Lecture Notes in Control and Information Sciences

Edited by M. Thoma

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Nonlinear Prediction Ladder-Filters for Higher-Order Stochastic Sequences

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Springer-Verlag
Berlin Heidelberg New York Tokyo

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ISBN 3-540-15635-6 Springer-Verlag Berlin Heidelberg New York Tokyo
ISBN 0-387-15635-6 Springer-Verlag New York Heidelberg Berlin Tokyo

Library of Congress Cataloging in Publication Data

Zarzycki, J. (Jan)
Nonlinear prediction ladder-filters for higher-order stochastic sequences.
(Lecture notes in control and information sciences; 73)
Bibliography: p.
1. Stochastic sequences. 2. Prediction theory.
3. Filters (Mathematics) I. Title. II. Series.
QA274.225.Z37 1985 519.2 85-12668

Offsetprinting: Mercedes-Druck, Berlin
Binding: Lüderitz und Bauer, Berlin
2161/3020-543210

PREFACE

In this work we shall be concerned with the problem of nonlinear least-squares prediction of higher-order stochastic sequences using nonlinear orthogonal digital filters. The nonlinear problem will be considered as a generalization of the linear least-squares prediction problem.

The linear least-squares estimation theory is associated with second-order stochastic sequences, for which the orthogonal prediction or innovations linear filters (producing white noise when driven by the given sequence) as well as modeling or shaping filters (whose output is statistically equivalent to the given sequence, when driven by white noise) can be established.

In practice, the linear orthogonal filters can be computed via recursive procedures, in which one will not have to recompute the whole filter each time the permitted complexity is increased. Hence, the same idea underlies both the ladder-structures implemented in modern digital filters theory, and the theory of orthogonal (Fourier) expansions in Hilbert spaces. One of the most important property of the orthogonal digital filter is preservation of 'energy' which assures inherent numerical stability of the filter. A remarkable result of this theory is that any transfer function can be realized by means of an orthogonal filter whose modular structure can be implemented using sophisticated 'building-blocks' with VLSI integrated circuits (namely CORDICS processors).

The linear theory results in the optimum (least-squares) stochastic approximation of second-order sequences. Therefore, the linear estimation

filter becomes the best possible filter for a Gaussian sequence (whose properties are completely characterized by the second-order statistics). If the underlying sequence is non-Gaussian, the linear estimation accuracy may be not satisfactory. In that case, a nonlinear approach to the problem should be introduced in order to improve the accuracy.

In this work we wish to present efficient algorithms of nonlinear least-squares prediction filters for higher-order stochastic sequences, resulting in the optimum approximate nonlinear digital filters of the Volterra-Wiener class. These nonlinear ladder-filters will generalize the linear filters, preserving most of their properties (orthogonality and modular realizations, among others), and yielding better estimation accuracy for higher-order (and non-Gaussian) stochastic sequences.

We will mention here only those papers which are closely connected to the subject of this work, reffering for more complete bibliography to the papers citied (and the references therein).

ACKNOWLEDGMENTS

I am particularly indebted to Professor Patrick Dewilde of the Delft University of Technology for his helpful suggestions and hints introduced in many stimulating and fruitful discussions, especially during my one-year stay in Delft, which has undoubtedly inspired this work.

I am also grateful to Professor Marian S. Piekarski of the Technical University of Wroclaw for his valuable comments and discussions concerning this work.

I wish to thank Mrs. Zdzisława Żabska for her careful typing of this manuscript.

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