also applied image processing to computer animation and created the programming language for bitmap computer-produced movies Beflix. Beflix was developed using the IBM 7094 computer attached to the Stromberg-Carlson 4020 microfilm recorder. The processed images were recorded step by step on each microfilm frame to produce animated films. This system was used by Stan VanDerBeek to produce the series *Poem Fields*[154], and from this collaboration Beflix evolved to TARPS (Two-Dimensional AlphaNumeric Raster Picture System). Later on, Knowlton created EXPLORER (Explicit Patterns, Local Operations), another image processing language. It considered the matrix of bitmap

152 Information summarized from, Wayne Carlson: *A Critical History of Computer Graphics and Animation*. Course contents available at the website of the Ohio State University: http://design.osu.edu/carlson/history/lessons.html

153 Kenneth Knowlton website: http://www.kenknowlton.com/

154 http://www2.tate.org.uk/intermediaart/StanVanDerBeek.shtm

dots as cellular automata, in which every dot was affected by the changes of their contiguous neighbours. In this way, the EXPLORER allowed to change the pattern by degrees, each cell of the pattern reacting to the cells around it or to random events specified by the program. Dan Sandin at the Chicago Circle of the University of Illinois created another image processor in 1971. It was combined with the DeFanti 3D language GRASS (Graphic Symbiosis System) to produce the Circle Graphics Habitat, an environment for experimental computer graphics, video production and the development of educational materials.

Meanwhile, following with the research in human-computer interaction started by Sutherland with the TX-2 at MIT's Lincoln Lab, Ron Baecker produced the first interactive computer animation system. GENESYS was produced in 1969 and it allowed artists without programming training to use a computer to animate freehand drawings. The drawings were created on the screen by means of a Rand tablet and animated through the drawing of motion paths, in which timing was indicated by means of the space between the dots composing the path. It also allowed the drawing to be modified in different frames. The different animated drawings can be assembled in a unique scene to create complex films and can be independently manipulated in their position and velocity. Another early interactive animation software was the Key Frame 3D Graphic Package created in 1971 by Marceli Wein and Nestor Burtnyk at the National Research Council of Canada in Ottawa. This software allowed the creation of images on the screen by means of a *mouse*. These images could be manipulated in shape and position in different keyframes, the transitional positions being calculated by interpolation by the software. Both systems were new HCI interfaces, which gave access to the direct manipulation of screened images to non-programmers. In addition, the National Research council contacted the National Film Board in Montreal to start a process allowing artists to experiment with computer animation.

Computer synthesis image evolved in the intersection between the needs of scientists to visualize complex structures. The requirements in the design of airplanes by the military industry that fostered the development of the first CAD systems, and an intensive mathematical research to develop the algorithms and formulas able to produce and manipulate increasingly more realistic images on the screen.

2.1.4.1.4.1 CAD/CAE/CAM systems

At the same Spring Joint Computer Conference of the American Federation of Information Processing Societies (AFIPS), where Sutherland presented his Sketchpad system, his advisor Steven Coons from MIT presented the paper *"An Outline of the Requirements of a Computer-Aided Design System"*, explaining some of the capacities of computers as a design and manufacturing tool to aid engineering. During World War 2nd, Coons worked on the design of aircraft surfaces, developing the mathematics to describe generalized 'surface patches'. At MIT's Electronic Systems Laboratory, he investigated the mathematical formulation for these patches, and in 1967 published one of the most significant contributions to the area of geometric design, a treatise which has become known as *"The Little Red Book"*.[155] His 'Coons Patch' was a formulation that presented the notation, mathematical foundation, and intuitive interpretation of an idea that would ultimately become the foundation for surface descriptions that are commonly used today, such as b-spline surfaces, NURB surfaces, etc. Another of his students, Lawrence Roberts, in 1965 implemented a homogeneous coordinate scheme for transformations and perspective. In 1964 Ruth Weiss from the Bell Labs created some of the first algorithms for converting equations of surfaces to orthographic views on an output device. The CGI program started by Evans at Utah also produced important algorithms aimed at rendering, lighting, texture mapping, atmospheric effects etc.

These algorithms will express a three-dimensional space on the computer and will establish the needed procedures to operate and represent it. This three-dimensional space became a new inscription process that enabled translating physical objects to the virtual space of computers, where it could be arranged in different assemblages and programmed. This interactive simulation of the shape and behaviour of physical objects

155 Steven A. Coons (1967) "Surfaces for Computer-aided Design of Space Forms", Project MAC Report MAC-TR-41, MIT

led to Computer Aided Design (CAD) and Computer Aided Engineering (CAE). At the same time, computers could be attached to manufacturing machines and control its operations towards an increasing efficiency of the process of automatization of manufacturing in Computer Aided Manufacturing (CAM). In this new field of research the development of workstations converged, where hardware was designed and coupled to accomplish different tasks, the research on computer graphics, where developments from other fields such as the entertainment industry were incorporated, and the proposal of new interactive interfaces allowing designers without programming knowledge to use the computer to accomplish specific tasks.

The First CAD project was the already mentioned DAC (Design Augmented by Computer) started in 1959. It was followed by a big range of companies that evolved hardware equipment and software, which became increasingly more available, evolving from big workstations sited in big labs to individual workstations and finally to personal computers, while entering into more stages of the production process. Among these companies, the Sutherland and Evans Computer Corporations was one of the leaders in high-end graphics workstations. MAGI (Mathematical Applications Group, Inc.), established in 1966, created SynthaVision solids software, which is considered the first commercial solid modeller program and one of the first systems to implement the later concept of ray-tracing for making images (this software would be used in the production of the film *Tron*). The MCS (Manufacturing and Consulting Services, Inc.) founded by Patrick Hanratty, who was working on the DAC, produced ADAM (Automated Drafting and Machining) software in 1972, from where most of the CAD/CAM systems available today stem, and in 1976 the AD-2000, a design and manufacturing system for the first 32-bit computers. In 1986, this company introduced the ANVIL-5000, a 3-D mechanical CADD/CAM/CAE system that, for over a decade, was the most powerful, fully integrated CADD/CAM/CAE software available, running on all classes of engineering computers from high-end workstations to personal computers. The Structural Dynamics Research Corporation (SDRC) was the first company to integrate 2-D drafting to Computer Aided Engineering (CAE) and creates Geomod that will precede Super FEA, Modal Plus a modal testing analysis and analysis program, and SuperTAB, the first commercial modelling package that ran on DEC workstations. In 1982, this company developed the I-DEAS software to address the growing MCAE (Mechanical Computer-Aided Engineering) market. In addition to the automotive industry, I-DEAS was also used in the design of military airplanes, electronics and consumer products and industrial equipment. Applicon, founded in 1969 by Fontaine Richardson was known for developing facilities for circuit synthesis and analysis. Computervision, also founded in 1969, introduced the first CAD terminal using raster display technology in 1978. John Wright founded united Computing and released UNIAPT, which was a minicomputer-based version of APT (Automatic Programmed Tool). In addition to a programming language used to compute tool paths for milling machines, it was one of the first CAM products sold to the actual end users. In 1973, United purchased ADAM software and implemented it as a single-user system named Uni-graphics. In 1981, Unigraphics introduced the first solid modelling system, Uni-Solids. In 1976, United was acquired by McDonnell Douglas and produced GRIP, a programming language to support parametric design. In 1970, M&S Computing was founded by two engineers from the NASA space program that would become Intergraph in 1980, the main innovation of which was the development of application-oriented user interfaces that communicated with users in the language of their applications, rather than in programming terminology. Intergraph grew to be the largest computer graphics company in the world with about 100 offices worldwide. Its flagship CADD product, IGDS (Interactive Graphics Design Software), was developed in the 1970's. In the 90's they started developing its products around the PC, powered by Intel processors. Bentley Systems, Incorporated was founded by Keith and Barry Bentley in 1984. The company's first product, MicroStation was based on Intergraph's IGDS product and provided cutting-edge CADD capabilities on a personal computer. Founded in December 1993, SolidWorks Corporation introduced the first powerful 3D CAD software available for a native Windows® environment. Autodesk was founded in 1982 by John Walker and created AutoCAD, a Computer Assisted Design (CAD) software package for 2D and 3D design and drafting, initially conceived for mechanical engineers; it is widely used by architects and other design professionals. Its file formats (DWG and its ASCII equivalent, AutoCAD DXF) have become the default standard for CAD packages. In 1985, Peter Smith and Livingston Davies founded Micro-Control Systems and released CADKEY, the first 3D PC CAD product.

First used by the military and locomotive industry, the CAD systems were soon applied to architecture, at the same time as advances were made in animation and film production. It revolutionized the processes of inscription used on the production of things towards the encounter with a simulated reality that intensified the capacities of space production at the same time in real and fictional worlds. In a society based on constant innovation and the release of new products, CAD/CAM/CAE systems had become incorporated into most of the procedures of industrial production. It made collaborative work easier and the reuse of already implemented solutions that could be easily adapted to new situations. Freed from material constraints, the objects conceived in virtual space could incorporate new data sets and result in unexpected forms that at the same time fostered research in new materials for their realization. As the capacity of simulated reality and incorporation of more data of computers evolved, more variables could be incorporated into the design, giving place to more innovative and well-adapted solutions. However, the use of libraries of pre-made building blogs, and the translation of standardized solutions to new environments without paying attention to local particularities, especially when applied to architecture, can lead to poor and undesirable results concerning the ecology of the space.

2.1.4.1.4.2 Scientific Visualization

Another field that intersected with the capabilities of computer graphics was scientific visualization. The use of computer graphics to explain and investigate physical phenomena and processes was soon explored in the development of this new technology. Early examples were the film *"A two gyro gravity gradient altitude control system"* produced by Ed Zajac at Bell Labs; the series of films of molecular structures produced by Nelson Max and Laurence Livermore. The visualization film on the interaction of two neighbouring galaxies produced at Ohio State University in 1977. In addition, the works of Jim Blinn at the Jet Propulsion Lab of NASA, who produced over 500 scenes for 52 half-hour programs describing physics and mathematics concepts for college students. Other examples are the three-dimensional imaging of medical datasets obtained by the clinical CT (Computer Axial Tomography), cartographic information and early computational fluid dynamics. However, Scientific Visualization was not defined until the late 1980s. In 1987, a SIGGRAPH panel released a report done for the National Science Foundation, Visualization in Scientific Computing, which was a milestone in the development of this emergent scientific field.

The panel of SIGGRAPH[156] defines scientific visualization as:

> *"Visualization is a method of computing. It transforms the symbolic into the geometric, enabling researchers to observe their simulations and computations. Visualization offers a method of seeing the unseen. It enriches the process of scientific discovery and fosters profound and unexpected insights. In many fields, it is already revolutionizing the way scientists do science…*
>
> *Visualization embraces both image understanding and image synthesis. That is, visualization is a tool both for interpreting image data fed into a computer, and for generating images from complex multi-dimensional data sets. It studies those mechanisms in humans and computers, which allow them in concert to perceive, use and communicate visual information. Visualization unifies the largely independent but convergent fields of: Computer graphics, Image processing, Computer vision, Computer aided design, Signal processing, User interface"*

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156 Mc.Cormick, B.H et al. (ed) "Visualization on scientific Computing". *Computer Graphics* 21,6 November 1987 ACM SIGRAPH, New York pp, 3-4

Scientific Visualization has become one of the main and most urgent areas of research of computer science and New Media. After the data deluge produced by the ubiquity of computation, it has extended its reach of application to new fields such as Social Computing and Culture Analytics and fostered a new epistemological approach. These questions will be addressed in the next chapter. At this point, I will introduce briefly the first software applications developed in this field.

The first visualization systems were referred to as modular visualization environments (MVEs). They were based on the dataflow paradigm and consisted of modules independently developed with standardized inputs and outputs that were visually linked together in a pipeline. The users accessed an interactive graphic networking or mapping environment, where they could select program modules from a library and specify the flow of data between them. Among these systems the IBM's Data Explorer, Ohio State University's apE, SGI's IRIS Explorer, Stardent's AVS and Wavefront's Advanced Visualizer were known. The latter comes from the animation industry, consisting of a modelling, animation and rendering package, which provided an environment for the interactive construction of models, camera motion, rendering and animation without any programming. These systems were developed to allow scientists without graphical expertise to access the computerized medium to analyse data patterns. They allowed for rapid prototyping and interactive modification in a system that was extendible by means of the programming of new modules and whose results could be reused and easily shared. Despite, the system having a poor performance in large data sets, at the same time the application of standardized resources could lead to poor results.

Most of the early visualization techniques dealt with 2D scalar or vector data that could be expressed as images, wireframe plots, scatter plots, bar graphs or contour plots. Contour plots are basically images of multivariate data that represent the thresholds of data values that can be drawn as curves in 2D space and shaded accordingly to the gradient value. These can be redrawn over time, to get an animated sequence of the evolution of a phenomenon. The rendering of 3D data was more complex, one of the early algorithms was the Lofting developed by Henry Fuchs, which involved tracing the important boundaries from the planar scans, and then joining the adjacent traces with triangles to create a 3D surface. Bill Lorensen and Harvey Cline of General Electric presented the most important 3D geometry conversion algorithm in 1987. The Marching Cubes algorithm shapes cubes between two adjacent planar data scans. Then it used a particular density value, or contour value, and 'marched' from cube to cube, finding the portions of the cube that had the same contour value, subdividing the cube as necessary in the process. When all surfaces of all cubes having the same value were presented, a 'level' surface or isosurface was created, which could then be rendered.

Data can be obtained from different sources such as scans, ultrasounds or computational fluid dynamics, another acquisition approach that is common in remote sensing, or the use of data obtained from sensors distributed in physical space that can trace different phenomena as radiation, particle, and fields associated with objects located beyond the immediate vicinity of a sensing device, most frequently used to acquire and interpret geospatial data. One of the first remote sensing related visualizations is seen in the animation *L.A. The Movie* produced by the Visualization and Earth Sciences Application (VESA) group at JPL.

L.A. The Movie is a 3D perspective rendering of a flight around the Los Angeles (California) area starting off the coast of Catalina Island. The remotely sensed imagery was rendered into perspective projections using digital elevation data sets from multispectral image data acquired by the Landsat earth orbiting spacecraft on 3 July 1985. Visualization maps of the earth surface became a common and available tool after Google purchased Keyhole Inc. in 2004, the pioneering software development company that created the earth viewer that Google would make available on the web as a navigational interface. It allowed embedding new layers of information and the visualization of different geolocated data obtained from the sensors of Ubiquitous Computing. Later on, this new interface produced on the intersection between visualization and new GIS (Geographical Information Systems) played an important role in the spread of a new cartography and a new approach to the management of urban space.

2.1.4.1.4.3 Virtual Reality

Finally, the capacity of computers to shape and operate a realistic image of the world led to the emergence of VR, the production of a new communication medium for human-machine interaction by means of a display that oversteps the screen towards an immersive space allowing multisensory perception. The development of VR played an important role in the translation of the human body and its capabilities inside the computer-created space of representation, which became immersive and able to react in real time towards more haptic forms of interaction.

The development of VR can be traced back to the first flight simulators produced at the end of the 50s, some early artistic proposals, appearing at the beginning of the 60s and the production of the first head mounted display produced by Sutherland in 1966 as a means of increasing human intellect. After these early developments, this field of research was reborn in the 80s, when it was done inside the screen as the scenery of video games and a new networked meeting place in virtual worlds inhabited by avatars. In the 90s, VR met the new geolocalized tracing technologies of Ubiquitous Computing, being replaced by a different approach, Augmented Reality.

Even if some Virtual Reality systems were successfully applied to the entertainment industry as in the Disney Quest Indoor interactive theme park,[157] this technology failed to reach the sphere of commonly used interfaces. This failure has been attributed to the expensive cost of the equipment required and the performance issues on the users interface, mainly concerning discrepancies with human perception. Another reported problem was that this technology, even though it has many possible applications as telerobotics, scientific data visualization, planetary surface exploration, video game development, large-scale simulation networks (SimNet) and interactive art, it has failed to target a field of application where it could become widespread and evolve with use. Finally, the success of Internet and the reach of Ubiquitous Computing, in which computation has been embedded in physical objects led to new approaches. Interaction moved away from the screened or projected simulated worlds and moved on to a tangible and social paradigm, which embedded interfaces in the physical world. Despite this, research into VR continues and nowadays we are seeing a new presence after Palmer Luckey developed a new approach to producing an inexpensive and smaller head-mounted display, the Oculus Rift, acquired by Facebook in 2014 for $2 billion, starting a new wave of investment in this research.[158]

Stephen R. Ellis defined Virtual Environments in its paper from 1994:[159]

> *"We can define virtual environments as interactive, virtual image displays enhanced by special processing and by nonvisual display modalities, such as auditory and haptic, to convince users they are immersed in a synthetic space."*

Virtual Environments work in the interoperation of three types of hardware, sensors used to track the position and movements of the interacting body, effectors as a stereoscopic display that stimulate the operator's senses and a system that links the sensors with the effectors to produce sensory experiences that resemble the ones produced in physical environments. These systems could be a simulation computer that shapes

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157 https://disneyworld.disney.go.com/entertainment/disney-springs/disney-quest-indoor-interactive-theme-park/

158 http://www.theverge.com/a/virtual-reality/intro

159 Stephen R. Ellis (1994) "What are Virtual Environments?"

the simulated space according to the movements of the interactor in the case of a head-mounted display, or in the case of teleoperation or robot manipulations control systems, sensors and cameras located on the remote site. It is software that determines the extent and character of the simulated environment, and at the same time the shape and kinematics of the objects and actors and the possible interactions according to a programmed predefined behaviour, drives these systems.

The *Sensorama* produced by the filmmaker Mort Heilig in 1962 is considered the first Virtual Reality system[160]. Aimed at being the cinema of the future, this system was an arcade style cabinet with a 3D display motion picture, stereo sound, a vibrating seat and a scent producer, all working in a coordinated way to produce a multisensory and immersive experience. Other artistic experiences developed this milieu and its applications. However, the development of VR as a new interactive display was produced in the intersection of the development of computer graphics with the production of flight simulators.

A flight simulator can be defined as a training environment aimed at reproducing on the ground the behaviour of an aircraft in flight. The first flight simulators were used to familiarize the pilot with the control systems such as the system developed by the Link Company in 1929. This system evolved to give a visual feedback, with the cyclorama in which the scene from the cockpit was painted on the walls of the training room. In 1939, Link's systems evolved to a more immersive experience with the celestial navigation trainer, which simulated nocturnal flight, representing the stars on a dome over the pilot. In the early 1960s, Link developed the Link Mark I computer to accomplish real-time simulation by computing aircraft equations of motion. Real-time simulation improved towards to a more responsive environment in which the visual feedback reacted to the calculated movements of the plane. Initially, these systems worked with film and closed circuit systems. The film system consisted of a 35 mm or 70 mm film shot from a real airplane that when reproduced was distorted by servo driven optics according to the pilot's interaction. The CCTV system moved a camera with a special optical lens over a physical terrain model or terrain board. Camera control was substituted by CGI systems in the 70s. Night-only systems usually used vector devices, rather than the raster scan display used today that gives the image complexity. The first of these systems was produced by the McDonnell-Douglas Electronics Corporation in 1971 and was called Vital II (Virtual Image Takeoff And Landing). In 1978, the Singer-Link DIG or 'Digital Image Generator' was developed. This device is considered one of the world's first-generation Computer-Generated-Image (CGI) systems. The U.S. Navy maintained an active simulation activity, particularly at their Naval Training Systems Centre in Florida (NTSC). Most notable was the early development of their VTRS, or Visual Technology Research Simulator. This simulator was an example of a 'target tracked' system, which placed an image of the air-to-air combat target dynamically in a larger scene, in this case on a spherical screen surrounding the trainer cockpit. In the interest of computation speed, the area of most visual interest (the target and its nearby surroundings) was rendered in higher detail, and inserted into a lower resolution background display representing the surrounding terrain.

The Air Force was also interested in low altitude simulation, so a more detailed rendering of the terrain was necessary. Their ASPT (Advanced Simulator for Pilot Training) installed in 1974 at Williams AFB in Arizona was one of the first examples of a multiple display, multiple CGI channel 'butted' display system, which was the model for most simulators built during the 80s and 90s. The field of view was divided between multiple CRTs surrounding the pilot, each fed with a signal from an independent but synchronized computer image generator. By aligning the boundary of one display with that of the adjacent one, it gave the feeling of a continuous image. The ASPT used seven CRTs with complex optics to eliminate overlapped images, in what they called the 'Pancake Window'. Each pentagonal window provided more than an 86° field of view. An alternate approach emerged from the Air Force Resource Laboratory. The Pancake Window mosaic display was becoming difficult to maintain. Seeking a low-cost, full-colour replacement for the dome, monochrome Pancake Window led to experiments with rear projection screens and CRT projectors. A bright, clear real

160 http://www.mortonheilig.com/InventorVR.html

image was formed at approximately arm's length from the pilot's eye. An example of this technology was the Boeing VIDS (Visual Integrated Display System). These display systems evolved concurrently to new image synthesis capabilities, in which the algorithms and graphic workstations developed by Evans and Sutherland played the main role. These were used to produce the flight simulators CT-5 and CT-6 created in the Evans & Sutherland Computer Corporation company, as well as the method to generate terrain, clouds and other objects developed by Gardner in 1984, which extended to simulate smoke and fire.

The Bell helicopter company developed the first head-mounted display. Designed to be worn by pilots, the Bell display received input from a servo-controlled infrared camera, which was mounted on the bottom of the helicopter. The camera moved as the pilot's head moved, and the pilot's field of view was the same as the camera's. This system was intended to give military helicopter pilots the capability to land at night in rough terrain. These experiments demonstrated that a human could become totally immersed in a remote environment through the eyes of a camera and preceded the head-mounted display developed at Harvard University in 1966 by Sutherland, who replaced the camera by computer-generated images. The Sutherland's head-mounted display was called the 'Sword of Damocles' due to its big and heavy design and offered a wire frame image of a closed room where the cardinal points were indicated on the walls. The viewer could go inside the room through a door and turn his head to view the windows on the different walls. After working at DARPA and being influenced by the theories of human-computer interaction and the augmentation of intellect by Licklider, Sutherland projected its VR device as the *Ultimate Display*: an interface allowing haptic interaction in a mathematical wonderland, where people could acquire knowledge about complex mathematical concepts –not realizable in the physical world- by means of interacting with them as we interact with physical objects.[161] The Head-mounted Display had a stereoscopic display, with a CRT for each eye and a mechanical tracking system, which later on would be substituted by an ultrasonic tracker.

Helmet mounted displays were used in flight simulators to substitute the expensive and difficult-to-maintain domes, one example being the head-mounted display developed by NTSC for American Airlines that used the target tracking approach that was also developed by Singer-Link in their ESPRIT (Eye-Slaved Projected Raster Inset) system. The NTSC system used eye and head tracking technologies, and projected from a lens on the helmet, so the higher resolution image was always coordinated with the pilot's view. The technology of head-mounted display produced another of the hallmark projects of VR, the Super Cockpit developed by the military engineer Thomas Furness at the Wright-Patterson Air Force in Ohio. The super Cockpit evolved from a flight simulator to a navigational tool that made use of a virtual environment.[162]

This multi-decade project, started in 1972, was addressed to solve problems such as the nocturnal navigation, the major complexity of the aircraft cockpit, in which many computers must be managed by one single pilot, and the need for pilots to balance their attention between the inside and the outside to make sense of the multiple received data. Thomas Furness proposed a paradigm shift consisting of a different way of presenting information. The Super Cockpit coupled the target system with the helmet display to produce a virtual environment where the multiple information from the navigation systems in the cockpit was projected as three-dimensional information to the field of view of the human commander. Thomas Furness left the army and founded the Human Interface Technology Laboratory at the Washington Technology Centre (WTC) in 1989, a centre focused on the research into virtual interface technology to transform virtual environment concepts and early research into practical, market-driven products and processes. The Super Cockpit project showed how computer generated images could become a way of providing useful information to increase our perception and knowledge of our actual environment; this would be further developed to lead to Augmented and Mixed Reality.

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161 Ivan E. Sutherland (1965) *The Ultimate Display.* Information Processing Techniques. Office, ARPA, OSD

162 See the Tom Furness presentation "Being the Future" at (Augmented World Expo) AWA 2015 http://AugmentedWorldExpo.com

Meanwhile, other approaches to Virtual Reality were developed outside the military industry, leading to the creation of immersive spaces and embodied interaction that spread to new fields of research. DeFanti, Dan Sandin, and Carolina Cruz-Neira at the EVL (Electronic Visualization Laboratory), formerly the Chicago Circle Habitat, produced the first CAVE (Automatic Virtual Environment) in 1992. It consisted of a stereo projection on all four walls and the floor of a room, aimed at scientific visualization and interaction with displayed objects. The EVL also produced the first data glove in 1977. The CAVE allowed immersing perception in a synthetic environment that responded to the subject actions. The data globe was aimed at translating the movements and dexterity of hands to the manipulation of the virtual environment to allow a more haptic interaction.[163]

This interaction was based on the tracking of shape, position and mobility of the hands, which were coded as input data. Gloves became interfaces with computer applications and computer controlled devices aimed at fields such as VR, telemanipulation, scientific visualization, puppetry, music performance and video games. The technology of data gloves will be developed through different approaches as position and visual tracking –related to computer vision- and combinations of more mechanical systems as magnetic, optical and acoustic tracking. Position tracking first experimented at MIT, where F.H Raab described the technology of the space tracking system Polhemus. It consisted of a device for position tracking with six degrees of freedom and based on orthogonal electromagnetic fields. This system was utilised to communicate the position of the hand to the computer, where this was translated to input data able to point and manipulate graphic objects. Visual tracking was implemented on the LED Glove; this used small LED lights that worked as markers that could be identified by the computer to determine position. This system was camera based and was only used for motion capture, not as an input device. Another visual tracking system consisted of software able to recognize a silhouette captured by a camera. This was the system developed by the artist and programmer Myron Krueger, after experimenting in natural interaction at the University of Wisconsin in the late 60s. He used this approach to create different games and experiment interactions that were integrated into his *Videoplace* project in 1975. The *Videoplace* produced an artificial responsive environment, where the viewer was transferred inside by means of scanning and projecting its silhouette, which can interact in real time with the graphic objects around the artificial space.[164] Pierre Wellner adapted this system to produce the Digital Desk at Rank Xerox Euro Park. It integrates computer images with real objects allowing the same non-device mediated interaction. Visual tracking experienced some problems in tracking movements of small parts of the body as fingers and working in real time, which led to experimenting with approaches relying on mechanical systems. The Sayre Glove used light-based sensors with flexible tubes, with a light source at one end and a photocell at the other. As the fingers were bent, the amount of light that hit the photocells varied, thus providing a measure of finger flexion. This was improved by Thomas G. Zimmerman to produce an optical glove in 1982. In 1989, Zimmerman worked with Jaron Lanier to incorporate ultrasonic and magnetic hand position tracking technology to create the Data Glove. The Power Glove was a low-cost version manufactured by the toy company Mattel as a controller for Nintendo video games. Another interesting project was the CyberGlove, developed by James Cramer at Stanford University to translate American sign language into spoken English, and the Space Glove released in 1991 by Virtual Entertainment Systems to be used in its virtual systems. Finally, the development of more accurate gloves involved research into robotics. The Dexterous hand master was created to operate the robotic hand Utah/MIT Dexterous Hand robot, developed by Arthur D. Little and Sarcos. This glove consisted of an exoskeleton hand device that was redesigned and sold by EXOS, aimed at the clinical analysis of hand function and impairment. Gloves and other body tracking systems such as suits equipped with led-light and sensors were developed for different purposes, among them, the measurement and understanding of the human body and the translation of its capacities to manipulate things and communicate, the teleoperation of robots, the mastery of animated characters for films and the pursuit of more natural interfaces. The latter one mainly experimented in the context of virtual environments,

163 David J. Sturman & David Zelzer (1994) "A survey of Glove based input", IEEE Computer Graphics and Applications

164 http://www.medienkunstnetz.de/works/videoplace/

in which the hands were translated as an image onto the field of view of the interacting human. This image works as the user manipulates extensions into this environment, where software triggers events in response to the recognition of the hands' movements. All these applications are based on the translation of the body or the hands inside the data space, to interact inside the simulated world produced by data processes, the human body must be quantified, in a way that its position, posture, and movements can be recognised and codified as input data.

The tracking and display devices produced on VR research were employed during the 80s and 90s by a new generation of artists crafting virtual worlds, where individual viewers could navigate and interact in an unfolding space. Among them feature *Angels, Osmose* and *Placeholder*. *Angels*[165] was conceived at MIT and developed at the Hitlab by Nicole Stenger between 1989 and 1991. It consisted of a 360-degree head mounted display, a 3D audio system (Crystal River), and the VPL Dataglove. The experience was developed by touching with the projected manipulative extension of the viewer's hand, the hearts hanging on a carousel, attending different scenes and assisting a choreography of abstract images representing angels. *Osmose*[166] is the work of Char Davies created in 1995 and developed using the SOFTIMAGE® 3|D modelling and animation development environment and Silicon Graphics Onyx2 Infinite Reality visualization supercomputer. It features an interactive 3D computer generated image and sound to create a virtual environment based on metaphorical aspects of nature that are accessed by means of a head-mounted display and reacts to the breath and balance of the viewer, which is tracked with a specially designed vest. Another VR project was the folklore-inspired *Placeholder*[167] by Brenda Laurel, produced at the Banff Centre for the Arts in 1993. It was an unfolding narration inspired by the local mythology and actual locations of the Canadian Rockies. This included three-dimensional video graphic scene elements, spatialized sounds and voices, and simple character animation aimed at constructing places in a virtual environment that could be visited concurrently by two physically remote participants wearing head-mounted displays. These works were high-technologically enabled realizations of previous artistic investigations aimed at including the audience interaction inside kinematic architectures and immersive environments. Jeffrey Shaw started its work on the 60s linked to the Expanded Cinema, where artists such as Peter Weibel were also involved. His work evolved from projects such as *MovieMovie* (1967) where images are projected onto an inflatable structure that changes with the actions of the performers, to the well-known *Legible City* (1989) project. In this, the visitor rides a stationary bicycle through a simulated representation of a city, which is formed of computer-generated, three-dimensional letters that form words and sentences along the sides of the streets. Using the ground plans of actual cities —Manhattan, Amsterdam, and Karlsruhe—The *Legible City* completely replaces the existing architecture of these cities with text formations written and compiled by Dirk Groeneveld. Travelling through these cities of words is consequently a journey of reading; moving across a path the cyclist/reader creates a recombination of these texts, and spontaneous conjunctions of meaning.

The mapping of the urban space and the application of VR to the creation of a surrogate trip was firstly developed for the interface of the *Aspen Moviemap*.[168] It originated in 1978 at MIT's Architecture Machine Group by Andy Lippman and a group of researchers including Michael Naimark and Scott Fisher. The *Aspen Moviemap* can be considered the first hypermedia system, a spatial interface for a multimedia database that recreated a navigable world where the viewer could be immersed and interact moving through the city of Aspen, Colorado, in a way that they could always continue straight ahead, come back, move left or right.

This information retrieval system consisted of a database of photorealistic images, reproducing all the streets of this village that were accessed via computer-controlled video discs -laser- or stylus-readable random-access disc that contains both audio and analogue video-. The recording of Aspen was done by means of four

165 https://www.digitalartarchive.at/database/general/work/angels.html. http://www.nicolestenger.com/angels2010.htm

166 http://www.immersence.com/osmose/

167 https://vimeo.com/27344103

168 Michael Naimark (2006) "Aspen the Verb: Musings on Heritage and Virtuality".

cameras, mounted on a jeep, each pointing in a direction and taking pictures every 3 metres. Each photo was linked to the other photos relevant for supporting the translated user movements. To make the demo livelier, the user could stop in front of some of the major buildings of Aspen and walk inside. Many buildings had also been filmed inside for the video disc. The display system used two screens, a vertical one for the video and a horizontal one that showed the street map of Aspen. The user could point to a spot on the map and jump directly to it instead of finding their way through the city.

The *Aspen Moviemap* project was a reaction to the gentrification process that was altering the touristic resort of Aspen and stressing the relation between representation and control. Here the cartography of the territory becomes a form of empowerment, thus starting a cultural trend that would be widely used in collaborative projects concerned with the collective construction of the territory at the beginning of the 21st century when mapping technologies became available thanks to projects such as Google Maps and Street View.

2.1.4.1.5 The translation to the Entertainment Industry

The work of the Collectives assembled around the new technology of Computer Graphics during the 60s and 70s contributed to the production of this intensive space of representation as well as to the definition of its capabilities and fields of research and application, which increasingly permeated more disciplines. The 80s were the times of stabilization and popularization of this technological assemblage that became economically profitable for both government and industry. These funded new research projects and programs, where new improved techniques emerged and new software and hardware facilities were adopted. New developments lead to the virtualization of procedures, producing this new space of representation. The hardware systems produced to digitize images to data structures, manipulated and displayed this data being translated into algorithmic functions performed by enclosed integrated circuits, which were assembled in personal computers. In this way, powerful applications developed into big labs became available to end-users. However, before this new synthetic space reached our computers, it was popularized in films and the new video games industry, a profitable field of application that contributed notoriously to the technological developments producing this space.

Between the Collectives and new software applications emerging during the 70's:[169]

> In 1974 Donald P. Greenberg becomes director of the Program of Computer Graphics (PCG) at Cornell University in Ithaca, New York. This group will be best known for pioneering work on realistic image synthesis, including the radiosity method for calculating direct and indirect illumination in synthetic scenes. The long-term goal of the lab is to develop physically-based lighting models and perceptually based rendering procedures to produce images that are visually and measurably indistinguishable from real-world images. They will contribute to the Wavefront render, and the renderer Lightscape. In 1974, Alex Schure established the Computer Graphics Laboratory (CGL) at the New York Institute of Technology (NYIT). It attracted Ed Catmull (then at Applicon) and Malcolm Blanchard to run his facility, who was soon joined by Lance Williams, Fred Parke, Garland Stern, and others from Utah. He also attracted other technology experts and artists, including Ralph Guggenheim, David DeFrancisco, Alvy Ray Smith and Ed Emshwiller. They worked on the development of software as the animation program Tween, the paint program Paint, the animation program SoftCel, and developed the innovative rendering technique called 'reflection mapping', which was used to provide realism to shiny objects in television and the movies. The quality of this department attracted George Lucas who hire Catmull, Smith, and Guggenheim to start his division, which eventually spun off as Pixar to start Lucas Film CG division.

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169 Information summarized from, Wayne Carlson *A Critical History of Computer Graphics and Animation*. Course contents available at the website of the Ohio State University: http://design.osu.edu/carlson/history/lessons.html

In 1978, Henry Fuchs arrived at the University of North Carolina at Chapel Hill and started the project pixel-planes at the Graphics and Image Analysis Research Centre at UNC, where he began exploring computer architectures for 3D graphics that were significantly faster than traditional architectures for applications that required high performance, such as medical visualization. The scalability and real-time rendering of this system revolved around a plane of processors, each with a few bytes of its own memory, operating in unison. Each pixel (picture element) on the screen was associated with a unique processor. The UNC team built the first molecular graphics system on which a new protein structure was solved. They also first proved that haptic displays augmenting visual displays could significantly improve a scientist's understanding of data. In 1976, Robert Cannon started the Computer Science Department at Cal Tech, then U.S. Assistant Secretary of Transportation for Systems Development and Technology, where incorporate Ivan Sutherland. Jim Kajiya was recruited by Sutherland in 1979, and they were later joined by Al Barr and Jim Blinn. The group developed fundamental mathematical approaches for computationally simulated physical objects. In 1986, Kajiya introduced the rendering equation as a way of modelling global illumination in an environment arising from the interplay of lights and surfaces. The rendering equation and its various forms have since formed the basis for physically-based rendering, enabling a new level of realism.

In 1974, Norman Badler started the Computer Graphics Research Laboratory in the Computer and Information Science Department of the University of Pennsylvania, this lab become the Centre for human Modelling and Simulation in 1994. The lab achieved international recognition for its research and specifically for the Jack software. Jack provides a 3-D interactive environment for controlling articulated figures. With his human-like ability to reach and grasp as well as detect and avoid "collisions" with objects in his virtual environment. In 1968, Charles Eastman at the Institute for Physical Planning at Carnegie Mellon developed the GLIDE system with Max Henrion and the General Space Planner (GSP) System, a software system for solving space planning problems.

These developments proved their commercial potential in emerging companies inside the advertising and filmmaker industry, among them Digital Effects, MAGI, Information International Inc (Los Angeles), which later became Digital Productions, Robert Abel and Associates (Los Angeles), Cranston/Csuri Productions (Columbus, Ohio), Pacific Data Images (Sunnyvale, California), Omnibus (Toronto) and Bo Gehring and Associates (LA).

The use of computer graphics in film production has become common, achieving a high level of realism and astonishment. The computer has generated images that have become widely known, among them: the tsunamis inundating the world in the production *2012* directed by Roland Emmerich in 2009. The pleating street of Paris, performed in one of the scenes of *Inception* directed by Christopher Nolan in 2010. Additionally, the amazing world produced by James Cameron and the use of 3D real-time cameras for the film *Avatar* in 2009. These images evolved from the work of the pioneering companies working in television, advertising and the first films incorporating computer-generated special effects - Close *Encounters of the Third Kind, Star Wars, The Last Starfighter* and *2001*- for which custom software and hardware was produced that improved the capacities of Computer Graphics.

The most relevant film in the spread of CG was *Tron*[170], produced by Walt Disney Productions in 1982 and directed by Steven Lisberger. *Tron* narrates the adventures of Kevin Flynn, a computer programmer interpreted by Jeff Bridges, who is transported inside the software world of a mainframe computer, where he must confront the tyrannical power of the Master Control Program, an artificial intelligence created by his opponent

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170 http://www.imdb.com/title/tt0084827/

Ed Dillinger that is illegally appropriating business and even government programs and absorbing them to increase its own capacities. Inside the Grid -the software space- Flynn must fight in the martial games, where he meets Tron and Ram, who will help him destroy the malicious software. Once in the Grid, the characters in *Tron* are set in a landscape that cannot exist in the real world and whose terrains and vehicles were created by computers. *Tron* was the first feature film in which computer generated imagery was extensively used. Four companies working in CG, MAGI, Digital Effects, Robert Abel and Associates and Information International Inc. (III), teamed up to produce the full fifteen minutes of the film consisting of moving images generated entirely by computers and the backgrounds used in more than two hundred scenes.

Digital Effects was founded in NYC in 1978 by Judson Rosebush, Jeff Kleiser, and five other partners, was in charge of the animation of the Bit character and the creation of the Tron character in the opening title sequence. MAGI (Mathematical Applications Group, Inc.) worked in the first part of the film; the gaming grid area where they created the *Lightcycles* for which it used its SynthaVision software, a system that combines solid modelling and ray casting to generate a limited variety of 3D designs that could be easily animated. Ray casting is a technique first developed to detect radiation and adapted to detect light when the company, initially aiming to evaluate nuclear radiation exposure, opened its CG department with the incorporation of Robert Goldstein and Bo Gehring in 1972. Even if this software process was limited in the construction of complex objects, it was efficient in the creation of fluid motion, the reason for which MAGI was responsible for most of the action sequences in the film.

Robert Abel & Associates provided the remaining animation for the opening sequence and for Flynn's transition into the Electronic World. The computer imagery present in the second half of the film, such as the MCP and the Solar Sailor, is the work of Triple-I. Information International Inc. with Demos and John Whitney. They recorded the visual images by tracing the lines of a drawing onto a digitizing tablet, this information then translated to the computer and its surfaces composed of polygons. There was a demonstration about this procedure at the SIGGRAPH'81 that convinced Disney Studios executives that computer animation could be successfully integrated into a motion picture. Accordingly the art director Richard Taylor, who headed the Entertainment Technology group at III and co-supervised the special effects at *Tron*, the most difficult and greatest achievements of the film being the integration of the two featured worlds. The conventional live action had to be matched to the computer-generated backgrounds in a coherent way. This involved the real characters performing in a virtual world. Even if *Tron* was not a box office success, its costume design and sound was nominated for the Oscar Awards, where it was recognized fourteen years later with the Academy Award for technical achievement. It was the starting point for the use of CG as a common resource in film production. This new industry led to the emergence of new companies during the 80s, among them the well know Lucas Film CG division that would become Pixar. These companies developed new research that produced software applications, which became common in the field of animation, data visualization, and CAD. Among them feature the Maya software, the MAX, the AutoCAD produced by Autodesk and the Photoshop created by Thomas Knoll (a Ph.D. candidate at the University of Michigan) in 1987, and used on the film *Abyss*, as well as Game Engines such as GameWare, produced by Wavefront, the exclusive game graphics and animation development software for the Atari Jaguar.

Among the Collectives that meet during the 80's[171]

> Wavefront technologies was founded by Mark Sylvester, Larry Barels and Bill Kovacs in Santa Barbara, California in 1984. In 1988, this company developed in partner with Silicon Graphics the Personal Visualizer software it providing an interface for high-end photo-realistic rendering that

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171 Information summarized from, Wayne Carlson *A Critical History of Computer Graphics and Animation*. Course contents available at the web side of the Ohio State University: http://design.osu.edu/carlson/history/lessons.html

was ported to Sun, IBM, HP, Tektronix, DEC, and Sony. In 1991, Wavefront produced the Composer, which will become a standard for professional 2D and 3D compositing and special effects in the feature film and broadcast/video fields. In 1992 they produced two new products for the entertainment industry the Kinemation -a complete 3D character animation system for creating synthetic actors with natural motion and muscle behaviour– and Dynamation, developed by Jim Hourihan –a powerful 3D animation tool that allowed interact to create and modify realistic images of dynamic events. In 1993, Wavefront acquired Thomson Digital Images of France, which had innovated in the area of Nurbs, modelling and interactive rendering and created the TDI Explore. A suite including 3D design for modelling, Anim for animation and Interactive Photorealistic Render (IPR) for rendering. In 1994, they collaborated with Atari to develop and market GameWare.

Alias Research was founded by Stephen Bingham, Nigel McGrath, Susan McKenna and David Springer with the aim to create an easy-to-use software package to produce realistic 3D animation for the advertising industry and post-production houses. In 1983, they produce its software Allias also used in the CAED industry. In 1990, they produced its third generation software that was branded 'Studio' for Industrial Design and PowerAnimator for the entertainment market. PowerAnimator attained a big success when ILM used it to create the chromium Killer cyborg, the enemy of Schwarzenegger in *"Terminator 2: the judgement day"* produced in 1991 and that was awarded the Best Visual Effects at the Academy Awards. In 1991, Rob Burgess (now CEO of Macromedia) was appointed president, the company bought Spacemaker technology and launched UpFront, a low-cost 3D Mac and Windows-based package for architects, this project will precede the development of Sketch!. In 1993, Alias started the development of a new entertainment software, later know as Maya, which will become the industry most important animation tool. Maya will be launched in 1998 by Alias Wavefront, after Alias research, Wavefront Technologies, Inc. and Silicon Graphics, Inc. merged into a new company. Its flag product is the result of merging the Wavefront's Advanced Visualizer and the TDI's Explore and the Alias Power Animator to provide a leader product in the key areas of bringing characters to life, create explosive visual effects and system architecture.

Softimage was founded in 1986 by National Film Board of Canada filmmaker Daniel Langlois. His vision was a software company that addressed the creation of 3D animation software not only for, but by artists. At this way, Softimage becomes a key company on the integration of animation and effects in a system addressed to the PC and available to mass-markets in games and web content industries. In 1988, it launched the Softimage Creative Environment 1.0, where for the first time were integrated modelling, animation and rendering. It will evolve to the IDEAS (Interactive Developer's Entertainment Authoring Software) this software included Softimage Creative Environment, NURBS support, polygon and colour reduction tools, dynamic simulations and inverse kinematics. It also featured Edition compositing, video-effects software, distributed ray tracer and the 3D particles kit. In 1995, Creative Environment became SOFTIMAGE|3D with a release that featured NURBS modelling, relational maudlin, trimming, instantiation, polygon reduction, tangent-to-path, constraint, Q-stretch, expressions, motion control, Actor, Particle, mental ray rendering, and metaclay. In 1998, Avid Technology, Inc. acquired Softimage.

Autodesk Inc. was founded in 1982 with a focus on design software for the PC. In 1986, Autodesk began efforts to develop an animation package. Key developers were Jamie Clay and the founder, John Walker. Autodesk's first animation package was AutoFlix (for use with AutoCAD and AutoShade), and AutoFlix 2.0 which included the Animation Tool Kit for AutoCAD. At the 1989 SIGGRAPH in Boston, Autodesk unveiled a new PC-based animation package called Autodesk Animator. As a full-featured 2D animation and painting package, Animator was Autodesk's first step into the multimedia tools realm. The software-only animation playback

capabilities achieved very impressive speeds and became a standard for playing the animation on PCs. MAX shipped as Kinetix 3D Studio MAX. Since its release in 1997, 3D Studio VIZ continues to gain more acceptance within the architectural community for design and visualization. As a result, it has shifted more specialized architectural users from MAX to VIZ. 3D Studio VIZ enables professionals in the architectural, land design and mechanical design sectors to design in 3D Studio VIZ and then transfer the images directly into a CAD environment. In January of 2006, Autodesk acquired Alias for $197M in cash, bringing the StudioTools and Maya software products under the Autodesk banner.

Finally, in 1971 George Lucas formed its own independent production company Lucasfilm Ltd. and In 1975 established Industrial Light and Magic (ILM) to produce the visual effects of *Star Wars*. In 1977, *Star Wars* opened and became the largest grossing film of all time to that date. It received six Academy Awards for original score, film editing, sound, art and set decoration, costume design, and visual effects, as well as a Special Achievement Academy Award for sound effects creations. The Lucasfilm Computer Graphics Group developed industry-leading hardware and software systems. The scanline rendering algorithm called REYES (Renders Everything You Ever Saw), the RenderMan's Shading Language. The system to do film editing EditDroid, the first non-linear editing system. It was based on SUN hardware coupled with a laserdisc system and 3/4" tape recorders. It had a custom touchpad used to make the cuts, and its interface used a timeline approach. John Knoll (who was a motion control technician) and his older brother Thomas Knoll (a Ph.D. candidate at the University of Michigan doing work in image vision) developed Photoshop in 1987. The raster graphic editor published by Adobe Systems. John Warnock and Charles Geschke, focusing on creative and publishing software, founded adobe Systems in 1982. Warnock created the PostScript page description language that will become a revolution in the publishing world. Adobe will create the industry standard photo editing software in Adobe Photoshop and the movie industry's special effects standard in Adobe After Effects. Photoshop was designed for Macs, based on the functionality of the Pixar Image Computer, and was used on the film *Abyss*. Pixar started as the Lucasfilm Computer Graphics Group in 1979, which was reorganized in 1983 to become Pixar and a games division.

The images and plot deployed at *Tron* were a legacy of the fascination of its director for the video games industry. This industry started in 1961 when Nolan Bushnell, then at Utah University, was one of the students who played *Spacewar!*. Bushnell, who had been working at the Lagoon Amusement Park, had the idea in 1968 to produce a spacewar-like game to be implemented into coin-operated arcade machines. The game called Computer Space was distributed in 1971 becoming a commercial failure due to its difficult operability. After that in 1972 Bushnell created the Atari company and the popular tennis game Pong. Pong was a big success, becoming the first video game that displaced pinball in arcades and becoming one of the first home distributed video games, after the games distributed in the first domestic video created, the Magnavox Odyssey console developed by Ralph H. Baer between 1966-1968. Pong started a long history traced by blockbusters such as Space Invaders created by Taito in 1978, Pac-Man created by Toru Iwatani at Namco in 1980 - the game that attained the biggest return of all times -, Donkey Kong released by Nintendo in 1981, whose hero Mario is still selling Nintendo consoles and Street Fighter released in 1987. Nolan Bushnell and Atari started a new entertainment industry grew until becoming one of the richest of our times. Thus, it had overstepped the income of film industry and reached 55.05 billion dollars in earnings that year.[172] If the film industry was popularizing the capacities of computer graphics to simulate a realistic world, video games would present this space as a habitable interactive interface.

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172 Data from http://www.statista.com/statistics/278181/video-games-revenue-worldwide-from-2012-to-2015-by-source/

> *"Video games are a window onto a new kind of intimacy with machines that is characteristic of the nascent computer culture. The special relationship that players form with video games has elements that are common to interactions with other kinds of computers. The holding power of video games, their almost hypnotic fascination, is computer holding power".*[173]

Spacewar! was created one year later by Sketchpad, but this popular video game was preceded by "tennis for two", created in 1958 by William A. Higinbotham at the Brookhaven National Laboratory – a US nuclear research lab in Upton, New York -. Higinbotham adapted the software of a missile tracking system, to entertain visitors. Another early game was the "tic-tac-toe", developed at MIT for the TX-0. This entertaining system had evolved concurrently with the simulated screened space constituted by the development of Computer Graphics. It fostered the improvement in displays, from the oscilloscope, where the tennis ball for two moves horizontally, to the popular X-Box and PlayStation consoles, which reproduced on our home televisions the photorealistic worlds of Myst or Doom. At the same time, this industry took part in the development of input devices for interaction, which had evolved from the first joysticks attached to *Spacewar!* to the use of more embodied forms of interaction facilitated firstly by the PowerGlobe and later on, by the Kinect camera used with PlayStation and the Wii command. Video Games production has fostered the editing of software which has been adapted to the development of game engines from GameWare to Unity[174]. Finally, Video Games met up with the personal computer and the Internet and increased its capabilities to result in a rhizomatic and open world inhabited and evolved by the contributions of players' communities from DUM to the currently popular Minecraft. If Computer Graphics gave birth to fields of research such as CAD, Data Visualization, and VR, laying out a new space of representation, video games evolved the modes in which this space would be inhabited. The first video games were popularized in arcades but soon developments occurred that brought them into the homes. The first video console was the Magnavox Odyssey, developed by Ralph Baer, a graduate from the American Television Institute of Technology (AITT) in Chicago, who was looking for a more interactive experience. With this aim, in 1966 he started the development of a low-cost device for attaching to a standard TV set. The device was based on the development of 'spot generators', a circuit that generates spots on the screen, which can move around. This simple mechanism was deployed to create a list of sports games such as ping-pong, volleyball, handball, hockey and even several shooting games to be used by a new light-gun. After several presentations, Magnavox released the console in 1972. While attending one of the presentations of The Odyssey, Bushnell came up with the idea of Pong, the game that would be firstly successfully distributed in homes and whose simple instructions: "AVOID MISSING BALL FOR HIGH SCORE"[175] replaced its failed predecessor Computer Space for a new philosophy: 'Easy to understand and difficult to master' that ensured the accessibility and success of this form of entertainment. The system project coded Darlene was based on the 'PONG-on-a-chip' circuit developed by General Instruments and was distributed as Home Pong, a dedicated –non-programmable– console. In 1975, Atari was acquired by Warner and the company started the Stella project that resulted in the production of the VCS, the best known 8-bit programmable system. However, the major success of the Atari came in 1980, when Atari became the first company to license an Arcade game to be distributed in home systems. The popular Space Invaders produced by the Japanese game maker Taito and licensed for North American release by Midway was adapted to the VCS by the designer Rick Mauer and became the killer app for the VCS. Other first generation consoles were the Odyssey 2 (Phillips G700) released in 1978, and the Astrocade from 1977.

173 Sherry Turkle (1984) *The Second Self: Computers and the Human Spirit*, ed. Simon & Schuster, New York, pp. 64-92, published at *The New Media Reader*

174 http://unity3d.com/

175 http://thedoteaters.com/

Meanwhile, in the arcade cabinets more compelling graphics, commands, and sounds were evolving at the same time, as well as new gaming plots and strategies. Games created a culture populated by space ships, invaders from outer space, kidnapped princesses, evil monsters and unexpected male heroes – the first female heroines did not appear until the five generation video consoles. Characters appeared inspired by fantasy folklore, spreading in best-selling films such as *Star Wars*, Indiana Jones and cult TV series such as Dr. Who and Star Trek, which could be controlled inside of programmed spaces shaped as mazes, platforms and sports playgrounds in which higher achievements are the result of the discovery and mastery of the internal logics driving the system's behaviour.

The spot generators of Odyssey evolved into sprite graphics, first produced by dedicated circuits, which were later replaced by software. Sprite was a two-dimensional image or animation that is integrated into a larger scene. This technique allowed unrelated bitmaps to be integrated creating an animated object that could be moved on a screen without altering the data defining the overall scene. Advances in storage and processors increased the versatility and quantity of the simultaneously performed sprites, increasing the quality of the onscreen experiences offered by Arcade Games. Then Pong Atari produced Tank, the first game using a ROM chip to hold graphic memory. Designed by Scott Bristow and released in 1974, Tank consisted of two tanks facing off in a maze, while trying to avoid land mines scattered about. The next step was the introduction of animated characters in the game Shark Jaws was released by Horror Games – created by Atari- in 1975. The same year Midway, a new player in the game industry, introduced the first game using a microprocessor, Gun Fight incorporated an 8080 CPU, allowing for more varied and randomized gameplay. Cinematronics was the first in using vector graphics in the game Space War designed by Larry Rosenthal and released in 1977. The next blockbuster of the industry came from Japan, when in 1978 Toshihiro Nishikado designed and programed their first video game and Taito entered the video game arena. In Space Invaders, players try to protect the planet from relentless hordes of aliens marching down the screen, with just a single-shot moving gun and four shot-blocking bunkers as protection. The game came to the western market licensed by Midway and spread to the homes of gamers by Atari. In 1978, Atari introduced new advances with its football game. Atari Football was the first game whose playing area exceeded the margins of the screen, allowing the player to move along the entire simulated grid. It also introduced a new control method, the track ball. It consisted of linking two graphic objects, the football player and the ball, in such a way as one follows the movement of the other. The same year the company started a project for the first holographic game, with the title Planet Grab, the game involved players piloting around a solar system claiming planets by touching them. The 3D game was never produced, but the idea was further developed as a vector graphics game called Asteroids. Released in 1979, Asteroids introduced a high-score system, allowing players to record their initials to be displayed next to their score. The first colour video game was Galaxian, released by Namco, another Japanese company established in 1974. In 1980, Namco produced Pac-Man, designed by Toru Iwatani, the most popular video game of all times. Pac-Man spread in popular culture through merchandising, pop songs, and cartoon TV series and had multiple versions. The same year Taito introduced speech to the arcade games. A human male voice was reproduced using a full 1.5 MHz chip, able to reproduce four sentences in the game Stratovox. The designer of the home video console Astrocade improved the voice system when he created Gorf in 1981, this game used the speech synthesis chip Vortrax. Emulating a human voice by use of speech patterns called phonemes, it enabled less memory requirements rather than using actual digitized phrases. The same year the first platform game by the company Universal the Space Panic was introduced. Platform Games deal with the player climbing ladders and running across platform levels to avoid life-ending objects. This concept was exploited in the Blockbuster Donkey Kong designed by Shigeru Miyamoto from Nintendo. This game, and its star Mario, began the golden age of the video game industry. Donkey Kong became the biggest selling arcade game of 1981 and started a series of games starring Mario, later on with his brother Luigi that resulted in the rebirth of the video entertainment systems market after the big crash of 1983.

Meanwhile the second-generation of video consoles appeared in the form of machines such as the Intellivision (1981), the first 16-bit console created by Mattel, Colecovision (1982), Philips G7400 (1983), Arcadia 2001, Vertex (1982), a portable vector scan home game machine, and the Atari 5200 (1982) including the ANTIC

graphics co-processor and four channel sound. Despite the improvements of second-generation home systems, these still offered a poor experience compared to arcades, which in 1983 incorporated laser disc technology to evolve into a more immersive space. In 1983, Cinematronics released Dragon's Lair. Developed over four years, the game was conceived by Rick Dyer and drawn by a team led by the Disney animator Don Bluth. Dragons Lair plots the adventures of the knight Dirk the Daring. His quest is to infiltrate a castle magically enchanted by the evil wizard Mordred and rescue Princess Daphne, guarded by the fire-breathing dragon Singe. Dragon's Lair consists of a total of 27 minutes of animation or 50,000 drawings recorded in computer controlled laserdisc that jumps from one scene to other accordingly to the actions performed by the player in each of the 800 decision points that make up the game. Released in arcades in July 1983 with a cost for a cabinet of $4,300 -double that of traditional arcades- achieving big success and grossing 32 millions worth of sales and becoming a popular phenomenon that spread through merchandising. Laser games started a new form of game production, where the dexterity of programmers was complemented with the production of animated and filmed action footage, the intervention of actors performing voices and the composition of soundtracks that conjointly promised a more immersive and lively experience. This procedure was applied to other laser disc games such as Space Ace, Astron Belted by Sega, the shooting game MACH 3 –realized by Mylstar and incorporating professionally shot aerial photography-, Q*bert, Firefox by Atari and many others that after experiencing relative success would completely disappear from of arcades by 1985. Even in this impressive environment the laser disc games offered a poor interaction encumbered by the technical problems of laser disc technology. In Dragon's Lair, the player can merely decide when and where Dirk should use his sword. Nevertheless, the characters of Dragon's Lair endured in the video game industry and popular culture for a long time. They became the characters of TV series and their adventures adapted to multiple versions to the gaming platform from where adventure games emerged, the personal computer. Fourteen years after its release, Dragon's Lair was incorporated as one of the only three video games in the Smithsonian Museum in Washington D.C., alongside Pong and Pac-Man.

Some failings of the giant Atari -the poor adaptation of Pac-Man and the disastrous video game adaptation of the bestselling film *E.T. the Extraterrestrial*- and the release into the market of about twenty million cartridges to be sold for $5 at Christmas, produced by more than 30 third-party game producers, resulted in the crash of game industry in 1983. The industry did not recover until a new generation of consoles appeared able to reproduce the new open and rhizomatic space that characterizes the games emerging from the new gaming platform, the personal computer. Sited in computers, games evolved towards the formation of a navigable space where the control of the graphic characters towards dominion and discovery of the systems logic was substituted by the identification with the avatar. The impersonated player moved across a rhizomatic world, which soon connected to the internet, allowing social interaction.

While arcade games were sited in bars and special venues, computer games spread through another public space, the Arpanet, where many students met at this time captivated by the new gaming sensation Dungeons and Dragons. Dungeons and Dragons is the most popular Role Playing Game (RPG) of all times. RPG is an open multiplayer game, where players perform in a fantasy world by means of incarnating one of the available character types. The context, rules and inhabitants of the world are provided in tomes from where the players can define scenarios and the nature of the game. Characters evolve throughout the game according to their available characteristics, which improve after accomplishing actions in which chance is introduced by rolling dices. The master is the facilitator of the game, somebody with a wide knowledge of the territory and the rules steering the world and who is able to provide an engaging story.

This game system was translated to computers shortly after the success of Spacewar!. Adventure appeared in 1972 and Zork in 1977 as text based games.

Engelbart and Ted Nelson developed the hypertext as an information retrieval system, but hypertext is also considered a narrative structure. Texts showing hypertext narrative structures are "*Finegan Wake*" by James Joyce or *"Hopscotch"* written in 1963 by Julio Cortazar and the very first one, "*The Garden of Forking Paths*",

written in 1941 by Jorge Luis Borges.[176] Borges' short story relates the existence of a book containing all the possible realizations of a plot, showing a special relation with time, with the possibility of various futures pointing to the undetermined. The existence and structure of this book is developed inside the main plot, a thriller conducting itself to a bifurcation and an unexpected end. In this way, hypertext is not a linear narration, which advances from point to point, deprecating all that is not involved in its path, but a matrix from where multiple paths and micro-local temporalities can emerge linked to events that can develop alternative linked situations; an intensive space where events introduce differentiation, starting new Transductions towards the actualization of a new dimension. In the electronic hypertext, events will be the inputs of the user, registered by means of buttons or text entered in the interface, these attached to programmed functions that will emit a new interface, which is composed of a new combination of the discrete units usually stored in a database. In this sense, hypertext is deep.[177] Its multiple realizations cannot be contained in a unique surface and it contains two separate layers, the visual one or analog, and the digital one or program. This deepness converts hypertext into an open navigable space, where the user is involved participating in a free play from where meaning emerges.

Characterizing electronic hypertext, Hayles point to nine characteristics:[178]

> *"They are dynamic images; they include both analogue resemblance and digital coding; they are generated through fragmentation and recombination; they have depth and operate in three dimensions; they are written in code as well as natural language; they are mutable and transformable; they are spaces to navigate; they are written and read in distributed cognitive environments, and they initiate and demand cyborg reading practices".*

One of the first electronic literary hypertexts was Michael Joyce's *Afternoon*[179], created in 1987 using Storyspace software.[180] This was developed by the author conjointly with David Bolter and presented in the *First International Meeting on Hypertext at Chapel Hill*. Storyspace offers a graphical interface, a map of pages and links, allowing the ordering of complex structures and assisting in the process of creative writing. It was used to create well-known hypertexts such as *Patchwork Girl* (1995) by Shelley Jackson or *Victory Garden* (1992) by Stuart Moulthrop. It is also used for teaching creative writing.

Even if it is of great interest, we will not follow here all the development of Electronic Literature. To summarize, it evolved into new expressive capacities when it considers the text as image, which can be rendered in different ways and related to other images. Another interesting evolution was to use hypertext with other software procedures. Jean Pierre Balpe mixed hypertext with generative language in *Trajectories*, created in 2000,[181] the computer generated words laid out a complex space that not only navigated across a set of predefined interrelated stories, but also evolved and generated through an ongoing interaction with the user. Nowadays, Electronic Literature has focused on showing the materiality of this medium. The exhibition *"New text: Literary and Artistic Explorations into what it means to read, write and create"* curated by Dene Grigar at ISEA 2015[182] included works that show the special characteristics of electronic media by embodying

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176 Jorge Luis Borges (1964) "The Garden of forking paths"

177 Katherine Hayles (2004) "Print Is Flat, Code Is Deep: The Importance of Media-Specific Analysis"

178 Katherine Hayles (2004): <op.cit.>

179 http://www.wwnorton.com/college/english/pmaf/hypertext/aft/,

180 http://www.eastgate.com/storyspace/

181 Jean Pierre Balpe (2000) "Le récit Interactif: Langage et écritures"

182 Dene Grigar (2015) "New text: Literary and Artistic Explorations into what it means to read, write and create"

its products. Among them, *Networked Optimization* by Silvio Lorusso and Sebastian Schmieg, a reprinting of well-known self-help books that only includes the most highlighted sentences by its readers, or *Print Wikipedia* by Michael Mandiberg, a printing of this popular open source project that becomes obsolete as soon as it is printed.

Another place from where the rhizomatic structure of hypertext evolved, where the narration was spatially distributed and discovered by the reader in a non-linear way by navigating the laid out space, was adventure games. Initially, adventure games were text based, lacking a graphical interface. They consisted of a database and a parse verb-noun programmed system. The system analysed the text introduced by the player and browsed in a database to purpose the linked action. The first text-based adventure game was Adventure, also known as Advent or Colossal Caves.[183] Willie Crowther wrote it in FORTRAN for the PDP-1 at Bolt, Beranek and Newman, Inc. (BBN), the Boston Company that was awarded the contract to develop the ARPAnet. Don Woods from the Artificial Intelligence Lab at Stanford expanded the game a year after when the game had become popular through Arpanet. In Adventure, you must explore the vast Colossal Caves, resolve the situations proposed inside and return to the starting point with as many treasures as you can.[184]

Zork was created by Dave Lebling, Marc Blank, Tim Anderson and Bruce Daniels at MIT. Lebling produced a parse using MDL (muddle) code, a Lisp-based language developed at MIT that enabled recognising adjectives and more complicated sentences. He and his colleagues used the new parse conjointly with the Interlogic system –programming technique developed at the artificial intelligence lab- to produce the maps and intricate problems that constituted the Underground Empire. The game included containers, where the players could keep useful objects, non-playable characters (NPC) and the passage of time, which allowed for triggering timed events introducing unexpected situations in the game. After incorporating the company Infocom, the Zork team started work to move the game to the already popular microcomputers. With this aim, the team produced a Z-machine, a virtual processor able to interpret the compressed code of Zork (ZIP) in any computer environment. The game was released on two floppy discs, the Great Underground Empire part I and II, at Christmas 1980. The company was acquired by Activision in 1986 that released *Beyond Zork*, created by Brian Moriarty in 1987, the first game version with a graphical user interface, it included the features characterizing RPG, the possibility to choose the playable character and to evolve it through assigning percentage statistics to such attributions as strength and dexterity.

Role Player Gaming was completely realized in its computerized version when they become networked on the internet. Graphical multi-user games started at PLATO (Programmed Logic for Automatic Teaching Operations),[185] a time-sharing system developed at the University of Illinois in 1960. Plato was accessed by graphical terminals, including a series of peripherals such as a lightpen, touch pad, and the voice synthesizer Vortex. Plato IV included the Blitzer orange plasma display that incorporated both memory and bit mapped graphics. These input/output devices allowed the students to create graphics, learn music and play games in a networked environment. Some of the games that become popular in this early system were the Star-trek based *Empire* and RPG such as *Rogue*, *Oubliette*, and *Avatar*.

The first MUD (Multi-User Dungeon) was written by Roy Trubshaw in 1978 in the PDP-10 at the University of Essex in England. MUD is a text-based multiuser world where people can log in and explore a set of 20 interconnected rooms and communicate through a rudimentary chat system. It also has an RPG system where the attributes of strength, stamina, and dexterity can be evolved by surviving battles. MUD was commercially licensed by Century Communications in 1984 and delivered by Compuserve in 1987 until it shut down in 1999.

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183 http://www.lysator.liu.se/adventure/

184 More about Video Games history at http://www.emuunlim.com/doteaters

185 More about Plato can be found at Ted Nelson (1974) *Computer Lib/Dream machines,* pp. DM 26-28 an the website of the PLATO History Foundation conducted by Brian Dear http://platohistory.org/

These first adventure games evolved into the complex navigable spaces of the first games rendered in 3D such as Doom, the first shooting game proposing first person perspective created by Id software in 1993, and Myst, the virtual world created by Cyan the same year. In these games, the narration becomes equated with movement, the space becoming a media type,[186] the movements and actions of the players now translated onto the computer-generated environment as avatars becoming rendered accordingly. The actions accomplished by the avatars trigger new events that unfold the database as spatial information, which generates new levels, scenarios or worlds.

An avatar is an interactive social representation of a user. Derived from the Sanskrit word 'avatara' (a god in earthly form), the avatar is understood as a delegate of the user agency in a virtual world. Avatars evolve from the parametrization of the human body that allows them to be translated inside virtual worlds as input data able to trigger coded events in it. This codification of human body evolved into an operative human representation in the first virtual human being, Jack.[187] Jack Software was developed between 1973-1989 at the University of Pennsylvania. It was a programmed human body, reproducing all the joints and a rudimentary intelligence allowing it to reach and grasp objects and avoid collisions with objects inside the virtual world by means of recalculating its position. This programmable human model could be moved with a *mouse* or programmed to perform tasks that engineers could observe and evaluate. The Jack's ability to act realistically in virtual environments determined its use in design as it could be observed to test the reach, range of motion inside a designed space. Jack software was improved to move to the desktop and become interactive, being controlled in real time by real people. On the desktop, these 3D human representations became surrogates of their operators. Their human shape allowed them to support social attributes such as body shape, clothing, and gestures and interact with other surrogates on the Internet, resulting in a personality that evolved by the Transduction of information between them and the human players.

Doom stems from the game engine created by John D. Carmack, aimed at the creation of an operative cyberspace, a 3D world that was self-generated in motion as a consequence of the performance of the player. In this world, the player embodied a marine engaged in saving the world from the invasion of the undead and demons. With this aim, the marine moved across a 3D-rendered labyrinthine structure shooting at everything that moves, moving from the current level to the next one, once it is clean. Doom sold more than 2 million copies, but its great popularity spread across a new marketing strategy that turned every player into a potential distributor. Doom was evolved to support networked multiplayer mode, as it goes on-line it make the Doom Wat software available, a game engine that allowed the players to introduce modifications and create their own levels that could be distributed as shareware. This strategy resulted in more than 20 million shareware versions installed worldwide. including a modified version of Doom II called Marine Doom[188] created by the Marine Corps Modelling and Simulation Management Office ("McMismo") as a training environment for real soldiers. In 1997, Id produced Quake, the super production of this company, another shooting game with more definition on the moving images, the addition of filmed footage, and the intervention of actors performing the voices of the main characters.

Myst was created by Rand and Robin Miller at Cyan, using Softimage software. This immersive environment contrasts with the directed fast action of Doom. Myst is a wandering world, familiar and strange at the same time where mechanical rules must sustain the world at the same time allowing unexpected events able to engage the players. Myst unfolds as a parallel world inhabited by complex characters and situations that evolve at the same time as space and the narration. The world is complemented in a series of books that create a backstory that defines the present and future of the game. In addition, there was a second part, Riven, produced in 1997 as a super-production, including four thousand images, and two hours of film.

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186 Lev Manovich (2002) *The Language of New Media*, "Navigable Space" pp. 213-244

187 http://kaufthal.com/portfolio/jack.htm

188 Rob Riddell (1997) "Doom goes to war", *Wired Magazine* 04.01.97

In 1997 Ultima Online appeared, the largest Internet gaming system yet conceived. Ultima was created by Richard Garriott (Lord British). It is an RPG game sited on the mystical land of Sosaria, where the hero must use might and magic to slaughter evil creatures roaming the landscape, in a journey where he increases experience and hits points that culminate in the encounter with the evil wizard Mondain. Ultima on-line places the Ultima universe, where players can meet with a large number of human counterparts, joining in guilds and participating in multi-character quests assigned by Lord British himself. In addition to a game, Ultima was the social space its creator conceived it to be *"a living breathing magical place, where people could forge true alternative lives"*[189] Indeed, Ultima was a highly coded space, featuring an economic system, which involved a set of ethics where work and dedication were rewarded, A territorialized nowhere where avatars can wander and evolve, but always according to a predefined array of options –roles, clothes, arms, behaviours– to which access was constrained to the accomplishment of predefined goals.

Lucas Arts proposed a new game concept in Habitat. The game was an open space to be defined and planned by the gamers. Habitat was created by Chip Morningstar and F. Randall Farmer as the first attempt to produce a very-large-scale, commercial, many-user, graphical virtual environment.[190] Habitat did not feature a fictional plot to be evolved by the users, but was conceived as an object-oriented model of the universe, an open world where the players could move around embodying their avatars, interacting with other players and with the objects around. These objects determined the semantics of the universe and what the avatars could do in each scenario. Each type of Habitat object had a definition consisting of a set of resources, including animation cells to drive the display, audio data, and executable code. Some objects were structural –the ground and the sky-, others defined the scenery -trees, houses- others were executable and implemented a series of standard behaviours, each of which was invoked by a different command or systems event by the kernel in the response to players input. Habitat was built on top of an ordinary commercial on-line system and used the inexpensive Commodore 64 as a frontend, communicating via a commercial packet-switching data network to a centralized backend system that sustains the world. The frontend provided the user interface. This was a real time generated display of a flat landscape constituted by the objects in each region, where the avatars of the other players around also appear. This interface also translated the player inputs to the backend. The backend maintained the world model and implemented its rules at the same time as keeping the player frontend updated of the constant changes affecting the world. The backend provided communication, not only between the players and the world, but also among the different players. The creators of Habitat planned it as an internet service, considering cyberspace as a medium of communication defined more by the interactions of their users than by the engineered technologies. Habitat was planned open-ended and pluralistic, conceived as a medium to increase the channels of communication among people. It offered a broad palette of possible activities from which the players could choose accordingly their preferences. Even though it was conceived as an open world for encounter, Habitat, like other similar artificial environments, remained as an island floating away from the richness and productivity of Internet, an enclosed space detached from the diversity that characterises the emergence of the net. In the highly modulated space, where everything becomes rendered in the same set of flat pixels there is no space for the noise and difference that characterises creation.

The future perspectives of the Habitat creators included eliminating the backend towards a more distributed system, supported by the clients' computers and allowing the players to participate in the construction of the environment. These goals would be accomplished in new projects mediated by a 3D graphical interface. One of the first interactive virtual worlds was the Alpha World, launched by Active World Inc. in 1995. In Alpha World, users could log in to navigate and explore 3D virtual worlds built by others. Alternatively, users could own land where to develop custom content. The world interface included browser capabilities, voice chat and basic instant messaging to communicate with other players. Other similar dystopias followed, among them the networked version of the game the SIMS and the most known virtual world, Second Life.

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189 Amy Jo Kim (1999) "Killers have more fun", *Wired Magazine* 05.01.98

190 Chip Morningstar and F. Randall Farmer (1991) "The Lessons of Lucasfilm's Habitat"

Second Life was created by Linden Lab and released in 2003 and is still on-line.[191] As its name indicates, Second Life is conceived as a parallel society, a place where players can contribute with money and/or work to a rudimentary economic system that counts on its local currency, the Linden Dollar, which can be traded to legal tender. In addition, it includes its own channels for communication and advertising. The game starts by choosing an avatar that can be personalized inside the free predetermined options, buying more cool stuff –this provided by the game owners or by the other players- or creating it using the modelling language of the game. After, the player can buy a piece of land and start constructing their own space, which can be monetized as they wish, producing shops to buy and sell virtual goods, renting portions of the space to other players, or offering services. The next step is to attract people to your place, by means of organising social events that can be announced in the Destination Guide, or advertising the offer of free virtual goods to the visitors. Second Life experienced big success, reaching one million users the first year that kept rising with the addition of institutions and trademarks, for which having a space in Second Life appear as a marketing opportunity. For some of the inhabitants of this cyberdistopia, this is a place to escape from real life and play a more successful role, while others just enjoy the opportunity to build 3D stuff inside an easy to manage environment with lots of predefined components that can be personalised and even complemented by some interactivity by means of short scripts. Second Life is still an available application on the net, but it has lost its popularity.

Even if networked virtual worlds promise an architectural project constructed from bottom-up, they remain as a proprietary and administered space, where any behaviour is defined by the programs managing the objects that compose it in a closed system, remaining detached from the complexity and excess of meaning that characterises everyday life. Virtual worlds, even if they have the capacity to gather people, lack the embodiment that characterises things and their capacities to enter into relation with new ecologies, where they can affect and be affected and lay out new possibilities.

Gaming inside coded space behind the screen lacks the potentiality of the *"jouissance"* and the ephemeral playgrounds proposed by the Situationists in the application of Lefebvre's theories of artistic experimentation.

Another consequence of the fascination with virtual worlds -dedicated to fictional games or social spaces- was the assimilation of the synthetic image with cyberspace, the operative cyberspace developed in Carmack's engine, where the simulated space is actualized by the interactions of the user, being assimilated into the space laid out by the interactions in the net, another navigable space.

The spatialization of the net starts with Mosaic, the first browser with a graphical interface. It was a gateway to the cyberspace laid out by the navigators as they jumped from one document to another inside the distributed and multidimensional aggregate that is the web. 3D navigable space was perceived as a resource to 'sensualize' the web, the aggregates of voxels rendered as polygons in flat screens becoming the building blogs of a space for the translation of the hypothetical disembodied consciousness[192]. In 1994 Mark Pesce, Gavin Bell and Anthony Parisi created VRML (Virtual Reality Modelling Language). VRML was a language for describing multi-participant interactive simulation networked via the global internet and hyperlinked with the World Wide Web. It allowed the construction of 3D scenes hyperlinked to other 3D-scenes and documents of other media types. The VRML was conceived as the 3D interface for the web, expected to subsume all the web archive inside a simulated space. Unable to subdue the variegated conviviality of internet and its multimedia nature inside a global algorithm that renders it as a formalized space, 3D has remained as another media type, available to the nomads of subjectivity and their interchange of information inside the net.

Finally, the graphical user interface has become the usual way to access computers. The interface and its interactivity hid the algorithmic procedures that manage this system, which shifted from a programming environment to a media system. In this use, the computer would soon be substituted for other devices.

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191 http://secondlife.com.

192 Mark Pesce (1995) "Ontos, Eros, Noos, Logos" Keynote address. International Symposium on Electronic Arts 1995

Playing electronic games has become a usual and ubiquitous activity. People play on portable devices while they are on public transport or waiting rooms, to maintain relations with acquaintances inside social networks, or in social gatherings around a video game console. Despite the crash of the video game industry in the USA, Japan was still selling video consoles. In 1985 a new generation of video consoles reached the market produced by Nintendo and its Famicom, the place to play Mario Bros, Atari and it's 7800, and new companies such as Sega and its Sega Master System with its own main character, Sonic. These will be followed by a fourth generation, with machines by Sega, Nintendo and Philips. Finally, the 90s consoles became able to render 3D graphics; it was the fifth generation of consoles, with machines such as the Atari Jaguar (1993), the Sega Saturn (1994) and the Sony PlayStation. Produced by Sony Computer Entertainment in 1994, this contained the same chip as the Geometry Transfer Engine and the Data Decompression Engine. It could render 1.5 million Flat-Shaded Polygons per second, 500,000 texture mapped and light-sourced polygons per second with 16.7 million colours, Gouraud shading, and texture mapping. In addition, it included a more tangible controller; the DualShock, which produced a vibration as a feedback event. Nintendo released the N64 in 1996, a 64-bit machine including RCP (Reality Control Processor) which mapped hardware registers to memory addresses and an RDP (pixel drawing processor) with Z-buffer, anti-aliasing, and realistic texture mapping (trilinear filtered MIP-map interpolation, perspective correction, and environment mapping).

These consoles substituted the computer as gaming platforms and introduced new peripherals and more social games, such as the popular Guitar Hero, which appeared in 2008, that included a guitar-like device equipped with sensors that track the performance of the proposed music while the player advances inside a 3D predefined scene or in network mode, in front a crowd of fans. Dance Star included a step pad, sensing the dancer's performance or the popular karaoke Singstar with an integrated microphone.

Later on came Kinect, a camera-based VR system that recognises the silhouette of the player that became rendered inside the screen, where they can interact with the graphic objects. Nintendo introduced the Wii, another VR system based on a controller equipped with sensors that translate the movements of the player inside the simulated space. These companies also produced the first portable systems, the Nintendo Gameboy, and the PSP, small screens integrated into controllers that enable playing anywhere. These machines soon incorporated an internet connection and a browser to navigate frequent sites and repalced the computer as an entertainment system. They signalled the end of the personal computer revolution and the beginning of the post-desktop era. At the same time the smartphone appeared, the most ubiquitous portable networked device, as well as tablets, the smart watch, the smart TV and the production of new displays able to convert entire building facades into networked screens. These devices were the carriers of a shift of paradigm from the simulation of space to the augmentation of space.

2.1.4.2 NETWORKED GRAPHICS: LINKING TO THE PHYSICAL WORLD

In the middle of the 90s a new technological procedure appeared, which was able to spread graphics in physical contexts, Augmented Reality.

> *"AR is an umbrella term that includes various approaches with a common goal: to enable people to take advantage of their skills in interacting in the everyday world while benefiting from the power of networked computing".*[193]

193 Wendy E. Mackay (1996) "Réalité Augmentée: le meilleur des deux mondes". *La Recherche*, Numéro Spécial 284: L'ordinateur au doigt et à l'oeil.

In contrast to VR, which isolates the user inside a simulated world, AR augments the perception of the everyday world with communication capabilities and digital information, which is contextualised and delivered in real-time. AR provides contextual information, overlaying it on the images of our surroundings and can be accessed in public screens or on our portable devices. Overlaying information in a physical environment requires a tight coupling between the view of the physical world and the image that computers can generate and read about the same. To be digitally augmented the world must be reduced to computable data. Throughout this chapter, I introduced early applications able to extract data from physical space and render it into navigable graphics. The *Aspen Moviemap* maps the space in pictures that stored in laser discs, can be assembled to simulate a surrogate trip; the *L.A. The Movie* interprets geographical data to model a realistic view of the land. The *Supercockpit* rends the pilot view inserting new graphical objects onto it, the information delivered by the multiple navigation computers inside the plane. Artistic interventions such as the *Legible City* assembled different data – the 3D model of a city with textual information- to produce new ways of experiencing the city. Finally, applications such as Google maps rends the aerial view of our world in the grid of Cartesian coordinates, a positional system that allows to geolocate and track the evolution of anywhere on the planetary map. Google maps is a Geographical Information System, a big database of geographical information that can be rendered to constitute a multi-layered map, the product of the assemblage of different technologies, among them, the Blue Marble, the visualization of our earth obtained after the first photo from space was taken in 1946.[194] It consists of a mosaic produced by the assemblage of the images of the land surface taken by the Terra satellites. In addition, the Geographic Position System, the net of satellites put in place by the Department of Defence of the United States in 1973, which enable calculating the coordinates of anything located on the surface of the land that can transmit an appropriate signal. These technologies were assembled to produce an easy-to-use GIS now available from our smartphones, where it is linked by platforms providing Location Based Services.

Rendering these data as images, computers learned how to read any image of our world as data. Computer vision combined with learning algorithms has become able to recognise a screened image, browse it in a database and link it to additional information as geolocation, sound, text or other images. Once the computer traces the image of our surrounding space, it can overlay interactive graphics to it, augmenting our perception of it. One application of Augmented Reality is the *Telescope of Augmented Reality* sited in the *Arc du Triomphe* in Paris. This project was developed in 2009 at the Laboratoire Paragraphe/CITU from The *Université Paris 8* and directed by Maurice Benayoun. It consists of a tourist telescope sited on the top of the monument. The telescope offers viewers an image of the panorama with overlaid information about the history of highlighted places. Another example is the *Augmented Asbury Park* realised by Edward Johnston, Michael Richison and Marina Vujnovic and presented at ISEA 2015.[195] This proposes a mapped drift across this historical amusement park from New Jersey. Users can use their smartphones on the indicated places and see overlaid a 3D reconstruction of the nowadays missing historical building. Augmented Reality has been applied for different purposes and fields of research such as the production of training environments, the recovery of historical heritage, the improvement of workplaces and for entertainment purposes. It has become available in our mobile phones by means of REST web services, such as that delivered by the *Layar* application and is being developed in more wearable devices such as the popular *Google Glass*[196] or the *Hololens* now in development by Microsoft and Magic Leap[197], Easy to wear head-mounted displays that allow superimposing digital information on the field of view of the wearer.

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194 http://www.airspacemag.com/space-exploration/FEATURE-FirstPhoto.html

195 Edward Johnston, Michael Richison and Marina Vujnovic (2015) "Augmented Asbury Park: Disrupting the Present with Remnants of History in Augmented Reality" at *Proceedings of the 21th International Symposium on Electronic Art. ISEA 2015-Disruption*

196 https://www.google.com/glass/start/

197 http://mashable.com/2015/10/20/magic-leap-augmented-reality/#1mnNbfSFssqp

At the same time, new ways to tag the physical space have been developed, such as QR codes, which can be disseminated on physical space, and when scanned by a mobile phone app these give access to the linked information stored on the World Wide Web. New networked devices have been embedded in our physical surroundings able to sense physical phenomena and process it as data, which are retrieved from the net and computed to deliver a response. All these new technological agents are leading to the increase of our space, a new paradigm that is being developed in research fields such as Ubiquitous Computing, tangible interfaces, wearable computing, intelligent buildings, intelligent spaces, context-aware computing, ambient intelligence, smart objects, wireless location services and sensor networks. All of them are approaches that are embedding computation in our daily environment by means of translating all our surroundings and even ourselves into operable data, laying out a space where everything is tracked and positioned. The question examined by the "*Software*" exhibition *"What is to live in the new computerized environment?"* is becoming an urgent subject to confront as we are immersed in interactive procedures. The augmented space will be incorporated into our daily environment changing our perception and interaction with the urban space and laying out new forms of administration at the same time as new possibilities to design it. Our cities will become Postdigital.

2.2 THE ALGORITHMIC MANAGEMENT OF DATA

> *"Indeed, the opposition between the notion of virtual reality and ubiquitous, invisible computing is so strong that some of us use the term "embodied virtuality" to refer to the process of drawing computers out of their electronic shells. The "virtuality" of computer-readable data -all the different ways in which it can be altered, processed and analysed- is brought into the physical world".*[198]

Embodied Virtuality is the term proposed here to refer to the constitution of the new Apparatus that is shaping our epoch. It is the net of practices, forms of knowledge and relations of power stemming from the encounter between human and non-human agents in the conformation of the ubiquitous technological system we are immersed in, and that here is considered simultaneously from the standpoints of its material foundations and the politics it involves. Embodied Virtuality is the result of a complex assemblage conducted by the principles of discretization and programmability. In other words, the codification of our reality attained after considering information as a quantifiable molecular unit, the bit. This unit is able to abstract any entity from our reality to the flow of data transmission of a new media ecology that is pervading our entire world. This ecology correlates with a new understanding of reality. Henceforth, reality is not considered anymore as constituted by independent entities defined by their attached representations, but as emerging from the ongoing interactions between the molecular entities forming a topological surface, where movement and change are continuous. The ecology composed by the cultural dynamics of our hyper-connected society is defined by the processes of a technology that mediates all the processes by means of which we index, sort and model our reality that now becomes translational entities modulated as computable data. The processing of this data is now able to simulate the ontogenetic processes from where our reality emerges. Therefore, Embodied Virtuality is the space of a new epistemology, whereby the entities forming our world are abstracted to data and reordered in an isomorphic model, inside a machine that by virtue of its capacity of computation can explore all possible spaces. Simulations can play the role of laboratory experiments in the study of emergence, complementing the role of mathematics in deciphering the structure of spaces of possibilities in which the behaviour of the equations refers to the pattern generated by their numerical solutions as presented graphically by the plot. The increasing capacity of computation, its recursion and coupling between states, transforms static mathematical models into dynamic computational processes. This capacity of simulation gives Embodied Virtuality a large capacity for both control and creation at the same time.

Computers can explore possibility spaces, all the ways in which a system can change, in a rigorous way, because the interactions in which capacities are exercised can be staged in a simulation and varied in multiple ways until the singular features of the possibility space are made visible. Therefore, all the possible ways in which the system can change can be predicted. This leads to a new exercise of power based on pre-emption. Pre-emption is not prediction but anticipation, the foreclosure of the singular by means of its modulation into a pre-defined set of probabilities. At the same time, the capacity of modulation that forecloses uncertainty can be exploited towards the encounter with always-new singular features that can make the system mutate out of control.

As computing is becoming ubiquitous, simulation and its attached capacities for control and hacking are moving out of the field of experimentation enclosed in labs to expand to our entire milieu. The ubiquity of computing is not only due to microprocessors and fast network connections allowing embedding computation into physical objects, but also due to the capacity of virtualization of its technological components; hardware, software, data structures and processes of encoding meshed in the computer as a meta-medium, where all the systems converge.

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198 Mark Weiser (1991) "The Computer for the 21st Century"

The emergence of computers was framed in the Second World War, a moment of exception that stressed the collaboration between the production of military weaponry, scientific research, and industry; they assembled in the Iron Triangle, an institution that continued during the Cold War and the related Space Race. In this situation, researchers and practitioners from diverse fields met around the production of a machine able to automatize the processing of complex data sets and to distribute its resources to improve collaboration. This machine was the space from which emerged a set of inscription processes, facilitating the production of hybrids or quasi-objects characterizing techno-science. It was involved in the most significant scientific events that shaped our epoch, from the launch of the atomic bomb in 1945 to the mapping of the human genome in 2003.

The agents traditionally used to translate the circulating references – such as maps, pictures, archives, techniques of measurement or blueprints - across the cascades of transformations, which according to Latour, form scientific knowledge. They all become digitized, arranged as data structures and rendered into the screen, where by means of wired transducers they could be navigated, multiplied, assembled to other systems and modified in real time. What is at stake in this abstraction of reality to data is not an operation of indexing that establishes referents to immutable entities making it representable, but the constitution of reality itself: the auto-spatialization of the relations of an active or dynamic object in communication with its environment. The models constituted by this process do not become projections inside the flattened space of Cartesian coordinates but instances of the auto-ordering of matter. The map is an example of this transformation. It will no longer be a static representation of a territory, but a navigational tool able to perform the territory on its own. The map will become a multi-layered information system, able to harbour heterogeneous data towards the constitution of a multi-featured space, where all data can be linked to simulate any kind of geolocated phenomena.

The net woven around Embodied Virtuality becomes a Rhizome that spreads beyond labs to offices, design workstations, industrial factories, even to art studios, where it will benefit from the investment of a wealthy entertainment industry that will foster its development at the same time as spread its practices into daily life. Computers will be embedded in our spaces of dwelling and our bodies. Computation will be applied to the understanding of our bodies and their enhancement. We will become the cyborgs of the non-human turn, no longer natural subjects acting in an artificial world, but relational nodes meshed into an ecology of human and non-human agents that determines our affordances, making us make.

Beyond the labs, computers are applied to production and economic management. Once computers become networked, production and finances could be managed from economic hubs and carried out in remote sites. Therefore, computers become meshed into the globalization that characterizes our geopolitical landscape. In addition, they will become the production system of a new entertainment industry aimed to the production of films, video games, and immersive spaces. These become big productions assembling all visual and performing arts to produce a high fictional simulation of our reality with which we interact by means of coded processes. Finally, computers will spread to homes and our bodies, firstly, as personal computers, entertainment systems and embedded in domestic appliances to become, later on, transformed to the always at hand communication devices that we know as smartphones. Integrated into our daily environment, computers could become enhancers of our creativity and knowledge. Networked computers laid out a space for encounter, which multiplies the Collectives we can participate and become involved in, at the same time as our instances for subjectivation. From the standpoint of the proponents of the Postmedia epoch, this meta-medium was understood as a meta-network of communication structures where interactivity is not only human-machine communication, but also social interaction. Meanwhile, for the first theorists of cyberspace, it became a new public sphere, the cresol of a new democracy characterized by its openness, freedom and anonymity.

Cyberspace was defined as a hyperlinked space emerging from the interactions of its users as a Collective Intelligence. The universal archive collectively contributed, geographically disseminated and continuously evaluated in real-time. This archive evolved from the hypertext system linking documents inside the universal

addressing system of URLs to incorporate metadata structures, which converted the actions and contributions of users inside the platforms of the Web 2.0 to machine-readable information. In this way, the architecture of participation producing this milieu encounters with algorithmic control.

In this milieu, data comes from everywhere. It can be user created by means of indexing content, but also registered by the tracking of the user's actions and created by networked machines sensing the physical milieu. The data produced as a side effect of our actions gives birth to the nowadays popular phenomenon of Big Data that characterizes our Datacentric Society, a society where the value and power of any institution depends on its capital knowledge; namely, the capacity to assemble large quantities of data and extract meaning from them. If initially internet was planned as open-system architecture, nowadays it is being bound by the companies that are providing applications to access it, at the same time as they store and privatize the data traces produced by their users.

Algorithms are working in all the processes of information that shape our culture. We produce information by means of programs. Image, text, and music processors are programs aimed at producing and manipulating these documents after arranging them as data structures and as relational tables, pixels, voxels and so on. These data structures are compound forms, multivariable, whose purpose is to facilitate to arrange logical aggregations of data in ways that dedicated programs and hardware can perform complex operations on its members. These documents are distributed on the web according to programmed protocols, and retrieved using browsers, which algorithms index information regarding its content and our preferences. Finally, data is analysed by mining algorithms able to rearrange it and extract patterns. These procedures, by virtue of which every interaction is coded and assembled into data structures processed by a distributed power, is leaving internet and user interactions to be disseminated in physical space. This occurs after affordable sensors become attached to physical objects that in turn become connected to the Internet and its capacity to process information, which nowadays is migrating from the Big Data centres of the Cloud to the disseminated small processors of Fog Computing. The progressive incorporation of computing into our daily environment is embedding our inhabited space into a new media ecology. This is becoming a self-referential system, which functioning cannot be understood by the detachment of its interrelated parts from its synthetic consistency. Ubiquitous Computing is a relational milieu that evolves with the interactions performed on it, which are mediated by opaque algorithms of which we are unaware. The systems mediating this milieu are now evolving from pull technologies, in which we interact asking for contextual information, to an interruption paradigm, where artificial intelligent algorithms can predict our actions and deliver filtered information about our surroundings in an anticipated way. Nowadays, systems of Ubiquitous Computing are performing in our spaces of dwelling, creating discontent. The capacity of surveillance of these systems, due to their interior interaction requires us to be incorporated into the system as traceable data, threatening our freedom and agency. These systems interface our perception of the environment, anticipating our needs and filtering our affordances in it. This behaviour leads to a new form of control based on the predictive capacities of a machine that computes possibilities until exhaustion. Finally, the relationality and fast processing of this milieu, in which everything becomes simultaneous, threatens our duration as a condition of creation, and of our participation in the production of our space..

Algorithms are multi-scalar entities with multiple dimensions and working at different levels of abstraction. They can be expressed as sentences in natural language, mathematical formulas, flow charts, operative code and always work meshed in an assemblage of hardware, software, data structures, computer architectures and available resources of speed and memory storage. Focusing on the pragmatics of these entities and considering how they enact our world involves opening the black boxes that form the systems in which they are embedded, that is to say, the critics of its material foundations.

The tradition of studying the material foundations of software is well established. It stems from Kittler, but also from the materialistic interpretation of Deleuze's ontology. We have already quoted the work of Katherine Hayles examining the changes produced in reading and writing after the digital-analogous double

nature of hypertext and the critical texts of *"Software Studies"* about particular software objects, languages, and structures edited by Matthew Fuller. We can also quote the analysis of the evolution of cultural software carried out by Lev Manovich in his book "*Software takes command*". We can add other well-known essays; the research into viruses conducted by Jussy Parika, where the author analyses viruses and worms as immanent expressions of computerized media culture. They show the genealogical traits of media condition emphasizing adaptability, automation, complexity and bottom-up intelligence. The application of forensic practices to the information stored on discs by Kirschenbaum on the study of analogue and digital patterns. The analysis of the Atari Video Console and the technical implementation of new platforms of gamers, where technologies sustain interactions and offer an epistemological framework from where social and cultural practices emerge, explained in the book "*Racing the Bean"* by Monfort and Bogost. The examination of the specific materialities of NoSQL databases and the shift from the relational model to a more granular way to produce and manage data arising from platforms, by Paul Dourish.

All these materialistic approaches to digital technologies involve understanding these technologies as assemblages, emergent wholes where hardware and software entangle with representational spatial practices, rules of use and conventions emerging from multiple levels of abstraction and diverse domains of practice, emergent wholes that results from a history, the evolution of the encounters among Collectives of human and non-human agents, in which material constraints and possibilities are involved, at the same time as need interests and relations of power. These result in material compounds with political implications. This essay lays out a less exhaustive but broader analysis of the complex net of Collectives from where the big assemblage of our media ecology emerges. Focusing on three of the main nodes of this net, the Personal Computer, the Internet and Computer Graphics, it identifies its main components, and traces its paths and encounters, through diverse systems and fields of application, where it mutated and opened new possibilities. The aim is to lay out the map of the production of these new wholes and their interconnections until forming the new diagrammatic space, based on circuitry and operating through the algorithmic management of data from where the virtualizing Apparatus that has abstracted our entire world to automated processes emerge. It deals with how the big Space of Transformation that has become networked computers and how it has been disseminated to all fields of life is assembled.

It follows a short summary of the Net traced in this chapter and the spread of Embodied Virtuality to our entire milieu.

The construction of this space started a long time ago, with the reduction of the quantified processes producing the extensive space to algorithms, sets of repeatable instructions that can be automated, that is to say, carried out by a machine. This machine became programmable, by means of relocating the movable parts, which materialized the algorithm in the machine, and universal with the Turing-Newman architecture of the stored program, which was codified as data and performed by switching relays of circuits. These circuits became tightly assembled and black boxed in the Integrated Circuit. These chips translated processing capacity from mainframes to individual workstations, personal computers, video consoles and even everyday objects. At the same time, programming was no longer the arrangement of plugs and wires in the mainframes, but coded expressions of the processes of the machine, which could be operated from networked terminals. The development of compilers separated program languages from machine code. High-level programming languages did not codify operations on the machine but a model of our world resulting in the assembly of the abstraction of any possible entity. The Unix architecture rearranged machine processes in separate modules, towards a system where complexity emerged from the interaction between its parts, which could always be increased, contributed to at different times from different Collectives and aimed at different purposes.

Meanwhile, computers became networked, first by terminals that allowed sharing and indexing of the documents stored in a mainframe and access to the programs stored on it by means of time-sharing systems. This system was decentralized and disseminated towards a net of networked personal computers with the processing capacity, after the development of packet-switching and the hypertextual addressing system

of URL's that formed the web. As the volume of transmitted information increased, the information was automatically filtered using metadata, first provided by the already setup schema of relational databases and later on by the granularity of attribute-value systems where the database emerged from the variegated items incorporated in the platforms of the Web 2.0. Programming moved from the connected computers to the net. First sited on the big servers of data centres of cloud computing and later on, with the division of tasks, to small processes operated by the technology of map-reduce, to the entire net. The net mutated from a space where people interact between them, sharing and tagging documents to a space where programs cooperate and mashup sharing data and code by means of technologies such as API and Ajax.

The interaction between humans and machines is mediated by input-output peripherals, attached to the machine that allows visualizing information and transducing with the system to retrieve and operate this information. The first input systems were keyboards allowing enter commands to the system to operate data, which, after some time, were outputted by printers. Direct manipulation emerged after the firsts screens were attached to computers. The first machine with an attached cathode ray tube was the Whirlwind, a machine incorporated into the war system and aimed at controlling aircraft positions: this display was the first one devoted not to monitor machine processes, but processes in the physical world. This first computer generated landscape yield to the first operable objects in the Sketchpad system. Here, the lightpen works as a transducer translating its change of position in real space to the screened space by means of a data structure. The vector codifies the control points- position and direction- to the mathematical expression of a geometrical figure, which can be operated on the screen. The lightpen became a joystick in the first computer games and a *mouse* in the personal computer. At the same time, the data structure evolved to allow 3D object reproduction. New input devices such as scanners transformed the image into a new data structure, the grid of pixels of the raster image, where any point of the image was reproduced as a point on the screen by means of the electron beam. Space reproduced on the screen became able to support a realistic simulation of our world composed by graphical objects with a programmed behaviour. This projected space became a space where scientists could reproduce and visualize the complex process, and at the same time, a space where designers could speculate and test physical spaces and machines. In addition, it was the Graphical User Interface, the symbolic handles to access the available options of the running programs. The GUI constrained the universal machine and converted it from a programmable space- the space of a new education and culture- to a media system from where to contribute and retrieve information. Finally, it was the space of a new simulated reality, rendered in real-time and modified by the actions of its users, that once on the internet became the metaverse, a new playground emerging from bottom-up actions where humans met by means of their digitized surrogates. With the development of VR, interaction became tangible after new devices appeared capable of translating our position and movements inside the dataspace. This simulated space projected to more immersive environments was linked to the physical world thanks to the development of geographical position systems and computer vision.

If cyberspace was traditionally visualized as a network of links, the space of Embodied Virtuality is laying out a new topology more likely to be figured as a cellular automaton, the abstract machine envisioned by Newman to shape an auto-reflexive and evolvable system. In this cellular automaton, every cellule works as a placeholder for a datum, that becomes an agent able to affect and be affected, according to a program that positions every possible input to an indexed space and defines the machine's behaviour. This behaviour consists of the order in which the change of state of a switched cell will transduce to the neighbour cells to draw a trail actualizing a new state on the machine, which will be interpreted as information, a readable text, image, music or new data able to switch a new cell and start a new transductive path. This space will foster a new epistemology linked to a new aesthetics working to make apprehensible the Ontology of Becoming the objects and actions emerging from the reciprocal Transductions of the cells observable at different granularity levels. These patterns are not related to any pre-existing cause but the regularities emerging from the continuous production of matter. It is a meta-model able to reproduce all the possible appearances of matter. As we will see in the next chapter, new technological assemblages joined this net and translated its capacities from simulated models on the screen to the management of our daily environment. The space of

Embodied Virtuality becomes not only able to show the Expression of matter, how it reaches existence, but to program its Becoming.

Otherwise, this diagrammatic space is not a grid but a chaotic milieu from where partially stable systems emerge with the potentiality of open-ended becoming, a diagram capable of representing any possible thing in the world as patterns of off-and-on-switches and that can be always reprogrammed extended and coupled with other diagrams. This diagram is the basis of a new techno-scientific ecology in which humanity is involved and where creation and the proposition of new forms of life could only be attained as Disruption.

The opaque algorithms of corporate companies are dominating this diagrammatic space. Algorithms are recursive and homeostatic performative expressions that filter reality, and accordingly its capacity of prediction. They reduce uncertainty by means of a modulation that deprecates all that is not predefined in its program as noise. Disruption will be the practice of an aesthetic of engagement that appropriates this space towards its intensification, the incorporation of noise as a difference able to actualize unexpected states. This practice involves going beyond the interface and its under-concretization to promote participative knowledge. The recovery of the Technicity described by Simondon, the transductive process for which information is no more a quantifiable abstract entity, but recovers its ontological value as neguentropy. The incorporation of unexpected datasets, the coupling with other systems, the submission to unexpected uses and the production of new transducers are all activities that imply considering computers not as a media system but as an embodied programming machine. Programing becomes a speculative activity able to produce new Nets of practice and knowledge. The aesthetics of this system is not in its capability to reproduce high definition representations of our world but on its poetics, its openness and capacity to encounter other systems towards the exploitation of its Virtual potentialities. New technologies have been developed and made available to a wide range of users that allow embodying this Apparatus and transducing with it to know and change the system. In the next chapter, we will see the technological developments that meshed computation in our space at the same time as opening these technologies to a multitudinous use, multiplying its fields of application. Data Visualization, Physical Computing, and Digital Fabrication are technologies taking part in the embedding of computation in our physical space. However, they can evolve into appropriated practices leading to new Spaces of Transformation and the production of new things to meet new Collectives and their situated problematics. The open data, DIY, DIWO, maker, citizens science and related movements are the spaces of a micropolitics engaged in the production of alternative spaces of practices and knowledge from where new forms of life can emerge.

3. POSTDIGITAL RESEARCH. THE WORLD AFTER THE DIGITAL REVOLUTION

"The stakes, this time, are unusually high. A mobile phone is something that can be switched off or left at home. A computer is something that can be shut down, unplugged, walked away from. But the technology we're discussing here –ambient ubiquitous, capable of insinuating itself into all the apertures everyday life affords it- will form our environment in a way neither of those technologies can. There should be little doubt that its advent will profoundly shape both the world and our experience of it in the years ahead."

Adam Greenfield (2006)
Everyware. The dawning age of Ubiquitous Computing.

3.0. THE POSTDIGITAL-CITY

> *"The modern city exists as a haze of software instructions. Nearly every urban practice is becoming mediated by code."* [199]

The changes occurred in urban space after its encounter with new media technology was a subject explored at the beginning of the Digital Revolution. The Architecture Machine Group, founded in 1967 by Negroponte at MIT, worked in methods to arrange data spatially with the aim of transforming computers into an empowering tool to manage our environment. This aim led to the creation of design tools allowing dwellers to collaborate in the design of their habitats towards the proposition of a participatory urbanism. The same group also produced the work *Seek*, shown at the "*Software*" exhibition, demonstrating how an artificially intelligent machine can rearrange our habitat accordingly to a preprogrammed plan and despite our actions. This project envisioned the embedding of computing technologies in urban space and the shift of focus this entails, from using computers for the understanding and scientific analysis of space to their use in space management and planning. Batty pointed at this change in 1979 and attributed it to the increasing availability of data produced in real-time on the web.[200] If at the beginning, computers were used to store and process data useful for city planners, nowadays they are operating real-time financial transactions, monitoring traffic and transportation flows, and mediating the perception of our space by means of interfaces to navigate geographical data in. Batty quotes some examples such as the CALTRANS system, developed by the California Department of Transportation and the GeoWeb, an interface for accessing geographical information on-line. It was begun at SUNY-Buffalo in 1995 by Brandon Plewe. As we have already seen, computers also allow simulating the evolution of space, as in the simulation of the urban growth in the San Francisco Bay area put on-line by Len Gaylos. This consisted of an animation morphed from maps and satellite imagery from 1972 until nowadays. In addition they are used for navigating virtual cities such as the already quoted Digital City and GeoCites, and Cyberville, put on-line by the National Computer Board in Singapore.

The changes produced by the linking of our habitable space with the internet was also considered by William J. Mitchell, who followed the tradition initiated inside the MIT Media Lab, working on the planning of cities after the Digital Revolution. In his book *"City of Bits"*, Mitchell argues: *"the crucial issue before us is not one of putting in place the digital plumbing of telecommunications links and associated electronic appliances, nor even of producing content for electronic delivery, but rather one of creating electronically mediated environments for the kinds of lives that we want to lead"*.[201] Mitchell considers cyberspace as anti-spatial, incorporeal, fragmented and asynchronous and mulls about the changes that city planning must afford to produce a city inhabited by cyborgs with new spatial needs due to telepresence and the conversion of information to bits.

The Bit City will be:

> *"This will be a city unrooted to any definite spot on the surface of the earth, shaped by connectivity and bandwidth constraints rather than by accessibility and land values, largely asynchronous in its operation, and inhabited by disembodied and fragmented subjects who exist as collections of aliases and agents. Its places will be constructed virtually by software instead of physically from stones and timbers, and they will be connected by logical linkages rather than by doors, passageways, and streets."*[202]

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199 A. Amin and N. Thrift (2002) *Cities: Reimagining the Urban*, pp. 125

200 Michael Batty (1997) "The computable city"

201 William J. Mitchell (1995) *City of Bits. Space, place, and the Infobahn*

202 William J. Mitchell (1995) <op.cit.>

In this city, the main civic activities such as labour, entertainment and, consummation will converge in computers, becoming the new focus at home and redefining the public-private boundaries, at the same time as making unnecessary the categories and rites of passage that identify the use of public space and make the city an interpretable place. In the connected city, buildings will become programmable interfaces produced by a combinable architecture and public spaces will become nodes providing connection to the infobahn.

Later advances such as Augmented Reality, Ubiquitous Computing, and Tangible Media linked bits and atoms in such a way as computing became mobile and distributed into local places. As we will see in the next chapter all these technologies relate in position and traceability, location becoming an identifying tag. After computation will be embedded in the physical realm, the context will be evaluated again and the anti-spatiality and asynchrony that characterizes cyberspace will be substituted by attention to the context and real-time. The city will be understood as a processual complexity, emerging from the real-time tracking of the relations and movements of entities positioned inside the Cartesian grid.

Nowadays, the answer to the question outlined by Mitchell: *"How should virtual and physical public space relate to one another?"* is continuously swinging between new technologically enabled possibilities; the deterritorialization and impoverishment of the urban periphery after the main economic activities moved to the networked hubs of the globalized world versus the overload of information in our space provided by the devices and facades equipped with Augmented Reality applications. The localization of urban activities and their algorithmic management versus the ephemeral occupations of the space by new Collectives assembled on the net. The standardized solutions of computerized efficient management versus the proposal of situated solutions developed locally by engaged citizens. Culture and history producing a flesh and stone city versus the deterritorializing power of networks.

The space proposed by Mitchell considers the city and its structures as an interface to the cyberspace and its delocalized linkage. However, the overlaying of the internet in urban space is not the laying out of access to the new immaterial realm, but the scattering of new localized technological agents with the capacity to enter into productive relations of Transduction. Rather than the ephemeralization of space, we attend to the possibility of its *'automatic production'*.[203]

Lefebvre[204] characterizes space as a social production, a collective process that cannot be explained by the traditional epistemologies focusing on the individual. The practices that codify, plan and construct our cities do not result from an individually predefined design but emerge meshed in a pragmatics implying an ensemble of relations between multiple agents, a complex production that evolved through time according to the technologies and transformations of the informational space, in which the possible channels of communications layer different typologies of form, from the closed cities shaped by feudalist regimes to the abstract space laid out by the operations of advanced capitalism. The latter is characterized as a space homogenized by the logics of control and surveillance, strongly hierarchized and segregated in functional parts. It is shaped by a logic of vision inherited from the perspective that frames our distance and involvement from and with places, at the same time as it pushes into the background of our perception the dysfunctional assemblages that populate the suburbs. Finally, the implementation of new technologies lead to what Castells calls the space of flux, the spatial logics of the nets producing globalization and forcing the dissolution of all spaces that are not connected to the global systems of production and management, becoming impoverished and unable to foster cultural relations.[205]

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203 Thrift, N. and French, S. (1994) "The automatic production of space"

204 Henri Lefebvre (2000) *The production of Space*

205 Manuel Castells (1991) *The Rise of Network Society. The Information Age: Economy, Society and Culture. Vol I*

To give an account of the ontogenesis of this complex space Lefebvre conceived the Unitarian Theory of Space, the analysis of space from three standpoints actuating simultaneously: the practiced, the conceived and the lived as intertwined in space production. How has the realization of the utopian technology that is able to simulate and program the future in our everyday life affected urban practices? How is the practiced space affected when the codes that define behavior are updated by intelligent machines able to mutate and adapt to our actions? Which conceived space is laid out by the new cartographies modeled in real time by the capacity of simulation of computers such as multidimensional and navigable surfaces? What capacities of appropriation of lived space do users (*usageurs*) have that have now become augmented bodies capable of leaping between multiple spaces and regimes of proximity?

The texture of our space is now constituted by data ontologies and sequences of commands, a new process of inscription, producing data with the capacity to auto-spatialize in a topological surface, the linearity of inherited transcendental principles substituted by the Big Here and Long Now laid out by the enacted multiplicities of Embodied Virtuality. This space entails a new ontology, epistemology, and politics that can be concretized in questions stemming from the analysis proposed by Lefebvre. What is the role of code in the spatial formation of everyday life and how is the *'programmable city'*[206] managed, planned and built? How is the capacity of tracking the fluxes described by the multiple uses and structures of space visualized in new mathematical models with a capacity of auto-completion and prediction? Finally, what are the capacities for the appropriation and hackability of this space towards the proposition of new futures?

The Practiced Space is being territorialized by computing processes. The fabric of everyday life becomes weaved into the circuitry of new artificial agents: automated cars, traffic and weather monitoring systems, navigation and guidance appliances, surveillance cameras and CCTV security systems, power grids and cash machines, are some examples of systems being introduced into our urban space that work with coded protocols of data obtaining and processing. The software meshes in powerful assemblages such as transportation systems, those providing the supply of resources, and in the more everyday aspect, related to personal communication and entertainment. As a result, a set of everyday tasks, domestic chores, work, shopping, traveling, communicating, governing and policing are mediated and modified by software. Computerized processes are changing how social, economic, and spatial life takes place, being performed by new artificial agents acting on the ecology of our spaces of dwelling and provided with what Mackenzie characterizes as *'secondary agency'*[207].

All these systems work retrieving and processing data. To the already massive production of data as a result of our interactions with the internet, nowadays accessible from everywhere, we must add the automated data produced by all the systems of Ubiquitous Computing, a deluge of data that is sustained in the advances in database design and systems of information management, the increasing capacity of storage at affordable costs and the new forms of data analytics. Big Data offers the promise of an objectively measured and real-time analysis of the functioning of urban infrastructures and the daily ongoing of urban life at a relatively low cost. The traditional procedures of data obtaining and statistics rely on samples, are generated on a non-continuous basis with a relatively small number of variables and aggregated in a relatively coarse spatial scale and limited access. These are complemented by 'small data', expensive methods such as surveys, case studies, and questionnaires for a more in-depth vision. Big Data opposes this data scarcity with systematic, dynamic, well-defined and fine-grained data obtained at low-cost, this data enabling the possibility of real-time analytics and adaptive forms of management and governance. The availability of fine-grained datasets, characterized by their relationality and plasticity, has led to a new paradigm in city planning and management, the *smartcity*.

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206 Kitchin, R. (2011) "The programmable city"

207 Adrian Mackenzie Wark (2003) "Transduction: invention, innovation and collective life"

Kitchin characterizes Big Data[208]:

- Huge in volume, consisting of terabytes or petabytes of data;
- High in velocity, being created in or near real-time;
- Diverse in variety, being structured and unstructured in nature, and often temporally and spatially referenced;
- Exhaustive in scope, striving to capture entire populations or systems (n = all), or at least much larger sample sizes than would be employed in traditional, small data studies;
- Fine-grained in resolution, aiming to be as detailed as possible, and uniquely indexical in identification;
- Relational in nature, containing common fields that enable the conjoining of different data sets;
- Flexible, holding the traits of extensionality (can add new fields easily) and scalability (can expand in size rapidly).

The smartcity is grounded in technological *Solutionism*. [209] This is the conviction that the smart administration of resources will result in a sustainable and efficient environment, as well as a neo-liberal approach that considers the city as a pole of attraction for entrepreneurship and innovation towards economic growth. This new paradigm in city planning is concretized in a technologically-enabled city that is characterized by the real-time understanding and control of urbanity enabled by Big Data, where the processing of data improves the performance and delivery of public services and the fostering of participation by the openness and transparency, which is promoted through web platforms that deliver urban data for its reutilization, fostering participation in the improvement of the urban space.

The *smartcities* are built upon the fast evolution of the embedding of Ubiquitous Computing in physical space. Able to communicate between them, the systems of Ubiquitous Computing are characterized by relationality and attention to the context. If programming was first aimed at the accomplishment of specific tasks, these systems stress situatedness of action and the importance of interaction and adaptation, characteristics that confer emergent properties to them.

Ubiquitous Computig accomplish feedback functions of control and regulation. Their capacity to sense and actuate in the environment is increased by the attachment of more sensors, which increases the variety of inputs, the implementation of artificially intelligent algorithms, which augments their capacity to infer knowledge of the environment, and the attachment of actuators, increasing the range of outputs, which give them more options to act and modify the environment.

The ubiquitous systems entail a wide range of concerns about the challenging of participation, and social management of space. The systems of Ubiquitous Computing actuate in the background, out of range of our perception. They becoming what Thrift calls *'technological unconscious'. "Software in the shape of embedded systems is now so widespread that we are no longer able to know it's extend"*.[210] They are sustained in a fuzzy and relational logic. We are unaware of being involved in their processes. This emergent functioning drives

208 Robert Kitchin (2014) "Big Data, new epistemologies and paradigm shifts"

209 Evgeny Morozov (2013) *To save everything, click here: Technology, solutionism, and the urge to fix problems that don't exist*

210 N. Thrift and S. French (2002) "The automatic production of space"

Greenfield to point to the loss of agency produced when we are engaged with them.[211] These intelligent systems become imperceptible assistants that are substituting our capacities to orientate and interact in space for a continuous monitoring and guidance. Greenfield also stresses the concerns about the modularity of pervasive systems. The Unix philosophy established a modular way of implementation and production of computing, the performance of a system emerging from the interaction of independently produced and assembled parts, which are aimed at specific functions. As complex computerized assemblages are being meshed into our daily activities we are becoming dependent on a system from which in the case of failure nobody has whole knowledge. To this list we can add that ubiquitous systems are recursive. Even with their emergent capacities, these systems work applying already implemented solutions to anticipated problems. The capacity of computing multiple probabilities and their outcomes is applied in these systems towards a pre-emptive control that reduces contingency. This results in the inability to foster and manage new events. The invisible architecture of computing is not aimed at representing but at pre-programming urban space.

To these concerns, Kitchin[212] adds the problems stemming from the fact that Big Data is biased. Even with its extension and supposed neutrality data is always situated. Data does not exist independently from the purposes and goals directing its gathering, the technological systems producing it, and the Collectives engaged in conceiving and managing it, in addition to the policies that regulate its management, privacy, and protection: *"raw data is an oxymoron"*; *"data are always already 'cooked' and never entirely 'raw'"*[213]. Kitchin also points out how the *smartcity* is fostering the technocratic government of the city, and centralizing power and decision making into a set of specialized offices implementing corporate solutions. This technocratic governance is not primarily fostered by the social but by the interests of big enterprises such as Cisco and IBM. Big Communications companies envision the development of new technologies related to Ubiquitous Computing as the *smartcity* and the Internet of Things as a new highly profitable market niche and they try to lead it by means of the development of standardized solutions to be applied globally, in spite of the cultural and geographic specificities of the targeted places.

The last concern attains to the major capacity of surveillance and segregation of these systems, which Graham names *'software-sorting'*[214], the capacity of computerized assemblages to regulate our access to space. Systems such as the enrooting of merchandises and passengers in airports or electronic ticketing in ground transportation -based on biometrics and traceable embedded circuits-, geographical information systems (GIS) -filtering the consumption and production of urban neighbourhoods-, and closed circuit television surveillance (CCTV) -implementing facial and gestural recognition- are creating spaces where the physical meshes with electronic mobility. These spaces are characterized by the setting up of allocated points where algorithms are exercising an action of filtering. The algorithmic management that functions in the social platforms, discriminating and filtering the access to information, is translated to the physical space by means of networked objects able to sense reality. Software-based access and the electronic legibility and representation of space are emphasising social inequalities and facilitating new forms of political intervention. Mediating our perception of space by means of the new cartographies of data modeling, these systems are not only regulating our access and allowance of circulation through space, but also filtering our affordances in it, in a way that some places are not perceived as not allowed to certain people but are simply effaced from their field of perception.

The Practiced Space concerns the codification of space, the laws, conventions, methodologies and material resources conducting the use and construction of space. In addition to laying out the imperceptible system of Ubiquitous Computing, new technologies are also changing the way in which the visible layer of our space

211 Adam Greenfield (2006) *Everyware. The dawning age of ubiquitous computing*

212 Robert Kitchin (2014) "Big Data, new epistemologies and paradigm shifts"

213 L. Gitelman (ed.)(2013) *'Raw Data' is an Oxymoron*

214 S. Graham (2005) "Software-sorted geographies"

is built. The processes of architecture had been augmented by technological appliances. The new simulations for the building and projecting of the structures shaping urban space has changed our understanding of the spaces of dwelling. Buildings will evolve from what Simondon classifies as *'first phase machines'*, immutable structures aimed at maintaining stability and control towards *'third phase machines'*, able to improve adaptations and the reorganization of their milieu[215]. Buildings will become able of auto-evolve and to adapt to new conditions in dialogue with their environment and inhabitants.

The space of Embodied Virtuality abstracts our milieu to data, which can be rendered into the screen as manipulable images. Projected onto the screen, space is intensified allowing the production of new unexpected morphologies. In addition, the sensors embedded in our buildings allow the tracking of the multiple flows going through it. Places becoming perceived as hubs channeling multiple encounters, places for negotiation between different uses, materials, economic restrictions and policies of regulation. The buildings become the result of temporal and dynamic processes. Finally, the embedding of sensors and actuators will allow a responsive architecture, producing environments able to perform an affective interaction with its occupants.

The adoption of computers for the design of the inhabited environment allows new processes of form-finding that go beyond the use of the computer as a tool- using applications such as AutoCad, 3D Max or Maya- and in which software becomes an active component in the production and deployment of architecture.

The software can work as a material inside the process of laying out a building. The architect Greg Lynn makes a tactical use of the animation package software Metaballs, produced by Wavefront, inside the architecture design.[216] This software allows laying out a non-Euclidian space, where the objects mutate according to programmed relations with the objects allocated in their surroundings. In this way, the 'blobs', or primitive objects inside the software, combine to create their own space. Instead of locating building blocks inside the invariant grid of Cartesian coordinates, this software recreates a space of reciprocal variation that harbors dynamic elements engaged in complex interactions. In this space, constraints are programmed as possible interactions between elements from where differentiations and the unfolding of unexpected morphologies emerge. In this process, software is not a mediation but the place of an intensified space where the design becomes a meta-model, allowing multiple instances of the ordering of matter. The architectural space emerges from the interactions between heterogeneous elements such as an event space. This procedure materializes in modular buildings, characterized by laying out complex trajectories where movement flows are prioritized as in the *Centre for Fulfilment, Knowledge, and Innovation*, a speculative project conceived for the city of Detroit and showed at the *"The Architectural Imagination"*, the exhibition curated by Log editor Cynthia Davidson and architect Mónica Ponce de León for the United States Pavilion at the *2016 Venice Architecture Biennale*.

Another paradigmatic example of the active intervention of software inside architecture is parametric design.

Parametric design consists of the modulation of heterogeneous data into a continual function. Parameters are variables that relate to other variables. They substitute constants inside the programmed design by ranges of probable values, in a way that sets of variables and their relationships determine the changes of a spatial form.

These parameters become a nexus of spatiotemporal events, capable of evolutionary processing when new variables are at once generated from and added to the set of initial values. In this way, parametric design allows the engineering of the overall levels of form to be manipulated at the same time, through the altering of specific parameters that are able to automatically adjust by building on data such as the gross area, total

215 Mortamais, E. (2015) "Sharing street: Composing multiple uses times and spaces in the today communication phase of urban evolution"

216 Greg Lynn Website: http://glform.com/

building height, and the number of floors. As the alteration of properties results in different outcomes of the overall form, the design can be modified and tested for different conditions, materials, budgets and expected uses. Ultimately, the goal of the parametric design is deep relationality, the real-time integration of the evolving variables of a built environment inside software systems able to create scenarios by responding to or preadapting data.

As we will see in the final chapter, the modulation of heterogeneous data to a continuous input will allow Speculative Production aimed at the Disruption of space, artistic projects that lay out structures that change in real-time according to a feed of endogenous data coming from social interventions.

Regarding the conception of buildings as evolving processes, Latour and Yaneva describe the building not as an immutable object but as an open process, the result of navigation across a landscape of controversial data.[217] They become modulators that distribute the flux of multiple actors.

The embedding of sensors inside buildings allows collecting data that can be mapped to audio-visual systems to produce visualizations of the social interactions evolving in which the building is enmeshed. The *Arch-OS* is part of the i-DAT Operating Systems project, which is managed by the Institute of Digital Art & Technology, and produced by members of the Centre for Media Art & Design Research, in collaboration with members of the School of Computing & Mathematics at Plymouth University.[218] It consists of a software-hardware system aimed at making the data generated by buildings tangible. This set of tools collects data from the building's energy management system, the computer and communication networks, the flow of people and social interactions, ambient noise levels and environment conditions. All this data can be mapped to visualizations and sonifications that link the building with its social use. In addition, the visualizations produced by *Arch-Os* and other similar projects can be projected to the public space by means of reactive surfaces, projection mapping, and digital facades, new ambient displays or interactive nodes inside urban space that modify buildings by the provision of real-time networked information. Mark Goulthorpe and dECOi Architects produced the *Hyposurface* in 2003.[219] This is a pliable surface controlled by actuators able to react to a wide range of inputs. It creates animated shapes that indicate the flow of data. Even if the *Hyposurface* is not featured in building structures but more aimed at artistic and entertainment events, it opens the door to the development of transformable facades. Projection mapping is an ephemeral occupation, an optical illusion that overlays a simulated transformative space onto the surface of a building that changes the perception of the building, meshing it with newly imagined possibilities. Digital Facades are a more stable place of projection. These low-resolution led displays equipped with sensors and the Wi-Fi connection had been attached to cultural centers, where it can be programmed with interactive projects in which streetwalkers can take part. These become a new playground, which integrates the building into the public space. Media Lab Prado in Madrid and another 10 European institutions took part in a three-year initiative funded by the Culture program of the European Union (2007-2013) to create a networked infrastructure of urban screens and media facades to circulate artistic and socially relevant projects.

All these projects overlay a space where the perception of the constructed space shifts from the permanence, separation, and ordering of space to an intensive space of relations.

Finally, we encounter architectonic projects where the embedding of computing is aimed at the creation of a responsive architecture able to make an affective interaction with the building's occupants. The invisible systems of Ubiquitous Computing becoming tangible inside the architectonic space, which is now conceived as a place for interaction.

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217 Bruno Latour and A. Yaneva (2008) "'Donnez-moi un fusil et je ferai bouger tous les bâtiments' Le point de vue d'une fourmi sur l'architecture"

218 http://arch-os.com/

219 http://www.hyposurface.org/

One of the first attempts to create an interactive building was the unrealized project from 1964 by the architect Cedric Price and the theatre director Joan Littlewood. *Fun Palace* had to be a transformable building emerging as conversational processes from the interactions of its occupants. This building-machine conceived with the advice of a committee of cyberneticians was aimed at becoming a space for leisure and the education of the masses. They considered human beings as subjects of learning and control and leisure as a chance to educate the new specialized workers of the modern society. This project is a paradigmatic example of the capacities of control of new technologies. In which technology does not work as an intensification of space but as a cybernetic machine that tracks and calculates the spontaneous movements and behaviours of its occupants. The building is an interactive construct that responds to the actions of the people within it while at the same time shaping them and their behaviour. The architect conceived as the engineer of social space, and their creation a concrete machine for techno-social construction.

Nowadays, the architect Philip Beesley and the Living Architecture System Group are working on the creation of responsive spaces where architectural constructs become performing instruments.[220] In its development, they use sensor-based systems that enable buildings to adapt their form, shape, and function to the occupants and the surrounding environment, towards an architecture where the goal of control and shaping the human is substituted by the laying out of an embodied interactive system able to respond in unexpected manners to the actions performed in its environment.

These places for interaction are developed by design methods involving cycles of dynamic visualization and simulation, and enhanced by design tools such as parametric software. Additionally, they implement distributed machine-learning methods for a more effective sensing of the environment and data retrieval, and experimentation with new materials.

The *Hylozoic Ground* is one of its most accomplished projects. It is inspired by Hylozoism, the ancient perception of life arising out of material. It consists of an immersive, interactive sculpture environment organized as a textile matrix supporting responsive actions and dynamic material exchanges. Building on early steps that have integrated lightweight digitally-fabricated structures, interactive mechanisms and sensor networks within new building structures, the group is now developing functions that pursue empathic feelings and that contain self-renewing metabolisms.

The Conceived Space has also mutated with the embedding of new technologies. Kevin Lynch attributed the legibility of the city to the organization of urban space in a mental image, a frame allowing the interpretation of information and the orientation of our actions.[221] The distribution in urban space of differentiated structures identified as paths, edges, nodes, districts and landmarks are structured in an open order where we organize our experiences and that conducts our orientation inside the space, indicating the allowed transit and use. This order can be interrupted and further developed, attached and overlaid with personal meanings. Thus, it forms a texture where identity, structure and meaning are woven together increasing its deepness until becoming a place. Nowadays, this framing image has been substituted by the tracking and guidance systems performing in our portable screens. Otherwise, the understanding of our space has shifted from meaning and narrative to operation and process. The *'rhythmanalysis'* proposed by Lefebvre[222] was based on the rhythms started by the movement of our bodies across paths and landmarks, starting new resonances able to appropriate the space and produce meaning as a process in which we are able to link space points to our needs, desires, purposes and experiences. Nowadays, this performative process able to narrate our space is being projected onto multi-layered simulations inside the screen, where we are tracked and projected as a translating point. Inside this operative simulation, the randomized wanderings of the Situationists aimed

220 Philip Beesley website: http://www.philipbeesleyarchitect.com/

221 Kevin Lynch (1960) *The image of the city*

222 Henri Lefebvre (1974) *La production de l'espace,* pp. 237

at the tergiversation (*détournement*) of space was projected as a set of points in a switchable layer, and the multiple tales we narrate across space substituted by the complex processes constituting the new, always at hand, interactive map.

As computing has become mobile and distributed in smartphones, our walks across urban space are guided by moving pointers that translate our location into a screened map. Maps are not mimetic representations of an already existing territory, the geographical space, but the performance of this territory by means of a cascade of processes of inscriptions aimed at calculating the possible navigation across pinpoints.[223] The advent of digital maps has stressed the constitution of the map as a navigational interface, changing our perception of the geographical map from a static representation of the immutable outside to a dynamic rendering. The digital map is the result of a process of production involving multiple Collectives and the operational surface, which changes to allow variegated functions and purposes. These maps are space producers that constitute our territory and where space encounters again with time. The GIS (Geographical Information System) is a complex information system, a set of related databases that allow including new features to the base map such as participation, anticipation, and reflexivity, features that add new dimensions to the perceived space and that can be combined to produce multiple outputs, complex assemblages of heterogeneous data delivered through an interface.

The spread of the use of mobile phones equipped with tracking sensors and GIS and the extension of the wireless network through which they communicate has sustained the development of LBS (Location Based Services). These are applications that react to our location in different manners, reporting it to exogenous servers that can manage real-time information for emergency relief and traffic services. Also in more everyday situations, projecting it onto the map of guidance systems or using it as an input for providing contextual information according to our enquiry for services. Finally, using it as a tag, that allows geolocating users contributed information in 'urban tapestries'. These services are negotiating the geography of our cities, in what Graham calls *'splintering urbanism'*.[224] They produce a profile of the user, recording its preferences and most frequented paths and use it to deliver an adapted access to spaces of consummation and leisure that are sorted according to social status and the economic possibilities of the users. In contrast, the practitioners of Locative Media appropriate them. This artistic practice consists of the proposition of alternate uses and experiences of urban space that can be overlaid on the map, as in the *'urban tapestries'* elaborated collaboratively by P*roboscis*. Finally, the geolocated data produced in real-time by these systems has been considered as an opportunity for the study of city flows. Carlo Ratti and his collaborators in the Senseable City Lab at MIT, use data obtained from the localization and tracking of phone users to create *'mobile landscapes',* a graphic representation of the intensity of urban activities and their evolution through space and time.[225] The tracking of mobile data for the representation of space usage was first accomplished in 2002 in the project by Esther Polak and the Waag Society, *Amsterdam Real Time*.[226] In this project, a group of volunteers reported the location of their daily movements across the streets of Amsterdam. These data streams were transmitted to a digital interface, where they appeared as drawn paths. In this way, a map of the city was produced, in which what was shown was not the planned territory but the practiced space resulting from the performative potential of walking.

The tracking of mobile phones allows collecting data seamlessly and on a large scale, and this was exploited in the Senseable City Lab for urban planning purposes. This methodology was first tested in Milan with the collaboration of a telecommunications company that facilitated the Erlang, a phone identifier. This

223 Latour, B., November, V. and Camacho-Hübner, E. (2010) "Entering a risk territory. Space in the age of digital navigation"

224 S. Graham and S. Marvin (2001) *Splintering Urbanism*

225 Ratti, C., Frenchman, D., Pulsselli, R. and Williams, S. (2006) "Mobile Landscapes: using location data from cell phones for urban analysis"

226 Project website: http://realtime.waag.org/en_index.html

information was used to count the number of phones near to a localized communications station. It was then translated into geographical coordinates to be rendered in a heat map, showing the intensity and evolution of space use in this city. This location-based cartography was later used to create a *'wiki city'* illustrating the use of the city in real-time and was refined to create the well known *Real-Time Rome* project, a set of geographical plots showing the mobility of citizens and public transport systems of this city.[227] This project was shown in the *Venice Biennale* of 2006. These visualizations are used to reveal patterns of activity inside urban space and raise questions relating to city planning such as the correspondences between the form and the uses of space, the identification of spaces of congestion and the efficiency of transport systems, as well as to provide services such as traffic improvement or emergency relief.

The methodology proposed at the MIT is an example of a set of new cartographic procedures that overlay the mapping of heterogeneous data to the geographical map. In addition to the data stream originating in the tracking of phone positions, there are projects that map the data obtained from other traceable devices such as the RFID tags attached to our credit cards as in the project led by the Innovation Centre from BBVA in 2014, aimed at monitoring tourism in Spain. Here, the interaction between identifiable credit cards and positioned TPV's allow a map of the tourism concentration and mobility in Spain to be created, as well as informing about the origin of tourists and their consumption preferences.[228] Another source is the data streamed by Physical Computing devices. As in the *Bio Mapping* project by Christian Nold, it consists of the creation of a wearable system that records the Galvanic Skin Response (GSR), which is a simple indicator of emotional arousal, in conjunction with the geographical location of its wearers.[229] This data is used to render emotional maps of the city. Another example is the use of Physical Computing devices aimed at sensing and reporting data about air quality, as in the *Green Watch* project developed by the *Laboratorie Paragraph/CITU* from Paris8[230] or the *Air* project initiated in 2006 by Preemptive Media Lab.[231] It consisted of a public social experiment in which people were invited to use monitoring devices to explore their neighborhoods, collecting data about pollution and fuel burning hotspots. Finally, there are maps geolocating data collected by institutions or contributed by citizens trough web platforms such as the *Oakland Crimespotting* by Stamen Design's, a mash-up between Google maps and the crime database compiled by the Police Department of Oakland.[232]

All these procedures form part of a new field of research that is being named as City Sensing (at the Senseable City Lab from MIT) Urban Computing (initiated by Kevin Slavin and Adam Greenfield in the NYU's Interactive Telecommunications Program) or Hyperurban (at the Laboratoire Paragraph/CITU of the University Paris8) that uses computational methods for the study of the urban fabric and its multiple associated phenomena, the complexity of which is becoming available as Big Data that cannot be processed using traditional methods. They are resulting in the modeling of our space according to different interests and purposes, producing a New Cartography that dissolves the traditional divide between physical and human geography. However, as Berry points, there is no object for the computational device to process without discrete encoding. In the process of transformation of the continuous flow of our everyday reality to discrete data, there is information about our world that has to be discarded.[233] The models produced by the rendering of data promise great efficiency and capacity of prediction, but at the same time they are normalizing our space and the subjects moving across to sets of knowable points. In addition, faced with these maps, we forget our dexterity in interpreting the city signs and our personal involvement in the places we are going across. The texture inside the computational space is no longer the precipitate of experiential events, but the product of the relations between databases.

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227 Project website: http://senseable.mit.edu/realtimerome/

228 Project website:https://info.bbva.com/es/noticias/ciencia/tecnologia/bbva-analiza-el-turismo-en-espana-a-partir-de-las-transacciones-con-tarjeta/

229 Project website: http://www.biomapping.net/

230 http://www.citu-paragraphe.univ-paris8.fr/spip.php?article1780

231 http://www.pm-air.net/

233 David M. Berry (2011) "The Computational Turn: Thinking about the Digital Humanities"

Space is augmented by asynchronous data collectively contributed inside a system that flattens our space into a model that operates at an abstract level and disembodied from the reality that produces these data. These models normalize people, reduce differences, discriminate parts of reality and support concrete institutional frameworks and kinds of knowledge.

Finally, these models, as they are produced from the same procedure of discretization, can be assembled to produce a new 'panoptic view'. Latour, in his *Paris, invisible city* project,[234] shows the city as a palimpsest of multiple networks; the underground structures as sewage providing unadvertised services of maintenance; the traffic signals and urban amenities showing the allowed transit and use of the space; the mass media and advertising assembling people in a common language and experience. Systems that cannot be perceived from the static panoramas, but have to be followed from inside as Oligopticons, sensed and translated into data, the movements across these networks can be modelled and assembled to conform city dashboards. The *City Forward* project by IBM is a web platform that allows navigating across multiple data models from different cities.[235] This aimed at the development of *smartcities* could be evolved to form control dashboards such as those produced by the same company for the operations centre in Brazil.[236]

The Space of Representation is the lived space, the space appropriated by the citizens, who can use it in unexpected ways to accommodate their own necessities and desires. This is the space for the revolutionary activity of art, its resistance to the present - the codified territory-, and the laying out of the future as the inexhaustible reservoir of possibilities emerging from the Virtual. This art is engaged in the enactment of a molecular politics resulting from the activation of the Collectives towards the production of the creative capacity of the difference. The appropriation of space encounters with new challenges and possibilities after information had become locally available from the scattered networked objects of Ubiquitous Computing. This increase in connectivity gave our bodies new sensory capacities provided by Augmented Reality applications and the continuous data streaming from the Internet of Things, at the same time as our bodies acquired the capacity to switch between multiple spaces and regimes of proximity. This electronically mediated space increased the available information about our immediate surroundings at the same time as allowing us to communicate to remote places. In addition, *space architectonics* performed by the capacity of our bodies to start new rhythms has become automated by the tracking of our movements operated by our mobile phones and other wearables and transformed when these rhythms resonate with the increased capacity of modulation of the non-human agents engaged in the hidden processes of computing. Nowadays, the appropriation of our space and the creative intervention on it involves a process of Disruption. This is understood as the critical exposure of the hidden processes and structures of power of our actual Apparatus. In other words, this is the opening of the black boxes of the technological unconscious operating in our space and the aware intervention in its Technicity.

MacKenzie defines Technicity after the work of Simondon

"Technicity refers to the extent to which technologies mediate, supplement, and augment collective life; the extent to which technologies are fundamental to the constitution and grounding of human endeavour; the unfolding or evolutive power of technologies to make things happen". [237]

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234 http://www.bruno-latour.fr/virtual/EN/index.html

235 http://www.ibm.com/smarterplanet/us/en/smarter_cities/article/city_forward.html

236 http://www.rio.rj.gov.br/web/guest/exibeconteudo?article-id=1419835

237 Adrian Mackenzie Wark (2002) *Transductions. Bodies and Machines at Speed*

The point of view practiced by Software Studies will allow an understanding of the origin and material foundations of the Apparatus dominating our space, at the same time as the later emergence of new technological procedures such as Physical Computing, Data Visualization and Digital Fabrication that embody the procedures of the programmable space. These technologies engage with the human and focus on their relation with technology. They harvest new forms of human-computer interaction that focus on education, artistic experimentation and its release into common space, where they become available to non-experts. In this way, they can be appropriated towards the exploitation of the creative potential of Embodied Virtuality. The spread of the aware use of new affordable technologies disseminated from new Collectives emerging locally inside urban areas can become a space for the emerging of a policy of hacking. This is understood as the phreaking or creation of technology for the achievement of a political or social goal. In the spaces of encounter and collective creation, the analogue practices of craftsmanship will embed with new practices of digital production that will move the Embodied Virtuality from the creation of the powerful illusion spread in cinema and video games to the material construction of new forms of citizenship, the enactment of the System of Simulacra proposed by Deleuze as a free space of play.

3.1 UBIQUITY AND RESPONSIVE SPACE

> *"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it".*[238]

Ubiquitous Computing is a new phase of technological evolution. In it, new advances such as the proliferation of bandwidth; the exponential growth of processor's capacity; the progressive miniaturization of electromechanical devices and the realization of Moore's law, towards the access to an increasing capacity of information storage, making it possible to embed computation capacity in the devices we interact with in our daily lives.

Ubiquitous Computing was first introduced by Mark Weiser in 1991, when working at Xerox PARC, in his paper *"The Computer for the 21st century"*. Weiser describes this new upgrade in the dissemination of computation as Embodied Virtuality" –*"the Virtuality of computer readable data, all the different ways in which it ca be altered, processed and analyzed is brought into the physical world"*-[239], and contrasts it with Virtual Reality. Whereas VR is a map, Ubiquitous Computing is a territory. As has been already shown, the diagrammatic space produced by the dissemination of computation already materialized in most of the processes producing our reality. The assemblage of hardware and software of Embodied Virtuality has been incorporated into scientific research, production and economic management, even in the mediation of our social relations and our subjectivation process. What characterizes Ubiquitous Computing is the new interaction paradigm it lays out. Human-Machine interaction is displaced from the simulated environments projected onto screens to the richness of the physical world. Ubiquitous Computing does not create a world inside the computer; instead, it looks for the enhancement of the actual world by means of embedding information into it. It constitutes new scenery where the user can enjoy the richness of the world around and focus on their tasks and social interactions, in an atmosphere where computers are substituted by dedicated distributed microprocessors that can be attached to the objects we usually interact with. In this way, UbiComp is the culmination of the post-desktop era. The computer vanishes into the background, its power to process information distributed around hundreds of networked processors disseminated all around us. In this new situation, information processing moves to the periphery, in which we are attuned without explicit attention. This Calm Technology may free humans from the enslaving passive display we must sit in front of to realize our tasks, whereby we can focus our attention on the task, the environment and the others around us without the interferences of the machine. However, programs and codes, from which we have not knowledge, fiercely territorialize these new enhanced environments in which we are involved. Interaction inside the simulated worlds of virtual reality involves our access to a dedicated space in which our agency is codified and translated inside a simulated world. Usually, interaction falls into a call-and-response rhythm, user actions followed by system events, inside a computer-produced environment from which we can decide to leave at any moment. In contrast, interacting inside Ubiquitous Computing implies being unaware of being engaged in a system that constantly tracks our behaviour to translate it into input data, inside a non-task driven relation, in which the system precedes our actions and establishes our affordances inside the augmented space.

The proposal laid out at Xerox PARC by Weiser and his team was aimed at enhancing the workplace by means of a system of three devices working at different scales and interconnected that can recognise and communicate their location to interact with each other. The smallest of these devices was the *tab*, a wearable tag, which works as an active badge –it identifies its wearer and communicates its location to the other devices-, working as a calendar and a diary. Equipped with a display it works as an extension of the computer. The second largest

238 Mark Weiser (1991) "The computer of the 21th century"

239 Mark Weiser (1991) <op. cit.>

device is the *pad*, its function, and size similar to scrap paper. It allows displaying and updating information on multiple portable surfaces that can be assembled in different spatial dispositions. Finally, the *board* is a large-scale display that can be used simultaneously by several people to collaborate and share information.

This first experiment was fostering new forms of interaction and the design of new interfaces to integrate a system where computational power comes from the interactions between physical devices performing small tasks around us, small computers that are not more, universal machines, but the dedicated modules of a ubiquitous networked system.

The Weiser dream points to an everyday life, where we are assisted by the devices of a system able to predict our behaviour and needs. It is a new space, where you can focus on what really matters while the small practical things of everyday life are solved by invisible machines working towards a desirable world, where failure is minimized and profit increased. In this responsive environment imperceptible devices and distributed displays wake us up at seven o'clock with our preferred music and soft lighting and prepare our breakfast according to our taste and the suitable caloric account for our daily activities. When we move through the house, lights and doors are activated automatically. While having breakfast, we can see a filtered selection of news according to our interests and be alerted about urgent messages. On our way to the office, our car displays the most convenient route and destination arrival time. Once at the office, our workplace is set up according to our preferences and scheduled tasks of the day. While moving around, our calls are enrooted to the nearest phone, and relevant information displayed on our nearest screens, meanwhile we are always reminded and updated about our next meeting or urgent task. Summarizing, the UbiComp envisions an environment that knows who we are, and what we need at any moment to be efficient.

This environment imagined in multiple films and science fiction series, where the characters interact with hype technological stuff such as the film *Minority Report*, based on the novel by Philip K. Dick, is already in place. It is being realized not only in the labs of the MIT Media Lab, the Microsoft Research, and the Milkshake Media from Austin, which acted as consultants for the design of the technological space in Steven Spielberg's film but in the applications of new commodities we have incorporated such as our personal belongings. Our smartphones are the most extended wearable computing devices, far from its primary function as a telephone; these networked devices have become intelligent assistants in our daily activities. They are equipped with different sensors and software applications that interact, sharing information among them and with online services. They work as scheduling calendars and alarm clocks, snoozing and displaying a description every time we have an appointment. In addition, as navigation tools that identify our position on a map augmented with multiple information items, and guides our steps to any desired destination. They also work as permanent browsers and listeners that multiply our presence inside the web, delivering us any relevant update occurring in any one of our subscribed platform services. They are also personal trainers tracking our physical activity throughout the day, and even as augmented reality applications that allow increasing our knowledge of scanned places and surrounding things. All these pull technologies are becoming substituted by an emergent system able to precede the user, such as the new devices appearing that work as bridges between the physical and virtual world and our phones start to interact with other networked devices distributed around us. The Near Field Communication (NFC) is a technology consisting of a set of communication protocols that allow the phone to exchange data with another device. Interacting with systems that feature NFC technology, our smartphone can operate as a smart card, allowing us to make transactions for payments, a key for opening a coded door or a ticket usable to access to a previously paid service or show. These kinds of technologies make room for a modular and seamless system, which is pervading all our spaces of activity. They migrate from our portable phones to our bodies, rooms, buildings and conquer the public space. They trace the path of the advancement towards a new situation that Adam Greenfield named 'everyware', where *"all the information we now look to our phones or web browsers to provide becomes accessible from just about anywhere, at any time, and is delivered in a manner appropriate to our location and context."*[240]

240 Adam Greenfield (2006) *Everyware. The dawning age of ubiquitous computing*, pp.1

In the situation defined by Ubiquitous Computing, the body becomes a source of data and a convenient platform for the delivery of networked services. Embedded with networked devices, our bodies become nodes able to sense a large amount of data associated with their daily activities. These data come from the sensing of our vital signs, but also from the sensing of the environmental conditions, our body reacts.

Our body is the vehicle with which we experience our world, not a separated predefined entity but a relational node, always in process, that defines itself transducing with the systems it is coupled with, in its daily activities. The possibility of augmenting the human body by means of attaching prosthesis and mechanical alterations to it to improve its performance in adverse situations was first proposed by Manfred Clynes and Nathan Kline in their article *"Cyborgs and space"*, published in 1960.[241] The cybernetic organism has fostered new fields of research inside techno-science such as bionics, the development of sophisticated electromechanical devices able to work in communication with the human body and restore or improve physical functions. At the same time, the concept Cyborg has been adopted to call the human being inside the continuum nature-culture; the human being not as an isolated entity but evolving from interactions with human and non-human agents inside their ecological environment.[242] The coupling of the body to artificial limbs is not the only procedure from where the cyborg originates. However, it is produced in the assemblage of the workers in the production line, the immersion in entertainment environments, in navigation inside the net and so on, in every ambient in which the body is immersed in complex hybridizations determining its affordances. Regarding the body transformations suffered in the coupling with different systems and the subjectivation processes emerging from it, Donna Haraway and movements stemming from her theories such as cyberfeminism, considers the human body as a hacking place. An organism that can overstep the traditional representations coded inside society by means of transducing with other systems. In other words, entering in new assemblages able to actualise new potentialities, new states, from where emerges a mutant identity from the indeterminacy that all human beings wear. In contrast, in the embedding of *everyware* into the human body, what is attached is not the multiplication of instances of subjectivation, but the refinement of biometrics – the technology of identification that relies on physical characteristics or behavioural traits to verify the identity of a person-, deployed as a source of control.

The pervasive computation of our bodies is developed as Wearables, clothing and accessories incorporating computers and electronics. In these, computing becomes intelligent assistance, a development of the personal computer in which computers are worm and interact with their users based on the contextual situation. Steve Mann from the Wearable Computer Lab at MIT[243] defines these enhanced garments as Existential Media, a constant augmentation that can be used in all facets of living, from where the author stresses their capacity to define new forms of social interaction through enhanced abilities for self-expression and self-actualization, by means of communicating physical sensations remotely, and to self-determination due to their capacity for providing information about our surroundings and even our physical signs in a non-obtrusive and private manner.[244]

This lab develops head-mounted displays, unobtrusive output devices, personal wireless area networks and other context sensing and communication tools to develop Wearables that work as augmented reality enablers, connections to Collective Intelligence and remembrance agents. The latter consists of an associative form of recall not based on user queries but on the continuous sensing of the activities and user context. An intelligent system working in the front end sensing our actions and in the back end browsing for archived information that can be useful for the actual task. These functions are exploited in devices such as *Wearcams* that can be deployed for guidance, a personal documentary, and personal safety.

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241 Manfred Clynes and Nathan Kline (1960) "Cyborgs and space"

242 Donna Haraway (1991) "A Cyborg Manifesto: Science, Technology and Socialist-Feminism in the late twenty century" at *Simians, cyborgs and women. The reinvention of nature*, pp. 149-183

243 http://www.wearcam.org/computing.html/

244 Steve Mann (1997) "Smart Clothing: The " Wearable Computer" and WearCam..."

Between the wearables that are being marketed nowadays we can quote, Augmented Reality devices as the Google Glasses, Intelligent watches– extensions of our smartphones, allowing to access from our wrists the most used apps-, equipment related to healthcare and sports performance such as fit bands, intelligent t-shirts and therapeutic patches, and finally, fashion design prototypes looking for new cool ways of self-expression. Whether or not the Google Glasses and I-watches are redundant extensions of our smartphones, all these technologies track our activities, collecting data that is shared in on-line databases, where it is collected for the creation of our profile or digital identity and used for different purposes. This entails privacy and security concerns. In addition, the devices aimed at collecting vital signs have the potential of becoming newly redefined technologies of the self, processes of subjectivation that bind us to our own identity and to an external power. Fit bands and *smartshirts* such as the ones produced by heddoko.com, www.xsensio.com or www.clothingplus.fi, are sensing devices that produce a continuous dataset of our vital signs, which can be sent to net services to be mined and convey health and performance improvement recommendations. This 'quantified self' is promoted towards the accomplishment of inner knowledge and informed self-improvement without the awareness of how it is involved in bio-politics, the definition of an optimal body and the submission of our behaviour to its preservation; taking part in a politics based on the *bare life* that deprecates differences, favoring a standardized and isolated body. Meanwhile, in the fashion stage file the prototypes of a new hype promoted by big technology companies, according to which self-expression is the exhibition of an identity measurable in its inner mechanisms. This is the case of the *Emotional Dress* developed in the frame of the *Skin* project commissioned by Philips.[245] It is a dress equipped with biometric sensing technology that measures skin signals to change the lighting of the outfit layer, or the *Cocktail Dress* produced in a student competition supported by the London College and Sony Erikson: a dress wired with Bluetooth technology, allowing the garment to light up when the wearer gets an incoming call. Most of these commodities and prototypes are linked to the Internet of Things, the evolution of the web towards its encounter with the physical world. In the Internet of Things, platform services, and algorithmic management are not only delivered inside the computers but in small appliances that can sense our world and contribute data towards the new phenomenon of Big Data.

In terms of dwelling spaces, the development of Ubiquitous Computing is aimed at projecting smart spaces able to adapt to their occupants and environment. Greenfield quotes in his book the development of mechanized doors which open after recognising the people going through and reactive floors able to sense the number of people occupying a room and send this information to a linked system, which adapts the ambient conditions in lighting and temperature. While these integrated domestic systems have not yet been commodified, the Internet of Things are reaching our homes producing domestic appliances connected to the net such as smart televisions or the fridges produced by Samsung. This is a fridge incorporating cameras inside and a tablet computer on its surface that works as a display where it is possible to attach messages, see the contents of the fridge and access internet services, and that can be accessed remotely through a mobile phone to see the contents inside the fridge when we are at the grocer's. The development of integrated systems and new schemes of Human-Computer interaction are more likely developed in working spaces.

Workplaces were the first target for the application of UbiComp at Xerox PARC, where Weiser developed his ubiquitous project. Hiroshi Ishii and the Tangible Media group of MIT went beyond the project by Weiser to propose a holistic office in the *Ambient Room*, a prototype featuring a new interaction paradigm, the Tangible Interaction.[246] Tangible Interaction aims to take advantage of our physical affordances, the complex ways we interact and manipulate physical objects. With this in mind the Tangible Media group goes beyond the GUI to propose the Tangible User Interface (TUI). Whereas VR systems project the movements of our body inside the virtual world, where we become pixels able to interact and manipulate other graphical objects rendered on the

245 This an other examples can be found in the book by Stefano Marzano, Josephine Green, C. van Heerden and J.Mama (2001) *New Nomads: An Exploration of Wearable Electronics*, published by Philips.

246 Hiroshi Ishii and Brygg Ullmer (1997) "Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms"

screen by the electron beam and Weiser's system disseminates computation on the physical environment, where the graphical user interface becomes available through the small terminals of a distributed system, the TUI links bits and atoms by means of embodying the symbolic handles of the GUI in physical icons. *Phicons* are physical objects embedded with digital information that can be manipulated in multiple ways. These new transducers do not translate movements as inputs to manipulate objects projected on the screen but are themselves the interface. Combined with Ambient Media- the use of light, airflow, and water to display foreground information in the periphery of human perception, the Tangible Interfaces accomplish a truly seamless integration of information technologies in the physical environment. The world becomes the interface. The *Ambient Room* is based on a steel case personal harbour unit augmented with MIDI-based infrared proximity sensors. Inside it, *phicons* can be used to display information on the background and bring it to the foreground when necessary. In the example discussed in the paper *"tangible bits"*, the office of a toy factory, a *phicon* -small car figurine- is linked to the information about the marketing of a recently released toy car. Putting the *phicon* near to a receptor, the internet traffic of the web advertising the toy car is displayed as a non-intrusive ambiance sound, falling water drops. In this way, each falling drop signals a visit on the web page. While the sound is constant it indicating normal traffic and when it stops or increases until reproducing the sound of heavy rain it indicates an event that requires attention such as the failing of the server, a poor marketing strategy or an unexpected increase in visits. These events can be brought to the foreground by means of relocating the *phicon* inside the room, where it can be detected by another sensor that will start actions to display the information on a computer. Tangible Interfaces were developed in other projects for different purposes; the *PSyBench* features synchronized distributed Physical Objects to allow remote collaboration.[247] *The PSyBench* is a shared working space, consisting of two copies of a workbench remotely located, containing distributed objects and featuring optical encoders and cameras, which sense the distribution of the 'shared' objects in it. When one object is displaced, sensors in the actual bench identify the new position and actuators in the remotely located copy move the corresponding object to the actual position. In 2012, the Tangible Media group proposed the concept of Radical Atoms, a new generation of Material User Interfaces based on research in new organic materials, which can change their form and appearance dynamically as reconfigurable pixels projected onto a screen do. These new objects are not interfaces, but programmable matter, Dynamic Physic Materials that can conform to structural constraints, transform their structure and behaviour, and inform new capabilities.

In the scale of buildings, we find architectural projects able to inform about their inner processes, such as the already discussed *Arch-OS* system, and new enhanced prototypes generated by the computation of digital morphologies, where surface and structure meet thanks to the development of new materials and the embedding of sensors able to react to the environment. This favours the intensification of architectonic space and the conception of buildings as a process meshed in the social production of space. This conception is evolving into a responsive architecture based on interaction. In this way, we find architectonic projects aimed at interacting with their inhabitants like the ones conducted by the Living Architecture Group or the most utilitarian ones aimed at adapting to environmental conditions, increasing their sustainability and efficiency. Among the latter, we can quote the *Carbon Tower*, an ongoing project by Testa and Weiser.[248] It consists of a forty-storey high rise, knit, braided and woven from carbon fiber, which dispenses with all internal bracing. In addition, this textile exoskeleton is managed digitally, equipped with sensors and actuators that synch the skin to adapt to ambient conditions. In these building projects, representation is substituted by programmed operability. The surface is no longer a support to communicate the function of the building and its attached values but a functional structure meshed with the building's functioning and integrated into its environment.

The design of buildings and city systems based on the computation of data has changed long-term planning to open it up to revisions, updates, real-time inputs, and contingencies. Able to sense and react to their environment, buildings become meshed into the urban ecology, which becomes a machine that constantly

247 Scott Brave, Hiroshi Ishii, and Andrew Dahley (1998) "Tangible Interfaces for Remote Collaboration and Communication"

248 http://www.testaweiser.com/

reterritorializes itself. The dissemination of computational power allows including software able to respond to real-time variations inside urban structures so to anticipate the emergence of potential changes. This leads to an algorithmic way of planning, defined by an extended Apparatus of prediction able not only to establish the condition of the present through the retrieval of past data but also to change these conditions according to data variations immediately retrieved from the environment. The continuity of form and function that characterizes the administrative planning of the city is guaranteed by the laying out of an integrated system programmed according to the logics of control and provided with a sensory layer that allows continuous change and adaptation. In terms of urban space, this new city planning paradigm has been summarized as the *smartcity*.

The *smartcity* is characterized by the proposition of an intelligent management of resources and integral city planning based on informational applications. These developed in response to the urgent problems our societies must confront such as overpopulation -it is estimated that in 2050 more than 75% of the world population will be concentrated in cities-, global warming, exhaustion of resources, safety and the aging of the population. Pioneering projects such as *Masdar*[249] initiated in 2008 at Abu Dhabi and *Songdo*[250] in Korea had been followed by the proposition of other integrated systems such as *Smart Puebla*[251], now in development in Mexico. At the same time, informational solutions are being applied to the definition and management of systems inside cities from all over the world. These systems are aimed at managing target issues inside the contemporaneous city such as economic development, transportation, social services, administration, education and workforce, public safety or citizen engagement.[252] Technological solutions that work in a continuous feedback loop inside the population, whose actions are captured by different sensors and converted to data. The processing of this data aimed at influencing the behaviour of the citizens, who from now on will be enclosed in a space submitted to the operational logics of a predictive system aimed at reducing uncertainty due to increased efficiency and safety. The *smartcity* relies in the vision of the city as a complex system in evolution and made up of multiple linked layers, new spatial dimensions enabled by technology. There is the layer in contact with the territory and its citizens, made up of frameworks that receive and send data; a sensory layer integrated by sensors, cameras, smartphones and mobile devices. In addition, this layer is connected to the public spheres from the internet, from where citizens can become sensors and data contributors they added through programmed interfaces to the matrix of algorithmic perception. This allows a bottom-up approach that is linked to terms such as co-surveillance, co-design, civic hacking, crowdsourcing and participatory sensing. All these terms express how citizens become another data source to feed the system. There are the multiple layers of processing and storage, a subterranean cloud architecture that enables a condition of real-time government, the levels where the applications aimed at particular services are specified and the platforms for integration and control that allow managing the whole system towards a generative automation of a responsive architecture that evolves and adapts itself generating new live conditions. Ubiquitous Computing enlarges the molecular algorithmic calculation of the inner mechanisms of computers to the macro scale where our dwelling spaces are territorialized.

The human-centred vision of Weiser, where computers work as imperceptible assistants, has been globalised towards an ecological view where humans are not the centre of interaction but another set of data points inside a whole machine of communicating nested systems. Inside this system, our consumption power is not tracked primarily to inform us towards a more responsible consumption, rather to be communicated to a smart grid that will redistribute the energy supply to a more efficient management. Our everyday car journeys will be tracked not to convey recommendations but rather to adjust traffic signals towards a self-improved traffic management. Our regular consumption will be tracked not to facilitate our acquisition of goods but rather to adapt the design, production, and distribution of consumables. This leads to a posthuman or cyborgian vision where our agency is translated to an integral computing system deploying complex mathematical models to predict and adjust our behaviour by means of controlling our affordances inside the environment.

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249 http://www.masdar.ae/

250 http://songdoibd.com

251 http://smartpuebla.org/.

252 https://smartercitieschallenge.org/cities

A new assemblage of technologies enables the development of Ubiquitous Computing. Weiser outlined the development of cheap low power computers, these including equally convenient displays and networks that tie them together and software systems implementing ubiquitous applications. New advancements had been produced that disseminated the local augmented environment projected by Weiser until becoming an integrating system connected to the global net. These systems are deployed to allow networked objects to communicate between them, be addressed as data packages inside the Net, be identified, be localized and sense the environment and process the information retrieved to produce a response. Among the technologies allowing objects to interchange information are wireless technologies such as GSM, UMTS, WIFI and Bluetooth, and many other Wireless Personal Area Networks now in development. Referring to the technologies that allow objects to be addressed inside the global Net there is the shift from the Internet protocol IPV4 to the IPV6. It is aimed at providing identification and location system for computers on the network and the routing traffic across the internet. The IPV4 was a 32-bit address. Thereof, IPV-6 is a 128-bit address, providing enough addresses to assign and identify every atom on earth. To be networked, objects also need to be uniquely identifiable. Technologies such as NFC, QR codes and RFID are systems that can be attached to objects and store information that can be accessed by a specific reading machine. The RFID tag is a chip that uses electromagnetic fields to store information allowing automatic identification and data capture. The capacity of storage of this system has increased after it has been connected to the Net by means of the EPC (Electronic Product Code). Developed by the Auto-ID centre from MIT, The EPC is a technology of the Internet of Things. It follows the internet structure using a distributed Object Name Service (ONS) that works like the DNS associating every EPC in a database of names and authorities, which provide information about the object. In the linkage between the internet and physical objects, systems that codify the information from traditional supports to data readable by a machine as machine vision, voice recognition, and automatized readers that allow recognizing scanned written characters as the OCR also intervene. In addition, in development are biometric technologies that allow a computer identify humans by means of reading human individual characteristics such as finger and iris prints. Networked objects are also aware of their localization, in such a way they can deliver information about their surroundings, localization uses to be provided by systems such as the GPS. Finally, smart objects are not only objects containing information but there are also things able to sense their environment, process this information and produce an action in response. These objects are equipped with different kinds of sensors that allow them to be aware of environmental changes such as temperature, light variations, and the presence of chemical substances, track movement as vibrations and velocity, and other small events around that find their sensing counterpart. These artificial perceivers are becoming smaller and cheaper, being attached to a multitude of systems for a wide range of purposes. Their counterparts are the actuators, which can be simple electromechanical systems built using piezo materials that give off an electrical charge when deformed and, conversely, deform when in the presence of an electrical field converting electrical signals into mechanical movement. Also, actuators can be audio-visual attached systems providing a more complex response, Finally, there are the microprocessors, small computers attached to things that can store a program conducting their behaviour.

These systems will evolve into the Internet of Things, a usual tag to identify the set of technologies that are connecting to the internet the enhanced objects of Ubiquitous Computing. The IoT technologies are the culmination of UbiComp towards a global system where objects communicate between them. However, the Internet of Things is not only able to extract data from the environment and structure it in databases, as was envisioned by O'Reilly in his introduction to the Squared Web, but to actuate in our world and control its processes. It is based on machine-to-machine communication, cloud computing, and networks of data-gathering sensors. It links objects that are not only enhanced with electronically readable information but also programmable towards a responsive behaviour.

The Internet of Things (IoT) was envisioned by Neil Gershenfeld from the MIT Media Lab in 1999 in his book *"When things start to think"* and introduced a concrete technological advancement by Kevin Ashton from the Auto-ID Centre, also from MIT, in the title of a presentation he made in 1999, at Procter & Gamble. In it, he proposed to attach RFID tags to the products of the assembly line for the computerized management

of the production process. Between 2008 and 2009, this term came to denominate a new technological hype, and after there were more objects that humans connected to the net. They have all become a global and growing phenomenon. There is an expected growth of 39% in 2016, which means that 500 million new devices will join the Net,[253] among them domestic appliances developed by big companies such as the already mentioned Samsung fridge or produced by startups sustained in crowdfunding platforms such as Kickstarter. Among them, smart bulbs controllable from the I-phone, Bluetooth stickers localizable from your phone to be attached to the user's belongings, air quality sensing devices and networked devices to alert where we must water our plants. Also, complex systems featuring artificial intelligence such as autonomous cars and self-dirigible drones and physical-cyber systems, big networks of sensors able to monitor an entire environment, some of them implemented in the *smartcities*.

The realization of IoT encompasses the development of specific software and hardware, including microcontrollers and operative systems such as those developed by Contiki[254] and TinhyOs, an Operative System for creating sensor networks and a platform from where they can be managed, developed at the University of Berkeley. Some of these platforms work upon proprietary software such as Tibbo Systems, AfreeGate Platform, Arrayent and others. Alternatively, open platforms exist accessed by a login system such as Xively[255], formerly known as Pachube[256]. This platform was developed by the architect Usman Haque in 2007 and allows connecting different things that in addition can communicate between each other. Another open platform is ThingSpeak[257]. In addition, there are open projects conducted to avoid control by corporate companies and to make this system accessible to the user. We can mention Reality Editor an open-source platform including an app, Hybrid Editor, which works by allowing the users to see and edit the functionalities of their networked objects.[258] Finally, the networkWe[259] is a project that aims to build a global open crowdsourced Internet of Things data network. It is built upon a new technology, the LoraWan, which features low battery usage, long range, and low bandwidth without the need for 3G or WiFi and so without WiFi codes and no mobile subscriptions. It was tested in Amsterdam, where it crowdsourced a complete city-wide Internet of Things data network in 6 weeks.

As standard open systems advance, the interoperability of these systems increases towards a global sentient network. Neil Gershenfeld promotes an Internet 0 for the networking of physical devices where objects are addressable by IPV6, connected directly to the net and transmit standardized data packages, which can be represented in the same way independently of the physical medium that conveys them. This will allow a myriad of objects to communicate and interoperate, taking advantage of the implemented advantages of the net such as its decentred architecture, robustness, interoperability and easy extendibility. Even if a web of objects searchable and readable by humans does not yet exist, things are becoming new nodes on the weaving of the net, new data contributors, the ubiquitous presence of which is being localized by browsers as thingful.net and www.shodan.io. Finally, smart objects are driving a convergence between hardware and software, in which the programmability of pixels is attaining matter. If software evolved virtualising hardware procedures, now we attend to the development of hardware that acts like software and software that is able to deal with the complexity of the physical world. Hardware that is Ip-addressable and programmable with high-level languages and API's able to be switched in coupled systems, and software managed with new learning algorithms able to infer knowledge of the environment.

253 https://iot.telefonica.com/blog/iot-trends-for-2016-everything-connected-everywhere

254 http://www.contiki-os.org/

255 https://xively.com/

256 http://www.haque.co.uk/pachube.php

257 https://thingspeak.com/

258 http://www.realityeditor.org/

259 https://www.thethingsnetwork.org/

3.1.1 TRANSDUCERS EVERYWHERE

> *"Everything reduces to a molecular binarism. The generalized digitality of the computerized society".*[260]

In 1960, Billy Klüver, a research scientist at Bell Telephone Laboratories, made the work of Jean Tinguely, *Homage to New York*, technologically possible. It was a machine sculpture that enacted its own destruction in a half-hour performance at the Museum of Modern Art of New York. It consisted of a big assemblage producing sound and the visual awareness of how the transmission of information between coupled mechanical systems produce self-modification of the assembled whole. This meta-machine signalled the end of the mechanical age and the beginning of the new technological milieu. This was pointed out by Pontus H. Hultén in the catalogue of the exhibition *"the machine at the end of the mechanical age"*, presented in the same museum in 1968: *"This exhibition is dedicated to the mechanical machine, the great creator and destroyer, at a difficult moment in its life when, for the first time, its reign is threatened by other tools."* [261] Tinguely described his work as a Situation, a poetic performance of creation and self-destruction. According to the artist, it suggested that machines that fail to function according to their program are a source of poetry. Machines can exceed their function and control, demonstrating the uncertainty and provocation inherent in complex ecologies, such as the city of New York itself.

The second artistic collaboration of Klüver, in this case with the artist Robert Rauschenberg, was to produce *Oracle*. Made between 1962 and 1965, *Oracle* was a sound/sculpture environment. It consisted of five elements assembled from junk materials and incorporating radio systems, which captured and played available radio broadcasts. First shown in the Leo Castelli in New York, this piece was an interactive work that showed the unperceived spectrum of information transmissions inside an environment and made it possible to be manipulated by the audience.

In autumn 1965, Klüver meet Knut Wiggen, who was organizing the *Stockholm Festival of Art and Technology* and both worked together to assemble a group of artists and engineers to create a series of interactive artworks. When the original plans for the festival failed, the exhibition moved to the 69th Regiment Armory at Twenty-five street and Lexington Avenue to be held as the *"EAT performance exhibition 9 evenings: theatre and engineering"*. In this setting for nine evenings, from October 13 to 23, 1966, performances were presented where artists interacted with technologically enhanced objects to modify the environment, sometimes with the active participation of the audience. Robert Rauschenberg took part in the exhibition with the work *Open Score*. A tennis match in which contact microphones were embedded to the racquets of the players, in such a way as the vibration produced by the balls hitting became an input processed to turn off the lights of the room. In the darkness was projected the records of spectators acting a program predefined by the artist. John Cage performed *Variations VII*. It aimed at improvising a sound melody from sensed outside and inside sounds. From the outside, radio broadcasts were retrieved by radio equipment, and at the same time, telephones were used to transmit the sound ambiances of 10 selected locations of the city. From the inside, the sound produced by the movement and interactions of the performers with various objects were picked up by distributed microphones and their internal brain activity sensed by the electrodes of a dedicated headset. Lucinda Childs also composed music, light effects, and image by sensing the environment. In this case, she used a Doppler sonar system that sensed the movements produced by dancers and objects performing around the Ground Effect Machine, a Plexiglas and metal cube that produces

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260 Brayan Massumi (1987) "Realer than Real. The Simulacrum according to Deleuze and Guattari"

261 Pontus K. Hultén, (1968) *The Machine as Seen at the End of the Mechanical Age*, ed. K.G. Pontus Hultén, Partially reproduced at the Foundation Langloise website.

an air cushion around. Alex Gray's *Grass Field* produced a field according to established parameters and the amplifications of biological phenomena such as the voltage generated by his muscle movement, his brain alfa waves, and his eye blinking, all filtered to data and processed to output the images and sound of an intimate ambiance. Deborah Hay's *Solo* performance created a modulated ambient where sound, light and dancers' performance were equalized. With this aim, wireless remotely operated cars determined the movements of the dancers. These performances took part in the program, among others: *Vehicle* by Lucinda Childs, *Kisses Sweeter than Wine* by Öyvind Fahlström, *Physical Things* by Steve Paxton, *Bandoneon!* by David Tudor, *Two Holes of Water – 3* by Robert Whitman and *Carriage Discreteness* by Yvonne Rainer. All used purposely developed technology such as the AMP equipment that connects inputs and outputs; decoders to analyse audio signals; modified TV sets and projectors; switching matrix to couple different systems; vocrhomes decomposing audio frequencies to channels; and interfaces to control the behaviour of the system in real-time. In addition, enhanced objects performed on stage such as the remotely driven carts, the enhanced racquets, and the Ground Effect machine. This equipment was used in the creation of situations that made the transmission of information among people-things and the environment tangible. Thus, they incorporated the surroundings of performers into an ecology in which all interact towards the production of unexpected effects. The *"Nine Evenings"* led to the foundation of the Experiments in Art and Technology (EAT) group created in 1966 by Billy Klüver, Robert Rauschenberg, Robert Whitman and Fred Waldhauer and announced to the press in 1967.

Experiment in Art and Technology statement of purpose by Bill Kluvert and Robert Rauschenberg,1967

> *"Maintain a constructive climate for the recognition of the new technology and the arts by a civilized collaboration between groups unrealistically developing in isolation. Eliminate the separation of the individual from technological change and expand and enrich technology to give the individual variety, pleasure, and avenues for exploration and involvement in contemporary life. Encourage industrial initiative in generating original forethought instead of a compromise in the aftermath, and precipitate a mutual agreement in order to avoid the waste of a cultural revolution".*[262]

EAT was active until the end of the Digital Revolution, taking part in the involvement between industry, technology and the arts that characterized the development of the Embodied Virtuality. These artists, aware of the crucial role of technology in the production of the human environment, were committed to the creation of hardware that embodied the computational processes embedded in social situations. Some of its projects were dedicated to education in the management of the new technological milieu. Among them featured *Children and communication* from 1971, consisting of the setting up in two locations of Manhattan of telephone lines, whose terminals included facsimile machines, electro-writers, telex machines and telephones. In these spaces, Robert Whitman created environments where children could access freely and experiment with the equipment. The more celebrated project by EAT was the design of the *Pepsi Pavilion* for the Expo 70. The artists and engineers of EAT created an immersive and responsive environment inside a dome. This was a space of 'live programming' produced by moving patterns of laser light, spatialized sound and a big spherical mirror, which made the visitors aware of their movements. A console inside the dome allowed pre-programming or control in real-time of the light and sound systems. The space produced was open to being explored and manipulated by the spectators and invited performers. It demonstrated the capacity of technological artefacts to be involved as experiential co-agents in space production.

The Experiments in Art and Technology explored the possibilities of embodiment and encounter of new technologies towards a more tangible interaction able to foster the appropriation of the technological milieu.

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262 Published by EAT News, New York, United States. Reproduced at *The Media Reader* and Foundation Langlois website

Embodiment is about being in the world. Paul Dourish takes this term from phenomenology and outlines its application in the design of Human-Computer Interaction. Phenomenology affronts the problems of transcendentalism and the dualistic conception of a mind separated from the body which harbours the transcendental structures that give form to our perception and where the possible action is elaborated previously to encounter the world. Husserl proposes the concept of *intentionality* to explain the phenomena of experience. *Intentionality* or 'being about' is a fundament of the veracity of perception and always perceives essences. However, this guarantee of experience was gained in the separation of the world or the *phenomenon,* which remains outside the field of philosophy. Heidegger rearticulates the relation between mental life and everyday experience through the concept of *Dasein* –'being in the world'- considering our perception as always situated inside the conditions of life, Henceforth, it turns the epistemological problem giving primacy to the ontological. Being is always previous to knowledge. Therefore, meaning stems from how this world reveals itself in our encounters with it, not in a bare perception but in a pragmatic relation. The world is characterized by its openness, in that it appears to us as 'always at hand'. The hermeneutic philosophy of Heidegger recovered the world as a concern for philosophy but considered it as subordinated to the human being, as a set of tools and resources to cover the needs of existence. In addition, Heidegger remains in the problem of intersubjectivity. However, if the world is revealed in our mental perception about our actions inside the *Lebenswelt* how can we achieve a common experience of the world? This is a problem of traditional sociology that considers general rules commanding social behaviour as an already given transcendental that can be unveiled through the study of social action. Schutz solves this problem, considering social rules as mental acts that are experienced individually and shared under the common assumption of the other's rationality.

Based on the phenomenological approach Dourish defines embodiment as:

> *"Embodiment is the property of our engagement with the world that allows us to make it meaningful".*
>
> *"Embodied interaction is the creation, manipulation, and sharing of meaning through engaged interaction with artifacts".*[263]

Even if this definition is correct, it lacks focus on the capacity of space production of the engaged interaction with technology. Phenomenological philosophy is framed inside a humanist tradition that oversteps the division between mind and body giving primacy to the human being and explaining the existence of the world as a necessary correlate derived from its acts and needs. It is guaranteed by the existence of transcendental structures inside our mind. In the terrain of HCI, this will translate into the consideration of interfaces as convenient tools, and we are absorbed in the accomplishment of its affordances, as perfect correlates of our dexterity. These tools, always at hand, are engaged unconsciously without questioning the framework they are setting up, where our action is conducted towards the driven accomplishment of predefined tasks.

As we have already seen, the problems of dualism were solved with the proposition and elaboration of the Virtual. The Virtual as a reservoir of infinite possibilities allows linking modern mathematics with the world and gives an account of the agency of matter, the mechanisms of innovation and inter-subjectivity and social action, which is no longer considered as separate from the natural realm.

The Virtual allows the multiplication of possible states and the understanding of the ontogenesis of our world as an actualization among other possibilities. Our world is not something already existing state, the correlate of our mental acts, but the emergence of a problematizing action in which multiple entities interact

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263 Paul Dourish (2004) *Where the Action Is. The foundations of Embodied Interaction*, pp.126

interchanging information towards the solution of a discordance that will produce the individuation of a new reality. The Virtual is not only a property of intensive space but itself a space of possibilities that remains attached to any actualized entity, by virtue of its Affects. It is the pre-individual attached to all human beings that allows them to transindividuate inside a Collective, which is assembled around a shared problematic. Individuation occurs by means of Transduction, a relation in which the interacting individuals are modified at the same time as they modify their environment. Participation becomes an engagement in which our identities emerge as a result of our involvement in the production of our milieu. Technicity explains the openness of our world not as something to be unconcealed but as the result of the aware interactions of a net of Collectives that meet inside a Space of Transformation producing new things. Embodiment and Encounter can be interpreted not only as a condition of the emergence of meaning but as a condition of Technicity; the setting up of the processes codifying our space as things we can manipulate towards a speculative experimentation able to produce new Transductions. Transduction is at the same time a relation engaged in the emergence of knowledge and the production of new things.

HCI has worked through the modelling of human capacities, abstracting it to data that can be projected inside the computer space, where human action was constrained inside a task-driven environment. Firstly, with the projection of the GUI, the personalization of a frame that was reproducing the human being and its space of action, setting up an interface of predefined affordances and concealing the programmability of the universal machine: then, by the modelling of the body and its environment, from where systems towards the production of a more tangible interaction were developed. It was based on transducers that converted our movements and body shape to data able to be output inside the computer space. The Polhemus system, developed at MIT, was a space-tracking system that used electromagnetic fields to determine the position of the user's hands. It was deployed in the development of data globes. These systems allowed projecting the movements of hands inside a graphical environment, where they could point to and manipulate other graphical objects. Data globes evolved through the implementation of more accurate tracking systems such as the Led Globe and the Data Globe. Finally, the Dexterous hand Master was a more complex system linking its movements not inside graphical space but to a robotic arm, which could be manipulated remotely. Finally, as Ubiquitous Computing embeds technology into our daily space, our movements and actions are abstracted to data and processed by relational and fuzzy systems. We become unaware of being engaged in machine-to-machine interactions that are producing our space.

The works of EAT place our body in a tangible interaction with its environment, not only defining computerized processes but also designing transducers able to input data from everyday events, in which our interactions with the involved objects and mechanism become tangible and transformed into outputs able to produce unexpected results. Artistic projects do not consider technological transducers as mediations working outside the focus of our attention, but deal with everything around us as agents with the capacity to "make us make": art, when working with data, does not reduce reality to the control of processes occurring on an imperceptible immaterial plane, but shapes it as things that one can experiment with. This experimentation increases our literacy regarding the technological medium while making it appropriable, in that its components can be aimed at new Transductions with the setting, from which new capacities can emerge.

The production of transducers rely on the capacity of simple electromechanical systems to transform the variety of fluxes of the world in differentials able to be codified as data and reprogramed in a computer, which can be coupled with other systems producing a response. The production of new transducers for the embodiment of computer processes in the material world led to new capabilities of pre-emption and control, but at the same time to the production of software and hardware appliances that made available the inner mechanisms of information transmission to non-experts, converting information into an interpretable experience. Here I will introduce Physical Computing, Data Visualization, and Digital Fabrication, new technological procedures and appliances that overstepped their field of origin to be involved in the literacy regarding the mechanisms that produce our contemporary Apparatus and its appropriation. These are technological projects that could mesh inside new Collectives towards the exploitation of the hackability that characterizes Embodied Virtuality and the fostering of citizens' intervention in the production of their space.

3.1.1.2 PHYSICAL COMPUTING

Physical Computing refers to a set of procedures aimed at the development and use of hardware and software that can sense and respond to the analogue world, at the same time as in its assemblage for the creation of transducers. The term was popularized by Dam O'Sullivan and Tom Igoe in the book "*Physical computing: sensing and controlling the world with computers*". Mainly addressed to education and art, the book is a pedagogical work based on a hands-on approach and aimed to the understanding of how the human being relates to the technological milieu.

Tom Igoe defines physical computing as:

> *"Physical Computing is an approach to learning how humans communicate through computers that start by considering how humans express themselves physically. A lot of beginning computer interface design instruction takes the computer hardware as given —namely, that there is a keyboard, a screen, perhaps speakers, and a mouse— and concentrates on teaching the software necessary to design within those boundaries. In physical computing, we take the human body as a given and attempt to design within the limits of its expression".* [264]

In this way Physical Computing does not teach on the mastery of software frames to accomplish specific tasks inside its boundaries, but develops experimental methods to work with the physical grounding of Human-Machine-Environment interaction. In practical use, the term most often describes handmade art, design or DIY hobby projects that use sensors and microcontrollers to translate the analogue input to a software system, and/or control electromechanical devices such as motors, servos, lighting or other hardware. It develops transducers that allow communicating with different features of the physical milieu.

Focusing more on projects that interact with humans and their bodies than on autonomous robots, physical computing takes a hands-on approach to experiment how the assemblage of available hardware components translates actions into signals, which are processed and converted to outputs for different purposes. This approach breaks the system in its fundamental processes. The sensors, electromechanical devices that are altered by the variations on the environment and produce a differential of energy that can be read by a computer; microcontrollers, the gateways between the physical and computer world. These are small very simple computers, which convert the differential output by the sensors to data. Finally, the communication between microcontrollers and computers where this data can be stored or transformed into a varied set of audio-visual or tangible outputs. Physical Computing is used in the production of machinic vision and sound recognition systems, tangible interfaces and environment sensors, used in sound and visual performances, data visualizations, gaming and the control of toys and small robots.

The hands-on approach gives a primordial role to prototyping, the production of non-definitive assemblages that can be tested before being altered or assembled again towards the projected result, the results aimed for and attained through experimentation more than through the use of previously elaborated schemes. This experimentation becomes possible inside dedicated platforms based on the principles of open source. Inside platforms are commercialized easy-to-assemble kits, where an environment for easy programming is offered, and a place for encounter with a community to share results and problematics in. Among these platforms, the most well-known are Wiring and Arduino.

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264 Definition from Tom Igoe website: http://www.tigoe.net/blog/what-is-physical-computing/

There are also associated platforms developed for the accomplishment of tasks not related to experimentation but to more professional applications. Fritzing is an open source initiative initiated at the University of Applied Sciences of Potsdam that develops an Electronic Design Automation software for electronics and hardware affordable to non-experts.[265] This platform offers tools for an advanced step in production. Within it, a working prototype can be translated into a blueprint to be shared and massively produced. In addition, there are proprietary software platforms offering already implemented solutions such as I-Cubex initiated in 1995 at the department of Kinesiology of the Simon Fraser University and nowadays produced by Infusion Systems. Mainly aimed at musicians, it comprises a system of sensors, actuators and interfaces configurable by a personal computer and communicating by means of MIDI, Bluetooth and the Universal Serial Bus (USB).

Wiring was the first produced open-source platform and is considered the antecedent of the popular Arduino. It was developed in 2003 by Hernando Barragan. It is an open-source electronics prototyping platform composed of a programming language, an Integrated Development Environment (IDE), and a single board microcontroller. Wiring means 'sketching with hardware' and was developed as Hernando's thesis project at the Interaction Design Institute of Ivrea under the direction of Cassey Reas. It was aimed at being a version of Processing dedicated to working with electronics.[266]

Processing is a programming language based on Java and enabled for artistic and educational use.[267] Initiated in 2001 by Cassey Reas and Ben Fry while both were students at MIT Media Lab within the John Maeda's Aesthetic and Computing research group, Processing is based on earlier projects such as the constructionist influenced Logo, aimed at teaching complex concepts inside an easy-to-program framework, and Design by Numbers by John Maeda that take up Papert's educational purposes. Design by Numbers was developed in 1999 as an introduction to computational design for artists and designers. DBN consists of a programming environment and a language. The environment provides a unified space for writing and running programs and the language introduces the basic ideas of computer programming within the context of drawing. Visual elements such as a dot, line, and field are combined with the computational ideas of variables and conditional statements to generate images. Processing took elements of DBN as the real-time display and enhanced it to become a useful platform for art production. A large number of students, artists, designers, researchers and hobbyists adopted this sketchbook software, which has contributed to promoting software literacy inside visual arts and aesthetic literacy within technologists. Its continuous success is due to its release to an open source community that has spread its use and expanded its potentialities with the development of third-part libraries, extensions, and translations. Processing has been adapted to new functions such as data visualization, computer vision, music composition, networking, 3D file exporting and programming, and electronics. In addition, it has been translated into other platforms and languages such as Javascript (P5.js), Phyton (processing.py), Ruby, Action-script, and Scala.

Massimo Banzi, also at the Interaction Design Institute of Ivrea, started Arduino in 2005. It is an electronic prototyping platform that offers an easy access to a whole body of knowledge about digital electronics. It stems from Wiring, Processing and the first single-board computer, KIM 1 created by Commodore in 1976. Arduino is based on the design of a simple microcontroller board that provides sets of digital and analogue pins that can easily connect and interface to expansion boards (named shields) and other circuits. The board features serial communication interfaces, including a serial bus (USB) for loading programs from a personal computer. The programs are developed in an integrated development environment (IDE), a cross-platform application written in the programming language Java. Massimo Banzi, David Cuartielles, Tom Igoe, Gianluca Martino and David Mellis integrated the initial Arduino core. Nowadays Arduino has evolved into a hardware and software company project and user community that manufactures open-source hardware, open-source

265 http://fritzing.org/

266 Daniel Shiffman (2009) "Interview with Casey Reas and Ben Fry", at *Rhizome*, published on-line: http://rhizome.org/editorial/2009/sep/23/interview-with-casey-reas-and-ben-fry/

267 https://www.processing.org/

software and microcontroller based kits for building interactive objects. The Arduino community spread abroad and became popular after it was associated with the Maker movement. The Maker movement is an evolution of Hackerlabs where the political aims had been substituted by a hobbyist approach meshed with the promotion of a neo-liberal economics evolved from the Do It Yourself and the *Whole Earth Catalogue*. Their more popular promoters are Chris Anderson, editor of Wired, and Dougherty, creator of the Make magazine and the Maker Fairs. Maker spaces are gatherings for amateurs, students, and practitioners of varied disciplines that encounter around the prototyping and modification of technological gadgets using affordable tools. This atmosphere fosters the fast creation of new products and the emergence of startups, the reason why they are perceived as able to propel economic growth.

In opposition, Collectives more engaged in artistic, social, research projects and the criticism and elucidation of our technological milieu adopted these tools as well; Citizen Labs, Fab Labs and Hacker Labs are spaces for the production of socially engaged devices and experiences. They become Spaces of Transformation where Collectives meet for the production of sensing devices, gamer experiences, hacked toys and disabled adapted appliances among many other things made to transform our spaces of dwelling.

3.1.2. THE DATA-SCAPE

> *"Information visualization (InfoVis) is the communication of abstract data through the use of interactive visual interfaces."*[268]
>
> *"Information visualization utilizes computer graphics and interaction to assist humans in solving problems."* [269]

Infographics and Information Visualization has become mainstream.[270] The visual rendering of information is used to tell compelling stories in the press. The custom visualizations built by the New York Times Interactive team is well known. The staff of Mashable also uses infographics to make sense of the evolution and trends of our connected world. There are also individual or company projects creating efficient interfaces to explain stories that were sometimes unnoticed, such as the *Drones* project by Pitch Interactive that used data from a set of official sources to render an animated and interactive storyline to follow every drone strike and victim in Pakistan.[271] They are also used in education to make sense of museum and library collections or in the elaboration of interactive maps, which give access to data in an understandable manner. As an example, the *Gapminder* project founded in Stockholm by Ola Rosling, Anna Rosling Rönnlund, and Hans Rosling in 2005 includes the Gapminder World.[272] It is an animated visualization allowing users to explore and interact with

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268 Keim, D.A.; Mansmann, F. and Schneidewind, J. and Ziegler, H.. "Challenges in Visual Data Analysis", Proceedings of Information Visualization (IV 2006), IEEE, p. 9-16, 2006. Quoted at Lev Manovich (2010) "What is Visualization?"

269 Purchase, H. C., Andrienko, N., Jankun-Kelly, T. J., and Ward, M. 2008. "Theoretical Foundations of Information Visualization", Information Visualization: Human-Centered Issues and Perspectives, A. Kerren, J. T. Stasko, J. Fekete, and C. North, Eds. Lecture Notes In Computer Science, vol. 4950. Springer-Verlag, Berlin, Heidelberg, pp. 46-64. Quoted at Lev Manovich (2010) "What is Visualization?"

270 Info-graphics, information visualization and data visualization are differentiated in its purposes and the outputs produced. Graphic visualization uses to be static and information visualization uses to include some kind of interactivity. Data visualization refers to the mapping in a computer from data to images. Henceforth, infographics and information visualization uses to make use of drawings and presentations sometimes borrowed from other disciplines to privilege storytelling. However, all take part in the same turn of knowledge and sometimes the limits between them blur in its application.

271 http://drones.pitchinteractive.com/

272 https://www.gapminder.org/

a repository of data about the health and wealth of every nation. Also, different kinds of social and market studies applies it to communicate its results as in the popular *Daily rituals of creative people* by Mason Currey.[273] Finally, they are widely used to analyse trends inside social networks such as in the project *The year in news 2014* by Echelon Insights.[274] This project combines different plots to provide a panoramic view of what America was talking about in 2014 after analysing 184.5 million tweets.

These visualizations are usually compounds of different graphic methods worked by means of the establishment of metaphoric relations that enable easy understanding and storytelling. They combine aesthetic and informative value as in the visualizations based on photographic real-image elaborated by Marion Luttenberg for the Moodley Brand Identity campaign of Caritas. [275] Finally, visualization relates to interface design and the creation of interactive content to be accessed from big screens and media facades, mobile phones, and tangible interaction systems.

In our connected society, data has become massively produced and sharing the graphical representation and understanding of information has become a fundamental skill of our literacy. However, infographics have a long history developed jointly with statistics and the study of social phenomena. It started in the 18th century with William Playfair and the development of the graphical methods of statistics. Playfair, considered the founder of these methods, invented several types of graphics to visualize quantitative data, still in use today, such as the bar chart in 1786 and the pie chart and circle graph in 1801. The discipline experienced a major development in the first part of the 19th century with the rise of social statistics, as a way of looking for regularities leading to the discovery of the laws of society. Some contributions from this period were the John Snow *Cholera Map*, produced by Doctor Snow in 1854, also considered one of the first GIS systems. Dr. Snow located on a map of London's Soho the known cases of cholera; this procedure allowed him to discover the source of the disease. Florence Nightingale invented the polar diagrams in 1858 to elaborate her reports about the conditions of medical care in the Crimean War. Another example is *Napoleon's March on Moscow* visualized by Joseph Minard in 1869.[276] He combined line charts to resume the dense information in a history flow. Bar and pie charts, histograms, line graphs and time-series plots, contour plots, and so forth were all invented in this epoch.

What all these visualizations have in common is to map data to different kinds of vector graphics, lines, curves, points and other geometric forms. In this operation, it is followed a process of reduction and spatialization. In this way, a phenomenon is reduced to quantifiable features; filtered according to a desired resolution and region of interest. Afterwards, these features are spatialized in some kind of topology constituted by geometric forms. This process defines the pipeline of visualization: data -> filtering -> mapping-> rendering-> Image. Mapping is the most decisive moment, where data is associated with a graphic representation, in which the spatial dimension is conveyed as the main source of meaning and other visual characteristics such as tone, size and shade are used to represent secondary features.

The development of computer graphics has brought new possibilities to Information Visualization such as the real-time rendering of data, the animation that allows incorporating temporal dimension and interactivity allowing the manipulation of the layout to explore different relations among the featured data. In addition, the use of software allows the visualization of large and complex datasets, by means of the application of algorithms able to calculate relations between large amounts of data and convey it to topography where these relations are expressed as measured distances. Thus, computer Data Visualization has become a relevant method for the understanding of the data deluge that characterizes our contemporary milieu.

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273 https://podio.com/site/creative-routines

274 http://echeloninsights.com/wp-content/uploads/2014/12/theyearinnews20141.png

275 http://snip.ly/vF80#http://marion-luttenberger.squarespace.com/#/infographics/

276 https://www.edwardtufte.com/tufte/minard

Computer graphic visualization was first applied to scientific research. Scientific visualization become one of the fields involved in the development of computer graphics, which advanced through the development of algorithms for the rendering of data obtained from scan techniques, ultrasound measures, and environmental sensing. These algorithms produced 3D realistic layouts and geographic visualizations such as the *L.A. The Movie* that evolved towards the interactive and multi-layered maps we have incorporated into our daily lives. The plots obtained from the pipeline that filters, maps and renders the data flow, allow the exploration of results from numerical analysis and extract meaning from complex and multidimensional datasets. In addition, the three-dimensional graphics obtained can be manipulated on the screen in a process of discovery and exploration that allow us to discern between the relevant and the ordinary. In other words, to find the singularities and thresholds from which a system can change. Therefore, visualization is deployed to build simulations where physical systems and their properties can be explored by means of experimentation towards the discovery and prediction of their functioning. In this way, inside the field of sciences, visualization is used for the understanding of complex phenomena such as the inner structures of organisms and the behaviour of stellar bodies. It is also used in the explanation of complex mathematical procedures, as in the animation *Sorting out Sorting*, a visualization of the Sorting Algorithm created by Ronald Baecker at the University of Toronto in 1980.[277]

Data Visualization is not a technology developed for computers but for humans. It takes advantage of human beings' capacities of perception, the plasticity of human vision to compare large and small features at the same time and find relations and inconsistencies inside data allowing them to perceive emergent properties such as subtle patterns and structures. It became an intuitive discovery method for data mining and exploratory data analysis. The rendering of data inside topological spaces allows the data to speak for itself. Visualizations are not only a way to communicate, retrieve or monitor information but a discovery technique where human perception meshes with algorithmic procedures. In contrast to placing data inside a predefined structure following pre-assigned categories, the algorithmic layouts sort the data according to previously unknown relations inside the dataset features. Amounts, classes, and intervals autospatialize according to the parameters of algorithms and the complex calculations of distance rates and associations. It becomes an experimental tool for knowledge formation. As computation has spread to all fields of research and everyday life, Data Visualization is being applied to the study of social interactions and the formation of our culture.

Now that data comes from *everyware*, produced by on-line and off-line computational procedures, the methods of scientific visualization have extended to other fields. becoming the most comprehensive field of Information Visualization. It has been applied to the study of the growing digitized materials of our cultural history, becoming one of the computational methods of Digital Humanities. Berry characterizes Digital Humanities as the application of computational methods to the analysis of a corpus of information that due to its extension cannot be studied by traditional procedures.[278] Inside this new field of research, visualization meshes with other technologies such as text analysis, where it is used to observe relations and clusters between bags of worlds. It has also been used in the elaboration of platforms where local histories are built, by means of the collaborative retrieval and analysis of heterogeneous documents. It takes part in a cohesive framework of analysis where documents can be geolocated, text mined and related to storytelling.[279]

Information Visualization has been also integrated into cultural anthropology and social analysis. Social Computing analyses human behaviour and cultural formation within the large amount of born-digital cultural objects generated in social networks such as images on Instagram, videos on YouTube, text in Twitter and Facebook posts. The content of these objects and their related tags as geolocation, time span or tags,

277 R. Baecker (1998) "Sorting Out Sorting : A Case Study of Software Visualization for Teaching Computer Science" at J. Stasko, J. Domingue, M. Brown, & B. Price, (Eds.), *Software Visualization: Programming as a Multimedia Experience*. MIT Press. pp. 369-381

278 David M. Berry (2011) "The Computational Turn: Thinking about the Digital Humanities"

279 Sandra Alvaro (213) "Big Data and Digital Humanities: From social computing to the challenges of connected culture"

are deployed as features in a database and analysed with the application of machine learning algorithms and Data Visualization layouts. This data can be geolocated, temporarily sorted, and text mined towards the discovery of informational and affective content. One of the main resources in the analysis of social media is Network Analysis, based on Graph Theory. Network layouts for visualization allow finding relations between social media content and user interactions. Therefore, it has become a powerful tool for the study of social behaviour, which is mined by the application of algorithms able to quantify and represent complex relations. Networks not only are the paradigmatic image of our connected society, they are also applied to show the procedures producing this space as the transmission of information inside platforms, the clustering of groups and the localization of the hubs between information transmitters. Initially dedicated to exploring the behaviour and user interactions inside social networks, the visualization and data analysis of networked content has evolved with the incorporation of technologies dedicated to image and sound computing, allowing the analysis of digitally produced cultural products. This has meshed the fields of Social Computing and Digital Humanities inside the new-born field of Culture Analytics.[280]

Finally, Visualization has been applied to the study of urban phenomena. Urban Computing visualizes the digital traces of citizens and connected objects overlaying it on a base map, the result used in urban planning and other urban interventions. Primarily aimed at the management of the city, the combination of Data Visualization with physical computing, which allows citizens to build their own sensing devices, has led to Citizens Science and the participation of new Collectives in the production of urban space.

As visualization has been applied to everyday cultural and social phenomena it has contributed to the creation of a new landscape, a new way of representing and territorializing our milieu.[281] This new landscape has substituted the static perspectival representation of the 18th century, with its delimited frame and hierarchical disposition of planes by a surface where entities are flattened inside a layout emerging from their relations.

One of the fundamental properties of software is that once it is being executed it takes place on such a fine temporal and symbolic scale and across such a vast range of quantities of data that it has an intrinsically different materiality than that which we are able to deal with unaided. The main interest of Visualization is that it can be applied to make the computing processes that are shaping our space human-perceivable. Henceforth, Visualization methodologies are a fundamental resource for contemporary literacy towards the understanding of the Datafied Society. Different open projects such as Many Eyes and Gephi conjointly with interfaces for the crowdsourcing and open analysis of data are spreading through the net, becoming a usual method for the understanding and production of our space.

3.1.2.1 NEW CARTOGRAPHIES

> *"DOTS, circles, bars, curves, symbols, etc., may be placed on a base map to give the geographic location of statistical data. When used in this way, the general term "statistical map" may be applied. Synonyms for statistical map are cartogram, map chart".*[282]

As transducers are everyware, data comes from everywhere. This is the last update of Embodied Virtuality, characterized by the dissemination of computing into a new technological milieu that embeds with the Apparatus, which is shaping the way we obtain knowledge and manage our environment. Visualization has spread to all disciplines mapping our world into the diagramatic space that characterizes this Apparatus.

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280 Lev Manovich (2015) "The Science of Culture? Social Computing, Digital Humanities and Cultural Analytics"

281 Sandra Álvaro (2014) "Complexity, multi-perspectivism and Tracking: A brief history of the meaning of image from the Postmedia to the Postdigital ages"

282 Wilard C. Brinton (1939) *Graphic presentation*, pp.153

Maps are the methodology of visualization that arises from the first renderings of remotely obtained data from our geographical space. These renderings constitute a realistic base-map and dynamic, where information can be overlaid. It works as a layout based on longitude and latitude coordinates. The statistical data obtained from different phenomena for the understanding of its spatial and temporal evolution can be located. This New Cartography has redefined our understanding of the city and the way we plan it, especially when it is linked with environmental data sensed from the networked objects of Ubiquitous Computing. Therefore, it leads to the management of our cities based on a bottom-up approach in which interactions are tracked and included as features that can be manipulated towards an increase of efficiency and control. However, these maps can also be used for the unveiling and Disruption of the hidden structures and processes shaping our space. At the same time, the map can work as a surface for encounter, the basis for the elaboration of platforms from where the space is territorialized and deterritorialized in the ongoing encounters between diverse Collectives.

New Cartography has been developed in relation to city planning as a surface where the physical boundaries and structures that forming the urban form encounters with the real-time tracking of its social use.

The *Real-Time Rome* project from MIT evolved inside the Senseable City laboratory to new methodologies focused on the visualization of the real-time city by means of the location on the geographical layout of data from phone communications. One example is the *Borderline* project (2010) which redefines the borders of Great Britain according to the social interactions –phone calls- among its inhabitants. The project uses an algorithm that creates optimal partitions of the territory according to people's communications. Another project developed at this Lab is *Signature of Humanity* (2013), a project conducted in collaboration with Ericson that explores the mobile phone networks from different countries focusing on spatiotemporal voice, *SMS*, and data traffic. The tracking of these interactions forms a big data set that is analysed in the quest for characteristic usages and regular dynamic patterns at both a collective and individual scale. This project was updated to the *A tale of many cities* that browsed mobile phone traffic patterns in London, New York, Hong Kong and Los Angeles during a 10 month period going from April 2013 to January 2014.

Another data source explored by this lab is the data sensed by networked objects. This is used for the crowdsourced sensing of the environment or in the tracking of the territories defined by non-human agents. The *Copenhagen Wheel* (2009) consists of the distribution of a device to be attached to bicycles, a common means of transport in this city. This networked object in communication with the user mobile phone converts bicycles to hybrid e-bikes. Among its functionalities, it allows saving the energy produced when cycling for its reuse when necessary. In addition, it senses e-bikes location and velocity, air quality and road conditions in real-time. Users can visualize and share this information from their smartphones, from where it is compiled for personal health improvement or shared on-line for producing collective awareness of environment quality. *Trash Track* (2009) attaches RFID tags to everyday garbage, allowing the visualization of the territories these waste objects describe from their place of disposal until their treatment in remote countries. *Backtalk* (2011) was created for the MOMA exhibition *"Talk to me: Design and the communication between people and objects"*.[283] It tracks the technological waste from the places where it is discarded to the countries and communities where it is reused. The project tags portable computers with RFID tags tracking them from their place of origin. Having reached their destination, the webcams of the laptops serve to set up a space of encounter where the new users of recycled computers can communicate and send messages to the place of origin. *The Monitour* (2016) updates these projects to produce a web application that visualizes the trajectory of e-waste in an interactive animation. This joint project with Basel Action Network (BAN) is aimed at discovering previously unknown international electronic waste routes. Finally, in 2015 this laboratory started the *Underworlds* project, which uses a net of heterogeneous sensors located on the sewage system to compile data about the presence of viruses, bacteria and chemicals and compile it in a database useful

283 http://www.moma.org/interactives/exhibitions/2011/talktome/

for health improvement and epidemiological research. Started with the participation of the Alm Lab, and sponsored by the MIT-Kuwait Centre for Natural Resources and the Environment, the project consists of a physical infrastructure, biochemical measurement technologies, and computational tools and analytics necessary to interpret and act on the assembled database.

Finally, the city is also visualized by means of the analysis of social media. As portable networked devices allow people to report their activities on-line as they are on their way and in real time, a big database of geotagged content has been produced that has proved useful to analyse urban activities. One of the projects by this lab using Big Data is *Los ojos del mundo/the world's eyes*, a project undertaken in 2007 with the collaboration of the Museum of Design from Barcelona. This project tracks tourism in this city and identifies its activities and places of concentration by means of the analysis of pictures downloaded to the sharing platform Flickr. This tracking produces visualization where tourists are and where they come from can be perceived, what they are interested in, and what is the attractiveness of the points of interest.

The internet and the data produced in its inside interactions is one of the most mapped spaces. In relation to geographical space, the data flows shared on the net can be geolocated in a map to track the unfolding of global phenomena inside the networked space such as in the project *GDLET* started in 1979 by Kalev H. Leetaru.[284] It agglutinates a large database of events extracted from the daily press from different countries. Nowadays *GDLET* consists of an earth globe where we can see how events unfold in real time, the database being updated every 15 minutes through the monitoring of different news media in over 100 languages. The engine applies text analysis to look for breaking events that are geolocated in the globe. The project seeks a better understanding of the connection between communicative discourse and physical societal-scale behaviour. The unfolding of global events is also visualized within the data transmission inside social networks such as Twitter, as in the already mentioned project, *The year in news*. The social networks are also analysed to see the localizations that agglutinate the most active users inside the city as in the project by Mapbox *Glowing geotagged tweets* that mapped tweets from Osaka, Bangkok, Mexico City, New York and other world hubs. However, the visualization of internet data flow uses to adopt other layouts where geographical references are substituted by delocalized topologies, where the web appears as a self-contained space emerging from its inner interactions.

The social web activity is visualized to extract insights about the production of Collective Intelligence. For example, the project from 2003 by Fernanda Viegas *History Flow* visualizes in a temporal flow the contributions and modifications to the Wikipedia's topics but mainly to track users' behaviour by means of seeing how information is transmitted across the social platforms as Twitter, for example in *Social Collider* (2009) by Karsten Schmidt, Sascha Pohflepp[285], for localizing the formation of communities as in *Pleiades* (2012) by Santiago Ortiz,[286] and for analysing Facebook's friends similarity as in the *Nexus* project (2007) by Ivan Kozik.[287] These projects map social media activity as networks layouts, a topology that is being widely used in Social Computing. In this layout, users are represented as nodes and their activities and relations as edges. The network presents a series of properties such as cliques, distances, bridges, centrality, and network structure that can be analysed by the application of algorithms. These properties allow modelling the behaviour of users that can be explored and manipulated for different purposes.

Another approach to the analysis of cultural products massively produced and shared on the media is the one elaborated by Lev Manovich in the Software Studies Initiative. Going beyond the nets of interactions and the analysis of textual content this research group has developed a rich media visualization method that allows comparing milliards of images without sampling or reducing them, at the same time looking for patterns that

284 http://gdeltproject.org/about.html

285 http://socialcollider.net/

286 http://www.visualcomplexity.com/vc/project.cfm?id=774

287 http://nexus.ludios.net/

reveal subtle differences and similarities in the production of our global culture. The methodology identified as Cultural Analytics produces interfaces where it is possible to analyse contemporary cultural phenomena and find the subtle differences that identify local cultures. In *Selfie City*, the global phenomenon of posting self-portraits on the web named as selfies is analysed in the context of different cities, among them Bangkok, Berlin, Moscow, New York, San Paolo and more recently London.[288] The analysis is conducted by the use of quantitative and theoretical methods to compare the gender of the portrayed people in each city, their mood -if they are smiling- and other features such as posture. All this information can be visualized in the interface *selfiexploratory*.

Another project by Lev Manovich with Daniel Goddemeyer, Moritz Stefaner, and Dominikus Baur is *On Broadway*, an extensive visualization of all the downloaded data around 13 miles of the Broadway street across Manhattan.[289] The data including pictures, Google Street View images and their histograms, taxi use, demographic, and social media statistics as Foursquare checkings, tweets, and Instagram pictures. The Interface offers a tour across this city where the contents produced by its citizens can be browsed; a composite city view that emerges from the interactions of hundreds of thousands of connected citizens.

All these maps show not only a new form of representation of our space but also how our space is being produced through the formation of Collectives and their technologically mediated interactions.

3.1.2.2 THE POLITICS AND EPISTEMOLOGIES OF NETWORKS

In 2007, Chris Anderson published *"The End of Theory: The Data Deluge Makes the Scientific Method Obsolete"* in Wired magazine.[290] In this controversial text, the editor of Wired foresees the changes that Big Data will produce in the understanding and management of our environment. Big Data does not mean just more, it means different. According to the author, in the Big Data era, the web is becoming the laboratory of social condition, now analysed in real time with computational methods. Therefore, the theories become unnecessary. The author focuses on companies such as Google and the way they collect and analyse data for conveying recommendations and update their services. Using examples such as the functioning of the Google Translator, he demonstrates how marketing and translation machines can perform useful tasks very well focussing only on data and forgetting about the context. As an example, the Amazon recommendation algorithm does not know about the books it recommends. What the books are about, which language they are written in or who their author is are secondary features for a system that computes all client purchases and conveys that if a significant number of costumers that had bought 'A' had also bought 'B', then the actual consumer buying 'A' may be also interested in 'B'. From the functioning of these data-driven systems, the author derives that in the most measured age in history, models are not necessary anymore. On the contrary, from the examples we have seen throughout this chapter we can conclude that one of the most important challenges of Big Data is not that the models are not necessary anymore but that the models are more powerful than ever before.

The author of *"The End of Theory"* explores the reduction process of data abstraction in very narrow fields of application and ignores some of the already quoted Big Data concerns. Big Data is supposed to capture a whole domain in a high resolution, without the need of *a priori* theories, from where it is deduced that patterns are inherently meaningful and truthful and that meaning transcends context in a purely inductive modus operandi. On the contrary, Big Data is always obtained inside a frame laid out by the employed technologies, the data ontologies employed in its ordering and the policing environment regulating its

288 http://selfiecity.net/].

289 http://www.on-broadway.nyc/

290 Chris Anderson (2007) "The End of Theory: The Data Deluge Makes the Scientific Method Obsolete" at *Wired* Magazine 16.07

propriety and sharing. Data is always created inside an assemblage territorialized by an Apparatus. It contains the material ground, the technology and the forms of knowledge and power. Making sense of data also occurs inside of a frame laid out by the constitution of a model. The modelling of data implies an operation of filtering in which the choosing, ordering and cleaning of the dataset is involved, followed by a process of spatialization in which a layout is chosen. Layouts are directed at different purposes and performed by algorithms that rather than neutral, are the result of discursive processes and the competence among different theories. Big Data does not work inside a radical empiricism where 'correlation is enough' and capacity of prediction substitutes explanation. On the contrary, the modelling and analysis of Big Data is performed in a speculative process that is able to affront complexity and non-linear causality by means of a transductive process where hypothesis are never considered as definitive but as the first step towards a process of experimentation where the models are continuously tested and elaborated again. It is a methodology that is closest to what Charles Sanders Peirce identifies as abduction rather that induction and deduction. We can say the quote by George Box is still valid: "All the models are wrong, but some of them (after a long process) are useful". What makes the computerized analysis of Big Data so powerful is that computers can perform this process in large amounts of data and very fast. Therefore, they acquire a big capacity to infer knowledge of our context. Machine Learning is a supervised method of Artificial Intelligence, the realization of the learning machines foreseen by Alan Turing. Learning machines appear first in Turing's paper *"Computing Machinery and Intelligence"* as a response to Ada Lovelace objection: *"the machine can only do what we tell it to do"*[291]. Turing describes in his paper that an intelligent machine is not one programmed to reproduce all the possible states of the human brain but one that can be trained to accomplish functions attributed to the human brain. Machine Learning is based on this principle: it consists of a neuronal net, a system that approximates the net of neurons in the human brain. The neural net can be fed with vast amounts of data from where it can extract patterns for the performing of a task. For example, the new Google Image Location consists of a deep-learning machine trained to find the location of almost any image using only the pixels it contains. The machine was trained with a database of images geolocated inside a grid that divides the world into 26,000 squares. The 126 million images of the database are used to feed the neural network. The machine looks for patterns, inside each picture associating frequently repeated distributions of pixels to the cell of the grid where they usually appear. After the training comes the testing, the machine is fed with new images without the location information. The machine must be able to look for patterns inside the image, contrast them inside its database, and approximate the cell of the grid from where the image was taken. Even if the PlaNet neural network does not have great accuracy, its results are close to the human being's results. A similar methodology has been deployed in the realization of the maps of world population created by Facebook, the most accurate until now with a granularity of five-meter squares. These maps have been made with a combination of image recognition and available datasets. The image recognition is based on a learning machine trained to read satellite images and discover patterns that can be attributed to signs of human habitation such as roads, houses, parking lots and so on. After that, the computer calculates the density of these patterns inside the 5 square metres cell of terrain. Later the data obtained by this method are combined with available census data of every region to estimate the result, the data of the population density of each square. Even if the algorithms able to lead with higher dimensional data -heterogeneous data sets resulting from considering facts inside its context- are still under development they are proving to be successful in inferring information from complex contexts, what confers them a great capacity for prediction.

Schroeder defines Big Data as research that represents a step change in the scale and scope of knowledge about a given phenomenon. He identifies the capacity to manipulate audience and customer experiences on an unprecedented scale and with unprecedented accuracy as the main threat of this technological stage.[292] Schroeder illustrates his thesis referring to the Facebook experiment *Emotional Contagion* conducted by

291 Alan Turing (1950) "Computing Machinery and Intelligence"

292 Ralph Schroeder (2014) "Big Data and the brave new world of social media research"

Kramer.[293] It describes how, over the course of one week in January 2012, the company altered the 'news feed' of two groups of the Facebook users. In one group, the company reduced the number of feeds with positive emotional content. Meanwhile, in the other one, it reduced the feeds with negative emotional content. After the setting up of these conditions, the experiment followed with the emotional analysis of the posts published by both groups. The analysis of 122 million words from 3 million posts demonstrated that the emotional content of the shared text was influenced by the experiment. It became more positive in the group where the negative content was filtered, and more negative in the other group. The *Emotional Contagion* experiment raised a considerable number of critiques about the unconsented manipulation and use of consumer's data by this company. Schroder goes beyond the discussion about privacy and the property of data, and points out as a major threat the big power that internet services companies have over our lives. In other words, how data can be used to manipulate people in powerful ways. In fact, the manipulation of users' data without their knowledge is an effect of the normal functioning of social platforms. Data inside the social web is managed by algorithms, which operate with a total lack of transparency. Every action we perform inside the net is collected as data, mined and managed by hidden algorithms. These determine which posts and in which order they appear in our 'news feed', the 'friends' we are more connected to, and convey friend recommendations and sponsored posts. These algorithms operate a model of our context that remains under the range of our perception. This model depersonalizes people and their interactions to a set of features that can be manipulated inside the model for the discovery of new patterns or regular laws. Deprecating differences, this kind of research leads to a deterministic approach by virtue of which these regularities are applied to the control of human behaviour, this application resulting in a loss of human autonomy.

The second consequence that can be deducted from this experiment is how Big Data has affected social research. Conducted in this way, social research is subdued to the availability of datasets. This implies, on the one hand, that social phenomena and relations that do not produce data are ruled out of the scope of social research. On the other hand, that research has moved from the academy to the labs of the big companies owning this data. As data remains protected under the property of companies, researchers must operate inside the bias of data that they do not know how it has been obtained and, outside the open discussion that must characterize the elaboration of knowledge, the lack of openness because the results of research must be presented without the explanation of the data sources and methodologies.

All the challenges explained give great power to the big companies controlling internet in determining the way in which our space is conceived and practiced.

In addition to being involved with Big Data analysis, Information Visualization is an artistic practice, works inside the framework of human perception and can be employed for revealing the algorithmic models that are performing our landscape. Even if these models normalize people and flatten our space the relationality and plasticity of data and the diagrammatic nature of the space they are spatialized opens these models to artistic experimentation. Data models can be disrupted to act as Rhizomes towards the connection with new datasets producing new insights, at the same time as being able to act as surfaces for the encounter of the molecular forces of the Collectives.

As Data Visualization has been part of our contemporary literacy a large amount of Data Visualization tools have become freely available on the web, dedicated to the elaboration of vector graphics such as Public Tableau[294], to the temporary interpretation of data as Flowing Media[295] -created by the team that produced *Many Eyes*- to

293 Adam D. I. Kramer, Jamie E. Guillory, and Jeffrey T. Hancock (2014) "Experimental evidence of massive-scale emotional contagion through social networks" *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* June 17, 2014 vol. 111 no. 24

294 https://public.tableau.com/s/,

295 https://github.com/FlowingMedia/TimeFlow/wiki

network analysis such as Gephi[296] and geographic visualization such as Carto DB[297] and the Google API[298]. There are also libraries to complement the capabilities of existing programming languages with graphic capabilities for rendering data, such as Gplot for the statistical language R, Prefuse for Processing, and D3.js for javascript.

Many Eyes, created in 2007 by Fernanda Viegas, Martin Wattenberg, and the VCL team, pioneered the democratization of Visualization, consisting of a platform where users could upload their data and use different pipelines to visualize and share the results, allowing experimentation with collaborative techniques. The project grew in popularity until it was closed in 2015 by the IBM Visualization and Behaviour group, which was maintaining it.

Many Eyes was followed by a large number of visualization apps with which people could visualize data for multiple purposes from business management to aesthetical creation. However, these tools remain inside the data flow paradigm. They employ already implemented models with standardized inputs and outputs. For a real literacy of the processes that produce our society what needs to be open are not the visualization tools, but the models, the algorithms that shape these visualizations.

Regarding this issue, the geographical visualization tool *Open Street Map*[299] offers an alternative. This base map is a community-driven open data project, produced by the mapping effort of over two million volunteers working around the globe. This map exploits local knowledge for the retrieving of data, in a process that is shared and known by all the people involved in its creation. This collective work is producing a useful and constantly updated map that on some occasions has been used in the management of emergencies, producing updated maps of safe routes after earthquakes and other natural disasters. In conjunction with initiatives such as Open Data and Open Government, which bring almost any important city in the world to share demographic and geographical data on the web for its free consultation and reuse, *Open Street Map* has become a habitual platform to visualize data and produce projects showing new findings about the city.

Carnivore is also a special case. It consists of a library for Processing produced in 2001 by Alexander Galloway and the Radical Software Group, consisting of a list of functions that allow tracking internet traffic from authorized clients, and is at the same time an artistic project. *Carnivore* criticises internet monitoring by governmental agencies by means of putting this capacity in the hands of everybody interested in using it. Carnivore, later named DSC1000, was a system implemented by the Federal Bureau of Investigation in the USA that was designed to monitor email and electronic communications. It used a customizable packet sniffer that could monitor all of a target user's Internet traffic. *Carnivore* tracked all the data produced by volunteer websites not to target it as suspicious, but to feed this data to the Processing software where it could be interpreted and animated to produce artistic images.

Conjointly with other artistic projects we will see in the next chapter how *Carnivore* contributes to the unveiling of the processes we are engaged in our daily life deciphering the modelling of our behaviour and the Politics of Networks.

3.1.3 DIGITAL FABRICATION

Digital Fabrication is the ultimate realization of the Internet of Things. Data becomes things and things become Data that can be transmitted through the internet and materialized everywhere.

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296 https://gephi.org/

297 https://carto.com/

298 https://developers.google.com/maps/

299 https://www.openstreetmap.org/#map=5/51.500/-0.100

Digital Fabrication is a new assemblage that includes Numerical Controlled Machines such as mills, laser cutters, and the popular digital printers, as well as new materials and other small machines and software used in the process of the creation of things. This is done jointly among the Collectives that met around the development and experimentation with this hardware and software and the places, virtual and physical, where they meet.

Digital Fabrication stems from the first computer controlled machines and the computer-aided design and manufacturing software in the same way that CAD systems moved from the big workstations to become available in personal computers. The machines associated with Digital Fabrication, especially 3D printers, have moved from big factories to the desktop, becoming a fast prototyping method available for research centres, design and architectural studios, educational institutions and new spaces for the meeting of new Collectives such as Fab Labs and Maker Spaces. The spread of these machines is producing changes in how research, education, and design are conducted. At the same time, it is fostering the speculation about a new economic and productive system able to mitigate the economic crisis and inequalities.

Neil Gershenfeld considers 3D printing as the machine of the Digital Fabrication Revolution and the culmination of the Internet of Objects. Things are not only networked inside the data flow but themselves travel across the net as data. Users can collectively contribute and modify these data packages to adapt it to their specific needs and produce it from anywhere. This leads to networked production and product personalization. In addition, autonomous Collectives become self-sufficient as they are able to assemble their own tools that can be projected and tested in a continuous experimentation, fostered by the fast prototyping techniques allowed by these machines.

Additive Manufacturing and its characteristics of networked production, high personalization, and fast prototyping have aroused great interest among the press. It is considered as the propeller of a new era based on innovation and a more sustainable and egalitarian mode of production. The increased capabilities of computer design in conjunction with the research in new materials have produced creative applications that have filed across newspapers, exhibitions, and the fashion catwalk. Among the most acclaimed, we can quote the innovations related to medical care, fashion design, personalized mass-production and architecture. Related to health care, 3D printed designs can incorporate patient data to produce personalized medicaments, and perfectly adapted prosthesis, for example Phonak produces perfectly adapted hearing aids at a competitive price and the anaplastologist Jan De Cubber creates 3D-printed replacement bones.[300] Another innovation related to health care involves the use of stem cells to produce organic tissues as vital organs for replacement. In the fashion catwalk, we attend to the creation of impossible dresses, sometimes enhanced with Ubiquitous Computing, such as the *Escapism Dress* created by Iris Van Herpen in collaboration with Daniel Widrig and Materialise.[301] In addition to the application of 3D printing to the production of personalized designs, the startup Electroloom[302] commercializes a system to design and print clothing in-house and the sports clothing enterprise Nike has produced the *Zoom Superfly Flyknit spike* for the Rio Olympics 2016, a couple of highly personalized sports shoes for the athlete Allyson Felix. In architecture, 3D printing is being applied for the production of new morphologies as in the *Arabesque Wall* produced by Benjamin Dillenburger and Michael Hansmeyer, a 3D print in sandstone measuring 109 cm x 140 cm x 305 cm -the largest 3D printed architectural component to date-. It explores the capacity of this technology to produce complex geometries with details in the resolution of micrometres. Also explored is the capacity of this technology to create solutions to the housing demand both faster and inexpensively. The Chinese company WinSun Decoration Design Engineering coassembled 10 3D-Printed concrete houses in a day for less than $5,000 each. Finally, 3D printing is also

300 Both projects showed at the exhibition: *Making a difference/a difference in making. Exploring the added value of 3d printing*, held at the Red Dot Design Museum Essen, German from 27th September to 30th October, 2016

301 Also showed at *Making a difference/a difference in making. Exploring the added value of 3d printing*

302 http://www.electroloom.com/

promoted in art conservation and popularization. The British Museum has released Sketchfab[303], a platform from where users can download scans of part of its collection for educational or hobbyist purposes. Users can also upload their own models. The New York Metropolitan Museum also released its own set of freely downloadable 3D models in 2012, stored in the popular platform Thingiverse.

In addition, 3D print is acclaimed as the promoter of a new kind of manufacturing able to revolutionize the current production system. Jeremy Rifkin considers 3D printers the machine of the third industrial revolution. In his bestseller *"The third Industrial Revolution"*[304], published in 2011 Rifkin exposes how 3D printing conjointly with Big Data and the global neural network produced by Ubiquitous Computing are revolutionizing traditional manufacturing and substituting the assembly line characteristic of 19th-century industrialization and mass production for a more locally distributed way of production. It is characterized by being directed at covering real needs and its low energy consumption. 3D printing allows startups and small to medium size enterprises to market their goods on internet sites that stretch over virtual space, enabling them to compete and even out-compete many of the giant business enterprises. Moreover, local production is reducing costs in marketing and goods shipping. In the new era, everyone can potentially be their own manufacturer as well as their own internet site and power company. The promoter of Maker movement Chris Anderson also stresses the value of 3D printing to promote innovation and the emergence of startups that can produce their products locally outside the big centres of production situated abroad.

Even if these prospects are exaggerated, 3D printing is still a slow process and quite expensive. 3D prints, especially after becoming affordable through open source initiatives, have changed design and education at the same time as fostering the emergence of new Collectives. Communities emerge around the production of objects that can be shared on the internet, updated and adapted for different purposes and tastes and downloaded for production anytime and from anywhere. The internet as a place for collective experimentation is now able to produce our reality on a more material level. In addition, the flexibility and complexity of CAD systems and parametric design are translated to material production in a fast prototyping method that allows extending the speculative research method of science to design and education. 3D printers can produce all the parts of a complex mechanism simultaneously and already articulated, without the need to acquire parts from different places and assemble it. This makes affordable continuous experimentation in design studios and education institutions that in addition can become autonomous and produce their own low-cost high-quality scientific equipment.

Additive manufacturing (AM) refers to various processes used to synthesize three-dimensional objects. It allows the production of objects that can be of almost any shape or geometry produced from a digital model by means of sequential layer addition of material through a 3D work envelope under automated control.

The roots of additive manufacturing come from the fifties when the first CNC (Computer Numerical Control) Machines appeared, milling machines wired to the digital mainframe computers. These first computer-manufacturing methods were subtractive. In the eighties in France Stereolithography or resin printing was patented and the first fast prototyping machines manufactured by companies such as 3D Systems, Stratasys, and Epilog Laser appeared. These systems brought the price of computer controlled manufacturing systems down from hundreds of thousands of dollars to tens of thousands, becoming available for research centres and big design and architectural studios. However, the popularization of this system was not fostered by these companies but by an open source project, the RepRap[305], and its continuator the Makerboot[306].

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303 https://sketchfab.com/

304 http://www.thethirdindustrialrevolution.com/

305 http://reprap.org/

306 http://www.makerbot.com/

The RepRap was inspired by the Von Newman's Universal Constructor, the creation of a machine able to replicate itself. RepRapPro is a portmanteau of REPlicating RAPid PROtotype. The project was started in 2005 by Dr. Adrian Bowyer, a Senior Lecturer in mechanical engineering at the University of Bath in the UK with the founding of the UK's Engineering and Physical Sciences Research Council, conceived as a self-replicating machine that grows and evolves not in an automated manner but delivered to a community. With this purpose, the machine is able to print most of its own components. The project consists of a computer-aided design (CAD) in the form of a 3D modelling application and computer-aided manufacturing (CAM) software and drivers that convert RepRap users' designs into a set of instructions to the RepRap hardware that turns them into physical objects. RepRap stopped its distribution on 15 January 2016.

RepRap open source project was adopted for the development of new machines, among them the popular Makerboot. The construction of this machine builds upon the early designs of RepRap but focusing on easy assembly and use and attractive design. Bre Pettis, Adam Mayer and Zack "Hoeken" Smith founded the company in 2009 to produce a community designed 3D printer. After closing the design of its products, not without controversy, Stratasys acquired the company on June 19, 2013.

Makerboot also created a platform to download and share ready to print models online, Thingiverse.com and easy to use tools for producing new models and translate them into a format suitable for the printer. Other popular platforms are Shapeways.com, ponoko.com, and studioludens.com, some of them including tools to convert scanned images into 3D models. Another system supporting the collective creation of 3D models is the 3D Warehouse by Google, a repository that works in conjunction with Sketchup, an application for easy 3D modelling. The 3D Warehouse harbours the exportable architectural models created by the users to fulfil the '3D buildings' layer of the Google Earth globe, a collectively produced navigable simulation of dwelling spaces at a global scale.

The most important contribution of RepRap was not the production and distribution of 3D printers making it affordable to new consumers, not even the possibility that these machines offered manufacturing things outside production factories, but was more the involvement of people in the production of a tool useful for making things. RepRap and then the more affordable Makerboot was adopted by makers, tinkerers and Collectives assembled around Do it Your Self and Do it With Others movements. The 3D printers would become the mainstay machine of the newly assembled Spaces of Transformation. Spaces where new Collectives assemble around the production of things related to the criticism of actual economic and managerial system and the proposal of new forms of innovation and production, the empowerment of citizens, the influence on educational goals and artistic experimentation.

3D printing and its characteristics have also been the subject of artistic creation. Golan Levin reflected on the capacity of these machines to distribute objects with the ability to challenge the actual production system and to appropriate the urban space and produced two well-known projects.

The QR stenciler and QR Hobo Codes[307] was produced at the FAT Lab (free Art and Technology) to take part in the exhibition *"Spontaneous Interventions: Design Actions for the Common Good"*[308], organized by the Institute for Urban Design to represent the United States at the 13th *Venice Architecture Biennale*.

The project consists of a stencil generator and a set of QR Hobo codes, meshing locative media and digital fabrication to offer a space annotation tool distributed through the internet.

307 http://fffff.at/qr-stenciler-and-qr-hobo-codes/developed

308 http://www.spontaneousinterventions.org/about/

The QR Hobo codes are based on the chalk-based 'hobo signs' developed by the 19th-century vagabonds and migratory workers to cope with the difficulties of nomadic life. The modern equivalents are signs translated to QR codes to be distributed in urban space as graffiti, a markup schema for digital nomads including the traditional annotations to provide directions, information and warnings such as ('turn right here', 'dangerous dog', 'food for work') and new ones adapted to new city life ('insecure wifi', 'hidden cameras', 'vegans beware'). Space annotating tools are distributed on the internet through the application QR stenciler, a stencil generator based on Processing that converts QR codes to a vector based stencil pattern suitable for the laser cutter. The QR_STENCILER was created by Golan Levin and Asa Foster III with support from the STUDIO for Creative Inquiry at Carnegie Mellon University.

The *Free Universal Construction Kit* is a set of adapters between 10 popular construction-kits shared freely on the internet as models to be 3D printed. Developed by Golan Levin and Shawn Sims at the STUDIO for Creative Inquiry, the project consists of a matrix of nearly 80 adapter bricks that enable complete interoperability between ten popular children's construction toys. These are developed as 3D printable models and distributed through popular platforms, among them Thingiverse. The freely distributed models enable free play out of the frame set up by the proprietary toy companies and ensures interoperability between closed systems enabling the production of previously impossible models.

3.1.4 FROM DEMATERIALIZED METAPHORS TO EMBODIED PRACTICES

The Space of Transformation is at the same time: (1) the space for the encounter and the emergence of Collectives set up around the production of a new Thing; (2) the process of creation of a new Thing as a problematic to be solved by the assemblage of a Collective of human and non-human agents, and; (3) the result of the process of creation, the Thing as a wearer of Affects capable of engaging in new assemblages.

The Space of Transformation is a concept to elucidate the Thing in the broadest sense, as the result of a situated process of nested Transductions, Transductions between disparate systems assembled to concretize in a new Thing; Transductions between the people affronting a problematic and the experimentation with the system towards a possible solution from where knowledge emerges; the Transduction between the agents involved that transindividuates in shared problematics in a process that forms their identities.

Digital Fabrication, Physical Computing, and Visualization are the latest updates of the Space of Embodied Virtuality, themselves Spaces of Transformation arising from the encounter of Collectives of humans –their founders and the large number of anonymous contributors to their development, educational centres and companies that harboured them, and the founding institutions that give economic support- and non-humans –platforms where people meet, the software and hardware employed in their production-. At the same time, these Things have woven big nets around them, new Collectives from science and engineering, art, politics, and education. They are all engaged in the promotion of new possibilities, new forms of knowledge and education, of design and production, and new political prospects.

Some of these Collectives gathered in the creation of new physical spaces. Fab Labs, Maker Spaces, Citizen and Media Labs are new Spaces of Transformation locally situated where different people meet and engage in the production of new Things, even if the motto 'build better things to build better communities' can be easily associated with neo-liberal and communitarianism prospects and that most of the times these activities vanish in the marketing of ready to made kits for hobbyists. Between the liberal experiences incarnated in the "Burning Man", the Maker fairs and the Lego kits and new communitarianism, self-sufficiency, or handmade beer producers, urban farmers and recycling crafters, a material culture emerged. It emerged from the individualistic ideology of the *"Whole Earth Catalogue"* reinterpreted by the thinkers of Silicon Valley, but also of the activist politics incarnated in Lawrence Lessing and the common-based peer production that

materialized in the creation of Linux, the Wikipedia and the RepRap, in University supported projects such as the MIT's Fab Labs and The Critical Making, in new design approaches as functional and Adversarial Design and artistic projects such as Critical Engineering, and finally, in the Civic and Citizen Labs that oppose the already programmed platforms for the participation of the *smartcities* with common self-managed projects.

All these are spaces for encounter, where technological procedures are embodied in the manipulation and setting up of things, spaces where a new Technicity arises, resulting from the appropriation of the means of production and the resulting literacy of engaging in its use. Finally, Hacker Labs and related spaces turn the public spheres arising from the appropriation of Internet and the setting up of navigable spaces for encounter, shaped according to metaphoric translations of everyday live places into spaces of practice and situated engagement in the production of the physical milieu.

The Fab Labs are an initiative started in the Centre for Bits and Atoms at MIT to bring their machines to new users who could foster their development by means of proposing new uses. These labs rely on the distribution of a standardized set of manufacturing machines through a net of physical spaces communicated by the internet. Their main aim is the development of machines that can produce all the equipment necessary for the lab, including the machines themselves. This research goal meshes with the development of a hands-on education for STEM students, and social aims such as the contribution to the development of less technologically advanced countries by means of the establishment of a self-sustained low-cost laboratory for high-tech. The first Fab Lab opened in December 2003 under the direction of Sherry Lassiter in the Technology Centre in inner-city Boston, and after that Fab Labs have spread all over the world.

The Fab Lab foundation describes these places as:

> *"Fab Lab is the educational outreach component of MIT's Center for Bits and Atoms (CBA), an extension of its research into digital fabrication and computation. A Fab Lab is a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship. A Fab Lab is also a platform for learning and innovation: a place to play, to create, to learn, to mentor, to invent. To be a Fab Lab means connecting to a global community of learners, educators, technologists, researchers, makers, and innovators- -a knowledge sharing network that spans 30 countries and 24 time zones. Because all Fab Labs share common tools and processes, the program is building a global network, a distributed laboratory for research and invention".*[309]

The established standard equipment of computer-controlled manufacturing tools developed at the CBA is replicable; auto-produced, and afterwards can be extended and personalized to adjust to local characteristics and needs. The list of this equipment is distributed through the Fab Lab platform.[310] It consists of a collection of tools for design, modelling, prototyping and manufacturing. Among the design tools, there is a computer used for 2D, 3D and mechanical design, modelling, data analysis, simulation, and the design of circuit boards. In addition, the computer is used for programming and interfacing with the fabrication tools and for internet access, communication, and documentation. Apart from this, there are modular computational construction kits developed at the CBA such as the Tower system. The fabrication tools include 3D milling and scanning machines and a laser cutter. The set also includes testing and instrumentation equipment such as oscilloscopes, voltmeter, function generator and tools to produce microcontrollers. Finally, the Fab Lab counts on the Think Cycle application to facilitate documentation.

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309 http://fabfoundation.org/

310 http://fab.cba.mit.edu/

The standardized equipment is not only aimed at production and self-sufficiency but also the transmission of knowledge. People from different Fab Labs can travel from one place to another and are always able to work with the existent equipment. Also, the Fab Labs share their projects in the platform from where they can be produced in any other Fab Lab and contributed to by interdisciplinary teams working hands-on, the members of which can be sited in different spaces. The projects always result from an assemblage of in-situ and on-line contributions.

The Fab Labs are also education centres for STEM and STEAM students based in a hands-on approach closer to the constructionist ideas of Papert. The labs offer an environment where students are empowered, pursuing their own objectives in a collaborative and supportive environment that offers the necessary infrastructure. In the Fab Lab, students do not follow a fixed curriculum. Instead, learning happens in an engaging context where students follow a cycle of imagination, design, prototyping reflection and iteration, a cycle of experimentation in which the students transduce with the system until reaching their goal and formalizing them in a repeatable schema. This educational work is supported by the Fab Academy, which provides instruction and supervises the investigation of the mechanisms under development. Managed globally through the internet it offers video lectures, instructional materials on-line, and a place to share and discuss the projects.

The Fab Labs have meshed with the urban fabrics as a source of citizens' empowerment. The Fab City project was launched in 2011 at the FAB7 conference in Lima by the *Institut d'Arquitectura Avançada de Catalunya*, the MIT Centre for Bits and Atoms, the Fab Foundation and the Barcelona City Council. The Fab City relies on a model for locally productive and globally connected self-sufficient cities inspired by the architect Vicente Guallard and his book "The self-sufficient city". It operates within the Fab Lab network, using it as a global infrastructure and knowledge source for the operation of a change of paradigm in the current industrial economy from 'Products In Trash Out' (PITO) to 'Data In Data Out' (DIDO). This change of paradigm relies on the capacity of Digital Fabrication to produce things locally and adapted to specific necessities that must reduce the importation and exportation of goods until occurring only in the form of data as information, code, designs and so on. One of the projects sustained by the Fab City is the *Smart Citizen Kit*, a global project aimed at the production of a physical computing device for sensing environmental conditions, which allows citizens to collect data and share it on a GIS platform, where the levels of pollution can be visualized.

Hackerspaces (aka Hacker Labs, aka Makerspaces, aka Hackspaces) *"are community-operated physical places, where people can meet and work on their projects"*[311]. Hackerspaces are diverse in their spaces of location –attached to public spaces such as libraries, civic centres, municipal spaces and so forth or private co-owned properties-, funding -sustained in by member fees, private donations and governmental aids-, and organization. They rely on the arrangement of a workspace and set of tools at the disposal of its members. These are aimed at the collaborative development of open projects, including common tools such as voltmeters, screwdrivers, solder stations, wires, batteries, sewing machines, in addition to CNC machines such as mills, laser cutters, 3D printers and Physical Computing tools such as Arduino kits and other microprocessors. Hackerspace engages with the tradition of open source software and hardware,[312] these are places for peer production and peer knowledge where people learn working collaboratively in hobbyist, artistic or civic projects. Usually, this main activity is complemented by the development of social life, through the organization of leisure and educational activities such as competitions, festivals, talks and workshops. Hackerspaces' origin is situated in Germany in the orbit of the Chaos Computer Club[313]. Founded in 1981, the CCC is one of the oldest and most influential civil organizations dedicated to digital culture, committed to the creative criticism of technology and the discussion of its effects on society, mainly focussing in control, surveillance and

311 www.hakerspaces.org

312 https://opensource.com/resources/what-open-hardware

313 http://www.ccc.de/en/

the promotion of free access to information. C-Base opened in Berlin in 1995 and is considered the first hackerspace, committed to hacker ethics, the development of technologies open to being modified by others, open sharing and peer production.[314] The Metalab was founded in 2006 in Germany and is known inside the community as the promoter of the fundraising model and principles that lead to the wide development of these centres. Hackerspaces spread throughout all Europe. In 2007, the project was exported to the USA where the NYC Resistor in New York and the HacDC in Washington were founded, followed by the Noise Bridge founded by Mitch Altman in 2008 in San Francisco. In 2010 David Li founded Xinchejian in Shanghai, the first hackerspace in China.[315] From there Hackerspaces spread all over the world, especially after the encounter with the promotion of crowdfunding and platforms such as Kickstarter and the Maker boom promoted by the magazine Make. Created by Dougherty, Make is a compilation of hobbyists of electronic projects and tutorials that use Physical Computing, open microcontrollers, and robotics. It is related to the popular Maker fairs.

In 2007 Hackerspace.org started a wiki that lists all the existent hackerspaces, provides support to the creation of new ones, and channels communication among them. Hackerspace.org stores collectively contributed documentation and patterns about the necessary equipment and budget, funding methods, legal settings, management, conflict resolution and the guide *"How to start a Hackerspace"*, jointly to a theoretical frame about the movement in the form of a list of publications. It also announces events, projects and open calls and collects tutorials and educative materials.

A Hackerspace is a place where people find support to work in what they love, and where is promoted the collective engagement with the flourishing of local economies and civic intervention in the places they are sited. This collectively bottom-up defined model has been adopted for related associative centers such as Citizen Labs and Media Labs, and other initiatives that sometimes emerge as spin-offs of Hackerspaces such as Think Tanks, Startup Incubators, and Co-working spaces.

Another initiative related to the capacities of the last update of Embodied Virtuality is Critical Making. Started by Matt Ratto at the University of Toronto, it is not related to the setting up of spaces and Collectives engaged in new modes of production but in the theoretical reflection about them. Critical Making branches with ethnographical research, constructionism and design proposals such as Critical Design, Participatory Design, and Media Archaeology. The aim of Critical Making is to connect technological systems and practices to critical scholarship and theories, and with this in mind, it sets up a frame where channels of discourse can be opened that increase traditional ethnographic practices such as storytelling and interviews with technologically enabled processes of production. It is inspired by the educational frame laid out by constructionism and the incorporation of the emotional dimension of learning. Constructionism paid more attention to the process than to the result, considering the technology as a transitional object, a material to work with rather than a tool or frame, with which the students can mesh around to overcome established ways of working towards a process of discovery. Ratto considers affectivity and the personal investment in the production process as a way of linking it to the understanding of the potentialities of technology and the problems of its application in everyday life. In this way, he organizes his methodology around collaborative workshops where participants engage with production and discussion. The workshops are developed in three phases.[316] Firstly, with the review of critical literature about specific ideas that can be translated into material prototypes and explored through fabrication. In the example put into practice in the conference, *Walled Gardens*, about the effects of proprietary companies on the internet, Ratto chose to materialise three different theories about the notion of networks: 'generalized exchange and gift economies', 'information commons', and 'information

314 http://www.c-base.de/),

315 http://xinchejian.com

316 Matt Ratto (2011) "Critical Making: Conceptual and Material Studies in Technology and Social Life", *The Information Society: An International Journal*, 27:4, 252-260

neighbourhoods' conceptualized after Jacobs. Each one of these theories was materialized in the program of a flower to be fabricated by the participants. Secondly, the participants build the prototypes collaboratively. In the mentioned example, the flowers were assembled as the cells of a cellular automaton. After seeing the evolution of the interactions between the cells, the flowers were reprogrammed to demonstrate the evolution of the network when flowers behave according to each theory. The last step of the workshop consists of the iterative process of reconfiguration and conversation. Trying different flowers dispositions inside automaton and discussing the results in relation to the proposed problematics. In the process, students not only learn technical skills but also become able to build a storytelling that links produced technological assemblages with the territories and nets they arise from and describe inside society. In this way, an affective engagement is produced and understanding with the work process in which things are no longer considered matters-of-fact but rather matters-of-concern.

In 2012, the artist Garnet Hertz published *"Critical Making"*, aimed at criticizing the commodification of Maker culture and its turn to a 'hackerism sanitized of politics'[317]. The book consists of a compendium of articles and interviews that assembled scholars and artists engaged in the conceptualization of the material ground and the processes of new technological production inside society. Among them Matt Ratto, Natalie Jeremijenko, Alex Galloway, Michael Dieter, Geert Lovink, Carl DiSalvo, Mackenzie Wark, Paul Dourish, and others. Throughout the pages of the book, they discuss how to shift the engagement with the production of objects from the training of the new industrial workforce, promoted from the commodified Making to a transformative experience for the object and the people working on it. This shift implies meshing material modes of engagement with critical reflection, at the same time as considering the transformative potential of technology inside society. Prototyping things can be a way to reimagine society with technology, coming back to the exploration of new potentialities proposed in the *"Hacker Manifesto"*.

The new material engaged forms of learning and exploring the world that originated in Fab Labs and Hackerspaces are depotentiated in its encounter with the economics of innovation and the self-expression of a commodified individuality. Making becomes either a process of playing with final products to produce better products or a process of engaging in the hobbyist activity as a mode of submitting ourselves to codified processes of subjectivation. In contrast, Making can become a way of participating in the production of our space. While they are engaged in the collective process of setting up a new thing, individuals transduce with the things and with the others around. They are all reunited in the assemblage of a new problematic as a way of experimentation from where the hidden mechanisms that codify our space can emerge, which become open for intervention. Making can become the engagement in the poiesis as a privileged mode of being; in which subjectivation occurs in the active participation on the net of Transductions that produce our spaces. The active participation firstly involves going beyond the codified interfaces that arrange our affordances inside the milieu to explore inside the circuitry producing these interfaces and secondly, the rewiring of this circuitry towards the setting up of new possibilities. In other words, Making can be linked to a poetics, which is understood as the unveiling of the mechanism by means of the setting up of unexpected functions.

This involves considering things and their relation to human beings from another perspective. Things are not objects in front of subjects. They do not need to be humanized as correlations of our actions and affections, places for the construction of individuals. Things are wearers of information that we transduce with and that transduce with our environment. The transformative potential of Things has been increased by new technologies. The networked objects of the IoT mesh in nets of Transductions that exceed our perception and extend beyond the moment and the space we are interacting with. Today, when the IoT is pervading our dwelling spaces, we need to reconsider how the Things are designed. In other words, a Critical Theory of Prototyping is necessary, as proposed by Lovink in his intervention in the *"Critical Making"* book.

317 Garnet Hertz (2012) *Critical Making*

The fast prototyping allowed by Additive Manufacturing has changed the process of design from a conceptual activity to an experimentation in which the results are attained after the setting up and testing and re-elaboration of prototypes. This process inside Hackerspace is conducted inside a Collective, from where multiple prototypes are assembled with individuals participating. From this process could emerge, not only the production of personalized objects, better adapted to local needs, but also the knowledge of how technological things work and how to they link and affect the milieu. As proposed here, a Critical Theory of Prototyping asks questions about which goals, plans, and models can guide the process of experimentation towards the setting up of Things with the power to increase our awareness of our milieu at the same time as setting up new possibilities.

In 1999, Anthony Dunne created the Computer Related Design Research Studio at London's Royal College of Art. Founded by a grant from Silicon Valley's Interval company, this studio was dedicated to investigating how the skills and knowledge of artists and designers might be applied to the design of information technology systems and products at a time when the machines characterized by silicon supported computation were entering the homes in the form of everyday appliances. The results of this research were published in the book *"Hertzian Tales"*[318]. In it, the author develops a critical design based on the 'aesthetics of use' disrupted by the artistic intervention of the 'post-optimal object'.

The designer proposes to go beyond the work of surface that characterizes traditional design, in which functionality is taken for granted, to resurface the mechanisms in which objects are involved. Traditional design remains on the surface of objects, which is considered as a support to symbolic attributes and values. Confined to the envelope of objects designers use its powerful capacities of visualization to produce a corporate identity and propagandize the desires and needs projected by this corporate entity. Dunne proposes opening the black box of the electronic object and embodying its functioning, in a way that the hitherto passive consumers can engage in the hidden processes of the mechanism. In this proposal, Dunne uses examples from tangible interaction such as Bishop's *Marbles Answering Machine*. It consists of an answering machine where messages are embodied in marbles, that users can manipulate, translating it inside the machine to reproduce, erase and answer it. This machine gives a physical support to information and its processes that can be manipulated towards the discovery of the pragmatics and poetics of data. Dunne uses embodiment to open the discussion about how commodity products limit our experiences and expose to criticism their hidden social and psychological mechanisms by means of integrating the aesthetic experience to everyday products. Taking as a model fictional literature and poetry, he explores mechanisms from where objects can explain their function and their relation to the milieu and subvert these mechanisms to produce an ambiguous conceptual object able to provoke. The 'post-optimal object' relies on the capacity of poetry to show the potentiality of language. Poetry forces language to have meaning outside the frame of attributed referents, becoming able to perform new meanings. The post-optimal object is the application of art poetics to design. The object produced in this way unveils how objects are placed while at the same time exploring the expressive capacities of electronic objects. Working outside their functional frame, domestic appliances become integrated into a poetics of everyday life that opens domestic territories to the laying out of new potentialities by means of programming unexpected relations between humans and their milieu.

Another proposal is Speculative Design elaborated by Benjamin H. Bratton. Considering design inside the fuzzy and highly-relational space laid out by the IoT, where humans are always transduced inside technological mediations, he proposes a post-human perspective. Going beyond the 'parliament of things' proposed by Latour, where things are considered as agents with a history to be elucidated, Bratton considers humans and things meshed inside a system working at multiple spatiotemporal scales. This is a platform working as a set of strategic potentialities where the IPV6 has multiplied the number of users. Inside the platform, the personalization operated by Human Centered Design obfuscates our correspondence with these non-human actors that this mechanism we have produced has put us into and its potentialities. Bratton proposes a

318 Anthony Dunne (2005) *Hertzian Tales. Electronic Products, Aesthetic Experience, and Critical Design*

cyborgian way to consider the multiscalar times and spaces operated by the relations between the human and non-human users. Inside the global system of IoT, algorithms re-open the composability of matter by design. In this setting, the intervention of design relies on the use of the models working with Big Data to generate prescriptive simulations able to determine how the project will frame the spatial or temporal terms of its intervention. The intervention inside the system relies on its protocological logics, according to anything that operates in one layer can be replaced by a completely different mechanism as long as it communicates protocologically with the layer above and below. This allows the introduction of new phase spaces of possibilities inside the system. However, this intervention does not set contents but the mechanism by means of which contents are created by the co-participation between humans and non-humans, which include algorithmic co-habitants. According to Bratton, this co-participation is one of the more difficult philosophical challenges to deal with.

The main challenge of elaborating a Critical Theory of Prototyping inside the space of Embodied Virtuality is how to elaborate strategies able to elucidate its pragmatics and poetics, how to elaborate prototypes able to produce an aesthetic experience and suspend our disbelief in change.

3.2 THE NEW TECHNO-SOCIAL APPARATUS AND ITS DISCONTENTS. TOWARDS A PLAYFUL INTERACTION BETWEEN HUMAN AND NON-HUMAN AGENTS

Every space is codified by an Apparatus. That is the Foucauldian assemblage that reunites the material ground with forms of knowledge, modes of production and the available exercise of power. The Apparatus produced with Embodied Virtuality is a crisis machine rather than a stable realm reunited around shared beliefs and values, shaped by the representations of power and interpreted by authorized theories and institutions, a pre-emptive machine. Hence, it is a system always tracing the continuation of its molecular constituents and computing all possible state spaces to adapt itself and foreclose the emergence of change. This Apparatus has evolved with the laying out of Embodied Virtuality, producing a new understanding of our environment, new forms of production and changing the protocols ruling the passing of our daily lives.

The development of our current technological milieu runs parallel to the fading out of the illusion of modernity: the division between nature and culture that ensured a transcendental outside the object of knowledge, and a privileged position to man as the subject of this knowledge.

The networking of computing machines laid out a space of disseminated communication where diverse tendencies struggled towards their appropriation. On the one hand, the Information Society[319] information laying out the space of fluxes - space submitted to the logic of networks, which nurtured globalization and the dissolution of places, and produced the hubs inhabited by the nomadic elite that travels across the nodes of control, at the same time as that the impoverished unconnected black holes unable to shelter structures towards the production of culture-. On the other hand, the realization of the Postmedia Epoch, -the disseminated archive collectively contributed and continuously evaluated. It was considered as a cresol of a new democracy based on the free and equal access to knowledge and communication and fostering a Collective Intelligence that was not able to reconnect with local space-. Finally, the counter-net, the laying out of Temporary Autonomous Zones[320] occupied by BBS systems, pirate software, and dystopian cyberpunks.

The last upgrade of Embodied Virtuality has laid out a space able to abstract all our reality to data and modulate it by means of a diagrammatic system that has taken shape in physical space by means of the multiplication of transducers. This space constitutes a Big Here and Long Now where the technologies that begun as technologies of observation, measurement and surveillance have become technologies of design, transformation, and governance.

The Big Here and Long Now is the result of the digitalization of our past and present cultural production, the tracking of our actions and the dissemination of sensors, which are attached to macro structures but also to the nanoparticles of new sentient materials. Thereafter, the Embodied Virtuality becomes a multi-scalar system, which computational processes and principles are applied to on a ubiquitous basis to the programming and knowledge of the particles constituting our matter, but also to the everyday affordable world, the management of big concentrations of humans, and even to the understanding of outer space. Applied to our daily environment, this system has changed the way we know and participate with the things around us, our modes of subjectivation and our geopolitical landscape. There is no 'out-there' from where the system can be turned off, observed and built, even a subject, a main node of interaction for which the system is modeled and put to disposition. Embodied Virtuality has become our space producer, shaping our culture and environment.

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319 Manuel Castells (1996) *The Rise of the Network Society*

320 Hakim Bey (1991) *T. A. Z. The Temporary Autonomous Zone, Ontological Anarchy, Poetic Terrorism*

As our cultural production goes on-line, it constitutes a massive dataset where archiving has been substituted by analysis and categories by patterns. Historical datasets are becoming digitized and made available on-line. In 2012 the New York City Municipal Archives released 870,000 digitized historic pictures; the Gaumont Pathé archives resumes the history of 20th century in 250,000 documents, 17,000 films, constituting 14,000 hours of recorded material;[321] the Spanish *Filmoteca Nacional* reunites films and the No-Do, the news programme turned into filmographic support, with the television production from the beginning of Spanish radio-television service until today;[322] the HathiTrust research centre has made available for research data extracted from 4,801,237 volumes, containing 1.8 billion pages.[323] To these initiatives, we can add on-line born archives that are growing every day such as The Internet Archive[324] and the International Movie Data Base[325]. Finally, there are the big datasets of digitally born content freely contributed by the users of platforms such as YouTube, Facebook, Twitter, Instagram, Pinterest, and so on. As these contents are becoming massive, their analysis is not affordable by means of traditional methods anymore, the reason why computational methods have been developed where culture as an object of study merges with the collective processes involved in its production. Text analysis, network graphs to analyse information transmission and influences between authors and works; probabilistic calculus applied to fill the gaps in historical documentation, and so on, are methodologies that allow visualizing culture as an emergent product of social interaction. The categories used to label and hierarchize contents inside a coherent whole have been substituted by patterns, which mean the ephemeral conformation sustained by the relations between entities inside the analysed ecology. Applied to the analysis of social interactions inside the web platforms, these methodologies create a large mnemonic system that focuses on predictability as a measure of efficiency. The methodologies applied to the discovery of the culture in the making can be applied to social management, submitting our space to the implementation of recursive solutions in neither negative or positive way, but simply homeostatic feedback. This system goes beyond the screen reaching the world that is not only modelled in computers but also actuated by the same: the opaque algorithms that are hidden behind the constraint of interfaces now commanding the possible interactions between humans and between humans and their environment. This homeostatic system is controlling our behaviour and challenging the emergence of cultural production as we know it.

The continuous contribution of data to the current computerized media ecology has changed the conditions of Participation. The principles of open source defined by Raymond in the 'bazaar system' have defined the usual method of technologically mediated production, the collective contribution to the development of things shifting from tech activism to the promotion of involuntary knowledge workers. The production of software relies on a permanent beta version, where the actions of users are tracked and reported to generate continuous updates. In addition, big companies such as Apple release freely accessible software development kits (SDK), which work on an integration of hardware, Operating System, a development environment (IDE), and software distribution platform. Thereby, this company engages their users in the development of a seamless experience labeled as Apple. Inside this system of production, we are all continuously feeding a machine by means of a modulated process of Transduction that does not produce knowledge.

At the same time, this system is changing the processes of subjectivation. Web platforms track data about all our interactions and submit them to the construction of an identity profile. This digital persona is not only commercialized to advertisers by companies such as Google without our consent, it also links our activities from one connected place to another, where it is setting up the space of interaction and filtering the available affordances on it according to the record of our past actions. The continuous tracking towards the constitution of a quantifiable-self impedes the separation between spheres of action and the incarnation of differentiated roles that allow the individuals to conduct themselves as actors in their everyday life. We become not *'actors*

321 http://www.gaumontpathearchives.com/

322 http://www.rtve.es/filmoteca/

323 https://analytics.hathitrust.org/features

324 https://archive.org/index.php

325 http://www.imdb.com/

without art"[326] but individuals overly determined according to external standards and formalizations, without the right to exercise our multiple selves. This self-contained identity explodes not only in the continuous Transductions that sustain human life but also in the encounter with the multiplication of agents promoted by the application of IPV6, both facts that multiply the situations in which individuals appear related to others, increasing their possible determinations and modes of action.

Finally, this system has produced a new geopolitics where the horizontal division in independently administered territories has given space to new organizations. Firstly, to the globalization and the networked centres of control distributed internationally. Secondly, to a new vertical paradigm, made up of the multi-layered globalized systems of data sensing, processing, and the control of Ubiquitous Computing.

The design of the space that is laid out by computer processes and its encounter with the physical world was firstly focused on the creation of electronically mediated environments, promoted by authors such as Mitchell, who considers the city as an interface, the point of encounter between humans and the algorithmic space. From this standpoint emerged interaction design and the production of platforms, which focused on the relation between humans and the space of computation. A platform is a set of strategic possibilities that establishes the conditions of content production and sharing. As interfaces have become tangible and distributed in space as everyday appliances, it is necessary to consider which new relations and Transductions are being produced, and which kind of contents emerge in the relations between sensing objects and the environment and between these objects and humans.

As computation has become ubiquitous, objects have become informational as much as physical without losing their materiality. This challenges the traditional position of objects as isolated matters of fact, established for the purposes of knowledge the potential of which is subdued to the realization of a particular compositional task and black boxed as the result of this knowledge. Things, when embodied and freed to actuate and being actuated in the mesh of daily life, produce patterns, potentialities, and codes that mix and interrelate, challenging their standardization. In addition, when they become networked they are able to carry information and start new Transductions inside the net objects, combining with other forms of life, enabling the tracking of new relations and the production of heterogeneous data that multiplies the emergent potentialities of platforms.

The EAT explored the potentialities of technology to create an intensified space, which mutated with the performances of the audience in relation to an augmented environment populated by co-agents and able to inform about the events occurring in it. In other words, the testing of new mediations towards a playful interaction with the environment that empowered the audience. Most recently, the exhibition *"Talk to me"*, held at MOMA in 2011, showed an inventory of everyday objects wearing communication potentialities. Curated by Paola Antonelli (Senior Curator) and Kate Carmody (Department of Architecture and Design), the exhibition focused on design that goes beyond functionality and focuses on affective relations with the users. The 194 works included, today displayed in a website,[327] show the embodiment of technologies in everyday objects and the multiplication of agencies that result from them: agencies enabled by new interfaces but also unhidden by visualizations, produced by the technological augmentation of bodies. Moreover, the new potentialities spread by critical designs working outside their normal use and the creation of new objects able to produce libidinal spaces. The exhibition's inventory is fragmented in six sections –objects, body, life, city, world and double entendre- that we will follow here for explanatory reasons.

The Objects section summarises the creation of a new material culture where objects in the form of domestic appliances, apps or toys are enchanted with the capacity to inform of their status at the same time, to show some personality, by virtue of which they can establish new relations becoming not only assistants but also companions. There are objects that link traditional stuff with technology bridging before separated worlds

326 Richard Sennett (1977) *Fall of Public Man*

327 http://www.moma.org/interactives/exhibitions/2011/talktome/

such as the *Bird Box* by Durrell Bishop, reuniting a die-cut paper birdhouse that shelters the mobile phone at night, and an alarm clock app featuring real singing birds. The project links an everyday appliance with a reproduced traditional environment that most cities lack. There is also critical design projects such as the *Technological Dream Series n. 1* produced by Antony Dunne and Fiona Raby. It consists of a set of four robots acting four different personalities. They show a possible future where robots will be not designed to accomplish specific tasks but instead might be given jobs based on behaviour and qualities that emerge over time accordingly their generative programs. Another robot not produced for functional purposes is the *Double taker* by Golan Levin et al. The *Double taker* is a sentient robot consisting of an articulated arm and a single eye that silently tracks the actions of an audience simulating an intelligent awareness thanks to a vision algorithm that detects the visitors and influences the movements of the arm. This section also includes interfaces such as the *Pachube* platform developed by Usman Haque for the Internet of Things and the one designed for the Barclays bank ATMs that features animations by Richard Hogg to personalize communication with customers. Finally, the tangible interface *The Big Red Button* developed by Russell Davis and Daniel Soltis. The writer used it in a presentation to advance their slides at the same time as making apparent the faceless nature of input mechanisms we are continuously engaged with.

In the section about the Body, prosthesis are listed increasing human capabilities not with functional appliances but with social skills. Among them, the *Communication Prosthesis* showed in the picture series by Sascha Nordmeyer, a rigid prosthesis that forces automatic facial expressions becoming a safe conversation stopper. Also, health assistants such as the *Personal Health Assistant* developed at the Department of Polytronic Systems Fraunhofer and the EMFT. The result of research in smart plastic polymers impregnated with electronic sensors consists of a biometric system, a wristband equipped with sensors and displaying vital sign information. Another health care appliance is the *Swallow-Signalling Pill*, a pill including a digestible antenna and a microchip that emits a signal to a receiver when the pill has been taken. Finally, interfaces that incorporate the audience's movements into a playful environment; *Tentacles 1.0* is a game to be played on a giant screen that displays the player's position via their I-phones. The players control the evolution of a living organism, Tenticules, in a social game where sharing or producing a scarcity of resources determines the survival of the digital creatures' population.

The Life section includes new technologically mediated ways of personal storytelling as the popular *Felton Annual Report*. Since 2005 Nicholas Felton has produced an annual report about himself based on his quantifiable experiences. Regarding the datification of individual life, there is also *Digital Remains*, a beautiful data storage equipped with a Bluetooth connection that allows users to log into the digital remains of a missed relative and receive their data on personal digital devices. Search algorithms dig through the data pulling out relevant personal traces. Also, several mechanisms are included to enhance ongoing everyday life. *Hyperreal Everyday Life* produced at the Design Interactions department at the College of Art is a device that alters the perception of our lives transforming it from mundane to epic by adding thrilling soundtracks and a head mounted prototype that crops the wearers' vision to the proportions of a panoramic movie screen. With a similar purpose, the work produced by Aaron Koblin et al. at the Google Media Lab, allows the audience to translate the action of the video-clip *We used to Wait* by Arcade Fire to the locations linked to their personal memories.

The City as a space of communication produced in constant negotiations is shown in visualizations featuring usually invisible relations such as the *What a hundred million calls to 311 reveal about NYC*. In it, Pitch Interactive plots the most common complaints reported to this service and distributed by the time spans of the day. The Senseable City Lab shows the already commented *Trash Track*. Stamen Design also uses data, in this case, to produce cartographies as in the *Prettymaps*, a set of maps from different cities that can be zoomed to different scales exploring the geographies produced on the mashup of data obtained from Open Street Maps, Land formation data from Natural Earth and place specific data from Flickr. The same company showed the application *Walking Papers*, a user-friendly mapping system that uses QR codes to annotate the terrain and submit data to the Open Street Maps platform. Related to the use of maps for the production

of urban space there are community building projects such as the *Garden Registry* by Futurefarmers. It is an on-line map portraying land use, where users can add their own gardening sites and identify potential future locations in San Francisco. In addition, devices and mechanisms are included to produce libidinal spaces. Among them, Aram Bartholl's *Dead Drops* is a digital system of communication working outside the Internet. A system now obsolete, the USB memory chip is distributed in the public space and made available to everyone who wants to share information outside the global network. In addition, playful situations produced such as an additional use of existing infrastructures like London's transportation system, appropriated by Toby Barnes and Matt Watkins to work as a platform for the real-time game, *Chromorama*. The commuters log in to play using their Oyster Cards and are grouped inside a team where they rack up points with each journey and strategically complete specific tasks and missions that alter their daily routines in order to gain a new perspective of the city. Another work meshing urban space with the interfaces and platforms of computer space is the film by Keiichi Matsuda, *Augmented (hyper) Reality: Augmented City 3D*. It shows the city as an immersive human-computer interface where the experience of moving and interacting with the three-dimensional environment is enhanced by an integrated layer of Augmented Reality.

Worlds extend the understanding of our ecosystem outside urban space tracking and visualizing complex processes that are usually ignored or unperceived. Among these projects features *Backtalk* by the Senseable City Lab and *They Rule* by Josh On, a website that builds an infographic image of the invisible networks of corporate power. Also, devices that enlarge our senses to understand the perceptual mechanisms of other agents around such us as *Animal Superpowers: Ant and Giraffe* by Chris Woebken, both devices that when worn, modify the perception of children allowing them to experiment the world from the tall standpoint of a giraffe or the augmented vision of an ant. Games also show the processes involved in complex events and ecosystems such as the *Antiwargame*, an online video game that explores the dynamics of terror and war and the *Dwarf Fortress* produced by Bay Games, a single-player fantasy game produced with ASCII (American Standard Code for Information Interchange) that generates its own complex world. The goal is to build a viable dwarf settlement in a vast user-generated world of continents and seas. In order to succeed, players must consider how a wide range of factors, including natural resources and weather conditions, influence their dwarf colonies.

Finally, Double Entendre is a section dedicated to communication issues where we can outline projects demonstrating the capacity of information to translate from one system to another showing the relations that are usually unperceived. The work by Natalie Jeremijenko, *Bat Billboard*, is a shelter and communication platform for bats. It adapts to the existing billboard structure as a refuge where urban bats find a safe space to live and hibernate. Monitoring equipment inside the billboard uses voice-recognition software to map and translate the calls of resident bats, matches them to archives of various call patterns and meanings, currently being compiled by biologists, and displays the resulting messages on a screen.

This varied set of projects show objects designed to embody communication processes in daily life. In the design process, objects are shown as things, assemblages not produced from scratch but inserted inside complex networks of more or less traditional practices and everyday appliances -gardening, following medical treatments, use the underground to commute inside the city...-that mesh with new capacities produced by new technologies such as data analysis and visualization, physical computing, tangible interaction, augmented reality, the design of interfaces and robotics. In this way new spaces of encounter between humans are produced -*Garden Registry, Backtalk, Dead Drops*-, and non-humans as with the embodied algorithms of *Technological Dream Series* and *Double Taker* and the simulated ones of *Tentacles 1.0* and with the animals of *Bat Billboard*, and between non-humans, the data interchange of the connected objects in *Pachube*. In addition, surveillance techniques such as data monitoring -*Personal Health Assistant* and *Swallow-Signalling Pill*- meshes with personal storytelling and the production of memories -*Felton Annual Report, Digital Remains, Walking Papers*-; and new ways to experience the environment -*Prettymaps, Animal Superpowers, Hyperreal Everyday Life*- that can reveal hidden relations and systems -*The Big Red Button, What a hundred million calls to 311.., Trash Track Augmented City 3D, They Rule*. Moreover, traditional objects

are put to work in unexpected situations -*Bird Box*- and playful situations are produced to disrupt the spaces and our ongoing daily life as in *Chromorama*, or to experiment with the evolution of complex systems as in the *Antiwargame, Dwarf Fortress*, and *Tentacles*.

In the rebuilding of traditional objects endowed with new capacities and their translation to unusual spaces, the creation of situations, and the speculation of fictional futures such as the afterlife and affective robots, things charged with new Affects are produced, able to start new relations and open new spaces of possibilities; objects that show the capacity to disrupt the Apparatus and intervene in the production of space. Hackerspaces and other related places where people encounter around experimentation and production of things open design to common space enacting Participation.

Participation inside hackerspaces occurs in the engagement of a shared problem and its embodiment in a material prototype open to collective experimentation, which can result in the hackability of established codes and the citizens' intervention in space production. At the same time new forms of participation arise, new processes of subjectivation and a valuation of the local that challenges the geopolitics of the current Apparatus.

Maneuvering in these prototypes opens up a process of Transduction that produces knowledge and increases Technicity. At the same time, this participation challenges the platforms of the Apparatus, where civic engagement is submitted as data and modulated towards the feedback loop that manages civic space in *smartcities*. When Hackerspaces becomes networked, information is not modulated to adjust to a set of established conditions and produce standardized solutions. However, projects, tutorials, theories and other resources are freely made available to a variety of practitioners to be downloaded and reused. This adapted information is reconnected to the specificities of local places. Platforms are sets of mechanisms put in place to allow the undirected use of these mechanisms to produce emergent effects that are not intended or planned in advance of the initiation of the mechanisms. The diagrammatic nature of the space of Embodied Virtuality where all contents are modulated allows the platforms for emergent effects. Thereafter, everything molecular and small has the potentiality to become massive. The new projects produced in Hackerspaces and the information they collect, especially in the case of the production of sensing devices, can enter the diagrammatic space where they are relinked, distributed and where they gain the possibility of producing societal changes.

The continuous prototyping carried out in these spaces allows reimagining the future, simultaneously to challenging the status quo of design, which is open to a speculative process produced in the concurrence of the molecular forces of the engaged Collective towards the exploration of the Virtual and the actualization of new affordances. The characteristic form of production exercised in Hackerspaces is allowed by the technologies produced in the latest upgrade of Embodied Virtuality. Physical Computing, Visualization and Digital Fabrication can be used outside the constraining frame of user-friendly platforms promoting Technicity and new pluralistic modes of subjectivation.

Physical Computing focuses on the relation of human beings with technology and the environment. It relies on the development of techniques for sketching with hardware such as Wired and Arduino, sketchbook software such as Processing and prototyping platforms for sharing and freely distributing the fabrication processes and their results. All these technologies involving software and hardware are developed from a hands-on approach that promotes literacy and new materially-engaged ways of knowledge. Moreover, they are freely shared as open source projects, thus favouring a varied use evolving outside of codified frames in which the procedures of the Art, their transformative power and situated criticism are approached. Physical Computing is employed in the production of transducers that can be attached to a vast range of objects –the robots and the sensing devices attached to *Trash Track* in the *"Talk to me"* exhibition are an example- embodied in manipulable objects equipped with sensing devices these transducers can extend informational capacities to usually unattended parts of the world and once networked contribute heterogeneous data to the global data flux altering the existing models that define our geopolitical frame.

Visualization differs from Physical Computing, rather than being circumscribed to its immediate surroundings, it leads with the massive data produced in global communications. Computer Visualization assists in the understanding of the data deluge that characterizes contemporary society by means of rendering it according to the human capacities of perception.

Data Visualization can work as a tool for the unveiling and criticism of the hidden processes shaping our society and can contribute new features to existing diagrams, disrupting assumed models. In a more artistic field, Visualization can produce new layouts, new metaphoric ways to spatialize data that are able to produce new meanings, as in the projects produced with *Carnivore*. Aesthetic layouts are not only concerned with the beauty, but also disrupt the analysis of data based on functional and preemptive applications pursuing new ways of understanding and perceiving the world. The artistic use of Data Visualization will be analysed in the conclusion of this essay. Meanwhile, in Hackerspaces visualization is conducted to expand the literacy about our datified milieu approaching infographic and storytelling techniques, creating new datasets related to Open Data and Citizen Science and producing maps collectively.

Hackerspaces house projects for collecting data by means of browsing the web or creating sensing devices. The web can be browsed to unveil the relations between apparently unconnected events, positions of power inside corporate companies, or the structure of public institutions and their relations. This data is deployed in infographics to narrate a story as in the *They Rule* project and citizens' journalism-related projects. The creation of sensing devices is related to Physical Computing and leads to Citizens Science. It consists of the creation of easy-to-assemble and economically affordable prototypes to sense the environment that can be widely distributed among the population, which they can use to crowdsource data about environmental conditions such as the level of noise and pollution. This data is automatically reported to platforms such as Xively where it can be freely consulted and used in visualizations creating awareness of our environment, as in the *Smart Citizens Kit* project. Taking part in the collecting of data, citizens become aware of the processes and bias involved in the production of datasets and their later analysis. In addition, they can create new datasets to fulfill the interstices of the global net, the black holes or unconnected places can be sensed by citizens working in these local places, translated to data and put in circulation inside the normalized procedures of the production of knowledge and challenging the global network that defines the actual geopolitical map. In addition, crowdsourced data is freely shared outside the proprietary restrictions of big companies and promotes open knowledge.

Visualization is also used inside Hackerspaces to produce maps that become platforms for the encounter of their members, where they can work collaboratively on the production of storytelling, shared knowledge about local places, and the promotion of new uses of space. These maps are aimed at reporting issues of the city or to share leisure activities, such as cycling routes in order to promote meeting up with others and gardening places as in the *Garden Registry* project. The production of maps reterritorializes space outside the goal of behaviour control and as an exploration of new possibilities.

Finally, Hackerspaces take advantage of the characteristics of networked fabrication and personalization associated with Digital Fabrication to reconnect the procedures and data circulating on the network to the local, where they are adapted to cultural specificities to cover local issues and situated needs, challenging the vertical paradigm of control of the platforms of Ubiquitous Computing. In addition, the collective Participation opens up new possibilities and the proposal to cover needs unattended by the commodified market as in the *RepRap* project. Digital Fabrication is an assemblage of different technologies aimed at embodying information processes by means of the production of things that can be added to the ecology of our everyday space, where by virtue of its Affects can start new relations and open up new possibilities. Among them feature things with the capacity to appropriate public space such as the *QR stenciler* and *Hobo Codes* and to criticize the actual production system such as the *Free universal Construction Kit*.

Hackerspaces are spaces of leisure, they open up a time of exception in the daily routine of obligations and attributions, where people can act outside the bracketed personalities assigned by social roles and tracking platforms. The Collective created around a common project blurs the boundaries between binary distinctions such as cultural/political and amateur/professional that reductively constrain the ways in which scholars across the arts, humanities, and social sciences understand the relationship of individuals and networks to the boundaries of cultural production and politics. People encounter outside molar assemblages becoming molecular units enacting matter outside of assigned plans and making usufruct of common resources. The experience in Hackerspaces challenges the status quo of design at the same time as offering new possibilities of subjectivation. People build their identities transducing with the project they are engaged in and the people they are working with. Working in an open space outside the social constrictions and making usufruct of shared resources offers new opportunities for action and approximates the potential for the creation of *jouisance* described by Lefebvre. The open experimentation outside preassigned goals and processes make the mediums apparent in their unpurposeful nakedness and free them for their appropriation for new uses. This approaches the *Profanation* as was described by Agamben. Space production becomes a collective creation where individuals are engaged in the setting up of relations in an unfolding process from where all the agents involved become redefined. This becomes a destituent power, a mechanism that suspends *bare life* by the playful engagement in a collective and permanent process of composition, in which human life is a result of the relations and enablers of the places it is set and in which technology can become emancipatory.

Urban space can emerge from the playful interaction that emerges in Hackerspaces by means of the proposition of social interventions and artistic projects.

The playful intervention in urban space is an artistic procedure inspired by the Situationists, who proposed the production of Situations that involved groups of people appropriating urban space to be used outside the codification of social norms. Urban Space aimed at being a place for social experimentation and culture production. Psychogeographic games alter the daily conditions in which city is perceived producing new situations and uses. This includes practices such as drifting across the streets of Paris guided by a London Map, one of the *dérives* proposed by Guy Debord.[328] The Situationist procedures influenced games such as the already mentioned *Chromorama* and artistic projects such as the *Serendipitor* by Mark Shepard. It consists of a way-finding mobile app that tracks the daily paths of the user across the city and proposes alternative paths to reach usual destination points, favouring serendipity, the possibilities of creative encounters. Gaming has also become a way of experiencing the intervention of new technologies in our space. The city games by Blastheory, *Uncle Roy all around you* and *Can you see me now?* shows the integration of physical and computer space. Players switch between physical space and its 3D on-line simulation to participate in a clue game where on-line and in-situ players cooperate to accomplish different goals, such as finding Uncle Roy. Playing as the collective appropriation of space for new uses emerging from the interaction of multiple agents outside functionalist goals which have become a common way of social intervention.

The *"Spontaneous Interventions: design actions for the common good"*[329] exhibition presented at the U.S. pavilion of the 13th International Venice Architecture Biennale themed *Common Ground* and held in 2012 lists interventions in urban space stemming from improvisational, guerrilla, tactical, participatory, open source and DIY procedures. Among these interventions featured *569 Acres*, an interface and community building project that lists available lots in Brooklin and encourages the inhabitants to re-envision new possibilities and usages for the vacant lots. Also, the *Air quality Egg* produced by Sensemakers, a sensing device to collect data about air quality and the application for getting lost *Déerive*, designed by architect Eduardo Cachucho. *Dérive* deals users a task card detailing an action, such as 'follow a couple', or 'find a tree'. Users are dealt a new task card every three minutes, prompting an unplanned journey through the city. Finally, the project by

328 Guy Debord (1956) "Theory of the Dérive"

329 http://www.spontaneousinterventions.org/

David Benjamin and Natalie Jeremijenko, *Amphibious Architecture*, senses the activity of fishes in the East River and the Bronx River and processes the data to produce an ephemeral and mutating architecture on the water's surface, by means of which are discovered the activities of these hidden members of the ecosystem.

In these interventions, Art, engineering, design, architecture, and urbanism, their boundaries blur and mesh in the proposition of hybrid experiences of place making, that are worked out not from abstract models but from inside and with the active Participation of the human and non-human space inhabitants.

All things have a poetics. Things takes part of worldliness, filling the opening up of the world in doing so. In the process, they synthesize, make possible and block other worlds. Making the territories expressive and opening them for appropriation is the capacity that defines Art, its revolutionary activity consisting of the extraction of new *lines-of-flight* that raise the Virtual towards the realization of new possible worlds, creating things that enter into our ecology and establishing new relations that attach new dimensions to the already existing assemblages, which mutate to constitute new dispositions of the real. A Critical Theory of the Prototype consists of, not so much in the application and testing of social theories on the development of prototypes, but more in the exploration of the pragmatic and poetics of objects, which is understood as the capacity that these have to co-function in the world, disrupting existing codes and proposing new possibilities. Postdigital Strategies is the proposal presented as the conclusion of this research. The Postdigital is a comprehensive concept inspired in art practice that describes the situation laid out by the rise of Ubiquitous Computing, at the same time as allowing the proposal of a set of procedures to exploit the transformative potential of data inside the diagrammatic space laid out by Embodied Virtuality; how the computation processes commanding our actual environment can become embodied as things, something that can be manipulated, experienced and can start new potentialities.

4. CONCLUSION: POSTDIGITAL STRATEGIES

"The game of the problematic and the imperative has replaced that of the hypothetical and the categorical; the game of difference and repetition has replaced that of the Same and representation. The dice are thrown against the sky, with all the force of displacement of the aleatory point, with their imperative points like lightning, forming ideal problem-constellations in the sky. They fall back to Earth with all the force of the victorious solutions which bring back the throw."

Gilles Deleuze (1994)
Difference and Repetition, pp. 284

4.1 THE POETICS OF POSTDIGITAL SPACE

> *"All objects have a poetics; they make the world and take part in it, and at the same time, synthesize, block, or make possible other worlds. It is one of the powers of art or of invention more generally to cross the planned relations of dimensionality—the modes or dynamics that properly form or make sensible an object or a process. As it does so, other worlds gently slip into, swell across, or mutate those we are apparently content that we live in"* [330]

The Postdigital names a situation where technology is embedded in all the spaces of knowledge and practice. The evolution of computing has defined a new inscription process that pervaded all fields of knowledge and later migrated from the labs to conquer all the spaces of human and non-human activity. After the spaces of production, leisure, and social relation converged in the screens of personal computers, in the postdesktop era computing migrated from computers to become ubiquitously distributed in physical space by means of networked objects able to collect and process data. The embedding of computing in physical space has produced a new organizational paradigm, space becoming multi-layered, constituted by the vertical Transductions between the systems for data processing and storage, the applications and services collecting data, and the platforms for integration and command. During this process, the capacity of Embodied Virtuality for simulating the multiple state spaces of a system fostered the production of new processes of abstraction and new generative algorithms leading to a new Apparatus based on pre-emption, where the technologies of description and surveillance became technologies able to automate management and control. In this way, the symbolic layer of the internet becomes operative. The data producing and processing operations become able to actuate on the environment by means of connected devices and accordingly to a system with the capacity to calculate probabilities until the exhaustion of uncertainty, and adapt itself to foreclose the possibility of change. However, at the same time as the molecular algorithmic calculus, defining the inner mechanisms of computers is enlarged to the macro scale where our spaces of dwelling are territorialized, the capacity of modulation and the diagrammatic space these processes produce allows to submit bottom-up actions and create crossroads between differentiated fields of knowledge, these new encounters enlarging the capacities for hackerism and Disruption of the system.

In this situation, the fascination for new technologies is being replaced by a reflexive criticism. The engagement in the appealing high-definition simulated worlds and the remixing and transmission of media contents is displaced by new creative processes focusing on the production of transducers, the obtaining and processing of data, the forms of knowledge stemming of the models produced in the rendering of data, and the algorithms involved in all the previous processes. Summarizing, creative processes engage in the questioning of the operational processes of the Apparatus, the forms-of-life they enable, and the possibilities for creation and collective intervention in the bosom of this space producer.

Art obtains its capacity for creation from the encounter with the Virtual, the indeterminacy attached to any system by virtue of which can be produced new actualizations towards an increase of reality. Opposed to the representation that conceals all the entities of our reality inside the hierarchized categories of a stable and accomplished whole, Deleuze proposes the System of Simulacra. The System of Simulacra is an ontological machine aimed at capturing the process of becoming, the processes of differentiation by means of what all the things that form our world reach existence. The System of Simulacra erases the filters of representation to allow the nomadology of thought and matter inside a diagrammatic space. In this way, the Simulacra substitutes the Representation grounded in transcendental principles from where all the reality emanates as a derivated existence by the differentiation of matter inside an intensive space. The principles of sufficient reason and linear causality ensure correspondence between objects and an identical subject changing to

330 Mathew Fuller (2005) *Media Ecologies*

the centres of envelopment produced by singularities, the individuation factors, producing extension after entering a new assemblage by virtue of its Affects and where subjects are engaged evolving themselves as part of the process. The simulacra are not false, they are the negation of any imposed reality coming from outside the issues of matter and codifying reality in immobile categories to assert the relational capacity, dynamism and creative capacity of matter itself. Inside the System of Simulacra, art becomes an Ontological Game, a game able to give itself its rules and resetting in every new attempt all the positions and relations of the entities on its board. This is the free process of experimentation, not leading to the accomplishment of a task or the reaching of a solution but to the flourishing of a poetics and a pragmatics by means of the exploration of all the possibilities inside the surface of the game. In this exploration, the mediums emerge from their concealment and the matter appears as a conveyor of singularities and new traits of expression. Art as Ontological Game may take the form of interventions, programs, performances and active objects directed at the instantiation of new particular elements of composition and new relations between them. It is able to spread heterogeneity by means of the transverse, the hybridization of divergent components, the imaginal, and the unexpected use, able to make matter expressive and start new assemblages. This experimentation relates to a technical-aesthetics directed to the understanding and fostering of the processes of matter towards new assemblages. It becomes able to: (1) open the black boxes of the mechanisms codifying our reality towards the understanding of things as agents and of the space as a collective production open for intervention; (2) setting up of new dynamic processes able to start new Transductions and produce new Collectives. Art captures intensities and activates Affects mobilizing the molecular forces of the populations; (3) modulate the existent towards the starting of new traits of resonance in which things assemble and co-function in new ways.[331]

This technical aesthetics is not related to beauty, codifications of style or the reproduction of the codifications of power towards permanence, neither to the study of the laws of perception to build a world of objects adapted to human conditions. On the contrary, art spreads new processes of differentiation between the decodification and recodification of our milieu to be engaged in its production. Therefore, aesthetics becomes a theory of the forms of becoming engaged in politics and the composability of our reality. Art and aesthetics challenge the unconnected objects of representation and the homeostasis of its permanence to create new embodied things that by virtue of its Affects can enter in new assemblages, start new traits of territorialization, and promote new affordances inside our ecology.

Inside the space of Embodied Virtuality in which all reality is abstracted to data and managed by algorithms, this aesthetics is involved in the discovery of the materiality of computing by means of the embodiment of its processes in things that can be manipulated and opened for speculation. The production of new Transductions lead us to ask about what the processes of Transduction that codify our world are and how algorithms take part in the composition of our space and our relations inside it.

Algorithms re-inaugurate the composability of matter at a more molecular level. They establish the ways in which the contents reduced to discretized data express themselves inside a diagrammatic space. The setting out of new Transductions can disrupt the systems and force them to work outside of the modulated amplification that domesticates Transduction inside a system of relays that filters everything not concerned with the maintenance of a task as noise.[332] Art produces new programs as in Critical Software[333] and new objects aimed at the Disruption of the homeostasis of the system, in other words, the intervention on the

331 See the interpretation of the System of Simulacra and the Ontological Game in the first chapter section 1.1.4 of this essay: *1.The ontology as the creation of the Common World > 1.1. Thought and Creation in Deleuze and Guattari > 1.1.4. Art and the critique of representation*, pp. 43-44

332 See the introduction of transduction and modulating amplification in the first chapter section 1.2.2 of this essay: 1.The ontology as the creation of the Common World > 1.1. Thought and Creation in Deleuze and Guattari > 1.1.2. Becoming and Transduction, pp. 38

333 Mathew Fuller (2003) *Behind the Blip: Essays on the Culture of Software*

composition of our reality by means of the emergence of noise that appears when the system is forced to work outside its frame or in new couplings.

The realization of Embodied Virtuality encompass Ubiquitous Computing and its evolution towards the Internet of Things; the networking of people processes and things inside the big net, that due to new processes of identification and tracking is producing Big Data; the modulation and processing of this data by learning algorithms towards the capacity of pre-emption, and the application of these systems to the management of urban space in *smartcities*. At the same time, it has produced new forms of knowledge and representation based on the discovery of patterns, temporary relations inside our ecology, in Data Visualization and new forms of design and production related to the modulation of data in parametric design. Finally, new Collectives and processes stemming from the open source and producing Physical Computing and Digital Fabrication have appropriated these processes in new Spaces of Transformation where they became linked to material culture. In these new spaces of production arise new collective processes of such collecting, visualizing, and mining data and new forms of knowledge and production materially engaged and emerging from the participation between human and non-human agents. Networked culture has evolved from the metaphoric rendering of our world on screens and discursive processes to a Technicity involved in speculation with the transformative power of technology. The proposal presented here is aimed at linking the new material networked culture with a poetics of space production by means of the proposal of a set of Strategies developed from Postdigital art and its relation with the Ontological Game described by Deleuze.

Inside the vertical ordering of space produced in the Transduction between the standardized platforms of Ubiquitous Computing aimed at the effectuation of a pre-emptive control, the capacity of Disruption of art relies on the diagrammatic nature of this space and its digital abundance. Compressed into a technological object the elements of a list becomes indexes of multiplicity. Once digitized things gain a wider phase space of potentials, they enter a diagrammatic space where each element can lead to multiple spaces of potentiality by means of its modulation inside a system that increases its dimensions of multiplicity as it expands its connections, the linkage between heterogeneous data increasing the dimensions of relationality and mobilizing the potential of Disruption.

The Postdigital will be used here to refer to the proposal of new artistic Strategies that summarizes the possible interventions and understanding of computing processes, towards the proposal of a Critical Theory of Prototyping. These Strategies stem from the critical engagement with the materiality of computer media that arise from the evolution of new media art and its turn from working with media systems to experimenting with the materiality of data towards the exploitation of the capacity of hackability of the Embodied Virtuality and the production of new things and affordances in our environment. These procedures do not assume information and the platforms for its transmission and collection as something already done rather than explore and experiment with the dynamics of data obtaining and processing, producing new transducers, and collecting new data that enters the diagram increasing its multiplicity by means of the submission to unintended usages, the setting up of malfunction programs, the hybridization between high-tech and traditional procedures, the meshing with social processes and ethnographic research and the speculation of fictional futures, towards the discovery of a poetics of data and the practice of and everyday art of resistance.

4.1.1 POSTDIGITAL ART

> *"The "post-digital" describes an approach to digital media that no longer seeks technical innovation or improvement, but considers digitization something that already happened and thus might be further reconfigured"*[334]

334 Florian Cramer (2013) "Post-Digital Aesthetics"

Postdigital is a term originating from art practice to designate a shift of focus in media art. This occurred after the end of the Digital Revolution and the consequent dissemination of digital technologies. In this shift of focus, art displaced its attention from the capacity of simulation and the hypertextual narration of contents towards the material ground of the new computerized environment.

The EAT assembled engineered transducers for the intensification of space and spreading education in the use of these technologies towards a cultural revolution and the *"Software"* exhibition questioned what is living in an environment mediated by computers by means of the exploration of the capacities of the new media and the definition of new processes. Nowadays, after the Internet has disseminated computation everywhere, Postdigital research focuses on the critical reflexion about the material conditions and possibilities of our new media ecology. In the pervasive space of Ubiquitous Computing, where technology vanishes in the background, Postdigital art practice is working to resurface the digital medium and test its possibilities. Art practice becomes an experimental research focusing on the materiality of this medium that branches out with the reflexion about the ontology and epistemologies that it fosters.

The term Postdigital first appeared in the text *"Aesthetics of Failure"* by the electronic music composer Kim Cascone.[335] Here, the author focuses on new electronic music manifestations, such as the ones grouped under the tag 'Glitch', and considers these as emerging from the incorporation of the 'failure' of digital technology. Glitches, bugs, application errors, system crashes, clipping, aliasing, distortion, quantization of noise are incorporated as raw materials of music composition. If at first electronic music was characterized by the techniques of the sample and remix facilitated by the virtual loop generated by the convergence of production and distribution inside the same medium, Glitch aesthetics use more deconstructive technologies to focus on the background and incorporate into the work the filtered data considered as noise. The Glitch, Microwave, Digital Signal Processing (DSP), sinecore, and microscopic music reduce music content to a minimum of information, which enables the digital media and the manipulation of the digital domain to be unveiled. Searching for the molecular units of this medium, the musicians become hackers engaged in fostering the potentialities of digital media by means of empirical investigation. Between the experimental Postdigital practices, quoted by Cascone we find, the unintended usages of devices; the hybridization and decomposition of digital files – mapping data from one domain to another- and the production of a fragmented content composed of stratified layers that intermingle and defer sense until the listener takes an active role in the production of meaning.

Other researchers considering the Postdigital such as Lev Manovich[336] and Ian Andrews[337] qualified this attention to the medium as a comeback to the modernism. In this way, the Postdigital shifts from the criticism of media characterizing the postmodern art to a more expressive approach based on the representation of the art process that characterized modern artworks. According to Ian Cramer the new Postdigital Art moves away from the hype of technology and its capacity to create high-fidelity representations of the real to focus on the questioning of the medium's capacities. With this in mind, Postdigital art creates works showing the digital medium. An example is the substitution of the acousmatic performance of music in laptops by the production of dedicated devices, assemblages that show to the audience their inner mechanisms. Among them, we can quote contemporary musicians that had abandoned the condition of using already assembled interfaces in their compositions to become involved in the production of their own musical instruments. This is the case of the works by Martin Messier, *Field*[338], or Myriam Bleu's *Soft Revolvers*[339]. In both works music meshes with performance, by means of transducers that translate the musician's gestures to data modulated as sound. Music emerges as an event emerging from the Transduction between the gestural movements

335 Kim Cascone (2002) "The Aesthetics of Failure: "Post-Digital" Tendencies in Contemporary Computer Music"

336 Lev Manovich (2002) "Generation Flash"

337 Ian Andrews (2000) "Post-digital Aesthetics and the return to Modernism"

338 http://www.mmessier.com/projects.html

339 http://www.myriambleau.com/soft_revolvers.html

of the composer/interpreter, their instruments and the digitation of them reinterpreted in a computer. Lev Manovich characterises this return to modernism as software critique and centres it on the artist producing their own software, branching off from the tradition of Software Studies and its consideration of software as producer of culture. Manovich considers software as an empowering tool and programming as an activity implied in politics. He includes among the Postdigital procedures the use of Data Visualization as a medium to unveil the inner connections and rules that codify our society.

Another approach to the Postdigital is presented by Florian Cramer, who focuses on the revalorization of the analogue shown by the revival of traditional forms of media such as zines, cassettes, and vinyl discs.[340] They opposing their electronic counterparts as blogs, mp3, and the electronic publishing on the internet after it became a corporate medium administered by the opaque algorithms of a few companies. In this way, the analogue is shown under the transformations produced by the digital. An example of this procedure is shown in the already quoted works of the exhibition commissioned by Dene Grigar, *"New text: Literary and Artistic Explorations into what it means to read, write and create"*.[341]

The collective involvement in more artisanal methods of production become a means to recover the Autonomous Zone open for collective experimentation of the Postmedia epoch. These old media are revalorized as a source of a material knowledge arising from the Transduction between the artisans and the materials they are assembling. This engagement with matter embedded with digital technologies in techniques and movements such as circuit blending and the Do It Yourself, practiced in the new emerging spaces open for collective experimentation such as Fab Labs, Citizen Labs and Maker Spaces.

Finally, Meel Alexenberg characterizes the PostDigital as a humanization of technologies by means of the redefinition of the role of artists now working on the hybridization of digital technologies with other systems of knowledge and creation.

In his work "*The Future of Art in a PostDigital Age*" Alexenberg describes PostDigital as:

"...artworks that address the humanization of digital technologies through interplay between digital, biological, cultural, and spiritual systems, between cyberspace and real space, between embodied media and mixed reality in social and physical communication, between high tech and high touch experiences, between visual, haptic, auditory, and kinesthetic media experiences, between virtual and augmented reality, between roots and globalization, between auto-ethnography and community narrative, and between web-enabled peer-produced wikiart and artworks created with alternative media through participation, interaction, and collaboration in which the role of the artist is redefined"[342]

It is the combination of all these standpoints from where the Postdigital extracts its potentiality as a new way to work with the computerized milieu our world is now immersed in. Art becoming a reflexive criticism conducted as material experimentation that shows the discontents of this milieu – tracking and surveillance of individuals, loss of agency and freedom, lack of duration as condition of both creation and subjectivation – at the same time that its potentiality is engaged in the fostering of new possibilities.

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340 Florian Cramer (2013) <op. cit.>

341 Dene Grigar (2015) "New text: Literary and Artistic Explorations into what it means to read, write and create" at Kate Armstrong (ed.) *ISEA 2015 disruption artistic program* Catalogue published in conjunction with the 21st International Symposium on Electronic Art held in Vancouver, Canada, from August 15 to19, 2015.

342 Mel Alexenberg (2011) *The Future of Art in a Postdigital Age: From Hellenistic to Hebraic Consciousness*

Postdigital Art and its attention to the background of the digital domain allows us to reconsider the space of Embodied Virtuality not as a simulated immaterial realm where our world is abstracted and projected as an avatar, but on the contrary, as the result of machinic processes embodied as manipulable things set around us. This turn in the materials of art practice will situate Postdigital experimentation as a valuable resource to criticise the effect of the dissemination of computation, characterizing Embodied Virtuality, in our daily environment, at the same time as making a first proposal about how to design the connected objects producing this environment. After computation has become ubiquitous, it being progressively embodied in the physical objects we interact with on a daily basis, the practices evolving from Postdigital art will become a source of Disruption. Disruption will be the practice of an aesthetics of engagement that appropriates this space towards its intensification, the incorporation of noise, as a difference able to actualize unexpected states. This practice involves going beyond the interface and its under-concretization to promote participative knowledge. The recovery of the Technicity described by Simondon, the transductive process for which information is no longer a quantifiable abstract entity, but recovers its ontological value as neguentropia. The incorporation of unexpected datasets, the coupling with other systems, the submission to unexpected uses, and the production of new transducers are all activities that involve considering computers, not as a media system but as an embodied programming machine. Programing becoming a speculative activity able to produce new Nets of practice and knowledge. The aesthetics of this system is not in its capability to reproduce high definition representations of our world but on its poetics, its openness and capacity for encountering other systems towards the exploitation of its virtual potentialities.

4.2 POSTDIGITAL STRATEGIES

The Postdigital Strategies will be elaborated following the evolution of a tradition already introduced throughout the previous chapters. Art embedded inside the evolution of Embodied Virtuality collaborating in the creation of new technologies and its normalization at the same time as exploring its uses and pushing away its borders.

Art was meshed in the evolution of Embodied Virtuality from its inception. The research into human perception conducted by Kenneth Knowlton led to the creation of the half-tone system and the development of the image processor Beflix, which was used by Stan Van Der Beek for the creation of the series *Poem Fields*, both contributing to the development of the data structures codifying computer image and the evolution of animation. Other animation packages such as GENESYS and design stations such as the Circle Habitat created by Dan Sandin and DeFanti, were developed jointly with artistic research. Artists were also involved in the production of VR, starting with the proposal of the cinema of the future in the *Sensorama* machine by Mor Heiling in 1962; followed by the experiments towards a more immersive interaction that was assembled in the *Videoplace* system by Myron Krueger in 1975; and culminating in the high-tech productions aimed at exploring storytelling and perception inside this medium exemplified by the works *Angels* by Nicole Stenger, *Placeholder* by Brenda Laurel and *Osmose* by Davies. Artists also experimented with the non-linear narrative of Hypertext. Ted Nelson tested the capacities of this medium to convey personalized knowledge in the *Labyrinth* catalogue of the *"Software"* exhibition, in 1970. Afterwards, Hypertext moved to artistic production, first in interactive installations such as *Lorna*[343] produced by Lynn Hershman in 1979, the reproduction of a room around a TV set from where the audience can choose different options to see the relations between Lorna and the space she decided to be confined. The *Mutabor*[344] by Friederike Anders, produced in 1988, is a system coupling video tape recorders to reproduce a video labyrinth linking the fragments contained inside each machine. The installation *Sonata*[345] produced in 1991 by Graham Weinbren also follows a hypertext structure. It consisted of a set of monitors reproducing fragments of different works that were composed together in real time by a commanding system. In 1987, Michael Joyce produced *Afternoon* using Storyspace the first hypertext literary work programmed in a computer, followed by the series of works that opened the genre of electronic poetry, among them *Patchwork Girl* (1995) by Shelley Jackson, *Victory Garden* (1992) by Stuart Moulthrop and the novel *Trajectories* (2000) by Jean-Pierre Balpe. The computer was also a medium to explore the generation of images by the programming of mathematical expressions as in the works by Manfred Mohr. Finally, the beginning of Internet was also meshed with artistic proposals aimed at exploring the capacities of remote communication and collaboration of this medium. We have already quoted the *Community Memory* started by E. Lipkin, M. Szpakowski and L. Felsenstein, in 1973, a database collectively contributed inside a time-sharing system that was used for creative production by means of linking contents with tags. In 1983, Frank Popper invited Roy Ascott to the exhibition *"Electra"*, about Electronic Art to conduct *"La plissure du texte"*[346] a fairy tale produced in real-time by the interactions between the personages, incarnated by artists located abroad and connected through the Minitel system, a commercial service predecessor of internet in France. At the same time, other artists were wondering about the capacities of remote communication, using phone connections. In 1980, Kit Galloway and Sherrie Rabinowitz created the *Hole in Space*[347], a public communication sculpture that reunites the passers-by in the Lincoln Centre for the Performing Arts in New York City, and "The Broadway" department store located

343 http://www.lynnhershman.com/lorna/

344 http://www.medienkunstnetz.de/works/mutabor-iii/images/3/

345 http://www.grahameweinbren.net/

346 http://alien.mur.at/rax/ARTEX/PLISSURE/plissure.html

347 http://c-uir.org/mup/examples/a-hole-in-space/

in the open air Shopping Centre in Century City (Los Angeles), by means of the real-time transmission and projection of a recorded image in each place. The same artists produced the *Electronic Café*[348] during the Los Angeles Olympics in 1984. In this, six communities around six public spaces of this city were able to contribute and share contents into a database. The telepresence, collaboration, community building and collective unstructured production examined in these works were be retaken by the already Internet-based projects *The Thing* and the *International City*.

Nowadays, New Media Art has a history emanating from the centres that fostered its emergence and categorized and ordered by specialised art historians according to the treatment they emphasised as distinctive and the group of artists they would introduce. In this way, new media art has been labelled as interactive art, technological art, electronic art, digital art, computer art, and ordered in subcategories such as net art, telematic art, generative art, logarithmic art, locative media, bio art, and so on. In addition, it has been placed in relation to the changes produced in our sensorium and cognition by means of the exploration of synaesthesia and dynamic and immersive environments; societal and environmental issues concerning surveillance, security, sustainability; and new subjectivation processes related to on-line identity and presence. Finally, the uses of this new space for artistic production has been related to the traditions of Avant Garde.

The first works exploring the creative possibilities of new technologies connect with art traditions such as Kinetic Art, with representatives such as Vladimir Tatlin, Nam Gabo, the light works by Lazlo Noholy Nagi, in which the aesthetic experience is not produced in the contemplation of the piece but its projected effects; also, in the poetic machines by Jean Tinguely. Another influence is the Dada movement and its collages, the meaning of which emerges from the composition of diverse fragments from recognizable cultural objects such as criticizing the discourse of power. Related to Dadaism are the Situationists and their creation of Situations for cultural production. Also Duchamp and his definition of the creative act as open to be completed by the audience. In this sense, also has a remarkable influence the Fluxus group and the invention of Happening by Allan Kaprow, who stablished the bases for performance art, where the audience is not only the place where meaning is conveyed but actual participants in the unfolding of the art work that is always realized in its effectuation not as a finished object. Another influence was Pop Art with the mechanically reproduced images by Andy Warhol and his experimental cinema. In addition, we encounter Josep Beuys and his concept of Social Sculpture and expanded art in which creativity is applied to daily life and the education not of better artists but of better human beings engaged in the production of their own subjectivities. With this aim, Joseph Beuys stressed the importance of communication with its 'multiples' and participation as a way of attaining societal change, an example being the project for the Documenta 7. *7,000 oak trees*[349]. Finally, the pioneer of video art Nam June Paik and his large-scale video sculptures disrupting mass communication and the music composer John Cage and the incorporation of noise and random events to musical composition. All these artistic manifestations link with the dissolution of the object as the referent of representation and the conception of a processual reality emerging from the interactions between the molecular elements of a common Matrix. Changes that the exhibition *"Les Immateriaux"* traced throughout experimental sciences, mathematics, the mechanical reproduction of image, architecture, social management, consumerism and so on, and which run simultaneously with the emergence of Embodied Virtuality.

Simultaneously to the participation of art in the creation of new media-objects and their testing, proposal of uses and normalization, where there are also artists exploring the margins of the new technological milieu. Tinguely explored the poetics of machines working out of its functional frame in *Homage to New York* (1960) and Raushemberg captures the spectrum of signals transmission of mass-communication to

348 http://www.ecafe.com/museum/history/ksoverview2.html

349 http://www.documenta.de/en/retrospective/documenta_7#

make it perceivable and open to the intervention of audience in *Oracle* (1965). Both works made use of new technologies incorporated by the collaboration with the engineer Bill Klübert who would later be involved in the creation of the EAT, a group of artists and engineers who were aware of the role that technologies play in cultural production becoming involved in the enrichment of technology and art towards a cultural revolution. The works of the EAT developed transducers to take advantage of the processes of data modulation that characterises Embodied Virtuality for the intensification of space and the incorporation of human audience, machines and environment in productive communications, that not only allow to produce space but also to increase literacy in the technological milieu. Some years later, the "*Software*" exhibition curated by Burnham questioned the changes that computerized processes produced to our daily relations with the environment, presenting works exploring the multiple narrations of hypertext, the encounter and collective productions mediated by technology, and the new epistemologies, space and behaviour management emanating from the abstraction and modulation operated by the processing of data.

At the end of the eighties, the personal computer was already a domestic commodity and the developments in Virtual Reality allow the production of immersive and interactive environments. On this point, Frank Popper situates the change from technological art, in which he includes laser art, holographic art and computer art to Virtual Art.[350] He defined it as an art engaged in the humanization of technology in which the experimentation with the new media leads to extra-aesthetic concerns such as the exploration of the cognitive and social issues it entails. Effectively throughout the eighties and the nineties, New Media Art emerged as a recognized artistic genre and became established in most of the centres and institutions dedicated to its development as well as the recognized genres of this field, most of them related to human computer interaction.

Among the works produced in this period, there are artworks exploring the changes in perception produced by the fragmented reality of data and assembled in the moment of its reception, mediated by technologically-enabled forms of interaction. The work *Iconoclast* aka *Zerseher*[351] created by Art+Com in 1991 stressed the active role of the viewer in the hermeneutics of the artwork, made apparent by a technological procedure. It consisted of the image of a classical artwork reproduced on a screen equipped with an eye tracker sensor that distorts the image at the point focused by the viewer. Another installation artwork showing the capacity of the virtual realm to double our presence into a simulation of our space in a manipulable surface is the *Tangible Image*[352] produced in 1991 by Peter Weibel; a room sensed by a camera and reproduced on a big screen in front of the viewer, and next to the screen a rubber pad equipped with sensors and reproducing a system of coordinates; when the pad is touched the image of the screen is altered at the corresponding coordinate point. *Breath*[353] by Ulrike Gabriel, created in 1992, is another space for embodied interaction with screened and acoustic data in which the sensed breath of the viewer alters the sound and abstract images projected onto a screen. The projects of Jeffrey Shaw, linked to the Expanded Cinema initiated with Peter Weibel, creates more immersive situations in which the viewer interacts physically to navigate and reassemble meaning inside a simulated environment as in the *Legible City* (1989). Here it, the spatialized database of words are actualized by cycling across the virtual world. In the encounter between machines and human beings, we can also include works related to bio art, such as the cyborgian experiments by Stelarc such as the *Involuntary Body Third Hand* (2003)[354] and Artificial Life, the capacity of simulation of computers dedicated to the reproduction of complex organisms and their behaviour, as in the works by Christa Sommerer and Laurent Mignonneau, between them *A-Volve* (1994-97)[355].

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350 Frank Popper (2007) *From Technological to Virtual Art*

351 https://artcom.de/en/blog-en/on-the-development-of-the-new-zerseher/

352 http://www.medienkunstnetz.de/works/das-tangible-bild/

353 http://www.medienkunstnetz.de/works/breath/

354 http://stelarc.org/?catID=20265

355 http://www.interface.ufg.ac.at/christa-laurent/

In the same period we encounter projects making use of the Net for artistic purposes. Among them feature projects focussing in the exploration of telepresence, remote action and collaboration. In this way, telematic art initiated by Roy Ascott was continued in the works of Paul Sermon such as *Telematic Dreaming* (1992)[356], a customized video conference system communicating two double beds, where the viewer can lay down next to the projected image of the viewer laying down in the remote place where the other connected bed is placed. The exploration of collective production inside this medium was explored in projects such as the *File Room*[357] started by Antoni Muntadas in 1994. This is a collectively contributed database related to censorship. Ken Goldberg's *teleGarden*[358] produced in 1995 links online collaboration with robotics and teleoperation, in the project where a miniature gardening parcel is attached to a robotic arm and streamed in internet, where connected users can observe and activate the arm to collaborate in its maintenance.

At the end of the nineties Internet was already a powerful ubiquitous medium and artists started to look at the processes commanding its functioning. We find critical artistic attitudes as in JODI's (Joan Hemskeerk and Dirk Paesman) *OSS* (1998)[359], a browser interface that spans the net interlinkages out of control. In the same period, Alex Galloway stressed the importance of code in the production of the protocols ruling this environment. Code is the only language that is executable and has potential to become a place for art making. The coding of data inside the net towards new renderings started the artistic use of Visualization. One of the first projects by Galloway was conducted in 1999 in collaboration with Mark Tribe, founder of the art community Rhizome. Using the Rhizome contents and interactions as a data source Galloway created an interface in which a star appeared each time a new document was read; this star increased its brightness every time the document was accessed again, the actions of the community producing a *Starry Night*[360]. In 2000, Galloway took part in the foundation of the Radical Software Group that created the already quoted *Carnivore*, an authorized surveillance system in which data was visualized as artistic renderings revealing new possible interpretations.

Works such as the ones produced by Galloway and the availability of new technologies allowing linking physical space to data produced a turn in art production. Hence, data was no longer the producer of a simulated reality that an isolated viewer could manipulate on a screen to become translators of social relations inside public spaces located on the net or on the streets that could be reassembled for an increased awareness of the medium and social intervention.

At the turn of the century, the coordinated systems reproducing space on interactive maps became like the physical realm by means of new technologies such as the GPS and GIS and the new artistic procedures appeared labelled as Locative Media. The projects under this label follow the ideas about collective space production by the Situationists as in the work by Esther Polak *Amsterdam Real Time*, and the project by Mark Shepard *Serendipitor*. It included in the *Citizens Survival Kit* a set of everyday objects embedding physical computing aimed at avoiding video surveillance in public places. Also related to the procedures of this category are the games produced by the Blastheory. Other projects focused on the capacities of rendering data in public spaces to incorporate the audience and produce collaborative architectures as in the *Relational Architectures* by Rafael Lozano Hemmer. Started in 2003, this series of works consists of the projection in the sky of light architectures, the patterns of which are altered online by a participatory audience.

The Postdigital emerges in this moment that data processes are codifying physical space and reconnecting with the origins of the artistic appropriation of this medium exemplified by the artists assembled in the EAT and the "*Software*" exhibition with a change of focus. While the former were engaged in the production

356 http://www.paulsermon.org/dream/

357 http://www.medienkunstnetz.de/works/the-file-room/

358 http://goldberg.berkeley.edu/garden/Ars/

359 http://oss.jodi.org/ss.html

360 http://www.marktribe.net/selected-archive/starrynight/

of transducers for the intensification of space and the definition of new embodied computing processes the audience was engaged in, the Postdigital confronted a system already standardized and black boxed towards its Disruption, the resurfacing of its components and its assemblage towards the exploration of new possibilities.

The procedures stemming from the text by Cascone -the unintended usage of devices, the hybridization and decomposition of digital files and the production of a fragmented content assembled with the participation of audience- can be extended, in the labour of some contemporary artists, towards procedures linking with social intervention, the unveiling of the politics and epistemologies of networks, the promotion of alternative spaces of production linked to Do it Yourself and the embodying of interactions increasing the awareness of our ecosystem, Strategies that appropriate the technologies of Embodied Virtuality and links material-based experimentation with this medium with the Deleuzian Ontological Game.

The Postdigital Strategies are summarized in three sets of related procedures.[361]

The Deciphering of Models. The opening of the black boxes codifying our reality and the inclusion of things as agents. This includes projects aimed at exploring the transformative power of technologies and the epistemologies and social processes that they entail by means of the identification of their components and embodiment in new situations and things able to start new Transductions. Among these things are objects that intercept with the communication and computing systems to show it's functioning or interrupt it, and objects able to produce new communication channels that unveil the agents involved in our environment. They all involve an open informatics that opposes the closed informatics of simulated worlds where the rules are established in advance by means of the laying out of open structures for Participation. These Strategies are explored through the works by Aram Bartholl, Julian Oliver, linked to the Critical Engineering working group, and the first works by Nathalie Jeremijenko.

The Embodiment of Social Processes explore the potential for cultural production and social intervention of the appropriation of the Ubiquitous Computing systems. The collective gathering and interpretation of data and the production of new transducers able to create new channels of communication inside our environment leads to the emergence of new Collectives of human and non-human agents, thus extending our perception of the agents involved in our ecosystems and increasing our Participation in the production of space. These Strategies are exemplified through civic projects produced in Hackerspaces and the works by Natalie Jeremijenko.

The Intensification of Space and Speculative Production look at the indeterminacy of software events and its Disruption to produce new things. These are interpretive and reductive operations carried out through specific arrangements according to the implicit politics of the dominant Apparatus and with aesthetic capacities towards forms of control and production. It includes projects that explore the hackability of Embodied Virtuality, the modulation of data-space towards the incorporation of noise and the setting up of new forms of expression that are embodied in the production of architectural projects. This is explored through the works by Cassey Reas, Usman Haque, and Philip Beesley.

These Strategies start in a reflexive analysis encompassing not only the devices and their functioning, but also the processes, social relations, and politics in which they are merged as matters-of-concern. With this aim, their practitioners reject generally standardized solutions to focus on situated issues arising from local communities. They do not accept information as a fact to be consumed passively and appropriate the spaces of knowledge and production for the common space. These Strategies arise from research such as production and are aimed at producing things that embody information and its processes, objects capable of invading the public space producing unexpected results and transforming the programmable space in writable information, where it becomes an interpretative experience open to creative intervention.

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361 A first draft of the Postdigital Strategies was presented in The 21st International Symposium on Electronic Art (ISEA 2015) and published as: Sandra Álvaro (2015) "Disruptive Strategies in The Postdigital City". *Proceedings of the 21st International Symposium on Electronic Art*. ISSN: 2451-8611 ISBN: 978-1-910172-00-1

There is not a clear division between Postdigital practices, some projects are on the crisscross of the procedures here described and most of the artists cited develop their work in all the fields distinguished here. In addition the projects and artists quoted here do not exhaust all Postdigital research, there are more artists and projects all around, and the projects shown here have been chosen primarily because of their relation with the production of urban space and secondly, because the direct knowledge of the author of the works and the availability of on-line documentation.

4.2.1. DECIPHERING MODELS

This section includes projects aimed at disrupting the processes and models involved in the production of our space. The artists quoted here are involved in the exploration of the relations between computer space and physical space and the criticism of media objects, cartographies, and visualizations that mediate our perception and actions inside it, as well as in the interruption of the Apparatus and the proposal of alternative embodied models. They consider space as a collective emergence, where all agents actuate thoroughly and multiply their dimensions and oppose the models that flatten entities to a set of known features and into a constrained binary action.

The work by Aram Bartholl[362] intermingles physical and computer space to explore how the feedback loop between both has altered everyday life. His procedure consists of the embodiment of media objects inside physical space. Working outside their medium these objects make apparent the processes of perception and action they are shaping and the way in which virtual worlds alter the relations inside our environment and the production of our subjectivities.

In his series Computer Game Objects, he shows how the participation inside virtual worlds engaged in the discovery of their commanding rules has trained our perception by means of linking the real world and its simulation in a different way. Concretely, the video games' influence is resurfaced by means of embodying the iconic objects guiding our actions inside games in urban space, in this way digital language is separated from technology and forced to work under the rules of physical space.

In *The Dust* (2004) he printed texture maps to created physical versions of the crates existing in the on-line game 'Counter Strike' and installed in corners in urban spaces and in *Speed* (2006) projected the flashing arrows from the video game 'Need for Speed Underground 2' in the streets of Bremen. These objects do not operate a gamification of urban space. On the contrary, they show and depotentiate the rules commanding simulated worlds. The most well-known of this series of projects is *WoW* (World of Warcraft) in which participants are invited to produce a three-dimensional tag with their name and wear it floating above their heads, thus translating to urban space the way that the avatars are identified inside the popular game. This project was featured in several exhibitions, among them the Festival Arts Electronica 2007 themed "Goodbye Privacy".[363] During the festival, the Pfarrplatz in the Linz's Marienstraße was renamed "Second City" and duplicated in Second Life. The two places were connected in a continuous interchange of protocols and aesthetic representations translated from one place to another. Therefore, the "Second City" square was redesigned to look like the Second Life metaverse, with big lettering, simplified urban furniture and allocated services allowing the festivalgoers to look and act as avatars. Among them was a hairdresser shop offering the weird looking avatars used to exhibit a medicine shop offering dietary and surgical recommendations to look like their avatars and the *Second City Shop* where the objects produced by the participants could be traded as both physical and virtual goods. All this produced a hub space where the protocols commanding

362 Aram Bartholl website: http://datenform.de/

363 Aram Bartholl (2007) "Second City"

virtual worlds were made apparent. Inside this space, Bartholl featured the workshop *WoW* and the T-shirts *Missing Image*, *Web Shirt* and *Profile Shirt*. Whereas the first one offered a wearable immersion in the simulated world, featuring the message covering virtual objects when a texture is missed, the other two criticized identity construction inside the same. The second one reproduced a typical user profile from a website to be filled in by the wearer with personal data by hand and the latter provided a long list of web 2.0 services to be checked out, both bring to light again the lack of privacy and the data we share on-line in our clothes.

Other produced wearables, where the producers of our social identity are embedded with our digital identity, are the *Tweet Bubble Series* (2009), four works that Bartholl developed during his artist in residence period at the V2_Lab and presented at the Test-Lab Fashionable Technology. The *Tweet Bubble Series* is about putting Twitter posts in wearables, and with this aim four models were produced. The *Classic Tweets*, a t-shirt made in a thermochromatic fabric that changes colour when it heats up, featuring usually used tweets. The *Loud Tweets*, featuring an LED-bar connected to an Arduino board and the tweeter feed. The *Pocket Tweet*, this t-shirt with a pocket where a speech bubble is cut-out, in which the wearer's mobile phone can be stored, featuring an application that shows the last message on the screen. Finally, the *Paper Tweet* was a social intervention. In a conference, you sign up, register with your Twitter account, and you get a label. The label has an RFID-tag embedded and during the event people with RFID readers can scan your label for new messages. If there is a new message, it is printed immediately at the desk. So you twitter your message during the conference, you are scanned, the message is printed at the desk, and you stick the new message on the badge.

Finally, in another project *Point Of View*, he uses Google imagery, creating a sculpture that represents the red map marker icon on the street, reproducing the aerial image we see on Google maps.

Related to these works is the deconstruction of the screen, low-tech screen projects inspired by the *Blinkenlights*[364] media facade of the Chaos Computer Club in Berlin, the first media facade assembled from synchronized lights and featuring a low-resolution computer screen with which passers-by can interact. *Random Screen* (2005) and *Papierpixel* are electricity-free displays that can be easily reproduced and in which pixels are controlled by mechanical processes, arising from 24 burning candles or using a punched tape system that must be pre-programmed by hand.

In addition, Bartholl produced projects aimed at the interruption of communication nets and the laying out of alternative places of encounter. *Silver Cell* is a pouch for a cell phone that acts as a faraday cage that prevents the phone from communicating with the tower or receiving signals in an attempt to stop the owner's location from being tracked or followed. *Dead Drops* (2010-2012) was produced during a residency at New York's Eyebeam Art and Technology Centre and takes its name from the imagined world of espionage. It consists of a network of USB memory chips located in physical space, constituting an anonymous off-line peer-to-peer file-sharing network by means of which everybody can store and upload information outside the protocols for identification and databasing of the Internet. The project includes a website with a manifesto that urges you to *"Free your data to the public domain in cement!"*,[365] instructions for the creation of new Dead Drops and a map to localize the existing ones. Nowadays, this net has 1,739 devices featuring a total memory of 12,723 GB.

Disrupting the protocols that rule network communication resulting in the extension of our knowledge and capacity of intervention in these systems is also the goal of Julian Oliver[366]. This artist starts disrupting the functioning of video games to evolve into the disruption of messages transmitted in mass-communication

364 http://blinkenlights.net/blinkenlights

365 http://deaddrops.com/

366 Julian Oliver website: https://julianoliver.com/output/

and the interruption of networked communication. Games were disrupted by means of mapping the data produced in gaming to another domain such as music in the project *q3aPd* (2002) or running the games in unintended couplings of software and hardware to produce glitch effects as in *Max Miptex* (2001). In 2007, Oliver started experimenting with Augmented Reality and produced *LevelHead* (2007) a spatial memory game that relates screened space with the manipulation of its physical support, the player having to manage with the different rules that command movement in both spaces. The interface of the game is a hand-held solid-plastic cube; there are three cubes, each one projecting on the screen a set of rooms corresponding to each of the faces of the cube and connected by doors. The goal of the game is to connect the cubes to help the small trapped personage find the way out. In addition, Augmented Reality was turned into a project of 'improved reality' in the project *The Artvertiser* (2008-2010), consisting of a dedicated device that records the space and features a machinic vision algorithm trained to recognise billboards in order to later replace their contents with art pieces. If there is a Wi-Fi connection close to the viewer, the replacement can be documented and shared on-line via Flickr or YouTube to provide an alternative memory of the city.

In other projects, Oliver resurfaced the mechanisms of code separating it from its execution, appearing disarmed and without effects. In the installation *Remote Install Installation of Software Art as Software Art Installation* (2013), software is shown as an unpurposeful process. The instructions that artists send to the gallery for the assemblage of an installation were substituted by the code instructions of a program that install themselves from the beginning to the end of the exhibition, the process of installation shown on a screen. In addition, in the project *Binary Operations: Stuxnet* (2012) the 'cyber weapon' and computer worm Stuxnet -the first discovered malware that spies on and subverts industrial systems- was presented in a variety of neutralized forms. As an example, a neutralized version of the virus was encrypted in the image of its target, the Siemens S7-300 system, using a steganography program embedded using the Rijndael encryption algorithm, with a key size of 256 bits. Another strategy for the resurfacing of computing and its relation to physical space consisted of the implementation of perceptual dependency between a computer and its environment. *PsWorld* (2010) is a program that disrupts the program Ps of the operative system to map computer processes to visual features of temporary events occurring in the environment where the computer is placed. In this way, if the Firefox process is mapped to the captured image of a bird, the processing of the application will stop as soon as the bird flys away from the frame of the camera. Therefore, control is evacuated from the interface and disseminated to the unpredictable complexity of the physical environment.

In 2011, Julian Oliver founded the Critical Engineering working group jointly with Bengt Sjölen and Danja Vasiliev. In their Manifesto[367], the artists consider engineering the most transformative language of our time that shapes our actions and communications. The Critical Engineering group is aimed at the study and exploration of this language, both exposing its influence and subverting the techno-political infrastructures, in order to start critical conversations about their impact and governance. The Critical Engineer notes that written code expands into social and psychological realms, regulating behaviour between people and the machines they interact with. Among its goals features the extension of knowledge of technological infrastructure, making the disempowering metaphors used in its description to disappear, such as 'the cloud' to reproduce the seams that join these technologies together to a relational system. Summarizing this group involves a task of technological excavation to reconstruct user-constraints and social action towards the empowerment of people being culturally, socially and critically productive.

Among the activities of this group is the proposal for workshops and the construction of disruptive objects able to exhibit the processes of the Apparatus and interrupt its normal functioning showing its effects on the relations between people and space production and increasing autonomy and capacity of intervention.

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367 OLIVER, J., Savičić, G., Vasiliev, D. (2011-2014) "The Critical Engineering Manifesto (2011-14)" Critical Engineering website: http://criticalengineering.org/ 28

Within this group, he proposed workshops to increase knowledge and autonomy about techno-political systems. Among them feature *The OtherNet* workshop about the installation, deployment, and administration of tools that implement decentralisation of network services, favouring locally-owned and controlled solutions. During the four days duration, the participants were introduced to the use of several open source systems allowing them to build a publicly-owned network that would give users greater control over their personal data, communications, and identities. Another intensive course was the *Net* Workshop introducing the participants to techno-politics, forensic, construction, and manipulation of computer networks. Engaging in the manipulation of networking hardware and the use of command line tools, the students not only learnt how to create computer networks but also how they can be used to manipulate us.

In addition, the group created networked objects able to disrupt the functioning of networked communication towards its interruption and manipulation. In 2011, they produced *Newstweek*, a network intervention awarded with the Golden Nica in the interactive art category of the Ars Electronica festival. Newstweek consists of a reality distortion device embedded in a wall plug that when connected scans the Wi-Fi connections around and routes all traffic through itself. The information travels across the network; specifically the news being read in the intercepted wireless devices are available to be remotely edited by a team of writers. The object becomes a tactical device for altering reality on a per-network basis. *Border Bumping* (2012) is a work of dislocative media aimed at demonstrating how mobile communication infrastructure redistributes our space and challenges its political borders. It consists of a mobile application and mapping tools. The application alerts the user moving in the vicinity of a political border when the smartphone changes to a foreign server. This information is used to redraw the limits of a map according to the servers' range. The artist followed with projects aimed at the disruption of information interchanged in the net. *Men In Grey* (2009-2014) is a street performance acted by the members of the group dressed as white-collar workers and carrying the M.I.G. suitcase. The suitcase captures, vocalises and manipulates chat sessions, web pages and other data harvested from open wireless networks, showing the result in its display. The *Men in Grey* survey network traffic and display its contents in the public space as well as unveil the data monitoring of governments and companies. Finally, we find a series of objects, poetic manifestations of 'cyber warfare' and 'cyber weapons'. *The Transparency Grenade* (2012-14) is a network intervention device. Shaped as a Soviet F1 Hand Grenade it detonates leaking the information around. It captures all the traffic at the site and securely and anonymously streams it to a dedicated server where it is mined for information and located on a map around the place of the detonation. Another of these objects is *No Network* (2013), shaped as a 1:25 scale model of the 1966 British Chieftain. This tank, when switched on, is able to interrupt all network signals within a 6-15 diameter around the object, enforcing our right to be disconnected.

Finally, we find the works by Natalie Jeremijenko[368]. While the previous artists work in the disruption of the protocols and surveillance of the techno-political Apparatus, Jeremijenko focuses on the criticism of the statistical interpretation of information and the reductive models it produces. This artist proposes alternative ways of collecting and embodying information, where objects are allowed to speak for themselves and information becomes open to being reinterpreted and reused. She produces physically-embodied reporting systems that show a complex and multidimensional reality resulting from the interactions between multiple agents.

Her first known project was *Live Wire* (1995) produced during a residency at Xerox PARC under the guidance of Mark Weiser and considered the first ubiquitous computing device. *Live Wire* embodied information in the ambience in a non-intrusive way but allowing awareness of the computing processes around us. This wiggling wire consisted of a wire connected to an engine activated when there was internet traffic and placed in the hall of the Xerox PARC.

368 Natalie Jeremijenko website: http://nataliejeremijenko.com/

In 1991 with Kate Rich she founded the *BIT* (Bureau of Inverse Technology) aimed at working with information technology as a primary matter and re-engineering technical systems to address the hidden politics of technology. The *BIT* was operative during a decade from 1994 to 2003 and produced systems aimed at rethinking the processes of data collection and interpretation to show the politics of information, who produces it and how and what are the institutional and expert filters imposed on public awareness. One of these projects was the *Suicide Box* (1996), a motion detection video system positioned in the range of the Golden Gate Bridge; the system was activated when detected vertical movement resulted in the recording of suicide events. The statistical data retrieved by the *Suicide Box*, was later analysed relating to the despondency index/ DI10 to refute the assumed relation between suicide and economic devaluation. The Bureau demonstrated that the Down Jones Index is exclusive information, a privileged and partial representation of 50 companies, which cannot be related to tragic social phenomena. The *Suicide Box* took part of a series of projects aimed at collecting data in public space from different sources such as voice recording chips or video cameras attached to remote-piloted planes. The use of open-ended popular formats to collect information like video in opposition to scientists' genres of information rendering makes information available for a wider legibility and interpretability. Video image or sound can be analysed by non-experts, reused and appropriated enabling diverse interpretations beyond the computer processing of data. Here, things are not reduced to data points but perceived in all their complexity. This non-reductive way of managing information focuses on physical processes, enabling things to speak for themselves. The *Fade-to-Black* project is a network of cameras placed in the public space that fades out the recorded image as the camera lens becomes polluted, this recorded natural process producing evidence and public awareness about air quality.

In 2003, Jeremijenko produced *One Trees*, another way of interfacing information by means of embodying it in natural processes. The project consisted of cloned trees situated in different public sites throughout the San Francisco Bay Area, and in subsequent years, these identical trees rendered the environmental and social differences they are exposed to, slowly and consistently recorded as they grew. The trees became a network instrument that mapped the microclimates of the Bay Area. Juxtaposing these biological and locally grown trees are simulated A-life trees, their growth determined by a Caron Dioxide meter, showing the discrepancies between artificial sensing systems and real processes, the project demonstrated information not as complete, accurate and factual but as partial and interpretable.

4.2.2 EMBODIMENT OF NEW SOCIAL PROCESSES

The projects assembled here appropriate information technologies for the Commonplace, this being understood as the intensive space for the emergence of Collectives that become engaged in the promotion of plural participation, the connection of the individual with the preindividual for the promotion of new forms-of-life. Thus, these projects challenge the dominated space of the technological milieu towards the promotion of a freed collective usage, considering life not from the standpoint of identity but from the conditions that enable knowledge and action.

As we have seen in the previous projects the resurfacing and Disruption of the techno-political artefacts operating in our environment necessarily involves the engagement of Collectives of human and non-human agents, informational processes are resurfaced in public spaces where the conditions of our usual relations with technological objects are altered to establish new possibilities for action. The collective engagement is evident in the workshops organized by Bartholl and Oliver where the participants involucres the work of their hands in the experimentation with the technological milieu increasing their literacy regarding it. These workshops are related to the already-exposed emergence of new Spaces of Transformation involved in the appropriation of Ubiquitous Computing, where people are gathered around the production of things.

Some of the projects produced in these collective spaces are aimed at the collective involvement on the sensing and data mining of their local space. Among them features the platform for the Internet of Things, *Pachube*, engineered by the architect Usman Haque, a digitally enabled place for the encounter between humans and non-humans, where people collecting data can share it in a public network, the data acquiring meaning in its circulation. Other projects such as *Sense your City/Data canvas*[369] and the *Data Citizen Driven City*[370] developed at Media Lab Prado focussed on the elaboration of open source hardware to sense the environment from a local standpoint and outside institutional interests. These projects open new channels of communication, networks of humans and non-human agents cooperating for increased awareness of the local environment.

The creation of new ways to interface communication towards the inclusion of non-human agents and the unveiling of the relations shaping our environment is what animates the work featured by Natalie Jeremijenko in recent years. Based on System's Theory, she reimagines the ecological relations between natural systems including technology as an augmentation and enabler of these relations. She develops mechanisms for gathering human and non-human agents around public and lifestyle experiments aimed at significant human and environmental health benefits. These include Strategies where people are involved in the redesign of energy supply, food and transportation systems that can contribute to the common good and increase soil, aquatic and terrestrial biodiversity. The management of urban space by Ubiquitous Computing systems is substituted by the design of situations and technological objects where algorithms become social emergence, the virtuous feedback loop between newly enabled connections and modified behaviours. Freeing information of its digital encoding and making it available for being collectively interpreted, civic engagement and sustainability is not commanded by an autonomous pre-emptive system but by the mutual support relations inside of a wider commons.

Jeremijenko is working on several ongoing projects framed in different institutions, among them, the *Farmacy*, initiated in 2010 and consisting of an urban farming system aimed at creating a community of urban farmers engaged in the growing of new edibles that increase health and diversity in urban areas. Among the projects inside this frame features *AgBags*, a durable inexpensive and easy to install in any facade growing structure that facilitates participatory research in vegetation-based systems design.

Another project is the *OZZ* (zoo backwards) an architecture of reciprocity for collective information and interpretation aimed at providing a space for interaction between humans and animals inhabiting urban environments. Included in this frame are the already-mentioned projects *Amphibious Architecture* and *Bat Billboard*. Structures, built for animals to find shelter, reliable food, population equilibrium and technologies by means of which they can communicate with humans. Another system developed is Robotic Geese, a remote controlled Goose robot that can be used to interact and understand geese. The robotic animal is equipped with a sensor and a camera activated to record animal reactions, which are later sent to an on-line database which can be annotated and purposed for the collective creation of a common language. This database is an open-ended archive of materials not generated by predefined categories and assumptions but open to the empirical richness of the actual interactions caused by the robotic geese and its ongoing interpretation. In addition, the geese are a transparent and active interface, not sensing passively but interacting with the real geese and causing reactions according to the idea that to observe a system is to interfere with it.

Another frame of experimentation is the *Environmental Health Clinic* at the NYU. This clinic approaches health from a holistic point of view and considers the interdependence with the environment. With this goal urban interventions are proposed that improve health conditions such as the NoPark. This project consists of the occupation of non-parking zones to convert them into engineered micro green spaces.

369 http://datacanvas.org/

370 http://thedatacitizendrivencity.com/

Another project implemented is the *BIKExMESSENGER*, a bicycle supporting a LED display on the wheel that updates information as it is ridden. The bike becomes a moving civic media display that hacks into the visual commons of the shared streets messaging significant and achievable transformations of the urban environment.

In all these projects interventions are understood as the involvement of humans and non-humans inside of Collectives where technology becomes the enabler of new Transductions addressed at increasing knowledge and re-engineering the environment.

4.2.3. INTENSIVE SPACE AND SPECULATIVE PRODUCTION

On the basis of most of the artworks introduced here there is code. Binary code resurfaces in the low-tech screens designed by Bartholl and is detached from the icons of games' interfaces when these are reproduced as innocuous cardboard prints and projected lights in the street. The use of coding is more exhaustive in the works by Oliver, where it becomes the battleground of the struggle between the Apparatus and its appropriation. The artists use code to translate data from differentiated domains and map it to new effects. He also manipulates it to cancel its malicious effects and to encrypt the intervened programs in images that result infected in an innocuous way, finally to program the connected devices able to disrupt networks and disclose in the public space its surveillance, control, and vulnerability. Natalie Jeremijenko uses it in her Physical Computing devices aimed at making apparent the relations with non-human agents in our ecosystem. In all these projects the code appears as the basis of a techno-social system commanding our Transductions with the environment and the others around, at the same time as interfacing our knowledge and possible actions. Computing processes becoming space and identity producers. The Strategies presented in this section explore the incompleteness and generative capacity of code. The capacity to apply recursion, parameters, geometric transformations, genetic algorithms and transcoding to make it evolve out of control, producing new dispositions of the data space that can be visualized and embodied in new architectural projects. In this way translated to the physical space as things, conveyors of new Affects and possibilities, the reality abstracted to the diagrammatic space of software can be modulated towards space intensification and speculative production.

Speculative Software takes advantage of the abstraction of hardware resources led by the process of virtualization to explore the potentiality of all possibilities, introducing creation and the possibility of change. It explores the capacity of software to operate reflect upon itself making visible its dynamics and opening up to transversal forms of connection, encounter the noise, and make the ordering of data categories or subjects spam out of control, leading to the possibility of a mutant epistemology and creative intervention.

In the digital age, the nature of form is trapped in the invisible realm of code. The capacity of manipulating data onto a screen has evolved with the application of algorithms able to simulate the form and behaviour of physical objects but also to create new morphologies emerging from the interaction of data structures inside a relational space. The coded objects surfaced on the screen are numerical relations that can recognise and react in the proximity of other objects and mutate their form with the addition of new parameterized variables and dynamic filters; these capacities can be translated to physical space by means of Digital Fabrication and Physical Computing. Physical objects become the result of the programming of data inside an intensive space and able to evolve with the interchange and processing of new data.

Casey Reas and Ben Fry were the initiators of Processing, the software graphic designed for educational and artistic purposes. This software sketchbook generates graphics exploiting the potential of the computer to render data as images with metaphoric and poetic meaning. *Carnivore* and the projects by Ben Fry exploited this potential to produce visualizations; the mapping of data to images for the discovering of the patterns

and the processual dynamism of the entities abstracted to these data. In this way, Ben Fry produced the *On the Origin of Species: the preservation of favoured traces*[371] project. It traced the changes throughout the editions of the book titled *"The Origin of Species"* by Charles Darwin to show how cultural products are also evolving through the relations with its environment.

Casey Reas' works[372] focus on the deconstruction of information by means of exploring the phenomenon of emergence through software. *The "Process Compendium"* is a compilation of his Process works produced between 2004 and 2010. A process interpretation in software is a kinetic drawing machine with a beginning but not defined end. These series are the result of algorithms actuating as a dynamic process, the recursive application of text instructions to elements that result in images mutated in an unforeseeable way.

Process 4[373]

> *"A rectangular surface filled with varying sizes of Element 1. Draw a line from the centres of Elements that are touching. Set the value of the shortest possible line to black and the longest to white, with varying greys representing values in between".*

This series was followed by the series *yes/no randomness* (2012) and the *Network A to D* (2009-2012). The first is an interpretation of randomness producing images such as working constrained inside a grid. The Networks are the result of a software that combines recorded drawings, produced by the *Processes* to produce fictional networks.

Signal to Noise (2012) starts a new artistic procedure in which primitive elements are substituted by data. In this project, terrestrial television signals sensed by an antenna are the raw material deconstructed to new data structures and assembled in a collage. Inspired by the collages of the 20th century built from the media of that time, *Signal to Noise* disrupts the visual codes circulated by contemporary mass-communication fracturing and distorting information to new forms of expression producing new visual assemblages. The software of *Signal to Noise* is also used in *100% Gray Coverage* (2013) and *Infinite Command Team* (2013). In both video collages the original TV images appear fleetingly inside as an almost imperceptible souvenir of the decodified message. *Ultraconcentrated* (2013) is a similar collage engine. In it, the original captured images from television are split into two screens according to its content, violent images and advertisement and submitted to the same instructions. The *Ultraconcentrated* software is also applied to the creation of the static images of the *Control Room* (2013). In 2014, he produced *A Mathematical Theory of Communication*, commissioned by Landmarks. This work consists of two murals produced with the images from *Ultraconcentrated* as a source and that synthesizes the theory of communication behind Reas' work, communication unfolding from an experimental and intuitive process that increases entropy at the same time as noise, aimed at disrupting it until the limit of legibility and confronting the viewer with the process of encoding, the computer vision algorithm that transforms the original imagery. The recodification of image processing is applied to more localized data sources in the generative collages *KNBC* (2015), the audio and visual distortion of television signals broadcast during December 2015 over the 602-608 MHz spread of the electromagnetic spectrum from a tower located at 34°13'32"N, 118°3'52"W and *https://www.youtube.com/results?search_query=adventuretime* (2015), a sample of the videos returned by the query of the title and sound coded by the colours of the images. *Linear Perspective* (2015) and *Today's ideology* (2015) use

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371 http://benfry.com/traces/

372 Casey Reas' website: http://reas.com/

373 Casey Reas (2010) *Process Compendium 2004-2010*

New York Time's images as a source, considered some of the most influential of the media framing the perception of our society. The project is inspired in the development of linear perspective, the codification of our vision operated during modernity inside a hierarchized frame of legibility and interpretation. In this way, each image is broadcast from a single point to an expanding field, as it moves from left to right, each one of them starting as a total abstraction and gaining legibility as it moves across the field. Another of the contemporary imagery codes deconstructed by the artists are the representation of our identities on-line. In *Followers 1k* (2015) the unique identities portrayed in the profiles of Casey Reas' twitter account followers were deconstructed and reassembled in a less differentiated mass acting as a self-portrait of the artist.

The disruptive processes executed by the artists inside the diagrammatic space of data processing had been applied to the embodiment of architectural forms. *Textile Room* (2012-13) is a collaboration between Reas and the architecture studio P-A-T-T-E-R-N-S, and North Sails' Flexible Composites division. The project is a portrait of the visual history of Los Angeles, a generative video collage assembled from film sequences taken here and projected over a crystal-shaped, quasi-rigid object with expressive qualities that interact with the video projection producing environmental effects. In addition, *Immuring* (2011) is a collaboration with the architecture studio davidclovers. The effects of Process 4 were formed and edited by davidclovers to create six prototypes of a speculative suburban home, the Lunar House.

The emergence of code and the modulation of data inside the diagrammatic space of computers can be applied to the creation of encounters between differentiated realities, where data can be captured in real-time in public space and modulated inside a computing system to produce emergent effects projected on the landscape. This is the case in the project by Usman Haque[374] *Marling* (2012), in which the voices of citizens are captured as data and given form through spectacular effects that hang in the air above the crowd, forming a delicate, intricate ceiling of animated colour. In this way, the noise produced by the playful interactions of the people around is transformed into signals interacting in an open communication system towards the emergence of unexpected assemblages, a poetics of connectivity that can occupy the space with ephemeral or more stable unexpected structures. The Speculative Production consists of the exploration of all the possibilities of the assembly between the entities of a reality towards its transformation and opening and the spread of new affordances inside its ecosystem. Ubiquitous Computing can be applied as a form of control but at the same time can be applied to the intensification of an open and emergent space. The already quoted project by Philip Beesley, *Hylozoic Soil*, combines Visualization procedures and Physical Computing to produce architectonic structures the form of which emerges from the intensive relational space of data and that are able to react and mutate after sensing the actions of people and environmental changes in its surroundings.

The division between content –data- and expression –code- inside computing opens a wide field for creation. Computers become a speculative machine where new forms of space production can be tested and reshaped. Resurfacing the code as a transformative process makes the arbitrariness and restrictions in which simulations renders our reality apparent and opens up this space towards the implementation of new models. The heterogeneity of urban space opens it to a multidimensional space that translated into the diagrammatic space of Embodied Virtuality can be tested, laid out and reassembled towards an increase of reality embodied in the exercising of our imagination and the work of our hands.

374 Usman Haque website: http://www.haque.co.uk/

4.3 FROM STREETWALKERS TO CITY BUILDERS

> *"The city as agglomeration of heterogeneous parts contains a myriad of magic doors and improbably secreted switching-systems opening up into other dimensions. There is an interplay between the one and the multiplicities it contains, that it might be, that it might have been, that it weaves in and out of as relations of dimensionality. Elements in a paratactic list always open up into a matrix of immanent universes. Each of the elements in a list is hypotactically stacked in relation to the immanence of what it is next to, what it abuts to and differs from. Such hypotaxis is virtual, that is, for its actualization it demands power to the imagination"* [375]

New Babylon was the first urban speculative machine conceived by the Situationist Constant as a theoretical construct to think a new conception of urban space. It was consisting of a modular structure enacted by the molecular forces of the Collective and intensified by technology. A set of unstructured floating boards that can be continuously reassembled to create Situations for the emergence of new uses and relations. An infinite nomadic place always mutating accordingly the desires of its inhabitants. *New Babylon* was never built, considering the space as a collective production it was conceived as a continuous prototype, taking the form of mock-ups, sketches, and blueprints for the speculation of the forms-of-life that space can enact. *New Babylon* was a project to be fulfilled by its future hypothetical inhabitants, meanwhile a source of new concepts to explore the possibilities of communal space.

Nomadology was a constant of the urbanism thought started by Lefebvre. Afterwards, wandering the streets became considered a performative act able to appropriate the space for new uses. The Situationists considered the encounter and distribution of bodies in public space as a method to construct new Situations able to overthrow the discourse and constraints of power and start a new culture. Otherwise, Michel de Certeau interpreted walking as a tactic act, an ongoing linkage across the non-codified interstices of urban areas to produce new traits of meaning. The urban space as the grid from to weave together the multiple experiences of its inhabitants, the assemblage of multiple tales producing collective meaning. Guattari considered urban space and the compelling problems it is attained by, in relation to new communication media and the capacity of the internet to assemble groups of individuals towards a consciousness able to consider ecology in all its complexity. Later on, the Internet as a place for the encounter of citizens concerned in the collective discussion of situated urban issues was realized around the squares of the *International City*.

Managing complexity is the ultimate goal of computing. Whit this aim, the urban space constituted by flesh and stone has encountered new agents. The bodies, relational nodes, segregating space as they move across the interstices of the immutable buildings are now also navigating the layer of the sensing and commanding systems of Ubiquitous Computing. The texture of our space rather than a precipitate of transmitted histories petrified in interpretable signs and personal memories become the result of the interlinkage between databases conveying answers to the queries from our connected devices at hand in real-time. In the Postdigital situation, the physical and computer space entangle in a continuous data feedback loop able to produce our space actualizing our affordances on it. It producing the automatized space producer we have relegated the solution of the important problems we face as overpopulation and sustainability.

The accomplishment of the inevitability of Ubiquitous Computing has been the scenery of science fiction productions foreseen bluish spaces submitted to the control of omniscient machines where human being has become superfluous, sometimes confined to some kind of metaverse, at the same time that postapocalyptic

375 Mathew Fuller (2005) *Media Ecologies. Materialist Energies in Art and Technoculture*, pp.14

landscapes where human beings struggle for its survival after the computing systems crashed. Following with this speculation let us come back to the public space, the Square portrayed at the beginning of this essay to see how it evolve with the Apparatus introduced throughout the chapters.

The last time we started our approach in the aerial view, the fabric of streets printed on a map. This map has evolved to a GIS system updated in real-time, a multi-layered reproduction of a Big Here and Long Now always at hand. Looking at it, we can see the actual distribution of things in space conjointly to the attached messages, pictures, and other information about. In addition, it also tracks and projects our position, it becoming the guidance system of a gamified relation with our environment. Our mobile phones with all its applications and integrated sensors guide our steps across the city towards the accomplishment of the tasks listed in our schedules and the recommendations conveyed by our health applications. A perfectly timed day on, in which we link public transports to arrive at work at the appointed hour, meanwhile we walk the recommended 5 Km a day, sometimes interrupted by overlaid information that rather than augment our perception of the surroundings obfuscates it behind cute monsters we can hunt to add to our collection. All this always shared on-line in the platforms performing our subjectivities according to norms of segregation that intermingle morals with fashion, to be good is to be localized and portrayed in the good places and events. As we are navigating this data landscape, the actual physical space vanishes. It becoming the support of conveniently filtered information and maybe a desirable background for a selfy. Beyond the screens there is not too much to see, you know people around you has been driven here by the same map you navigate, hence as you are in the right place for your activities, economic status, and taste, people around will be same as you are. Anyway if some intruder has lost his path until arrive here, the vision and gestural recognizing algorithms of the surveillance systems will target him and report the surveillant drones, which will follow him back his suitable place. Our square has become an interface we are provided and conducted across towards our destination. There are some vending machines distributed in the stops of a space perfectly planned for the circulation of the expected number of people. In the stops are also displays providing statistical information about the weather, air quality, epidemics, and demographics; short advertisements are also broadcasted to urge you to reduce your power consumption and waste when necessary. The corridors drive to the platforms of transportation systems synchronized with your phones in a way you always take the most convenient transport with a no more of three minutes waiting time, other displays in the waiting area show three minutes short news reports synchronized with the arrival of the transport. A more efficient air cleaning system has substituted the vegetation; instead of, there are a couple of service robots detecting people gatherings and their equipment. A group of young people dressed in sports clothes and carrying a ball just arrived. One of the robots moves towards them to show a map in its screen and give instructions. The group must take a bike from the rental, only allowed in the path to the 'green area', drive five minutes, stop to the open air coffee shop or the zoo during fifteen minutes, afterwards, the football playground will be available for 45 minutes. Every district has a 'green area' conveniently placed as it can be reached by bike from the squares located in residential and working areas. These are big spaces equipped for leisure and sports activities and perfectly scheduled after computing data from the inhabitants' calendars, fit bands, and social nets with the purpose to avoid agglomerations and provide the desired space to everybody. Finally, in the Square, there is a squad of maintenance robots, they occupied in cleaning and fixing everything before the participatory citizens can report it to the generalized monitoring and surveillance system. The hidden geographies that structured the space had being substituted by platform services and their management migrated to a faraway control room. In this highly efficient system built around the citizens, human beings are considered a flow of data circulating across a managed space and there is nothing they can engage with, events had been evacuated and everything unexpected is perceived and managed as a potential threat.

The planned space of *smartcities* is a space of quantified processes, mobility across urban space, power consumption, waste processing, air quality are computed inside a homeostatic system we only can access by means of interfaces that constrains our affordances and limits our actions to the reach of desired results.

The projects introduced in the development of the Postdigital Strategies go beyond the spaces of art contemplation to mesh with architecture, urban planning, engineering and social intervention. The processing of data inside the intensive space of Embodied Virtuality by Casey Reas is embodied in the cladding of speculative spaces of dwelling and projected upon spatial structures to produce new environments. Ephemeral structures that change our relation with space and that Usman Haque produces by means of modulating social actions and integrating it to its shaping. This social interaction integrated by Philip Beesley to the development of a living architecture. Finally the architectures of participation developed by Natalie Jeremijenko producing the new Spaces of Transformation of a wide ecology that integrates new agents. Engineering is employed in the production of new objects and spaces for the Disruption of the Apparatus and the laying out of an improved reality in the works by Julian Oliver and to embody information in interpretable structures by Natalie Jeremijenko. These projects conjointly the ones by Aram Bartholl produce new things able to embody computing processes in Spaces of Transformation where people can assemble and intervene in social construction.

Postdigital Strategies fulfill the space with new things charged with Affects able to start new relations and challenge the pre-programmed environment. At this way, the electronic transducers around us are not the integrating parts of a seamless system ruling the pace of our daily life but a space of possibilities, a free medium delivered to our hands to construct with it. The material ground of a poetics in which data abstraction and its modulation can be opened to speculate about all that can be. Space produced not as a result of the computing of processes for the sustainability of a *bare life* but emerging from the activities of new Spaces of Transformation where Collectives encounter engaged in the raising of a situated knowledge and the production of new forms-of-life.

Short time after the firsts computers become networked, Tomlinson invented the killer app that will determine the use of this medium as a system not only to link information but for the communication between people. Video Games had known their killing games that established its genres and fostered the spread of the simulated space. The touch screen transformed our mobile phones from machines for communication to all-assistants we are not able to left at home. Finally, the GPS system transformed the map to the navigating tool shaping our space. Nowadays big companies are trying to commercialize domestic appliances and wearables embedding computing trying to develop the next finding that will incorporate Ubiquitous Computing and change the conditions of our daily life. Meanwhile, Ubiquitous Computing has been appropriated an incorporated to new procedures of Making able to engage people in the production of things, which in virtue of its Affects can produce new Spaces of Transformation. Civic engagement is not more relegated to discursivity and symbolical acts of occupation but rooted in the active transformation of matter. Find the new killing innovation of Ubiquitous Computing is in our hands. There is still the opportunity to incorporate Digital Fabrication and the modelling capacities of Visualization to a Critical Theory of Prototyping based on the poetic ambivalence between model and project. A place for speculating about new possibilities and the production of things where efficiency can encounter with the productive capacity of difference. The laying out of an open space where everybody and everything can actuate as agents and where complexity is not something to be managed but the best opportunity for knowledge and creation.

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- Gameplay (2014), written by Matt Barton, Bill Loguidice. Directed by Richard Goldgewicht for Lux Digital Pictures
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5.3 INDEX OF REFERRED WORKS

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1854	*Cholera Map*	John Snow	http://www.ph.ucla.edu/epi/snow/snowmap1_1854_lge.htm	176
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1869	*Napoleon's 1812-1813 Russian Campaign*	Joseph Minard	https://www.edwardtufte.com/tufte/minard	176
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1970	*Pepsi Pavilion*	EAT	http://www.fondation-langlois.org/html/e/page.php?NumPage=401	170
1970	*Software. Information Technology: its new meaning for Art* [Exibition]	Jack Burnham (Curator) - Jewish Museum in Brooklyn, NY City	https://monoskop.org/Software_(exhibition)	21, 105-107, 137, 149, 210, 213, 215
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1972	*Adventure*	Willie Crowther	http://rickadams.org/adventure/	129, 131
1973	*Community Memory*	E. Lipkin, M. Szpakowski and L. Felsenstein	http://www.neatorama.com/2012/08/07/Community-Memory-Worlds-First-BBS-and-Online-Troll/	97, 213
1975	*VideoPlace*	Myron Krueger	http://www.medienkunstnetz.de/works/videoplace/	120, 213
1977	*Zork*	Dave Lebling, Marc Blank, Tim Anderson and Bruce Daniels	https://archive.org/details/a2_Zork_I_The_Great_Underground_Empire_1980_Infocom	129, 131

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2008	*The Artvertiser*	Julian Oliver	http://theartvertiser.com/	220
2009	*The Green watch*	Laboratoire Paragraphe/CITU	http://www.citu-paragraphe.univ-paris8.fr/spip.php?article1780	158
2009	*The Copenhagen wheel*	MIT Senseable CityLab	http://senseable.mit.edu/copenhagenwheel	179
2009	*Trash Track*	MIT Senseable CityLab	http://senseable.mit.edu/trashtrack/	179, 198, 199, 200
2009	*The world's eyes*	MIT Senseable CityLab	http://senseable.mit.edu/worldseyes/	180
2009	*Social Collider*	Karsten Schmidt, Sascha Pohflepp	http://socialcollider.net/	180
2009	*Borderline*	MIT Senseable CityLab	http://senseable.mit.edu/network/network&society2.html	179
2009	*Makerboot*	Bre Pettis, Adam Mayer and Zack "Hoeken" Smith	http://www.makerbot.com/	186-187
2009	*Tweet Bubble series*	Aram Bartholl	http://datenform.de/tweet-bubble-series-eng.html	219
2009	*Men in Grey*	The Critical Engineering working group:Julian Oliver and Daniil Vasiliev	https://criticalengineering.org/projects/men-in-grey/	221
2009	*On the Origin of Species: the preservation of favoured traces*	Ben Fry	http://benfry.com/traces/	225
2009	*Network A-D*	Casey Reas	http://reas.com/	225
2010	*Hylozoic Ground*	Philip Beesley	http://www.philipbeesleyarchitect.com/	156, 226

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2010	*Serendipitor*	Mark Shepard	http://survival.sentientcity.net/	202, 216
2010	*Dead Drops*	Aram Bartholl	http://deaddrops.com/]	199, 219
2010	*PsWorld*	Julian Oliver	https://julianoliver.com/output/psworld	220
2010	*Farmacy*	Natalie Jeremijenko	http://environmentalhealthclinic.net/farmacy/	223
2010	*NoPark*	Natalie Jeremijenko	http://www.environmentalhealthclinic.net/portfolio_page/nopark/	223
2011	*Glowing geotagged tweets*	Mapbox	http://thecreatorsproject.vice.com/blog/glowing-geotagged-tweets	180
2011	*Caritas Kontaktladen*	Marion Luttenberg for Moodley Brand Identity	http://snip.ly/vF80#http://marion-luttenberger.squarespace.com/#/infographics	176
2011	*BackTalk*	MIT Senseable CityLab	http://senseable.mit.edu/backtalk/	179, 199
2011	*Graffiti InfoViz Tools*	Golan Levin	http://fffff.at/qr-stenciler-and-qr-hobo-codes/	187-188, 201
2011	*Talk to Me: Design and the Communication between People and Objects* [exhibition]	Paola Antonelli (curator)-MOMA, NY	http://www.moma.org/interactives/exhibitions/2011/talktome/	179, 197-200
2011	*Newstweek*	Julian Oliver and Daniil Vasiliev	http://newstweek.com/	221
2011	*AgBags*	Natalie Jeremijenko	http://environmentalhealthclinic.net/farmacy/agbag/	223
2011	*OZZ (Zoo Backwards)*	Natalie Jeremijenko	http://www.environmentalhealthclinic.net/xooz/	223

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2011	*Bat Billboard*	Natalie Jeremijenko	http://www.nyu.edu/projects/xdesign/ooz/	199, 223
2011	*Robotic Geese*	Natalie Jeremijenko	http://www.nyu.edu/projects/xdesign/ooz/	223
2011	*BIKExMESSENGER*	Natalie Jeremijenko	http://www.environmentalhealthclinic.net/portfolio_page/bike-messenger/	224
2011	*Immuring*	Casey Reas	http://reas.com/immuring/	226
2012	*Pleiades*	Santiago Ortiz	http://www.visualcomplexity.com/vc/project.cfm?id=774	180
2012	*DcD City*	MediaLab Pardo	http://thedatacitizendrivencity.com/	223
2012	*The Free Universal Construction Kit*	Golan Levin	http://fffff.at/free-universal-construction-kit/	188, 201
2012	*Spontaneous Interventions: design actions for the common good* [exhibition]	Bureau of Educational and Cultural Affairs of the U.S. Department of State (ECA) – Venice Biennale 2012	http://www.spontaneousinterventions.org/about	187, 202-203
2012	*Amphibious Architecture*	Natalie Jeremijenko	http://www.nyu.edu/projects/xdesign/ooz/	203, 223
2012	*Binary Operations: Stuxnet*	Julian Oliver	https://julianoliver.com/output/stuxnet-binary-operations	220
2012	*Border Bumping*	Julian Oliver	http://borderbumping.net/	221
2012	*Transparency Grenade*	Julian Oliver	http://transparencygrenade.com/	221
2012	*Signal to Noise*	Casey Reas	http://reas.com/signal_to_noise_s/	225

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2012	*Yes/No*	Casey Reas	http://reas.com/	225
2012	*Marling*	Usman Haque	http://www.haque.co.uk/marling.php	226
2013	*Signature of Humanity*	MIT Senseable CityLab	http://senseable.mit.edu/signature-of-humanity/	179
2013	*Remote Install*	Julian Oliver	https://julianoliver.com/output/remote-install	220
2013	*The OtherNet Workshop*	Julian Oliver and Daniil Vasiliev	https://criticalengineering.org/courses/othernet/	221
2013	*NETworkshop*	Julian Oliver and Daniil Vasiliev	https://criticalengineering.org/courses/networkshop/	221
2013	*No Network*	Julian Oliver	http://julianoliver.com/output/no-network	221
2013	*100% Gray Coverage*	Casey Reas	http://reas.com/gray_coverage/	225
2013	*Infinite Command Team*	Casey Reas	http://reas.com/infinite_command/	225
2013	*Ultraconcentrated*	Casey Reas	http://reas.com/ultraconcentrated/	225
2013	*Control Room*	Casey Reas	http://reas.com/control_room/	225
2013	*Textile Room*	Casey Reas	http://reas.com/textile_room/	226
2014	*Tracking tourism in Spain*	Innovation Centre BBVA	https://info.bbva.com/es/noticias/ciencia/tecnologia/bbva-analiza-el-turismo-en-espana-a-partir-de-las-transacciones-con-tarjeta/	158

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2014	*A tale of many cities*	MIT Senseable CityLab	http://senseable.mit.edu/manycities/	179
2014	*City Forward*	IBM	http://www.ibm.com/smarterplanet/us/en/smarter_cities/article/city_forward.html	159
2014	*SelfieCity*	Lev Manovich	http://selfiecity.net/	180-181
2014	*On Broadway*	Lev Manovich	http://www.on-broadway.nyc/	181
2014	*Soft Revolvers*	Myriam Bleu	http://www.myriambleau.com/soft_revolvers.html	210-211
2014	*A mathematical theory of Communication*	Casey Reas	https://landmarks.utexas.edu/artistdetail/casey_reas	225
2015	*Networked Optimization*	Silvio Lorusso and Sebastian Schmieg	http://silviolorusso.com/work/networked-optimization/	131
2015	*Daily rituals of creative people*	Mason Currey	https://podio.com/site/creative-routines	176
2015	*The year in news 2014*	Echelon Insights	http://echeloninsights.com/wp-content/uploads/2014/12/theyearinnews20141.png	176-180
2015	*Drones*	Pitch Interactive	http://drones.pitchinteractive.com/	175
2015	*Underworlds*	MIT Senseable CityLab	http://underworlds.mit.edu/	179-180
2015	*Augmented Asbury Park*	Edward Johnston, Michael Richison and Marina Vujnovic	http://www.augmentedasburypark.com/	136
2015	*Field*	Martin Messier	http://www.mmessier.com/projects.html	210-211

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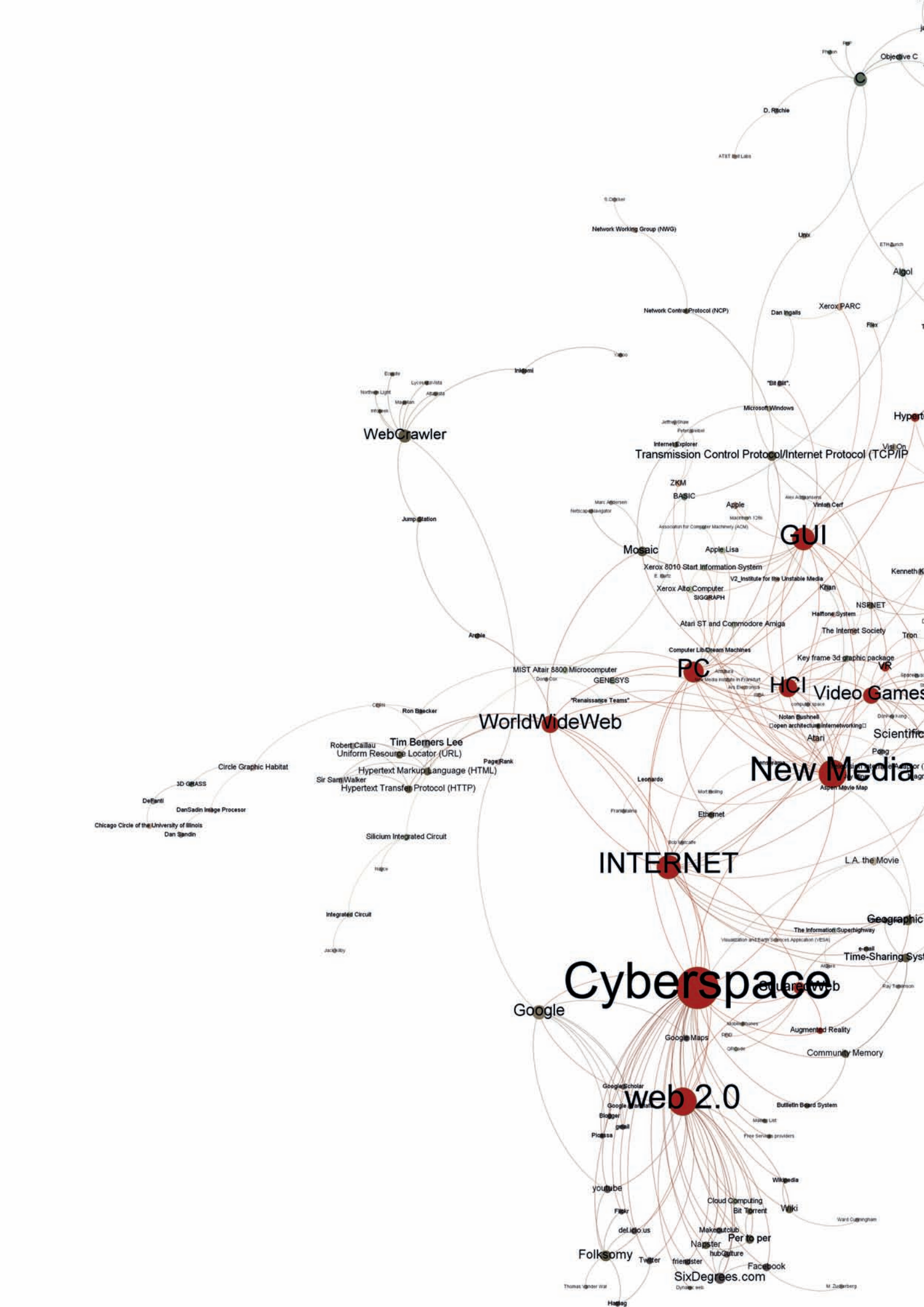
2015	*Sense Your City*	DataCanvas	http://datacanvas.org/	223
2015	*New text: Literary and Artistic Explorations into what it means to read, write and create"* [exhibition]	Dene Grigar (curator) – ISEA 2015	http://isea-archives.org/?page_id=34885	130-131, 211
2015	*Print Wikipedia*	Michael Mandiberg	http://printwikipedia.com/	131
2015	*KNBC*	Casey Reas	http://reas.com/kttv/	225
2015	*https://www.youtube.com/results?search_query=adventuretime*	Casey Reas	http://reas.com/youtube/	225
2015	*Followers 1K (ayfabtu)*	Casey Reas	http://reas.com/ayfabtu/	226
2015	*Linear Perspective*	Casey Reas	http://reas.com/linear_perspective/	225-226
2015	*Today's Ideology*	Casey Reas	http://reas.com/ideology/	225-226
2016	*Center for Fulfillment, Knowledge, and Innovation*	Greg Lynn – Venice Biennale 2016	http://glform.com/	154
2016	*The Monitour*	MIT Senseable CityLab	http://senseable.mit.edu/monitour/	179
2016	*Making a difference/a difference in making. Exploring the added value of 3d printing* [exhibition]	the Red Dot Design Museum Essen, 27th September to 30th October, 2016	http://a-difference-in-making.com/	185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D. Ritchie
Network Working Group (NWG)
Unix
Algol
Network Control Protocol (NCP)
Dan Ingalls
Xerox PARC
Flex
WebCrawler
Transmission Control Protocol/Internet Protocol (TCP/IP
Microsoft Windows
Internet Explorer
ZKM
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Robert Caillau
Uniform Resource Locator (URL)
Pong
Circle Graphic Habitat
Page Rank
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Sir Sam Walker
Leonardo
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