

Preface

Ambiguity is always present in any realistic process. Imprecisely defined classes play an important role in human thinking. The ambiguity may arise from the interpretation of the data inputs and/or in the rules used to describe the relationships between the informative attributes. Fuzzy set theory derives from the fact that most natural classes and concepts are fuzzy rather than crisp nature. On the other hand, people can approximate well enough to perform many desired tasks. The fact is that they summarize from massive information inputs and still function effectively. Fuzzy logic provides an inference structure that enables the human reasoning capabilities to be applied to artificial knowledge-based systems. It constructs a means for converting linguistic strategy into control actions and thus offers a high-level computation. For complex systems, fuzzy logic is quite suitable because of its tolerance to some imprecision.

From a system theoretic viewpoint, fuzzy logic establishes mathematical strength to the emulation of certain perceptual and linguistic attributes associated with human cognition, whereas the science of neural networks provides a new computing tool with learning and adaptation capabilities. The theory of fuzzy logic provides an inference mechanism under cognitive uncertainty, computational neural networks offer exciting advantages such as learning, adaptation, fault tolerance, parallelism, and generalization. Fuzzy logic technology is now being used in numerous consumer and electronic products and systems, even in the stock market and medical diagnostics. Fuzzy logic is at the forefront for global technological, economical, and manufacturing competitions. An equally important aspect of this new surge of interest in fuzzy logic is the educational aspect of fuzzy logic and fuzzy logic applications, including control systems. Fuzzy controllers are expert control systems that smoothly interpolate between hard-boundary crisp rules.

Fuzzy control methods and algorithms, including many specialized software and hardware available on the market today, may be classified as one type of intelligent control. This is because fuzzy systems modeling, analysis, and control incorporate a certain amount of human knowledge into its components (fuzzy sets, fuzzy logic, and fuzzy rule base). Using human expertise in system modeling and controller design is not only advantageous but often necessary. Compared with conventional

approaches, fuzzy control utilizes more information from domain experts and relies less on mathematical modeling about a physical system.

This book is an enlarged and enhanced version of the author's lecture notes in fuzzy sets, fuzzy logic, fuzzy systems, and fuzzy control theories. The book is intended for senior undergraduates and first-level graduate students in several engineering programs with control system orientation. It represents a continuing effort in the pursuit of analytic theory and rigorous design for fuzzy control systems.

In writing this volume, I took the approach of referring within the text to papers and/or books which I believe taught me some concepts, ideas, and methods. I further complemented this by adding some remarks, observations, and notes within and at the end of each chapter to shed some light on other related results. I apologize in advance in case I committed injustice and assure all of the colleagues that any mistake was definitely unintentional.

Throughout this book, the following terminologies, conventions, and notations have been adopted. All of them are quite standard in the scientific media and only vary in form or character. Matrices, if their dimensions are not explicitly stated, are assumed to be compatible with algebraic operations. In symmetric block matrices or complex matrix expressions, we use the symbol $\bullet$ to represent a term that is induced by symmetry.

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Single and Interconnected Systems

Mahmoud, M.S.

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