Preface

We describe in this book, new methods for building intelligent systems using type-2 fuzzy logic and soft computing techniques. In this book, we are extending the use of fuzzy logic to a higher order, which is called type-2 fuzzy logic. Combining type-2 fuzzy logic with traditional SC techniques, we can build powerful hybrid intelligent systems that can use the advantages that each technique offers. We consider in this book the use of type-2 fuzzy logic and traditional SC techniques to solve problems in real-world applications.

This book is intended to be a reference for scientists and engineers interested in applying type-2 fuzzy logic for solving problems in pattern recognition, intelligent control, intelligent manufacturing, robotics and automation. This book can also be used as a 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.

In Chap. 1, we begin by offering a brief introduction of the potential use of type-2 fuzzy logic in different real-world applications. We discuss the application of type-2 fuzzy logic in problems of pattern recognition. We also describe the use of type-2 fuzzy logic in problems of intelligent control of non-linear plants. We also outline the application of type-2 fuzzy logic in real-world applications of intelligent manufacturing, robotics and automation.

We describe in Chap. 2 the basic concepts, notation, and theory of type-2 fuzzy logic, which is a generalization of type-1 fuzzy logic. Type-2 fuzzy logic enables the management of uncertainty in a more complete way. This is due to the fact that in type-2 membership functions we also consider that there is uncertainty in the form of the functions, unlike type-1 membership functions in which the functions are considered to be fixed and not uncertain.

We describe in Chap. 3 a brief overview of the basic concepts from bio-inspired optimization methods needed for this work. In particular, the methods that are covered in this chapter are: particle swarm optimization, genetic algorithms and ant colony optimization.

We offer in Chap. 4 a representative review of the works using a bio-inspired optimization technique, like genetic algorithms (GAs), for automating the design process of type-2 fuzzy systems. This overview has the goal of providing the reader with an idea of the diversity of applications that have been achieved using genetic algorithms for type-2 fuzzy system optimization.

We describe in Chap. 5 a representative review of works on optimizing type-2 fuzzy systems using different kinds of particle swarm optimization (PSO) algorithms to illustrate the advantages of using this optimization technique for automating the design process of type-2 fuzzy systems.

We describe in Chap. 6 a representative and brief review of the works that have used ant colony optimization (ACO) to illustrate the advantages of using this optimization technique for automating the design process or parameters of type-2 fuzzy systems.

We describe in Chap. 7 some other works reported in the literature optimizing type-2 fuzzy systems using different kinds of optimization algorithms (other than GAs, PSO or ACO, which were covered in previous chapters). Most of these works have had relative success according to the different areas of application. In this chapter, we offer a representative and brief review of these types of works to illustrate the advantages of using the corresponding optimization techniques for automating the design process or parameters of type-2 fuzzy systems.

We describe in Chap. 8 as an illustration the optimization of the membership functions' parameters of an interval type-2 fuzzy logic controller in order to find the optimal intelligent controller for an autonomous wheeled mobile robot. The optimization method that was used is based on the chemical reaction paradigm. Simulation results with the chemical optimization paradigm are very good and are shown to outperform other optimization methods for the same control problem.

We describe in Chapter 9 a method for the design of a Type-2 Fuzzy Logic Controller (FLC-T2) and a Type-1 Fuzzy Logic Controller (FLC-T1) using Genetic Algorithms. The two controllers were tested with different levels of uncertainty to regulate speed in a direct current motor. The controllers were synthesized in Very High Description Language (VHDL) code for a Field Programmable Gate Array (FPGA), using the Xilinx System Generator of Xilinx ISE and Matlab-Simulink. Comparisons were made between the FLC-T1 versus FLC-T2 in VHDL code and also with a Proportional Integral Differential (PID) Controller. To evaluate the difference in performance of the three types of controllers, the t-student statistical test was used with the type-2 controller resulting to be the best one for this problem.

We describe in Chap. 10 a general overview of the area of type-2 fuzzy system optimization. Also, possible future trends that we can envision based on the review of this area are presented. It has been well-known for a long time, that designing fuzzy systems is a difficult task, and this is especially true in the case of type-2 fuzzy systems. The use of GAs, ACO and PSO in designing type-1 fuzzy systems has become a standard practice for automatically designing this sort of systems. This trend has also continued to the type-2 fuzzy systems area, which has been accounted for with the review of papers presented in the previous chapters. In this chapter a summary of the total number of papers published in the area of type-2 fuzzy system optimization is also presented, so that the increasing trend occurring in this area can be better appreciated.

We end this preface of the book by giving thanks to all the people who have help or encourage us during the writing of this book. First of all, we would like to thank our colleague and friend Prof. Janusz Kacprzyk for always supporting our work, and for motivating us to write our research work. We would also 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, CONACYT and DGEST, in our country for their help during this project. We have to thank our institution, Tijuana Institute of Technology, for always supporting our projects. Finally, we thank our families for their continuous support during the time that we spend in this project.

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Springer

http://www.springer.com/978-3-642-28955-2

Recent Advances in Interval Type-2 Fuzzy Systems
Castillo, O.; Melin, P.
2012, X, 90 p. 52 illus., 35 illus. in color., Softcover
ISBN: 978-3-642-28955-2