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A NEW APPROACH TO WIENER-LIKE MODELING

L. R. Castro†, O. E. Agamennoni‡, and C. E. D'Attellis§

†*Dto. de Matemática, Univ. Nac. del Sur, 8000 Bahía Blanca, Argentina*
lcastro@ criba.edu.ar
‡*Dto. de Ing. Eléctrica y de Comp. - C.I.C., Univ. Nac. del Sur, 8000 - Bahía Blanca, Argentina*
ieagamen@ criba.edu.ar
§*Dto. de Matemática, Fac. de Ingeniería, Univ. de Buenos Aires, C1063ACV - Buenos Aires, Argentina*
ceda@ favaloro.edu.ar

Abstract— **In this paper we propose a Wiener-like approximation scheme that uses Rational Wavelets for the linear dynamical structure and Orthonormal High Level Canonical Piecewise Linear functions for approximating the nonlinear static part. This structure allows to approximate any nonlinear, time-invariant, causal dynamic systems with fading memory and has the following advantages: capability of time-frequency location, design of the linear dynamic part taking into account the *a priori* knowledge of the system, and minimum number of parameters of Orthonormal High Level Canonical Piecewise Linear functions determined straightforwardly.**

Keywords: Nonlinear identification, Wiener modeling, wavelets, ONPWL Functions.

I. INTRODUCTION

Wiener structure consists of two different blocks in cascade: a linear single-input multiple-output dynamic system and a multiple-input single-output memoryless nonlinear mapping. In its original work, Wiener (1956) used Laguerre filters and Hermite polynomials for the linear and nonlinear part, respectively. But its numerical complexity (see Billings (1980)) has restricted the use of discrete versions of Wiener series to few applications, as shown in Korenberg (1982). In order to improve the original Wiener's structure, different schemes have been proposed (Söderstrom and Stoika (1989), Korenberg and Paarmann (1991), de Figueiredo and Chen (1993), Sentoni *et al.* (1996) and Castro *et al.* (1999, 2002)).

In this article we propose to use rational wavelet system transfer functions (as defined in Pati, (1992)) for approximating the linear dynamic part. The selection of the linear filters is based on results developed in the theory of wavelets in signal processing and allows to build up a constructive modeling strategy. This procedure also leads to a tailored identification structure of the linear part that has two important features: the capability of time-frequency location and the design of the linear dynamic part taking into account the *a priori* knowledge of the system.

For modeling the static nonlinearity we have chosen Orthonormal High Level Canonical Piecewise Linear (ONPWL from now on) functions (see Lin *et al.* (1994), Kang and Chua (1978), Julián *et al.* (1999, 2000)) similarly as in Castro *et al.* (1999). In particular, the class of all continuous PWL functions defined over a compact domain in $\mathbf{R}^m$, partitioned with a *simplicial boundary configuration* (see Chien and Kuh (1977)), is considered. This choice has been motivated by several facts: this class of functions uniformly approximate any continuous nonlinear function defined over a compact domain in $\mathbf{R}^n$ (see Chien and Kuh (1977), Julián *et al.* (1999, 2000)) and the canonical expression introduced in Julián *et al.* (1999) uses the *minimum and exact* number of parameters. As a consequence of this, an efficient characterization is obtained from the viewpoint of memory storage and numerical evaluation. Another relevant aspect is that the parameters of the ONPWL functions associated to the approximation of the nonlinear function can be obtained efficiently *via* the resolution of a linear system characterized by a lower triangular full rank matrix (Julián *et al.* (1999, 2000)).

With the proposed structure it is possible to obtain a compact approximation of nonlinear discrete, time-invariant, causal systems with fading memory using a finite number of rational wavelet system transfer functions and an ONPWL function with a certain number of parameters which can be determined straightforwardly.

The paper is organized as follows. In Section II we present some definitions and well known results that will be used throughout the article. We also define the rational wavelet system function and describe its localization properties and give a brief description of the ONPWL functions as well. In Section III we present the approximation structure proposed and state the approximation theorem. In Section IV we give a constructive example and in Section V conclusions are drawn.