Preface

This book deals with the construction and use of rational orthogonal basis functions in modelling and identification of linear dynamical systems. It gathers results of the research efforts of nine specialists in the field, who have been very much intrigued by this subject over the past 10 to 15 years.
Since the early 1990s, the theory and application of non-conventional basis functions have attracted more and more attention in the fields of systems and control theory and signal processing. This research extends the systems theory of Laguerre functions and Kautz functions, which were introduced several decades ago. However, the important contributions to efficiently solving problems of system identification and approximation using these functions were only clarified about a decade ago. Since then, generalizations of the classic basis functions have been worked out, which incorporate a huge amount of freedom for design and adaptation.

Decomposing dynamical systems in terms of orthogonal expansions enables the modelling/approximation of the system with a finite length expansion. By flexibly tuning the basis functions to the underlying system characteristics, the rate of convergence of these expansions can be drastically increased. This leads to highly accurate models (small bias) being represented by few parameters (small variance). Additionally, algorithmic and numerical aspects are more favorable. The basis functions are applied in problems of identification, approximation, identification for control (uncertainty modelling), and adaptive filtering. Besides powerful algorithms, they also provide useful analysis tools for understanding the underlying identification/approximation algorithms.

Independent seeds for this work were planted around 1990 starting with the Ph.D. thesis of Peter Heuberger in Delft, under supervision and with impetus of Professor Okko Bosgra, on the use of basis function models in identification and transformation. Around the same time, Bo Wahlberg, in Sweden, published his work on the identification of Laguerre models. His objective was to generalize the theory of Lennart Ljung on identification of high-order

finite impulse response models. This work started in a discussion with Graham Goodwin (when Bo Wahlberg was a post-doc in Newcastle, Australia) who pointed to the work by Guy Dumont on control using Laguerre models. A few years later, in 1993, Brett Ninness completed his Ph.D. thesis in Newcastle, Australia, on deterministic and stochastic modelling. Since then, developments within the field, as well as international cooperation, have grown steadily. Sabbatical visits of Bo Wahlberg and József Bokor to Delft, of Paul Van den Hof and Håkan Hjalmarsson to Newcastle, Australia, and of Tomás Oliveira e Silva and Brett Ninness to Stockholm were all very fruitful and generated, besides new research results, also an increasingly growing enthusiasm for this problem field, of which the interesting and relevant fields of applications were growing steadily. New Ph.D. students entered the area, among them Zoltan Szabó in Budapest and Thomas de Hoog in Delft, who both finished their theses in this area and became contributors to this book. Besides this group of people, many more colleague researchers and students were involved in developing the insights and results that are reported here. This is witnessed in the extensive bibliography that is added.

Discussion on publishing a book on orthogonal basis functions dates back to 1995, when the three editors met for a 2-day session in the Netherlands and produced a first table of contents. Later, the project was extended, the scope widened, and international collaboration became more pronounced. The first joint result of this collaboration was the organization of a pre-conference tutorial workshop at the 1997 IEEE Conference on Decision and Control, in San Diego, CA, which was followed by a similar workshop at the 1999 IFAC World Congress in Beijing, P.R. China, and the organization of a tutorial session at the 12th IFAC Symposium on System Identification, 2000, in Santa Barbara, CA. The written material that was produced for these events served as a starting point for the book that is now completed.

Nine international authors have contributed to this project, which culminated in a carefully edited and coordinated volume of 13 distinctive chapters, authored by different groups of authors. The various chapters can be read independently, but the material has been carefully selected and structured to make up a comprehensive text with a logical line of reasoning:

- Construction and analysis of generalized orthogonal basis function (GOBF) model structures (Chapters 1–3)
- System identification in a time domain setting, and related issues of variance, numerics, and uncertainty bounding (Chapters 4–7)
- System identification in the frequency domain (Chapters 8–9)
- Design issues and optimal basis selection (Chapters 10–11)
- Transformation and realization theory (Chapters 12–13)

The book is written as a research monograph with a survey focus. It is meant to be interesting for a broad audience, including researchers and graduate

students in systems and control, as well as in signal processing. It also offers comprehensive material for specialized graduate courses in these areas. Control engineers may appreciate the abundance of technical problems that can be solved efficiently by the tools developed here.

We enjoyed working on this book. We hope that you as a reader enjoy reading it, and we welcome any feedback that you might have.

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