Preface

The research book includes some of the most recent research in the theoretical foundation and practical applications of control systems engineering. The chapters in this book present an overview of various applications for developing advanced computational intelligent methods in control systems in different areas. Due to the variety and complexity of the systems which involve vagueness, imprecision, and uncertainty, neural and fuzzy systems represent suitable approaches for control systems. They offer many advantages over conventional control methods.

The book includes eight chapters and presents various computational paradigms in control systems engineering. A number of applications and case study are also introduced.

Chapter 1 by Ieroham Baruch and Eloy Echeverria Saldierna present the use of a Recurrent Neural Network Model (RNNM) incorporated in a fuzzy-neural multimodel for decentralized identification of an aerobic digestion process. The analytical model of the digestion bioprocess represented a distributed parameter system, which is reduced to a lumped system using the orthogonal collocation method, applied in four collocation points. The proposed decentralized RNNM consists of five independently working Recurrent Neural Networks (RNN), so to approximate the process dynamics in four different measurement points plus the recirculation tank.

Chapter 2 by Petia Georgieva and Sebastião Feyo de Azevedo is focused on developing of a feasible model predictive control (MPC) based on time-dependent recurrent neural network (NN) models. A modification of the classical regression neural models is proposed suitable for prediction purposes. In order to reduce the computational complexity and to improve the prediction ability of the neural model, optimization of the NN structure (lag space selection, number of hidden nodes), pruning techniques, and identification strategies are discussed. Furthermore, a computationally efficient modification of the general nonlinear MPC is proposed termed Error Tolerant MPC (ETMPC). The NN model is imbedded into the structure of the ETMPC and extensively tested on a dynamic simulator of an industrial crystallizer.

In Chap. 3 by Nikolaos A. Sofianos and Yiannis S. Boutalis, the recent developments in the field of Intelligent Multiple Models-based Adaptive Switching Control (IMMASC) are discussed. It provides at the same time all the essential information about the conventional single model and multiple models adaptive control, which constitute the base for the development of the new intelligent methods. The work emphasizes on the importance and the advantages of IMMASC in the field of control systems technology presenting control structures that contain linear robust models, neural models, and T-S fuzzy models. One of the main advantages of switching control systems against the single model control architectures is that they are able to provide stability and improved performance in multiple environments when the systems to be controlled have unknown parameters or highly uncertain parameters. Some hybrid multiple models control architectures are presented, and a numerical example is given in order to illustrate the efficiency of the intelligent methods.

Chapter 4 by D. Vijay Rao and V. V. S. Sharma presents the integration of case-based reasoning and decision theory based on Computational Intelligence techniques and its usefulness in the retrieval and selection of reusable software components from a software components repository. Software components are denoted by cases with a set of features, attributes, and relations of a given situation and its associated outcomes. These are taken as inputs to a Decision Support tool that classifies the components as adaptable to the given situation with membership values for the decisions. This classification is based on Rough-Fuzzy set theory and the methodology is explained with illustrations. In this novel approach, CBR and DSS (based on Rough-Fuzzy sets) have been applied successfully to the software engineering domain to address the problem of retrieving suitable components for reuse from the case data repository. A software tool called RuFTool is developed as a decision support tool for component retrieval for reuse on Windows platform with MS-ACCESS as the back-end and Visual BASIC as the front-end to this purpose. The use of rough-fuzzy sets increases the likelihood of finding the suitable components for reuse when exact matches are not available or are very few in number.

Chapter 5 by D. Vijay Rao and Dana Balas-Timar is stressing on considerable efforts on designing military training simulators using modeling, simulation, and analysis for operational analyses and training. Air Warfare Simulation System is an agent-oriented virtual warfare simulator that is designed using these concepts for operational analysis and course of action analysis for training. A critical factor that decides the next course of action and hence the results of the simulation is the skill, experience, situation awareness of the pilot in the aircraft cockpit and the pilots' decision-making ability in the cockpit. Advances in combat aircraft avionics and on-board automation, information from on-board and ground sensors, and satellites poses a threat in terms of information and cognitive overload to the pilot, and triggering conditions that makes decision making a difficult task. The authors describe a novel approach based on soft computing and computational intelligence paradigms called ANFIS, a neuro-fuzzy hybridization technique, to model the pilot agent and its behavior characteristics in the warfare simulator. This emerges as an interesting problem as the decisions made are dynamic and depend upon the actions taken by enemy. It is also build a pilots' database that represents the specific cognitive characteristics, skills, training experience. Authors illustrate the methodology with suitable examples and lessons drawn from the virtual air warfare simulator.

Chapter 6 by Juš Kocijan and Alexandra Grancharova explain that systems can be characterized as complex since they have a nonlinear behavior incorporating a stochastic uncertainty. They show that one of the most appropriate methods for modeling of such systems is based on the application of Gaussian processes (GPs). The GP models provide a probabilistic nonparametric modeling approach for black-box identification of nonlinear stochastic systems. This chapter reviews the methods for modeling and control of complex stochastic systems based on GP models. The GP-based modeling method is applied in a process engineering case study, which represents the dynamic modeling and control of a laboratory gas–liquid separator. The variables to be controlled are the pressure and the liquid level in the separator and the manipulated variables are the apertures of the valves for the gas flow and the liquid flow. GP models with different regressors and different covariance functions are obtained and evaluated. A selected GP model of the gas–liquid separator is further used to design an explicit stochastic model predictive controller to ensure the optimal control of the separator.

In Chap. 7 by N. Paraschiv, M. Oprea, M. Cărbureanu, and M. Olteanu are introduced two computational intelligence techniques, genetic algorithms and neuro-fuzzy systems, for chemical process control. The authors present the objectives and conventional automatic control of chemical processes and the computational intelligence techniques for process control. A case study that describes a neuro-fuzzy control system for a wastewater pH neutralization process is presented in detail.

Chapter 8 by R. Krishna Priya, C. Thangaraj, C. Kesavadas, and S. Kannan is focused on image segmentation technique based on Modified Particle Swarm optimized—fuzzy entropy applied for Infra Red (IR) images to detect the object of interest and Magnetic Resonance (MR) brain images to detect a brain tumor. Adaptive thresholding of input IR images and MR images are performed based on the proposed method. The input image is classified into dark and bright parts with Membership Functions (MF), whose member functions of the fuzzy region are Z-function and S-function. The optimal combination of parameters of these fuzzy MFs are obtained using Modified Particle Swarm Optimization (MPSO) algorithm. The objective function for obtaining the optimal fuzzy MF parameters is considered to be the maximum the fuzzy entropy. Through numerous examples, the performance of the proposed method is compared with those using existing entropy-based object segmentation approaches and the superiority of the proposed method is demonstrated. The experimental results obtained are compared with the enumerative search method and Otsu segmentation technique.

We believe that scientists, engineers, professors, students, and all interested in this subject will find the book useful and interesting.

The book is due to the excellent contribution by the authors. We are grateful to reviewers for their constructive and enlightening comments. The excellent editorial assistance by the Springer is acknowledged for the excellent collaboration and patience during the evolvement of this volume.

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