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Adaptive Filters and Acoustic Echo Control

Least-squares (LS) optimal filtering has been used extensively in many different applications, such as control, communications, and geophysical signal processing. Recursive or adaptive filtering refers to a particular design procedure, where we learn more about the unknown filter's model each time new experimental evidence becomes available. Adaptive filters are used in applications where the system and/or the environment are time-varying.

The development of efficient algorithms for adaptive filtering has been the focus of intensive research over the last three decades. The efficiency of an algorithm is measured against a number of performance indices, such as convergence rate, tracking rate, computational complexity, roundoff error robustness, and numerical stability. In a parallel processor environment, the issues of computational parallelism and pipelinabilty become major design factors. All these issues must be considered by the algorithm designer in order to achieve the best tradeoff for the application at hand.

Acoustic echo control is a highly demanding application area. Designing adaptive filters for such applications is a really challenging task. The problem of acoustic echo control arises wherever a loudspeaker and a microphone are placed within an enclosure in a way that the microphone picks up the signal from the loudspeaker as well as the reflections from the borders of the enclosure and the various objects inside. Teleconferencing systems and hands-free cellular phones are typical examples where echo control is of paramount importance. What makes such applications very demanding is the highly nonstationary nature of the involved signals and systems, as well as the very long filters required. Filters of a few thousand taps are typical in many cases.

The first article "Efficient LS Adaptive Algorithms for FIR Transversal Filtering: A Unified View," by George-Othon Glentis, Kostas Berberidis, and Sergios Theodoridis, presents an overview, in a unified perspective, for a class of algorithms known as FIR transversal filtering algorithms. This is the family of algorithms used in echo-control applications. They start with the Wiener optimal LS filter, and each algorithmic scheme is viewed as a specific recursive algorithm for the solution of the associated Wiener-Hoff equations. The article begins with the more conventional algorithms, such as LMS and RLS, and then moves to recently proposed schemes, such as block-exact algorithms, which are particularly suited for acoustic-echo-control applications.

The second article, "Acoustic Echo Control—An Application of Very-High-Order Adaptive Filters," by Christina Breining, Pia Dreiseitel, Eberhard Hänsler, Andreas Mader, Bernhard Nitsch, Henning Puder, Thomas Schertler, Gerhard Schmidt, and Jan Tilp, presents an overview of the acoustic-echo-control problem, with an emphasis on hands-free telephone systems. Stereophonic audio conference systems are also considered and discussed. A number of adaptive algorithms are described and their performance is investigated in the context of acoustic-echo-control application. Finally, important from a practical point of view, implementation issues and parameter control mechanisms are highlighted.

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Sergios Theodoridis is co-editor of *Adaptive System Identification and Signal Processing Algorithms* (Prentice Hall, 1993) and *Pattern Recognition* (Academic Press, 1998). He has served as an associate editor for the *IEEE Transactions on Signal Processing*, is on the editorial board of the *EURASIP Signal Processing Journal*, was the EUSIPCO-98 General Chairman, and is a Fellow of IEE.

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