Available at
www.ElsevierComputerScience.com
POWERED BY SCIENCE DIRECT
Signal Processing 85 (2005) 215–225
SIGNAL PROCESSING
www.elsevier.com/locate/sigpro

Blind identification and equalization of two-channel FIR systems in unbalanced noise environments

Roberto Diversi*, Roberto Guidorzi, Umberto Soverini

Dipartimento di Elettronica, Informatica e Sistemistica, Università di Bologna, Viale del Risorgimento 2, 40136 Bologna, Italy

Received 17 November 2003; received in revised form 27 September 2004

Abstract

Blind identification is a very significant problem in many contexts where only the output of transmission channels can be observed. The solutions that can be found in the literature are limited to the case of equal amounts of additive noise on the observations. This paper proposes new identification procedures that can be applied to the case of two FIR channels affected by unknown and unbalanced amounts of additive noise. The identified models are then used for the minimal variance deconvolution of the unknown input signal. Several Monte Carlo simulations also confirm the good performance of these procedures in severe SNR conditions.

Keywords: Blind identification; Blind equalization; Linear systems; FIR systems

1. Introduction

The interest in the so-called "blind identification" problems has remarkably increased during the last decade [3]. These problems refer to the estimation of the behavior of transmission channels in the absence of information on their input. The solution of this problem is often considered as a first step toward the subsequent deconvolution problem, i.e. the determination of the unknown input sequence.

Problems of this type can be found in many fields and are of particular interest in communications where the distortion caused by multipath interference, sometimes defined as "convolutive noise", affects transmission quality and channel bandwidth. This problem, which can be properly treated by means of equalization procedures, is particularly critical in mobile environments like modern personal communication systems. Their digital nature is, in fact, sensitive to intersymbol interference (ISI) that can limit both frequency selectivity and bandwidth, since the transmission of every symbol must be extended in order to assure proper decoding.

*Corresponding author. Tel.: +39 051 209 3770.
E-mail addresses: rdiversi@deis.unibo.it (R. Diversi), rguidorzi@deis.unibo.it (R. Guidorzi), usoverini@deis.unibo.it (U. Soverini).

0165-1684/$ - see front matter
doi:10.1016/j.sigpro.2004.09.013

In some cases it is possible to identify the channel characteristics by applying input training sequences; blind equalizers assure, however, larger bandwidths since they do not require specific time slots dedicated to identification.

Several blind identification schemes can be found in the literature [3,13]. Since communication channels are, in general, non-minimum phase, the second-order statistics of stationary signals are not sufficient for their identification; for this reason, some blind identification approaches are based on higher-order statistics of the received signal. These approaches are computationally demanding and require a large number of samples, so that they are unsuitable for fast-varying environments.

When the signal received on a single sensor is oversampled or multiple sensors are available, the blind identification problem can be solved by using only second-order statistics. In these cases, the system to be identified can be considered as a single-input–multi-output system [12,14]. Several approaches have been proposed: cross-relation methods [9,15,16], subspace methods [1,12], maximum likelihood methods [4,10] and methods assuming the input whiteness [2,14].

This paper introduces, on the basis of errors-in-variables identification techniques, new blind identification procedures for two-channel FIR systems driven by arbitrary unknown inputs. These procedures, which extend and complete the preliminary results reported in [6,7], rely on the properties of the family of solutions of the Frisch scheme [5] and on the shift properties of time-invariant systems. Among their features, it is worth mentioning the estimation of the channels order and the determination of the noise variances. The proposed methods, different from the methods already present in the literature, can also be applied when the channel outputs are affected by unbalanced amounts of noise. The extension to a number of channels greater than two is not straightforward and will be treated elsewhere.

The whole paper is organized as follows. Section 2 contains a statement of the problem while Section 3 recalls some properties of two-channel FIR systems. Section 4 describes two robust criteria that can be used also when the assumptions of the considered scheme are not exactly satisfied. Section 5 concerns the minimal variance deconvolution of the unknown input signal, i.e. the step usually performed after the identification of the channels. Section 6 reports several Monte Carlo simulations that show the good results of the proposed methods in unbalanced contexts and in noise environments worse than those affordable with traditional methods. Short concluding remarks are finally given in Section 7.

2. Statement of the problem

The models considered in the paper consist of two linear, discrete, time-invariant FIR channels driven by the same input, as shown in Fig. 1.

The noiseless outputs $x_1(t)$, $x_2(t)$ are linked to the input $u(t)$ by the convolution model

$$x_1(t) = \mathbf{h}_1(z^{-1})u(t) = \sum_{k=0}^{L} h_1(k)u(t-k), \tag{1}$$

$$x_2(t) = \mathbf{h}_2(z^{-1})u(t) = \sum_{k=0}^{L} h_2(k)u(t-k), \tag{2}$$

where $\mathbf{h}_1(z^{-1})$, $\mathbf{h}_2(z^{-1})$ are polynomials of degree L in the unitary delay operator z^{-1}:

$$\mathbf{h}_i(z^{-1}) = h_i(0) + h_i(1)z^{-1} + \cdots + h_i(L)z^{-L}, \quad i = 1, 2. \tag{3}$$

A model of this kind can be used for describing the case of a single unknown source in the presence of either spatially or temporally distributed sensors.

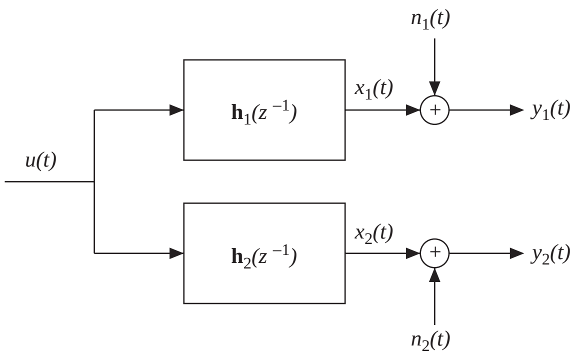

Fig. 1. Block structure of the considered two-channel FIR system.