

UNIVERSIDAD POLITECNICA DE CATALUÑA

Departamento de Teoria de la señal y comunicaciones

**TECNICAS DE PROCESADO Y
REPRESENTACION DE LA SEÑAL
DE VOZ PARA EL
RECONOCIMIENTO DEL HABLA
EN AMBIENTES RUIDOSOS**

Autor: Francisco Javier Hernando Pericas

Director: Climent Nadeu i Camprubi

Barcelona, mayo 1993

REFERENCIAS

- [Ace92] A. Acero, R.M. Stern, "Cepstral Normalization for Robust Speech Recognition", Proc. ESCA-ETRW Speech Processing in Adverse Conditions, pp. 89-92, Cannes-Mandelieu, Noviembre 1992.
- [Ame88] M. Amengual, *Análisis de Espectro y Envolvente Espectral*, Tesis Doctoral, Escuela Técnica Superior de Ingenieros de Telecomunicación de Barcelona, Universidad Politécnica de Cataluña, Febrero 1988.
- [And79] A. Andreevski, J.P. Binquet, F. Debili, C. Fluhr, Y. Hlal, J.S. Liénard, J. Mariani, B. Poudroux, "Les Dictionnaires en Forme Complète et leur Utilisation dans la Transformation Lexicale et Syntaxique de Chaînes Phonetiques Correctes", 10èmes JEP du GALF, Grenoble, Mayo 1979.
- [Ari88] Y. Ariki, S. Mizuta, T. Saka:, Trans. IEICE Japan, nº 5, p. 790, 1988.
- [Ata67] B.S. Atal y M.R. Schroeder, "Predictive Coding of Speech Signals", Proc. Conf Commun. and Process.-1967, pp. 360-361, 1967.
- [Ata76] B.S. Atal, "Automatic Recognition of Speakers from their Voices", Proc. IEEE, pp. 460-475, Abril 1976.
- [Bah80] L.R. Bahl, R. Bakis, P.S. Cohen, A.G. Cole, F. Jelinek, B.L. Lewis, R.L. Mercer, "Further Results on a Continuously Read Natural Corpus", Proc. ICASSP-80, pp. 872-875, Denver, Abril 1980.
- [Bah83] L.R. Bahl, F. Jelinek, R.L. Mercer, "A Maximun Likelihood Approach to Continuous Speech Recognition", IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 5, nº 2, pp. 179-190, 1983.
- [Bah88] L.R. Bahl, P.F. Brown, P.V. de Souza, R.L. Mercer, "A New Algorithm for the Estimation of Hidden Markov Model Parameters", Proc. ICASSP-88, pp. 493-496, Nueva York. Abril 1988.

- [Bak75] J.K. Baker, "The DRAGON System - An Overview", IEEE Trans. ASSP, vol. 23, nº 1, pp. 24-29, Febrero 1975.
- [Bak76] R. Bakis. "Continuous Speech Recognition via Centisecond Acoustic States", en 91st Meeting of the Acoustical Society of America, Abril 1976.
- [Bau67] L.E. Baum, J.A. Egon, "An Inequality with Applications to Statistical Estimation for Probabilistic Functions of a Markov Process and to a Model for Ecology", Bull. Amer. Meteorol. Soc., vol. 73, pp. 360-363, 1967.
- [Bau68] L.E. Baum, G.R. Sell, "Growth Functions for Transformations on Manifolds", Pac. J. Math., vol. 27, nº 2, pp. 211-227, 1968.
- [Bau72] L.E. Baum, "An Inequality and Associated Maximization Technique in Statistical Estimation of Probabilistic Functions of Markov Processes", Inequalities, vol. 3, pp. 1-8, 1972.
- [Bea91] V.L. Beattie, S.J. Young, "Noisy Speech Recognition Using Hidden Markov Model State-Based Filtering", Proc. ICASSP-91, pp. 917-920, Toronto, Mayo 1991.
- [Bel57] R.E. Bellman, *Dynamic Programming*, Princeton Univ. Press., 1957.
- [Ber91] A.D. Berstein, I.D. Shallom, "An Hypothesized Wiener Filtering Approach to Noisy Speech Recognition", Proc. ICASSP-91, pp. 913-916, Toronto, Mayo 1991.
- [Bol79] S.F. Boll, "Supression of Acoustic Noise in Speech Using Spectral Subtraction", IEEE Trans. ASSP, vol. 27, nº 2, pp. 113-120, 1979.
- [Bol92] S.F. Boll, "Speech Enhancement in the 1980's: Noise Supression with Pattern Matching", *Advances in Speech Signal Processing*, ed. por S. Furui y M.M. Sondhi (Mercel Dekker, Nueva York), pp. 309-325, 1992.
- [Bon87] H. Bonneau, J.L. Gauvain, "Vector Quantization for Speaker Adaptation", Proc. ICASSP-87, pp. 1434-1437, Dallas, Abril 1987.

- [Bou87] H. Boulard, C.J. Wellekens, "Speech Pattern Discrimination and Multilayer Perceptrons", Research Report M.211, Philips Research Laboratory, Bruselas, Septiembre 1987.
- [Bri82] J.S. Bridle, M.D. Brown, P.M. Chamberlain, "An Algorithm for Speech Recognition", Proc. ICASSP-82, pp. 899-902, París, Mayo 1982.
- [Bri84] J.S. Bridle et al., "A Noise Compensating Spectrum Distance Measure Applied to Automatic Speech Recognition", Proc. Institute of Acoustics (U.K.), Autumn Conference, Windermere, 1984.
- [Bri90] J.S. Bridle, "Alpha-Nets: A Recurrent 'Neural' Network Architecture with a Hidden Markov Model Interpretation", Speech Communications, vol. 9, pp. 83-92, 1990.
- [Bro92] M.K. Brown, L.R. Rabiner, "On the Use of Energy Contours in LPC-Based Recognition of Isolated Words", Bell Syst. Tech. J. vol. 61, nº 10, pp. 2971-2987, Diciembre 1982.
- [Bro87] P. Brown, "The Acoustic-Modeling Problem in Automatic Speech Recognition", Tesis doctoral, Computer Science Department, Carnegie Mellon University, Mayo 1987.
- [Bur67] J.P. Burg, "Maximum Entropy Spectral Analysis", Proc. 37th Meeting of the Society of Exploration Geophysicists, 1967.
- [Bur85] D. Burton, "Applying Matrix Quantization to Isolated Word Recognition", Proc. ICASSP-85, pp. 29-32, Tampa, Marzo 1985.
- [Cad80] J.A. Cadzow, "High Performance Spectral Estimation - A New ARMA Method", IEEE Trans. ASSP, vol. 28, nº 5, Octubre 1980.
- [Cad82] J. A. Cadzow, "Spectral Estimation: An Overdetermined Rational Model Equation Approach", Proc. IEEE, vol. 70, nº 9, pp. 907-939, 1982.
- [Car91] B.A. Carlson, M.A. Clements, "Application of Weighted Projection Measure for Robust Hidden Markov Model Based Speech Recognition", Proc. ICASSP-91, pp. 921-924, Toronto, Mayo 1991.

- [Cas90] F. Casacuberta, E. Vidal, B. Mas, H. Rulot, "Learning the Structure of HMM's through Grammatical Inference Techniques", Proc. ICASSP-90, pp. 717-720, Albuquerque, Abril 1990.
- [Col80] R.A. Cole, A.I. Rudnický, V. Zue, D.R. Reddy, "Speech as Patterns on Paper", en R.A. Cole ed., *Perception and Production of Fluent Speech*, Lawrence Elbaum Associates, Hillsdale, Nueva Jersey, 1980.
- [Com89] D. Van Compernelle, "Noise Adaptation in a Hidden Markov Model Speech Recognition System", *Computer Speech and Language*, vol. 3, pp. 151-167, 1989.
- [Cha90] L. Chang, M.M. Bayoumi, "Parametric Modeling of State Transitions in Hidden Markov Model", Proc. EUSIPCO-90, pp. 1387-1390, Barcelona, Septiembre 1990.
- [Che87] Y. Chen, "Cepstral Domain Stress Compensation for Robust Speech Recognition", Proc. ICASSP-87, pp. 717-720, Dallas, Abril 1987.
- [Cho86] Y.L. Chow, R.M. Schwartz, S. Roucos, O.A. Kimball, P. Price, G.F. Kubala, M.O. Dunham, M.A. Krasner, J. Makhoul, "The Role of Word-Dependent Coarticulatory Effects in a Phoneme-Based Speech Recognition System", Proc. ICASSP-86, pp. 1593-1596, Tokio, Abril 1986.
- [Dal88] N. Dal Degan, C. Prati, "Acoustic Noise Analysis and Speech Enhancement Techniques for Mobile Radio Applications", *Signal Processing*, vol. 15, 43-56, 1988.
- [Dau83] B.A. Dautrich, L.R. Rabiner, T.B. Martin, "On the Effects of Varying Filter Bank Parameters on Isolated Word Recognition", *IEEE Trans. ASSP*, vol. 31, pp. 793-806, 1983.
- [Dav80] S.B. Davis y P. Mermelstein, "Comparison of Parametric Representations for Monosyllabic Word Recognition in Continuously Spoken Sentences", *IEEE Trans. ASSP*, vol. 28, pp. 357-366, 1980.
- [Dem77] A.P. Dempster, N.M. Laird y D.B. Rubin, "Maximum Likelihood from Incomplete Data via the EM Algorithm", *J. Roy. Stat. Soc.*, vol. 39, nº 1, pp. 1-38, 1977.

- [Der86] A.M. Derouault, B. Mérialdo, "Natural Language Modeling for Phoneme-to-Text Transcriptions", IEEE Trans. PAMI, vol. 5, nº 2, pp. 742-749, 1986.
- [Der87] A.M. Derouault, "Context-Dependent Phonetic Markov Models for Large Vocabulary Speech Recognition", Proc. ICASSP-87, pp. 360-363, Dallas, Abril 1987.
- [Don78] W.J. Done, "Estimation of the Parameters of an Autoregressive Process in the Presence of Additive White Noise", Computer Science Dep., Unive. Utah, Informe UTEC-CSC-79-201, Diciembre 1978.
- [Dud73] R.O. Duda, P.E. Hart, "Data Description and Clustering", *Pattern Classification and Scene Analysis*, vol. 1, pp. 211-216, John Wiley & Sons (1973)
- [Dum88] P. Dumouchel, V. Gupta, M. Lennig, P. Mermelstein, "Three Probabilistic Language Models for a Large-Vocabulary Speech Recognizer", Proc. ICASSP-88, pp. 513-516, Nueva York, Abril 1988.
- [Dut87] D. Dutoit, "Evaluation of Speaker-Independent Isolated-Word Recognition Systems over Telephone Network", Proc. EUROSPEECH-87, pp. 241-244, Edimburgo, Septiembre 1987.
- [Dvo91] S. Dvorak, T. Hörmann, "High-Performance Speech Recognition in Noise by Continuously Updated Reference Templates", Proc. EUROSPEECH-91, pp. 1375-1378, Génova, Septiembre 1991.
- [Eph84] Y. Ephraim, D. Malah, "Speech Enhancement Using a Minimum Mean Square Error Short-time Spectral Amplitude Estimator", IEEE Trans. ASSP, vol. 32, pp. 1109-1121, 1984.
- [Eph87] Y. Ephraim, J.G. Wilpon, L.R. Rabiner, "A Linear Predictive Front-End Processor for Speech Recognition in Noisy Environments", Proc. ICASSP-87, pp. 1324-1327, Dallas, Abril 1987.
- [Eph89] Y. Ephraim, D. Malah, B.H. Juang, "On the Application of Hidden Markov Models for Enhancing Noisy Speech", IEEE Trans. ASSP, vol. 37, pp.1846-1856, 1989.

- [Fan60] G.C.M. Fant, *Acoustic Theory of Speech Production*, Mouton and Co., Gravenhage, Holanda, 1960.
- [Fen88] M.W. Feng, F. Kubala, R. Schwartz, J. Makhoul, "Improved Speaker Adaptation using Text Dependent Spectral Mapping", Proc. ICASSP-88, pp. 131-134, Nueva York, Abril 1988.
- [Fer80] J.D. Ferguson, "Variable Duration Models for Speech", Symposium on Application of Hidden Markov Models to Text and Speech, pp. 143-179, Princeton, 1980.
- [Fla72] J.L. Flanagan, *Speech Analysis Synthesis and Perception*, Springer-Verlag, 1972.
- [Fri79] B. Friedlander, M. Morf, T. Kailath, L. Ljung, "New Inversion Formulas for Matrices Classified in Terms of their Distance from Toeplitz Matrices", Linear Algebra and its Applications, vol. 27, pp. 31-60, 1979.
- [Fri85] B. Friedlander, K.C. Sharman, "Performance Evaluation of the Modified Yule-Walker Estimator", IEEE Trans. ASSP, vol. 33, pp. 719-725, Junio 1985.
- [Fuk72] K. Fukunaga, *Introduction to Statistical Pattern Recognition*, Academic Press, Inc. 1972.
- [Fur84] S. Furui, "On the Role of Dynamic Characteristics of Speech Spectra for Syllable Perception", Trans. Fall Meet. Acoust. Soc. Japan, vol. 1-1-12, Octubre 1984.
- [Fur86] S. Furui, "Speaker-Independent Isolated Word Recognition Using Dynamic Features of Speech Spectrum", IEEE Trans. ASSP, vol. 34, nº 1, pp. 52-59, 1986.
- [Fur88] S. Furui, "A VQ-Based Preprocessor Using Cepstral Dynamic Feature for Speaker-Independent Large Vocabulary Word Recognition", IEEE Trans. ASSP, pp. 980-987, Julio 1988.
- [Fur89] S. Furui, *Digital Speech Processing, Synthesis, and Recognition*, Marcel Dekker, Inc. , 1989.

- [Fur92] S. Furui, "Toward Robust Speech Recognition under Adverse Conditions", Proc. ESCA-ETRW Speech Processing in Adverse Conditions, pp. 31-42, Cannes-Mandelieu, Noviembre 1992.
- [García Gómez y Gómez Mena] R. García Gómez y J. Gómez Mena, Universidad Politécnica de Madrid, Comunicación personal.
- [Gau86] J.I. Gauvain, "A Syllable Base Isolated Word Recognition Experiment", Proc. ICASSP-86, pp. 57-60, Tokio, Abril 1986.
- [Ger70] W. Gersch, "Estimation of the Autoregressive Parameters of a Mixed Autoregressive Moving-Average Time Series", IEEE Trans. AC, vol. 15, pp. 583-588, Octubre 1970.
- [Ghi86] O. Ghitza, "Auditory Nerve Representation as a Front-End for Speech Recognition in a Noisy Environment", Computer Speech and Language, nº 1, pp. 109-130, 1986.
- [Gis90] H. Gish, Y. Chow, J.R. Rohlicek, "Probabilistic Vector Mapping of Noisy Speech Parameters for HMM Word Spotting", Proc. ICASSP-90, pp. 117-120, Albuquerque, Abril 1990.
- [Gom90] J.F. Gómez, *Métodos de Reconocimiento Robustos con los Modelos Ocultos de Markov*, Tesis Doctoral, E.T.S.I. Telecomunicación de Madrid, Universidad Politécnica de Madrid, Febrero 1990.
- [Gon88] Y.F. Gong, J.P. Haton, "A Specialist Society for Continuous Speech Understanding", Proc. ICASSP-88, pp. 627-630, Nueva York, Abril 1988.
- [Gra76] A.H. Gray, Jr., J.D. Markel, "Distance Measures for Speech Processing", IEEE Trans. ASSP, vol. 24, nº 5, pp. 380-391, Octubre 1976.
- [Gra84] R.M. Gray, "Vector Quantization", IEEE ASSP Magazine, vol. 1, nº 2, pp. 4-29, 1984.
- [Gup87] V.N. Gupta, M.Lennig, P. Mermelstein, "Integration of Acoustic Information in a Large Vocabulary Word Recognizer", Proc. ICASSP-87, pp. 697-700, Dallas, Abril 1987.

- [Han87] B.A. Hanson, H. Wakita, "Spectral Slope Based Distortion Measures for All-Pole Models of Speech", IEEE Trans. ASSP, vol. 35, nº 7, pp. 968-973, 1987.
- [Han90] B.A. Hanson, T.H. Applebaum, "Robust Speaker-Independent Word Recognition Using Static, Dynamic and Acceleration Features: Experiments with Lombard and Noisy Speech", Proc. ICASSP-90, pp. 857-860, Albuquerque, Abril 1990.
- [Hat87] J.P. Haton, N. Carbonnel, D. Fohr, J.F. Mari, A. Kriouille, "Interaction between Stochastic Modeling and Knowledge-Based Techniques in Acoustic-Phonetic Decoding of Speech", Proc. ICASSP-87, pp. 868-871, Dallas, Abril 1987.
- [Her85] H. Hermansky, B.A. Hanson, H. Wakita, "Perceptually Based Linear Predictive Analysis of Speech", Proc. ICASSP-85, pp. 509-512, Tampa, Marzo 1985.
- [Her91] H. Hermansky, N. Morgan, A. Bayya, P. Kohn, "Compensation for the Effect of the Communication Channel in Perceptual Linear Predictive (PLP) Analysis of Speech", Proc. EUROSPEECH-91, pp. 1367-1370, Génova, Septiembre 1991.
- [Her91b] J. Hernando, C. Nadeu, "A Comparative Study of Parameters and Distances for Noisy Speech Recognition", Proc. EUROSPEECH-91, pp. 91-94, Génova, Septiembre 1991.
- [Her92a] J. Hernando, J. Cobo, C. Nadeu, "Reconocimiento del Habla en Ambientes Ruidosos mediante Modelos Ocultos de Markov Discretos", Proc. V Simposium Nacional de Reconocimiento de Formas y Análisis de Imágenes, pp. 212-219, Valencia, Septiembre 1992.
- [Her92b] J. Hernando, C. Nadeu, D. Riu, "Comportamiento de la Transformación Bilineal de Frecuencias en el Reconocimiento de Habla Ruidosa", Proc. V Simposium Nacional de Reconocimiento de Formas y Análisis de Imágenes, pp. 220-221, Valencia, Septiembre 1992.

- [Her92c] J. Hernando, D. Riu y C. Nadeu, "Técnicas de Modelado AR Robusto de la Señal de Voz para el Reconocimiento del Habla en Ambientes Ruidosos", Proc. URSI-92, pp. 134-133, Málaga, Septiembre 1992.
- [Her92d] J. Hernando, C. Nadeu, E. LLeida, "On the AR Modeling of the One-Sided Autocorrelation Sequence for Noisy Speech Recognition", Proc. ICSLP-92, pp. 1593-1596, Alberta, Octubre 1992.
- [Her92e] J. Hernando, C. Nadeu, "AR Modeling of the Speech Autocorrelation to Improve Noisy Speech Recognition", Proc. ESCA Workshop on Speech Processing in Adverse Conditions, pp. 107-110, Cannes-Mandelieu, Noviembre 1992.
- [Her93a] J. Hernando, J.B. Mariño, C. Nadeu, "Multiple Multilabeling Applied to HMM-Based Noisy Speech Recognition", aceptado en el ICSP'93, que tendrá lugar en Pekín en Octubre de 1993.
- [Her93b] J. Hernando, C. Nadeu, J.B. Mariño, "A Comparative Study of Techniques for HMM-Based Noisy Speech Recognition", aceptado en el NATO Advances Institute, New Advances and Trends in Speech Recognition and Coding, que tendrá lugar en Bubión (Granada) en Junio-Julio de 1993.
- [Hir91] H.G. Hirsch, P. Meyer, H.W. Ruehl, "Improved Speech Recognition Using High-Pass Filtering of Subband Envelopes", Proc. EUROSPEECH-91, pp. 413-416, Génova, Septiembre 1991.
- [Hol86] J.N. Holmes, N.C. Sedgwick, "Noise Compensation for Speech Recognition Using Probabilistic Models", Proc. ICASSP-86, pp. 741-744, Tokio, Abril 1986.
- [Hua89] X.D. Huang, M.A. Jack, "Semicontinuous Hidden Markov Models for Speech Signals", Computer Speech and Language, vol. 3, pp. 239-251, 1989.
- [Hun80] M.J. Hunt, M. Lennig, P. Mermelstein, "Experiments in Syllable-Based Recognition of Continuous Speech", Proc. ICASSP-80, pp. 880-883, Denver, Abril 1980.

- [Hun89] M.J. Hunt, C. Lefebvre. "A Comparison of Several Acoustic Representations for Speech Recognition with Degraded and Undegraded Speech", Proc. ICASSP-89, pp. 262-265, Glasgow, Mayo 1989.
- [Ita68] F. Itakura, S. Saito, "An Analysis-Synthesis Telephony Based on Maximum Likelihood Method", Proc. Int'l Cong. Acoust., C-5-5, 1968.
- [Ita75] F. Itakura, "Minimum prediction residual principle applied to speech recognition", IEEE Trans. ASSP, vol. 35, 1975, pp. 67-72.
- [Ita87] F. Itakura, T. Umezaki, "Distance Measure for Speech Recognition Based on the Smoothed Group Delay Spectrum", Proc. ICASSP-87, pp. 1257-1260, Dallas, Abril 1987.
- [Jel76] F. Jelinek, "Continuous Speech Recognition by Statistical Methods", Proc. IEEE, vol. 64, nº 4, pp. 532-556, 1976.
- [Jel80] F. Jelinek, R. Mercer, "Interpolated Estimation of Markov Source Parameters from Speech Data", en *Pattern Recognition in Practice*, North-Holland, 1980.
- [Jua85] B.H. Juang, L.R. Rabiner, "Mixture Autoregressive Hidden Markov Models for Speech Signals", IEEE Trans. ASSP, vol. 33, nº 6, pp. 1404-1413, 1985.
- [Jua86] B.H. Juang, S.E. Levinson, M.M. Sondhi, "Maximum Likelihood Estimations for Multivariate Mixture Observations of Markov Chains", IEEE Trans. IT, vol.32, nº2, pp. 307-309, Marzo 1986.
- [Jua87a] B.H. Juang, L.R. Rabiner, "Signal Restoration by Spectral Mapping", Proc. ICASSP-87, pp. 2363-2371, Dallas, Abril 1987.
- [Jua87b] B. H. Juang, L.R. Rabiner, J. G. Wilpon, "On the Use of Bandpass Lifting in Speech Recognition", IEEE Trans. ASSP, vol. 35, nº 7, pp. 947-953.
- [Jua91] B.H. Juang, "Speech Recognition in Adverse Environments", *Computer Speech and Language*, vol. 5, pp. 275-294, 1991.

- [Jua92] B.H. Juang, K.K. Paliwal, "Hidden Markov Models with First-Order Equalization for Noisy Speech Recognition", IEEE Trans. Signal Processing, vol. 40, n° 9, pp. 2136-2143, Septiembre 1992.
- [Jun89] J.C. Junqua, H. Wakita, "A Comparative Study of Cepstral Lifters and Distance Measures for Additive Models of Speech in Noise", Proc. ICASSP-89, pp. 476-479, Glasgow, Mayo 1989.
- [Jun90] J.C. Junqua, Y. Angelade, "Acoustic and Perceptual Studies of Lombard Speech: Application to Isolated-Words Automatic Speech Recognition", Proc. ICASSP-90, pp. 841-844, Albuquerque, Abril 1990.
- [Kan86] Y. Kaneda, J. Ohga, IEEE Trans. ASSP, vol. 34, n° 6, p. 1391, 1986.
- [Kay79] S.M. Kay, "The Effects of Noise on the Autoregressive Spectral Estimator". IEEE Trans. ASSP, vol. 27, n° 5, pp. 478-485, Octubre 1979.
- [Kay80] S.M. Kay, "Noise Compensation for Autoregressive Spectral Estimates", IEEE Trans. ASSP, vol. 28, n° 3, pp. 292-303, Junio 1980.
- [Kay87] S.M. Kay, *Modern Spectral Estimation*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1987.
- [Ken90] P. Kenny, M. Lenning, P. Mermelstein, "A Linear Predictive HMM for Vector-Valued Observations with Application to Speech Recognition", IEEE Trans. ASSP, vol. 38, n° 2, 1990.
- [Kla76] D.H. Klatt, "A Digital Filter Bank for Spectral Matching", Proc. ICASSP-76, pp. 573-576, Filadelfia, 1976.
- [Kla82] D.H. Klatt, "Prediction of Perceived Phonetic Distance from Critical Band Spectra: A First Step", Proc. ICASSP-82, pp. 1278-1281, París, Mayo 1982.
- [Koh84] T. Kohonen, K. Mäkisara, T. Saramäki, "Phonotopic Maps - Insightful Representation of Phonological Features for Speech Recognition", Proc. 7th ICPR, pp. 182-185, Montreal, Julio-Agosto 1984.

- [Kop85] G.E. Kopec, M.A. Bush, "Network-Based Isolated Digit Recognition Using Vector Quantization", IEEE Trans. ASSP, vol. 33, nº 4, 1985.
- [Kuh81] M. Kuhn, H. Ney, H. Tomachewski, "Fast Non Linear Time Alignment for Isolated Word Recognition", Proc. ICASSP-81, pp. 736-740, Atlanta, Marzo-Abril 1981.
- [Lag87] M.A. Lagunas, M. Amengual, "Non-Linear Spectral Estimation", Proc. ICASSP-87, pp. 2035-2038, Dallas, Abril 1987.
- [Lee88a] K.F. Lee, "Large-Vocabulary Speaker-Independent Continuous Speech Recognition: the SPHINX System", CMU Report, CMU-CS-88-148, Abril 1988.
- [Lee88b] K.F. Lee, H.W. Hon, "Large Vocabulary Speaker-Independent Continuous Speech Recognition", ICASSP-88, pp. 24-27, Nueva York, Abril 1988.
- [Lev83] S.E. Levinson, L.R. Rabiner, M.M. Sondhi, "An Introduction of the Application of the Theory of Probabilistic Functions on a Markov Process to Automatic Speech Recognition", The Bell System Technical Journal, vol. 62, nº 4, Abril 1983.
- [Lev86] S.E. Levinson, "Continuously Variable Duration Hidden Markov Models for Automatic Speech Recognition", Computer Speech and Language, vol. 1, pp. 29-45, 1986.
- [Lim78] J.S. Lim, A.V. Oppenheim, "All-Pole Modeling of Degraded Speech", IEEE Trans. ASSP, vol. 26, n 3. pp. 197-209, 1978.
- [Lim79] J.S. Lim, A.V. Oppenheim, "Enhancement and Bandwidth Compression of Noisy Speech", Proc. IEEE 67, pp. 1586-1604, 1979.
- [Lin80] Y. Linde, A. Buzo, R.M. Gray, "An Algorithm for Vector Quantizer Design", IEEE Trans. COM, vol 28, nº 1, pp. 84-95, Enero 1980.
- [Lip87a] R.P. Lippman, "An Introduction to Computing with Neural Nets", IEEE Trans. ASSP, vol. 4, nº 2, pp. 4-22, 1987.

- [Lip87b] R.P. Lippman, B. Gold, "Neural Classifiers Useful for Speech Recognition", 1st International Conference on Neural Networks, IEEE, Junio 1987.
- [Lip87c] R.P. Lippman, E.A. Martin, D.B. Paul, "Multi-Style Training for Robust Isolated-Word Speech Recognition", Proc. ICASSP-87, pp. 705-708, Dallas, Abril 1987.
- [Lip88] R.P. Lippman, "Neural Nets for Computing", Proc. ICASSP-88, pp. 1-6, Nueva York, Abril 1988.
- [Lle92] E. Lleida, J.B. Mariño, J. Salavedra, A. Bonafonte, "Syllabic Fillers for Spanish HMM Key Word Spotting", Proc. ICSLP-92, pp. 5-9, Alberta, Octubre 1992.
- [Mak75] J. Makhoul, "Linear Prediction: A Tutorial Review", Proc. IEEE, vol. 63, nº 4, pp. 561-580, Abril 1975.
- [Mak85] J. Makhoul, "Vector Quantization in Speech Coding", Proc. IEEE, vol. 73, nº 11, 1985.
- [Man89a] D. Mansour, B.H. Juang, "The Short-Time Modified Coherence Representation and Noisy Speech Recognition", IEEE Trans. ASSP, vol. 37, nº 6, pp. 795-804, 1989.
- [Man89b] D. Mansour y B. H. Juang, "A Family of Distortion Measures Based upon Projection Operation for Robust Speech Recognition", IEEE Trans. ASSP, vol. 37, nº 11, pp. 1659-1671, 1989.
- [Mar81] J. Mariani, "Reconnaissance de la Parole Continue par Diphonèmes", en *Processus d'Encodage et de Décodage Phonétiques*, Symposium Galf-Greco, Tolosa, 1981.
- [Mar87] J. Mariani, "Hamlet: A Prototype of a Voice-Activated Typewriter", Proc. EUROSPEECH-87, pp. 222-225, Edimburgo, Septiembre 1987.
- [Mar87] S.L. Marple, Jr., *Digital Spectral Analysis with Applications*, Prentice-Hall, Inc., 1987.

- [Mar90] J.B. Mariño, A. Bonafonte, A. Moreno, E. Lleida, C. Nadeu, E. Monte, "Recognition of Number by Using Demisyllables and Hidden Markov Models", Proc. EUSIPCO-90, pp. 1363-1366, Barcelona, Septiembre 1990.
- [Mas92] E. Masgrau, J.M. Salavedra, A. Moreno, A. Ardanuy, "Speech Enhancement by Adaptive Wiener Filtering Based on Cumulant AR Modelling", Proc. ESCA Workshop on Speech Processing in Adverse Conditions", pp. 143-146, Cannes, Noviembre 1992.
- [Mat86] H. Matsumoto, H. Imai, "Comparative Study of Various Spectrum Matching Measures on Noise Robustness", Proc. ICASSP-86, pp. 769-772, Tokio, Abril 1986.
- [Mat89] K. Matrouf, F. Néel, J.L. Gauvain, J. Mariani, "Adaptive-Syntax Representation in an Oral Task-Oriented Dialogue for Air-Traffic Controller Training", Proc. EUROSPEECH-89, pp. 1:187-190, París, Septiembre 1989.
- [Mat91] H. Matsumoto, H. Mitusi, Trans. IEICE Japan, nº 8, p. 1257, 1991.
- [McA80] R.J. McAulay, M.L. Malpass, "Speech Enhancement Using a Soft-Decision Noise Supression Filter", IEEE Trans. ASSP, vol. 28, pp. 137-145, 1980.
- [McG83] D.P. McGinn, D.H. Johnson "Reduction of All-Pole Parameter Estimation Biass by Successive Autocorrelation", Proc. ICASSP-83, pp. 1088-1091, Boston, Abril 1983.
- [Mer88] B. Merialdo, "Phonetic Recognition using Hidden Markov Models and Maximum Mutual Information Training", Proc. ICASSP-88, pp. 111-114, Nueva York, Abril 1988.
- [Miy88] M. Miyoshi, Y. Kaneda, IEEE Trans. ASSP, vol. 36, nº 2, p. 145, 1988.
- [Mon92] E. Monte, *Reconocimiento Automático del Habla mediante Redes Neuronales y Modelos Híbridos*, Escuela Técnica Superior de Ingenieros de Telecomunicación de Barcelona, Universidad Politécnica de Cataluña, Abril 1992.

- [Mor86] R. De Mori, L. Lam, "Plan Refinement in a Knowledge-Base System for Automatic Speech Recognition", Proc. ICASSP-86, pp. 1217-1220, Tokio, Abril 1986.
- [Mye81] C.S. Myers, L.R. Rabiner, "A Level Buiding Dynamic Time Warping Algorithm for Connected Word Recognition", IEEE Trans. ASSP, vol. 29, nº 2, pp. 284-297, 1981.
- [Nad85] A. Nadas, "On Turing's Formula for Word Probabilities", IEEE Trans. ASSP, vol. 33, nº 6, 1985.
- [Nad88] A. Nadas, D. Nahamoo, M.A. Picheny, "Speech Recognition Using Noise-Adaptive Prototypes", Prcc. ICASSP-88, pp. 517-520, Nueva York, Abril 1988.
- [Nad89] C. Nadeu, E. LLeida y J. Hernando, "Modeling of the Analytic Spectrum for Speech Recognition", Proc. EUROSPEECH-89, pp. 215-218, París, Septiembre 1989.
- [Nad91] C. Nadeu, J. Pascual y J. Hernando, "Pitch Determination Using the Cepstrum of the One-Sided Autocorrelation Sequence", Proc. ICASSP-91, pp. 3677-3680, Toronto, Mayo 1991.
- [Nag88] H. Nagabuchi, Trans. IEICE Japan, nº 5, p. 1100, 1988.
- [Nak88] M. Nakamura, K. Shikano, "A Study of English Word Category Prediction Based on Neural Networks", ATR Technical Report, TR-1-0052, Noviembre 1988.
- [Nak90] Y. Nakadai, N. Sugamura, Proc. ICSLP-90, pp. 1141-1144, Kobe, 1990.
- [Ney88] H. Ney, A. Noll, "Phoneme Modeling Using Continuous Mixture Densitys", Proc. ICASSP-88, pp. 437-440, Nueva York, Abril 1988.
- [Ney90] H. Ney, "Acoustic-Phonetic Modeling Using Continuous Mixture Densities for the 991-Word DARPA Speech Recognition Task", Proc. ICASSP-90, pp. 713-716, Albuquerque, Abril 1990.

- [New73] A. Newell et al., *Speech Understanding Systems: Final Report of a Study Group*, North-Holland, 1973.
- [Nis87] M. Nishimura, K. Toshioka, "HMM-Based Speech Recognition Using Multi-Dimensional Multi-Labeling", Proc. ICASSP-87, pp. 1163-1166, Dallas, Abril 1987.
- [Opp75] A.V. Oppenheim, R.W. Schafer, *Digital Signal Processing*, Prentice-Hall, 1975.
- [O'Sh87] D. O'Shaughnessy, *Speech Communcation, Human and Machine*, Addison-Wesley Series in Electrical Engineering: Digital Signal Processing, 1987.
- [Pal82] K.K. Paliwal, "On the Performance of the Quefreny-Weighted Cepstral Coefficientes in Vowel Recognition", *Speech Commun.*, pp. 151-154, Mayo 1982.
- [Par76] T.W. Parsons, *J. Acoust. Soc. Am.*, nº 4, p. 911, 1976.
- [Pau86] D.B. Paul, R.P. Lippmann, R.P. Chen, C. Weinstein, "Robust HMM-Based Techniques for Recognition of Speech Produced under Stres and in Noise", *Speech Tech* 1986, Nueva York, Abril 1986.
- [Pau88] D.B. Paul, E.A. Martin, "Speaker Stress-Resistant Continuous Speech Recognition", Proc. ICASSP-88, pp. 283-286, Nueva York, Abril 1988.
- [Pee88] S.M. Peeling, R.K. Moore, "Isolated Digit Recognition Experiments Using the Multi-Layer Perceptron". *Speech Communication*, vol. 7, nº 4, pp. 403-410, Diciembre 1988.
- [Pis85] D.B. Pisoni, R. Bernacki, ii. Nusbaum, M. Yuchtman, "Some Acoustic-Phonetic Correlates of Speech Produced in Noise", ICASSP-85, pp. 1581-1584, Tampa, Marzo 1985.
- [Por84] J.E. Porter y S.F. Boll, "Optimal Estimators for Spectral Restoration of Noisy Speech", Proc. ICASSP-84, pp. 18A.2.1-18A.2.4, San Diego, Marzo 1984.

- [Pow87] G.A. Powell, P. Darlington, P.D. Wheeler, "Practical Adaptive Noise Reduction in the Aircraft Cockpit Environment", Proc. ICASSP-87, pp. 173-176, Dallas, Abril 1987.
- [Rab68] L.R. Rabiner, "Digital-Formant Synthesizer for Speech Synthesis", J. Acoust. Soc. Am. 43, pp. 822-828, 1968.
- [Rab82] L.R. Rabiner, A. Bergh, J.G. Wilpon, "An Embedded Word Training Procedure for Connected Digit Recognition", Proc. ICASSP-82, pp. 1621-1624, París, Mayo 1982.
- [Rab84] L.R. Rabiner, K.C. Pan, F.K. Soong, "On the Performance of Isolated Word Speech Recognizers Using Vector Quantization and Temporal Energy Contours", AT&T Bell Laboratories Technical Journal 63(7):1245-1260, Septiembre 1984.
- [Rab85a] L.R. Rabiner, B.H. Juang, S.E. Levinson, M.M. Sondhi, "Recognition of Isolated Digits using Hidden Markov Models with Continuous Mixture Densities". AT&T Tech. Journal, vol. 64, nº 6, pp. 1211-1233, Julio 1985.
- [Rab85b] L.R. Rabiner, S.E. Levinson, "A Speaker-Independent Syntax-Directed Connected Word Recognition System Based on Hidden Markov Model and Level-Building", IEEE Trans. ASSP, vol. 33, nº 3, pp. 561-573, 1985.
- [Rab86a] L. R. Rabiner, B.H. Juang, "An Introduction to Hidden Markov Models", IEEE ASSP Magazine, vol. 3, nº 1, pp. 4-16, 1986.
- [Rab86b] L.R. Rabiner, B.H. Juang, S.E. Levinson, M.M. Sondhi, "Recognition of Isolated Digits Using Hidden Markov Models with Continuous Mixture Densities", AT&T Tech. J., vol. 64, nº 6, pp. 1211-1222, Julio-Agosto 1986.
- [Rab88] L.R. Rabiner, J.G. Wilpon, F.K. Soong, "High Performance Connected Digit Recognition Using Hidden Markov Models", Proc. ICASSP-88, pp. 119-122, Nueva York, Abril 1988.
- [Rab89] L.R. Rabiner, "A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition", Proc. IEEE, vol. 77, nº2, Febrero 1989.

- [Ras90] J. Rascado, *Reconocimiento Robusto del Habla con Parametrización LPC*, Proyecto de Fin de Carrera, Departamento de Teoría de la Señal y Comunicaciones, Universidad Politécnica de Cataluña, 1990.
- [Roe87] D.B. Roe, "Speech Recognition with a Noise-Adapting Codebook", Proc. ICASSP-87, pp. 1138-1142, Dallas, Abril 1987.
- [Ros59] R. Rosenblatt, *Principles of Neurodynamics*, Spartan Books, New York, 1959.
- [Rum86] D.E. Rumelhart, G.E. Hinton, R.J. Williams, "Learning Internal Representations by Error Propagation", en *Parallel Distributed Processing: Exploration in the Microstructure of Cognition*, vol. 1: *Foundation*, D.E. Rumelhart y J.L. McClelland Eds, MIT Press, 1986.
- [Rus81] G. Ruske, T. Schotola, "The Efficiency of Demi-Syllable Segmentation in the Recognition of Spoken Words", Proc. ICASSP-81, pp. 971-974, Atlanta, Marzo-Abril 1981.
- [Rus82] G. Ruske, "Auditory Perception and its Application to Computer Analysis of Speech", *Computer Analysis and Perception vol. II, Auditory Signals*, C.Y. Suen y R. De Mori, Eds. Boca Raton, FL: CRC Press, 1982.
- [Rus85] M.J. Russell, R.K. Moore, "Explicit Modeling of State Occupancy In Hidden Markov Models for Automatic Speech Recognition", Proc. ICASSP-85, pp. 5-8, Tampa, Marzo 1985.
- [Sai66] S. Saito y F. Itakura, "The Theoretical Consideration of Statistically Optimum Methods for Speech Spectral Density", Informe nº 3107, Electrical Communication Laboratory, N.T.T., Tokio (1966).
- [Sak79] H. Sakoe, "Two-Level DP Matching - A Dynamic Programming Based Pattern Matching Algorithm for Connected Word Recognition", IEEE Trans. ASSP, vol. 27, nº 6, pp. 588-595, 1979.
- [Sak89] H. Sakoe, R. Isotani, K. Yoshida, K. Iso, T. Watanabe, "Speaker-Independent Word Recognition Using Dynamic Programming Neural Networks", Proc. ICASSP-89, pp. 29-33, Glasgow, Mayo 1989.
- [Sch75] M.R. Schroeder, "Models of Hearing", Proc. IEEE, Septiembre 1975.

- [Sch81] M.R. Schroeder, "Direct (Nonrecursive) Relations between Cepstrum and Predictor Coefficients", IEEE Trans. ASSP, vol. 29, pp. 297-301, Abril 1981.
- [Sch84] R.M. Schwartz, Y.L. Chow, S. Roucos, M. Krasner, J. Makhoul, "Improved Hidden Markov Modeling for Acoustic-Phonetic Recognition of Continuous Speech", Proc ICASSP-84, pp. 35.6.1-35.6.-4, San Diego, Abril 1984.
- [Sch87] R.M. Schwartz, Y. Chow, F. Kubala, "Rapid Speaker Adaptation Using a Probabilistic Spectral Mapping", Proc. ICASSP-87, pp. 633-636, Dallas, Abril 1987.
- [Sch89] R. Schwartz, O. Kimball, F. Kubala, M.W. Feng, Y.L. Chow, C. Barry, J. Makhoul, "Robust Smoothing Methods for Discrete Hidden Markov Models", Proc. ICASSP-89, pp. 548-551, Glasgow, Mayo 1989.
- [Seg91] J.C. Segura, *Modelos de Markov con Cuantización Dependiente para Reconocimiento de Voz*, Tesis Doctoral, Facultad de Ciencias, Universidad de Granada, Noviembre 1991.
- [Sej86] T.J. Sejnowski, C.R. Rosenber, "NETtalk: a Parallel Network that Learns to Read Aloud", Technical Report, Johns Hopkins University, ECCS-86/01, Junio 1986.
- [Sen88] S. Seneff, "A Joint Synchrony/Mean-Rate Model of Auditory Speech Processing", Journal of Phonetics, vol. 16, pp. 55-76, 1988.
- [Shi82] K. Shikano, M. Sugiyama, "Evaluation of LPC Spectral Matching Measures for Spoken Word Recognition", Trans. IECE, vol. J65-D, nº 5, pp. 535-541, Mayo 1982.
- [Shi86a] K. Shikano, K.F. Lee, R. Reddy, "Speaker Adaptation through Vector Quantization", Proc. ICASSP-86, pp. 2643-2646, Tokio, Abril 1986.
- [Shi86b] K. Shikano, "Evaluation of LPC Spectral Matching Measures for Phonetic Unit Recognition", CMU-CC-86-108, Carnegie Mellon Univ., Pittsburg, 1986.

- [Shi90] Y. Shiraki, M. Hoda, "Speaker Adaptation Algorithms Based on Piece-Wise Moving Adaptive Segment Quantization Method", ICASSP-90, pp. 657-660, Albuquerque, Abril 1990.
- [Sin88] H. Singer, J.L. Gauvain, "Connected Speech Recognition Using Dyssyllable Segmentation", Proc. Acoustic Society of Japan Conference, Octubre 1988.
- [Slu68] G.S. Slutsker, "Nelinejnyp Method Analiza Recevych Signalov", Trudy Niir, nº 2, 1968.
- [Soo87] F.K. Soong, M.M. Sondhi, "A Frequency-Weighted Itakura Spectral Distortion Measure and its Application to Speech Recognition in Noise", Proc. ICASSP-87, pp. 625-628, Dallas, Abril 1987.
- [Sor91] H.B.D. Sorensen, "A Cepstral Noise Reduction Multi-Layer Neural Network", Proc. ICASSP-91, pp. 933-936, Toronto, Mayo 1991.
- [Sta89] B.J. Stanton, L.H. Jamieson, G.D. Allen, "Robust Recognition of Loud and Lombard Speech in the Fighter Cockpit Environment", Proc. ICASSP-89, pp. 675-678, Glasgow, Mayo 1989.
- [Ste86] P.E. Stern, M. Eskenazi, D. Memmi, "An Expert System for Speech Spectrogram Reading", Proc. ICASSP-86, pp. 1193-1196, Tokio, Abril 1986.
- [Sto92] P. Stoica, T. Söderström, S. Van Huffel, "On the Equivalence of SVD and TLS Based Yule-Walker Approaches to Frequency Estimation", Proc. EUSIPCO-92, pp. 669-672, Bruselas, Agosto 1992.
- [Sug82] M. Sugiyama, K. Shikano, "Frequency Weighted LPC Spectral Matching Measures", Electronics and Communications in Japan, 65A (12), pp. 1-9, 1982.
- [Sug83] N. Sugamura, K. Shikano, S. Furui, "Isolated Word Recognition Using Phoneme-Like Templates", Proc. ICASSP-83, pp. 723-726, Boston, Abril 1983.

- [Sug85] K. Sugawara, M. Nishimura, K. Toshioka, M. Okochi, T. Kaneko, "Isolated Word Recognition Using Hidden Markov Models", Proc. ICASSP-85, pp. 1-4, Tampa, Marzo 1985.
- [Tak89] T. Takara, "Isolated Word Recognition Using Continuous State Transition-Probability and DP-Matching", Proc. ICASSP-89, pp. 274-277, Glasgow, Mayo 1989.
- [Tak91] Y. Takebayashi, H. Tsuboi, H. Kanazawa, "A Robust Speech Recognition System Using Word-Spotting with Noise Immunity Learning", Proc. ICASSP-91, pp. 905-908, Toronto, Mayo 1991.
- [Tam88] S. Tamura y A. Waibel, "Noise Reduction Using Connectionist Models", Proc. ICASSP-88, pp. 553-556, Nueva York, Abril 1988.
- [Toh87] Y. Tohkura, "A Weighted Cepstral Distance Measure for Speech Recognition", IEEE Trans, ASSP, vol. 35, n° 10, Octubre 1987.
- [Tou74] J.T. Tou, R.C. González, "Pattern Classification by Distance Functions", *Pattern Recognition Principles*, pp. 75-109, Addison-Wesley Publishing Company, Inc., (1974).
- [Usa91] T. Usagawa, Y. Morita, M. Ebata, Proc. Korea-Japan Joint Symposium on Acoustics S1-3-J3, p. 222, 1991.
- [Var90] A.P. Varga, R.K. Moore, "Hidden Markov Model Decomposition of Speech and Noise", Proc. ICASSP-90, pp. 845-848, Albuquerque, Abril 1990.
- [Vin68] T.K. Vintsjuk, "Recognition of Words of Oral Speech by Dynamic Programming", *Kibernetika*, vol. 81, n° 8, 1968.
- [Vis86] V. Viswanathan y C. Henry, "Evaluation of Multisensor Speech Input for Speech Recognition in High Ambient Noise", Proc. ICASSP-86, pp. 85-88, Tokio, Abril 1988.
- [Vit67] A.J. Viterbi, "Error Bounds for Convolutional Codes and an Asymptotically Optimum Decoding Algorithm", IEEE Trans. Information Theory, vol. 13, n° 2, pp. 260-269, 1967.

- [Wai87] A. Waibel, T. Hanazawa, G. Hinton, K. Shikano, K. Lang, "Phoneme Recognition Using Time-Delay Neural Networks", ATR Research Report, TR-I-0006, Octubre 1987.
- [Wan91] H. Wang, F. Itakura, IEICE Technical Report SP91-62, p. 15, 1991.
- [Wid75] B. Widrow, J.R. Glover, Jr., J.M. McCool, J. Kaunitz, C.S. Williams, R.H. Hearn, J.R. Zeidler, E. Dong, Jr., R.C. Goodlin, "Adaptive Noise Cancelling: Principles and Applications", Proc. IEEE, vol. 63, nº 12, pp.1692-1716, 1975.
- [Wil85] J.G. Wilpon y L.R. Rabiner, "A Modified K-Means Clustering Algorithm for Use in Isolated Word Recognition", IEEE Trans. ASSP, vol. 33, nº 3, pp. 587-594, 1985.
- [Wil88] J.G. Wilpon, D.M. DeMarco, R.P. Mikkileni, "Isolated Word Recognition over the DDD Telephone Network - Results of Two Extensive Field Studies", Proc. ICASSP-83, pp. 55-58, Nueva York, Abril 1988.
- [Wil91] J.G. Wilpon, C.H. Lee, L.R. Rabiner, "Improvements in Connected Digit Recognition Using Higher Order Spectral and Energy Features", Proc. ICASSP-91, pp. 349-352, Toronto, Mayo 1991.
- [Yam91] H. Yamada, H. Wang, F. Itakura, "Recovering of Broad Band Reverberant Speech Signal by Sub-Band MINT Method", Proc. ICASSP-91, pp. 969-972, Toronto, Mayo 1991.
- [You88] S.R. Young, W.H. Ward, "Towards Habitable Systems: Use of Word Knowledge to Dynamically Constrain Speech Recognition", Proc. 2nd Symposium on Advanced Man-Machine Interface through Spoken Language, pp. 30-1, 30-12, Hawai, Noviembre 1988.
- [Zel77] R. Zelinsky, P. Noll, "Adaptive Transform Coding of Speech Signals", IEEE Trans. ASSP. vol. 25, pp. 299-309, Agosto 1977.
- [Zue86] V.W. Zue, L.F. Lamel, "An Expert Spectrogram Reader: a Knowledge-Based Approach to Speech Recognition", Proc. ICASSP-86, pp. 1197-1200, Tokio, Abril 1986.

- [Zue88] V. Zue, "Recent Speech Recognition Results at MIT", DARPA Review Meeting, Pittsburgh, Junio 1988.