Fuzzy Neural Intelligent Systems
Mathematical Foundation and the Applications in Engineering
Preface

Fuzzy systems and neural networks have been regarded as the main branches of soft computing. Most research works have been focused on the development of theories and design of systems and algorithms for specific applications. These works have shown that neuro-fuzzy systems indeed demonstrate their exceptional intelligent capability for computing and learning. However, we may be aware that there is little theoretical support for existing neuro-fuzzy systems, especially their mathematical foundation. From the literature, a neuro-fuzzy system is defined as a combination of fuzzy systems and neural networks such that the parameters of fuzzy systems are determined by neural network learning algorithms. The intention is to take the advantage of neural network methods to improve or to create a fuzzy system. On the other hand, a fuzzy neural network is defined as the use of fuzzy methods to enhance or to improve the learning capabilities of a neural network. Unfortunately, little work has been done in the fuzzy neural network area. The main features of this book give a layout of mathematical foundation for fuzzy neural networks and a better way of combining neural networks with fuzzy logic systems.

This book was written to provide engineers, scientists, researchers, and students interested in fuzzy systems, neural networks, and fuzzy neural integrated systems a systematic and comprehensive structure of concepts and applications. The required mathematics for reading this book are not beyond linear algebra and engineering mathematics.

This book contains 19 chapters and consists of three major parts. Part I (Chapters 1-5, 10, 11) covers the fundamental concepts and theories for fuzzy systems and neural networks. Part II (Chapters 6-8, 12, 13) provides the foundation and important topics in fuzzy neural networks. Part III (Chapters 14-19) gives extensive case examples for neuro-fuzzy systems, fuzzy systems, neural network systems, and fuzzy neural systems. In short, Chapter 1 briefly introduces fundamental knowledge of fuzzy systems. These include fuzzy sets, fuzzy relations, resolution theorem, representation theorem, extension principle, fuzzy clustering, fuzzy logic, fuzzy inference, fuzzy logic systems, etc. Chapter 2 discusses determination of membership functions for a fuzzy logic system. Chapter 3 reveals mathematical essence and structures of neural networks. Chapter 4 studies structures of functional-link neural networks and fuzzy functional-link neural networks. Chapter 5 describes flat neural networks, computational algorithms, and their
applications. Chapter 6 describes the structure of fuzzy neural networks in detail, from the multifactorial functions point of view. Chapter 7 discloses mathematical essence and structures of feedback neural networks and fuzzy neural networks, where it is indicated that stable points of a feedback can be, in essence, regarded as fixed points of a function. Extending the idea from Chapters 6 and 7, Chapter 8 introduces generalized additive weighted multifactorial functions and the applications to fuzzy inference and neural networks. Chapter 9 discusses interpolation mechanisms of fuzzy control including some innovative methods and important results. Chapter 10 shows the relations between fuzzy logic controllers and PID controllers mathematically. Chapter 11 discusses adaptive fuzzy control by using variable universe. Chapters 12 and 13 introduce factor spaces theory and study of neuron models and neural networks formed by factor spaces. Chapter 14 gives the foundation of neuro-fuzzy systems. Chapter 15 explores the nature of data and discusses the importance of data preprocessing. Chapters 16 to 18 give engineering applications of both fuzzy neural and neuro-fuzzy systems. Chapter 18 shows the application of hybrid neural network and fuzzy systems. Chapter 19 gives the on-line learning and DSP implementation of fuzzy neural systems, followed by myoelectric applications.

The materials of this book can be used as different graduate courses (15-week semester courses):

- **Introduction to Fuzzy and Neural Systems**: Chapters 1-8, 12, 13.
- **Introduction to Intelligent Control**: Chapters 1-5 10,15.
- **Advanced Intelligent Control**: Chapters 9, 11, 14-19.

Of course, this book can also be used as a self-study textbook and reference book.
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