

Oscar Castillo, Patricia Melin, Janusz Kacprzyk, Witold Pedrycz (Eds.)

Hybrid Intelligent Systems

Studies in Fuzziness and Soft Computing, Volume 208

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Hybrid Intelligent Systems

Analysis and Design

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Preface

We describe in this book, new methods for analysis and design of hybrid intelligent systems using soft computing techniques. Soft Computing (SC) consists of several computing paradigms, including fuzzy logic, neural networks, and genetic algorithms, which can be used to produce powerful hybrid intelligent systems for solving problems in pattern recognition, time series prediction, intelligent control, robotics and automation. Hybrid intelligent systems that combine several SC techniques are needed due to the complexity and high dimensionality of real-world problems. Hybrid intelligent systems can have different architectures, which have an impact on the efficiency and accuracy of these systems, for this reason it is very important to optimize architecture design. The architectures can combine, in different ways, neural networks, fuzzy logic and genetic algorithms, to achieve the ultimate goal of pattern recognition, time series prediction, intelligent control, or other application areas.

This book is intended to be a major reference for scientists and engineers interested in applying new computational and mathematical tools to design hybrid intelligent systems. This book can also be used as a textbook or major reference for graduate courses like the following: soft computing, intelligent pattern recognition, computer vision, applied artificial intelligence, and similar ones. We consider that this book can also be used to get novel ideas for new lines of research, or to continue the lines of research proposed by the authors of the book.

The first contribution by Witold Pedrycz deals with hybridization schemes in architectures of Computational Intelligence. The description of the hybridization schemes is described. While the essence of Computational Intelligence hinges profoundly on the symbiotic use of their underlying technologies (viz. Neuro-computing, granular computing, and predominantly fuzzy sets, and evolutionary optimization), there are several other equally promising development avenues where a hybrid usage of the underlying technologies is worth pursuing. In this study, the author concentrates on the hybrid concepts and constructs available within the realm of Granular Computing (GC). Given the highly diversified landscape of

GC, the author discusses main directions of forming hybrid structures involving individual technologies of information granulation, elaborate on the fundamental communication, interoperability, and orthogonality issues and propose some general ways of building hybrid constructs of GC, which are of immediate interest to system modeling realized in the realm of Computational Intelligence. The author also sheds light on the central role of the concepts of information granularity, information granules and ensuing hybrid constructs. Furthermore the author emphasizes a role of hierarchical modeling that is directly supported by stratified aspect of information granules formed at nested levels of specificity. The central issue of human-centricity of such models is also highlighted.

The contribution by Oscar Montiel et al. deals with an evolutionary optimization of a Wiener model. There exists no standard method for obtaining a nonlinear input-output model using external dynamic approach. In this work, the authors are using an evolutionary optimization method for estimating the parameters of an NFIR model using the Wiener model structure. Specifically, the authors are using a Breeder Genetic Algorithm (BGA) with fuzzy recombination for performing the optimization work. The BGA was selected because it uses real parameters (it does not require any string coding), which can be manipulated directly by the recombination and mutation operators. For training the system, amplitude modulated pseudo random binary signal (APRBS) were used. The adaptive system was tested using sinusoidal signals.

The contribution by Cornelio Posadas-Castillo et al. deals with the synchronization of chaotic neural networks with a generalized Hamiltonian systems approach. In this paper, the authors describe a Generalized Hamiltonian forms approach to synchronize chaotic neural networks unidirectionally coupled. Synchronization is thus between the master and the slave networks with the slave network being given by an observer. In particular, we present two cases of study: the first is a second-order 3×4 CNN array, and the second is a CNN with delay. The chaotic CNNs are used as transmitter and receiver in encrypted information transmission.

The contribution by Oscar Montiel and Oscar Castillo deals with Mediative Fuzzy Logic, which is a novel approach for handling contradictory knowledge. In this paper, the authors propose a novel fuzzy method that can handle imperfect knowledge in a broader way than Intuitionistic Fuzzy Logic does (IFL). This fuzzy method can manage non-contradictory, doubtful, and contradictory information provided by experts, providing a mediated solution, that is why it is called Mediative Fuzzy Logic (MFL). A comparative study of the results given by MFL, IFL and traditional Fuzzy logic (FL) was performed.

The contribution by Ieroham Baruch deals with direct and indirect adaptive neural control of nonlinear systems. A comparative study of various control systems using neural networks was done. The paper proposes to use a Recurrent Trainable Neural Network (RTNN) identifier with back-propagation method of learning. Two methods of adaptive neural control with integral plus state action are applied – an indirect and a direct trajectory tracking control. The first one is the indirect Sliding Mode Control (SMC) with I-term where the SMC is resolved using states and parameters identified by RTNN. The second one is the direct adaptive control with I-term where the adaptive control is resolved by a RTNN controller. The good tracking abilities of both methods are confirmed by simulation results obtained using a MIMO mechanical plant and a 1-DOF mechanical system with friction plant model. The results show that both control schemes could compensate constant offsets and that - without I- term did not.

The contribution by Eduardo Gomez-Ramirez deals with a simple Tuning of fuzzy controllers. The number of applications in the industry using the PID controllers is bigger than fuzzy controllers. One reason is the problem of the tuning, because it implies the handling of a great quantity of variables like: the shape, number and ranges of the membership functions, the percentage of overlap among them and the design of the rule base. The problem is more complicated when it is necessary to control multivariable systems due that the number of parameters. The importance of the tuning problem implies to obtain fuzzy system that decrease the settling time of the processes in which it is applied, or in some cases, the settling time must be fixed to some specific value. In this work a very simple algorithm is presented for the tuning of a fuzzy controller using only one variable to adjust the performance of the system. The results are based on the relation that exists between the shape of the membership functions and the settling time. Some simulations are presented to exemplified the algorithm proposed.

The contribution by Nohe Cazarez et al. deals with a stability and robustness Study from type-1 to type-2 fuzzy logic control. Stability is one of the more important aspects in the traditional knowledge of Automatic Control. Type-2 Fuzzy Logic is an emerging and promising area for achieving Intelligent Control (in this case, Fuzzy Control). In this work, the authors use the Fuzzy Lyapunov Synthesis, as proposed by Margaliot, to build a Lyapunov Stable Type-1 Fuzzy Logic Control System. Then an extension from a Type-1 to a Type-2 Fuzzy Logic Control System was done, ensuring the stability on the control system and proving the robustness of the corresponding fuzzy controller.

The contribution by Roberto Sepulveda and Patricia Melin deals with a comparative study of controllers using type-2 and type-1 fuzzy logic. Uncertainty is an inherent part in controllers used for real-world applications.

The use of new methods for handling incomplete information is of fundamental importance in engineering applications. This paper deals with the design of controllers using type-2 fuzzy logic for minimizing the effects of uncertainty produced by the instrumentation elements. Simulations of the type-1 and type-2 fuzzy logic controllers were done to perform a comparative analysis of the systems' response, in the presence of uncertainty.

The contribution by Oscar Castillo et al. deals with evolutionary computing for topology optimization of type-2 fuzzy controllers. In this paper, the authors describe the use of hierarchical genetic algorithms for fuzzy system optimization in intelligent control. In particular, the authors consider the problem of optimizing the number of rules and membership functions using an evolutionary approach. The hierarchical genetic algorithm enables optimization of the fuzzy system design for a particular application. The approach was illustrated with the case of intelligent control in a medical application. Simulation results for this application show that the optimal set of rules and membership functions for the fuzzy system was obtained.

The contribution by Giovanni Pazienza et al. deals with decision trees and CBR for the Navigation System of a CNN-based Autonomous Robot. In this paper, the authors present a navigation system based on decision trees and CBR (Case-Based reasoning) to guide an autonomous robot. The robot has only real-time visual feedback, and the image processing is performed by CNNs to take advantage of the parallel computation. The approach was validated by successfully testing the system on a SW simulator.

The contribution by Arnulfo Alanis et al. deals with intelligent agents in distributed fault tolerant systems. Intelligent Agents have originated a lot of discussion about what they are, and how they are different from general programs. The authors describe in this paper a new paradigm for intelligent agents. This paradigm helped us deal with failures in an independent and efficient way. The authors proposed three types of agents to treat the system in a hierarchic way. A new way to visualize fault tolerant systems (FTS) is proposed, in this paper with the incorporation of intelligent agents, which as they grow and specialized create the Multi-Agent System (MAS). The MAS contains a diversified range of agents, which depending on the perspective will be specialized or evolutionary (from our initially proposal) they will be specialized for the detection and possible solution of errors that appear in an FTS). The initial structure of the agent is proposed in [1] and it is called a reflected agent with an internal state and in the Method MeCSMA [2].

The contribution by Mahmoud Tarokh deals with an approach for genetic path planning with fuzzy logic adaptation for rovers traversing rough terrain. The paper develops a genetic algorithm approach to path planning for a mobile robot operating in rough environments. Path planning consists of a description of the environment using a fuzzy logic framework, and a two-stage planner. A global planner determines the path that optimizes a combination of terrain roughness and path curvature. A local planner uses sensory information, and in case of detection of previously unknown and unaccounted for obstacles, performs an on-line planning to get around the newly discovered obstacle. The adaptation of the genetic operators is achieved by adjusting the probabilities of the genetic operators based on a diversity measure of the population and traversability measure of the path. Path planning for an articulate rover in a rugged Mars terrain is presented to demonstrate the effectiveness of the proposed path planner.

The contribution by Ricardo Guerra et al. describes chattering attenuation using linear-in-the-parameter neural nets in variable structure control of robot manipulators with friction. Variable structure control is a recognized method to stabilize mechanical systems with friction. Friction produces non-linear phenomena, such as tracking errors, limit cycles, and undesired stick-slip motion, degrading the performance of the closed-loop system. The main drawback of variable structure control is the presence of chattering, which is not suitable in mechanical systems. In this paper, the authors design a variable structure controller complemented with Linear-in-the-Parameter neural nets to attenuate chattering. Experimental validation applied to a three degree of freedom robot mechanical manipulator is shown to support the results.

The contribution by Selene Cardenas et al. describes tracking control for a unicycle mobile robot using a fuzzy logic controller. The authors develop a tracking controller for the dynamic model of unicycle mobile robot by integrating a kinematic controller and a torque controller based on Fuzzy Logic Theory. Computer simulations are presented confirming the performance of the tracking controller and its application to different navigation problems.

The contribution by Julian Garibaldi et al. describes intelligent control and planning of autonomous mobile robots using fuzzy logic and genetic algorithms. This paper describes the use of a Genetic Algorithm (GA) for the problem of offline point-to-point autonomous mobile robot Path Planning. The problem consist of generating “valid” paths or trajectories, for an holonomic robot to use to move from a starting position to a destination across a flat map of a terrain, represented by a two dimensional grid, with obstacles and dangerous ground that the Robot must evade. This means that the GA optimizes possible paths based on two criteria: length and difficulty.

The contribution by Pilar Gomez-Gil describes the role of neural networks in the interpretation of antique handwritten documents. The need for accessing information through the web and other kind of distributed media makes it mandatory to convert almost every kind of document to a digital representation. However, there are many documents that were created long time ago and currently, in the best cases, only scanned images of them are available, when a digital transcription of their content is needed. For such reason, libraries across the world are looking for automatic OCR systems able to transcript that kind of documents. In this work the authors describe how Artificial Neural Networks can be useful in the design of an Optical Character Recognizer able to transcript handwritten and printed old documents. The properties of Neural Networks allow this OCR to have the ability to adapt to the styles of handwritten or antique fonts. Advances with two prototype parts of such OCR are presented.

The contribution by Thompson Sarkodie-Gyan describes object recognition using fuzzy inferential reasoning. This paper introduces a vision-based pattern recognition scheme for the identification of very high tolerances of manufactured industrial objects. An image-forming device is developed for the generation and the capture of images/silhouettes of the components. A simple but effective feature extraction algorithm is employed to produce distinguishable features of the components in question. Radial basis function (RBF) based membership functions are used as classifiers for the pattern classification. For the decision making process, a fuzzy logic based inferential reasoning algorithm is implemented for the approximate reasoning scheme.

The contribution by Olivia Mendoza and Patricia Melin describes the fuzzy Sugeno integral as a decision operator in the recognition of images with modular neural networks. The authors describe the implementation of the Fuzzy Sugeno Integral formulas for integration of responses in modular neural networks. In this work the authors illustrate their approach with modular neural networks for image recognition, using images divided in parts. The Fuzzy Sugeno Integral was used to make a final decision. Simulation results show that the approach has potential application.

The contribution by Patricia Melin et al. describes modular neural networks and fuzzy Sugeno integral for pattern recognition for the case of human face and fingerprint. The authors describe in this paper a new approach for pattern recognition using modular neural networks with a fuzzy logic method for response integration. A new architecture for modular neural networks for achieving pattern recognition in the particular case of human faces and fingerprints is proposed. Also, the method for achieving response integration is based on the fuzzy Sugeno integral with some modifications. Response integration is required to combine the outputs of

all the modules in the modular network. The authors applied the new approach for fingerprint and face recognition with a real database from students of our institution.

The contribution by J. A. Ruz-Hernandez et al. describes optimal training for associative memories with application to fault diagnosis in fossil electric power plants. In this contribution, the authors discuss a new synthesis approach to train associative memories, based on recurrent neural networks. They propose to update the weight vector as the optimal solution of a linear combination of support patterns. The proposed training algorithm maximizes the margin between the training patterns and the decision boundary. This algorithm is applied to the synthesis of an associative memory, for fault diagnosis in fossil electric power plants. The scheme is evaluated via a full scale simulator to diagnose the main faults occurred in this kind of power plants.

The contribution by F. Rivero-Angeles and Eduardo Gomez-Ramirez describes the acceleration output prediction of buildings using polynomial artificial neural networks. Severe earthquake motions could make civil structures to undergo hysteretic cycles and crack or yield their resistant elements. The present research proposes the use of a polynomial artificial neural network to identify and predict, on-line, the behavior of such non-linear systems. Predictions are carried out first on theoretical hysteretic models and later using two real seismic records acquired on a 24-story concrete building in Mexico City. Only two cycles of movement are needed for the identification process and the results show fair prediction of the acceleration output.

The contribution by Ileana Leal and Patricia Melin describes time series forecasting of tomato prices in Mexico using modular neural networks and Parallel Processing. In this paper, the authors give a brief explanation of the concepts of Time Series, the Neural Networks, the Modular Neural Networks, and Parallelism is given. Modular Neural Networks and Parallel Processing are used for Time Series Forecasting of the Tomato Price in Mexico. The modular neural network was implemented in a parallel architecture for improving the accuracy and efficiency of the obtained results.

The contribution by Patricia Melin et al. describes modular neural networks with fuzzy Sugeno integration applied to time series prediction. The authors describe in this paper the application of several neural network architectures to the problem of simulating and predicting the dynamic behavior of complex economic time series. The authors use several neural network models and training algorithms to compare the results and decide at the end, which one is best for this application. The authors also compare the simulation results with the traditional approach of using a statistical model. In this case, real time series of prices of consumer goods were used to test the models. Real prices of tomato and green onion in the U.S. show

complex fluctuations in time and are very complicated to predict with traditional statistical approaches.

The contribution of Kacprzyk, Zadrozny and Wilbik presents the use of the Sugeno integral as a means for a fuzzy linguistic quantifier based aggregation to the extraction of trends in time series data. The authors start with the use of the well-known Sklansky and Gonzalez algorithms to derive a piecewise linear approximation of time series data. Then, the concept of classic Yager's linguistic summary of a data(base) is employed to derive linguistic description of trends in time series data. Two basic types of linguistic descriptions (summaries) are proposed that refer to the frequency of occurrence and duration of trends. As opposed to the classic Zadeh's fuzzy logic based calculus of linguistically quantified propositions employed in Yager's approach, the authors propose here the use of the Sugeno integral which provides more intuitively appealing results.

We end this preface of the book by giving thanks to all the people who have help or encourage us during the making of this book. We would like to thank our colleagues working in Soft Computing, which are too many to mention each by their name. Of course, we need to thank our supporting agencies for their help during this project. We have to thank our institutions for always supporting our projects. Finally, we thank our families for their continuous support during the time that we spend in this project.

Tijuana, Mexico
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Calgary, Canada
July 2006

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