

FUZZY SYSTEMS THEORY and ITS APPLICATIONS

Edited By

Toshiro Terano

Faculty of Engineering
Hosei University

Kiyoji Asai

Faculty of Engineering
Osaka Institute of Technology

Michio Sugeno

The Graduate School of Nagatsuda
Tokyo Institute of Technology

Translated By

Charles G. Aschmann, III



ACADEMIC PRESS, INC.
Harcourt Brace & Company, Publishers

Boston San Diego New York
London Sydney Tokyo Toronto

CONTENTS

<i>Preface</i>	ix
Chapter 1 OUTLINE	1
1.1 The How, What, and Why of Conversion to Fuzzy Systems	1
1.2 The Concept of Fuzzy Theory	8
1.3 Applications Now and the Future Outlook	9
References	16
Chapter 2 THE BASICS OF FUZZY THEORY	19
2.1 Quantification of Ambiguity	19
2.2 Fuzzy Sets	21
2.3 Crisp Sets	23
2.4 Operations with Fuzzy Sets	26
2.5 α -Cuts and the Extension Principle	29
2.6 Operations with Fuzzy Numbers	34
2.7 Fuzzy Propositions	37
References	39
Chapter 3 FUZZY RELATIONS	41
3.1 Fuzzy Relations	41
3.2 Operations for Fuzzy Relations	44

3.3 Basic Properties of Fuzzy Relations	46
3.4 Fuzzy Relations and Fuzzy Reasoning	46
3.5 Fuzzy Relational Equations	54
3.6 Various Types of Fuzzy Relations	57
3.7 Similarity Relations and Fuzzy Order Relations	59
References	67
Chapter 4 FUZZY REGRESSION MODELS	69
4.1 Linear Possibility Systems	69
4.2 Linear Possibility Regression Model	72
4.3 Examples of Applications	77
4.4 Supplementary Note	83
References	83
Chapter 5 STATISTICAL DECISION MAKING	85
5.1 Fuzzy Probability and Fuzzy Entropy	85
5.2 Fuzzy-Bayes Decision Making	88
5.3 Fuzzy Discrimination Methods	95
References	99
Chapter 6 FUZZY QUANTIFICATION THEORY	101
6.1 Characteristics of Fuzzy Quantification Theory	102
6.2 Fuzzy Quantification Theory I	105
6.3 Fuzzy Quantification Theory II	109
6.4 Fuzzy Quantification Theory III	114
6.5 Fuzzy Quantification Theory IV	119
6.6 A Note on Applications	121
Notes	122
References	123
Chapter 7 FUZZY MATHEMATICAL PROGRAMMING	125
7.1 Basic Concept and General Formulation	125
7.2 Fuzzy Linear Programming	128
7.3 Supplementary Note	135
References	136
Chapter 8 EVALUATION	137
8.1 Fuzzy Measure	138
8.2 Fuzzy Integrals	140
References	145

Chapter 9	DIAGNOSIS	147
9.1	Ambiguity in Diagnosis	147
9.2	Diagnosis Using Fuzzy Relations	149
9.3	Diagnosis Using Symptom Patterns and Degrees of Conformity	152
9.4	Applications of Knowledge Engineering in Diagnosis	154
	References	156
Chapter 10	CONTROL	159
10.1	The Form of Fuzzy Control Rules and Inference Methods	159
10.2	Planning of Fuzzy Controllers	165
10.3	Features of Fuzzy Control	168
	References	168
Chapter 11	HUMAN ACTIVITIES	169
11.1	Human Reliability Models	170
11.2	Data Entry Systems	174
11.3	Multistage Decision Making Using Fuzzy Dynamic Programming	178
	References	185
Chapter 12	ROBOTS	187
12.1	Path-Judging Robot	187
12.2	Object-Grasping Robot	192
12.3	Placement Inference Robot	197
	References	202
Chapter 13	IMAGE RECOGNITION	203
13.1	Shape Recognition and Distance/Direction Information: Extraction Using a CCD Camera	203
13.2	Texture Analysis of Aerial Photographs	209
	References	215
Chapter 14	DATABASES	217
14.1	Standard Databases	217
14.2	Fuzzy Databases	219
	References	228
Chapter 15	INFORMATION RETRIEVAL	231
15.1	Information Retrieval and Modeling of Estimation Processes Using Fuzzification Functions	232

15.2	Prototype Document Retrieval System	239
15.3	Characteristics of Request Concepts and Recognition Efficiency	242
15.4	The Role of <i>A Priori</i> Knowledge and Intelligent Interfaces	245
	References	246
Chapter 16	EXPERT SYSTEM FOR DAMAGE ASSESSMENT	247
16.1	Expert Systems and Fuzzy Knowledge	247
16.2	Expression of Problems that Contain Uncertainty	251
16.3	Dempster–Shafer Theory and Its Extension to Fuzzy Sets	253
16.4	SPERIL System	258
	References	262
	<i>Index</i>	265