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Fuzzy Model Identification for Control

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Preface

Overview

Since the early 1990s, fuzzy modeling and identification from process data have been and continue to be an evolving subject of interest. Although the application of fuzzy models proved to be effective for the approximation of uncertain nonlinear processes, the data-driven identification of fuzzy models alone sometimes yields complex and unrealistic models. Typically, this is due to the over-parameterization of the model and insufficient information content of the identification data set. These difficulties stem from a lack of initial a priori knowledge or information about the system to be modeled. To solve the problem of limited knowledge, in the area of modeling and identification, there is a tendency to blend information of different natures to employ as much knowledge for model building as possible. Hence, the incorporation of different types of a priori knowledge into the data-driven fuzzy model generation is a challenging and important task.

Motivated by our research into this topic, our book presents new approaches to the construction of fuzzy models for model-based control. New model structures and identification algorithms are described for the effective use of heterogenous information in the form of numerical data, qualitative knowledge and first-principle models. By exploiting the mathematical properties of the proposed model structures, such as invertibility and local linearity, new control algorithms will be presented.

Since the monograph presents recent results of fuzzy model identification and model predictive control, it is primarily aimed at researchers and graduate students of process control and identification. A great deal of exposition is given in the beginning of every chapter to give the reader a firm understanding of the basics of fuzzy modeling, modeling of dynamical systems, system identification, and model-based control. Hence, these parts of the book can be used as a textbook for courses about intelligent control.

As most of the illustrative applications are taken from real-world processes and from process engineering practice, the book will be useful for electrical, process and chemical engineers interested in process identification, nonlinear and intelligent-control techniques.

In addition to the text, there are supporting MATLAB files which provide a computational platform for exploration and illustration of many of the ideas and algorithms presented in the book.

Organization and Features

Although the book has been written for professionals and practitioners in process control, it is also accessible to graduate students in electrical, chemical and process engineering. Technical prerequisites include an undergraduate level knowledge of control theory and linear algebra. Additional familiarity with fuzzy systems is helpful but not required.

The book is divided into five chapters. Chapter 1 presents the concept of the framework proposed in this book to incorporate different types of information into the identification of fuzzy models. Chapter 2 gives an introduction to fuzzy modeling and presents the structure of the fuzzy models we will use. Beside the analysis of the properties of Takagi–Sugeno fuzzy models, a new fuzzy model based on *multivariate membership functions* (FMM) will be presented. After an introduction to input-output models of dynamical systems, Chapter 3 describes the structures of fuzzy models proposed to effectively represent dynamical systems. Based on the concept of block-oriented modeling, the *Hybrid Fuzzy Convolutional Model* and the *Fuzzy Hammerstein Model* will be introduced in this section. Chapter 4 is intended to propose several identification algorithms that can be used for the identification of the parameters of the previously presented fuzzy models. This chapter presents a grey-box approach for incorporating prior knowledge into the data-driven identification of dynamic fuzzy models of the Takagi–Sugeno and FMM type, where knowledge about the modeled process is translated into inequality constraints on the parameters. The presented fuzzy models can be effectively utilized in inverse model-based and model predictive control algorithms. The description of these controllers and the illustrative simulated and real-time applications will be presented in Chapter 5. Real-time control results and the analysis of dynamic properties of the models show that when the modeling framework proposed in this book is applied, not only physically justified models are obtained, but also the performance of the model-based controller improves with regard to the case where no prior knowledge is involved.

The book is abundantly illustrated by

- Figures (over 130);
- References (280) which give a good overview of the current state of identification and control of dynamic systems and fuzzy modeling, and suggest further reading material for students and researchers interested in the details of the discussed algorithms;
- Examples (over 20) which contain simulated or real-life identification and control problems;

To provide additional information, the book has a Web site which contains information resources (links, on-line papers and transparencies) for researchers interested in fuzzy and model-based control. Furthermore, the simulation examples by means of `MATLAB/SIMULINK` program files are available at the Web site: `www.fmt.vein.hu/softcomp`.

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