SET-MEMBERSHIP ESTIMATION THEORY FOR COUPLED MIMO WIENER-LIKE MODELS

M.P. ALVAREZ†, L.R. CASTRO‡, J.L. FIGUEROA§ and O.E. AGAMENONNI *

†*Dto. de Matemática, Univ. Nac. del Sur, 8000 B. Blanca, Argentina. palvarez@criba.edu.ar*
‡*Dto. de Matemática and IIIE (UNS-CONICET), Univ. Nac. del Sur, 8000 B. Blanca, Argentina. lcastro@uns.edu.ar*
§ *Dto. de Ing. Eléc. y de Comp., IIIE (UNS-CONICET), UNS, 8000 B. Blanca, Argentina*
Dto. de Ing. Mecánica, Univ. Nac. del Litoral, 7500 Santa Fe, Argentina. jfigueroa@uns.edu.ar
∗ *Dto. de Ing. Eléc. y de Comp., CIC and IIIE (UNS-CONICET), UNS, 8000 B. Blanca, Argentina. oagamen@uns.edu.ar*

Abstract— **In this paper, an approach for identifying coupled multiple-input, multiple-output (MIMO) Wiener-like models is presented. Each multiple-input, single-output (MISO) model structure contained in the MIMO model is parameterized using finite sets of discrete Laguerre transfer functions followed by High Level Canonical Piecewise Linear (HLCPWL) that represents the static memoryless nonlinear block. For each MISO model, the parameters of the HLCPWL functions are found via Set-membership (SM) estimation theory, under mild error constraints. In this way, each MISO Wiener-like model is described as a set of parameters for the nonlinear static subsystem, whose values are obtained by solving a linear programming problem. The MIMO Wiener-like model structure is then represented as a set of coupled input-output MISO models, converting the identification of a coupled MIMO system into the identification of MISO systems. In order to validate the proposed identification algorithm, an illustrative example is provided.**

Keywords— **Wiener like-models, nonlinear systems identification, HLCPWL functions, set-membership estimation theory, UBB error.**

I. INTRODUCTION

Controller design, fault detection, optimization, prediction and simulation are based on models that describe the dynamic behavior of a real system, making the identification of nonlinear dynamical systems from multiple-input, multiple-output data a very important subject.

Block-oriented models have proved useful as simple nonlinear models that describe the behavior of a great number of nonlinear dynamical systems over a large operating range. They consist of the interconnection of a linear, time-invariant dynamical block ($\mathcal{L}$) and a static memoryless nonlinear block ($\mathcal{N}$). One advantage of these models is that they combine a simple parametrization as well as good approximation properties. Furthermore, they require low computational effort and are suitable for controller design, making them attractive as models for control. For a complete state of the art and recent advances in this area, the reader is referred to Giri and Bai (2010).

In this work we assume that a parametric coupled MIMO system is identified using a Wiener-like structure for each MISO nominal model contained in the MIMO model. The linear dynamic part of each MISO model is represented by a finite number of Laguerre filters (Álvarez *et al.*, 2011), while the static nonlinearity is represented by HLCPWL functions (Lin *et al.*, 1994; Julián *et al.*, 1999).

This model has the advantage of reducing the identification of each MISO nonlinear dynamical system to two simpler steps: the identification of a linear dynamic system and the approximation of a nonlinear static function using some adequate structure.

In the literature, several approaches can be found to perform the nominal identification of block-oriented nonlinear models. Within this class, two of the most widely used model structures are the Wiener model, where $\mathcal{L}$ precedes $\mathcal{N}$ (Wigren, 1993), and the Hammerstein model, where $\mathcal{N}$ is followed by $\mathcal{L}$ (Haber and Unbehauen, 1990). These structures are present in a wide variety of fields with applications in the area of communications (Hadjiloucas *et al.*, 2004), medicine (Celka and Colditz, 2002), biology (Hunter and Korenberg, 1986) and chemical engineering (Zhu, 1999) ; Visala *et al.*, 1999). A detailed review of applications can be found in Janczak (2005).

Results for the Wiener models identification using different linear dynamic representation, as well as different nonlinear approximation approaches, have been presented (Billings, 1980; Castro *et al.*, 2003; Agamenonni, 2004). The main difficulty in the identification of nonlinear block-oriented systems is that the internal signal is not available for measurement. Most of the contributions assume invertibility of the nonlinearity (Gomez and Baeyens, 2004). Identification of SISO Wiener models with non-invertible nonlinearity, when