

Tutorial proposal

Processing of audio signals by neural networks

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Abstract

It is well known that the most important techniques for digital signal processing (DSP) are based on linear models. In some cases due to intrinsically non-linear nature of the phenomenon, non-linear circuits are needed. Usually, in these cases, custom model-based architectures are specifically studied.

In last years new adaptive non-linear circuits have been studied and applied in many real-world fields. Among various circuits for non-linear DSP, neural network paradigm is one of the most effective technique to solve general purpose non-linear problems.

Neural networks in fact represent an established technology that can be efficiently used in several non-linear signal processing problems like: filtering, signal analysis and synthesis, signal compression, classification, etc.

The main drawback for the use of neural networks for DSP is the computational cost that can be very high and unacceptable for low cost real time processing.

In this tutorial low structural-computational complexity neural networks, suitable for real-time DSP applications, are presented.

Several audio real-world applications are also discussed.

The main subjects are:

Neural architectures for real-time DSP;

Applications:

1. Speech signal enhancement;
2. Old recording signal restoration;
3. Low cost loudspeakers linearisation by predistortion;
4. Non linear models for sound synthesis.

References:

1. Gianandrea Cocchi and Aurelio Uncini, "Subbands Neural Networks Prediction for On-line Audio Signal Recovery", IEEE Trans. on Neural Networks special issue on Neural Networks for Multimedia Applications, 2002.
2. Mirko Solazzi and Aurelio Uncini, "Regularising Neural Networks Using Flexible Multivariate Activation Function", accepted for publication on Neural Networks.
3. Aurelio Uncini, "Sound Synthesis by Flexible Activation Function Recurrent Neural Networks", Proc. of "Italian Workshop on Neural Networks (WIRN02)", Vietri Sul Mare (Salerno), Springer-Verlag Ed., May 2002.
4. Aurelio Uncini, "Audio Signal Processing by Neural Networks", accepted for publication on Neurocomputing.
5. Celani A., Bartoloni S., Uncini A., Piazza F., "A multirate approach to multichannel blind deconvolution", Circuits and Systems, 2002 IEEE International Symposium on , Volume: 1, pp. 677-680, 2002.
6. Aurelio Uncini, Andrea Nalin and Raffaele Parisi, "ACOUSTIC ECHO CANCELLATION IN THE PRESENCE OF DISTORTING LOUDSPEAKERS", Proc. of European Signal Processing Conference, Eusipco2002. Sept. 2002.

Topic areas: Intelligent Sensory Processing & Perception: Audition

Short Biography

Aurelio Uncini - He is Associate Professor in Circuits Theory, at the Dipartimento della Scienza e Tecnica dell' Informazione e della Comunicazione University of Rome "La Sapienza" - Italy. He received the laurea degree in Electronic Engineering from the University of Ancona, Italy, on 1983 and the Ph.D. degree in Electrical Engineering in 1994 from University of Bologna, Italy.

From 1984 to 1986 he was with the "Ugo Bordoni" Foundation, Rome, Italy, engaged in research on digital processing of speech signals. From 1986 to 1987 he was at Italian Ministry of Communication. From 1987 to 1993 he has been a free researcher affiliated at the Department of Electronics and Automatics - University of Ancona and where from 1994 to 1998 he was assistant professor. Since November 1998, he is Associate Professor at the Department INFOCOM - University of Rome "La Sapienza" where he is teaching Circuits Theory and Digital Processing of Audio Signals. He his author of more than 100 papers in the field of circuits theory, optimisation algorithms for circuits design, neural networks and signal processing. Prof. Uncini is a member of the Institute of Electrical and Electronics Engineers (IEEE), of the IEEE Neural Networks for Signal Processing Technical Committee, of the Associazione Elettrotecnica ed Elettronica Italiana (AEI), of the International Neural Networks Society (INNS) and of the Societa' Italiana Reti Neuroniche (SIREN).

Selected last years publications

- 1 Gianandrea Cocchi and Aurelio Uncini, "Subbands Neural Networks Prediction for On-line Audio Signal Recovery", IEEE Trans. on Neural Networks special issue on Neural Networks for Multimedia Applications. July 2002.
- 2 Mirko Solazzi and Aurelio Uncini, "Regularising Neural Networks Using Flexible Multivariate Activation Function", accepted for publication on Neural Networks.
- 3 Luca Ianelli and Aurelio Uncini, "Learning of physical-like sound synthesis models by adaptive spline recurrent neural networks", IEE Electronics Letters , Volume: 38, Issue: 14, pp. 724 – 725, 4 July 2002.
- 4 Aurelio Uncini, "Audio Signal Processing by Neural Networks", accepted for publication on Neurocomputing.
- 5 Mirko Solazzi, Aurelio Uncini, Elio D. Di Claudio, and Raffaele Parisi, "Complex Discriminative Learning Bayesian Neural Equalizer", Signal Processing, Dec. 2001
- 6 Stefano Traferro and Aurelio Uncini, "Power-of-Two Adaptive Filters Using Tabu Search", IEEE Transactions on Circuits and Systems-II: Analog and Digital Signal Processing, Vol. 47, No. 6, June 2000.
- 7 Paolo Campolucci, Aurelio Uncini and Francesco Piazza "A Signal-Flow-Graph Approach to On-line Gradient Calculation", Neural Computation, vol. 12, nr. 8, August 2000.
- 8 Paolo Campolucci, Aurelio Uncini, Francesco Piazza, Bhaskar D. Rao, "On-Line Learning Algorithms for Locally Recurrent Neural Networks", IEEE Trans. on Neural Networks, Vol. 10, No. 2, pp.253-271 March 1999.
- 9 Aurelio Uncini, Lorenzo Vecci, Paolo Campolucci and Francesco Piazza, "Complex-valued Neural Networks with Adaptive Spline Activation Function for Digital Radio Links Nonlinear Equalization", IEEE Trans. on Signal Processing, Vol. 47, No. 2, February 1999.

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- 11 Lorenzo Vecci, Francesco Piazza, Aurelio Uncini, "Learning and Approximation Capabilities of Adaptive Spline Activation Function Neural Networks", Neural Networks, Vol.11, No.2, pp 259-270, March 1998.

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