

Unbiased Blind Adaptive Channel Identification and Equalization

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Abstract—The blind adaptive equalization and identification of communication channels is a problem of important current theoretical and practical concerns. Recently proposed solutions for this problem exploit the diversity induced by sensor arrays or time oversampling, leading to the so-called second-order algebraic/statistical techniques. The prediction error method is one of them, perhaps the most appealing in practice, due to its inherent robustness to ill-defined channel lengths as well as for its simple adaptive implementation. Unfortunately, the performance of prediction error methods is known to be severely limited in noisy environments, which calls for the development of noise (bias) removal techniques. We present a low-cost algorithm that solves this problem and allows the adaptive estimation of unbiased linear predictors in additive noise with arbitrary autocorrelation. This algorithm does not require the knowledge of the noise variance and relies on a new constrained prediction cost function. The technique can be applied in other noisy prediction problems. Global convergence is established analytically. The performance of the denoising technique is evaluated over GSM test channels.

Index Terms—Blind equalization, blind estimation, convergence, denoising, linear prediction.

I. INTRODUCTION

BLIND channel equalization exploiting the channel diversity induced by sensor arrays and/or time oversampling has attracted a lot of research efforts over the last few years. Methods can be found in the literature, based on the optimization of various second-order criteria, which offer fast converging alternatives to the previously reported higher order statistics (HOS)-based techniques [1], [2]. For the most part, algebraic and second-order statistical techniques have been proposed that exploit the structural properties (Hankel, Toeplitz, *et al.*) of the single-input multiple-output (SIMO) channel or data matrices. The information on channel parameters or transmitted data is typically recovered through subspace decompositions of the received data matrix (deterministic methods, e.g., [3], [8], [9], [10]) or that of the received data correlation matrix (stochastic methods, e.g., [4], [6]).

Although very appealing from the conceptual and signal processing points of view, the use of the aforementioned techniques in real-world telecom applications faces serious

challenges. First, subspace-based techniques are usually computationally involved and difficult to implement in contexts with strict delay/complexity constraints. To a large extent, adaptive signal processing solutions are better suited to high dynamic conditions commonly encountered in telecom (especially wireless) applications. Note, however, that instances of adaptive second-order equalization methods can be found, including [11] and [16].

Another drawback of subspace-based methods lies in the fact that they rely on the existence of numerically well-defined dimensions of the signal or noise subspaces or other related subspaces. Since these dimensions are obviously closely related to the channel length, subspace-based techniques are extremely sensitive to channel order modeling errors [7].

The prediction error methods (PEM's) offer an alternative to the class of techniques above. PEM's, which were first introduced in [5] and later refined in [7], exploit the i.i.d. property of the transmitted symbols and apply a minimum prediction error filter on the received data. When the PE filter is chosen long enough, the filter output becomes white and corresponds to a signal free of intersymbol-interference (ISI), which in turn can be used to estimate the channel.

The PEM offers great practical advantages over most other proposed techniques. First, channel estimation using the PE method remains consistent in the presence of channel length mismatch.¹ In fact, we can actually improve the reconstruction performance offered by PEM by capturing the energy of the more distant and less significant channel taps (which corresponds to a practical case of channel length overestimation) just by increasing the prediction horizon. This property guarantees the robustness of the technique with respect to the difficult channel length estimation problem. This is unlike subspace-based approaches in which the incorporation of smaller taps in the channel model introduces ambiguities and degrades the identification/equalization performance. Another significant advantage of the PE method is that it lends itself easily to a low-cost adaptive implementation.

Unfortunately the PEM not only has attractive properties, but it is also known to be sensitive to channel additive noise. Additive noise induces residual ISI in the output of the prediction error filter, which in turn causes inconsistency in the channel estimate. For this reason, a denoising procedure must be applied to remove the predictor's bias [7].

In the existing batch implementations of PEM, we solve the noise problem by removing the pre-estimated noise contribution from the signal's second-order statistics. Then, approximately

¹When the assumed channel length is greater than the theoretical channel length.

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