

Contents

Preface	ix
1 Classical Fuzzy Cluster Analysis	
1.1 Motivation	1
1.2 Types of Data	4
1.3 Similarity Measures	5
1.4 Clustering Techniques	8
1.4.1 Hierarchical Clustering Algorithms	9
1.4.2 Partitional Algorithms	10
1.5 Fuzzy Clustering	17
1.5.1 Fuzzy partition	17
1.5.2 The Fuzzy c -Means Functional	18
1.5.3 Ways for Realizing Fuzzy Clustering	18
1.5.4 The Fuzzy c -Means Algorithm	19
1.5.5 Inner-Product Norms	24
1.5.6 Gustafson–Kessel Algorithm	24
1.5.7 Gath–Geva Clustering Algorithm	28
1.6 Cluster Analysis of Correlated Data	32
1.7 Validity Measures	40
2 Visualization of the Clustering Results	
2.1 Introduction: Motivation and Methods	47
2.1.1 Principal Component Analysis	48
2.1.2 Sammon Mapping	52
2.1.3 Kohonen Self-Organizing Maps	54
2.2 Fuzzy Sammon Mapping	59
2.2.1 Modified Sammon Mapping	60
2.2.2 Application Examples	61
2.2.3 Conclusions	66
2.3 Fuzzy Self-Organizing Map	67
2.3.1 Regularized Fuzzy c -Means Clustering	68
2.3.2 Case Study	75
2.3.3 Conclusions	79

3	Clustering for Fuzzy Model Identification – Regression	
3.1	Introduction to Fuzzy Modelling	81
3.2	Takagi–Sugeno (TS) Fuzzy Models	86
3.2.1	Structure of Zero- and First-order TS Fuzzy Models	87
3.2.2	Related Modelling Paradigms	92
3.3	TS Fuzzy Models for Nonlinear Regression	96
3.3.1	Fuzzy Model Identification Based on Gath–Geva Clustering	98
3.3.2	Construction of Antecedent Membership Functions	100
3.3.3	Modified Gath–Geva Clustering	102
3.3.4	Selection of the Antecedent and Consequent Variables	111
3.3.5	Conclusions	115
3.4	Fuzzy Regression Tree	115
3.4.1	Preliminaries	120
3.4.2	Identification of Fuzzy Regression Trees based on Clustering Algorithm	122
3.4.3	Conclusions	133
3.5	Clustering for Structure Selection	133
3.5.1	Introduction	133
3.5.2	Input Selection for Discrete Data	134
3.5.3	Fuzzy Clustering Approach to Input Selection	136
3.5.4	Examples	137
3.5.5	Conclusions	139
4	Fuzzy Clustering for System Identification	
4.1	Data-Driven Modelling of Dynamical Systems	142
4.1.1	TS Fuzzy Models of SISO and MIMO Systems	148
4.1.2	Clustering for the Identification of MIMO Processes	153
4.1.3	Conclusions	161
4.2	Semi-Mechanistic Fuzzy Models	162
4.2.1	Introduction to Semi-Mechanistic Modelling	162
4.2.2	Structure of the Semi-Mechanistic Fuzzy Model	164
4.2.3	Clustering-based Identification of the Semi-Mechanistic Fuzzy Model	171
4.2.4	Conclusions	182
4.3	Model Order Selection	183
4.3.1	Introduction	183
4.3.2	FNN Algorithm	185
4.3.3	Fuzzy Clustering based FNN	187
4.3.4	Cluster Analysis based Direct Model Order Estimation	189
4.3.5	Application Examples	190
4.3.6	Conclusions	198
4.4	State-Space Reconstruction	198
4.4.1	Introduction	198

4.4.2	Clustering-based Approach to State-space Reconstruction	200
4.4.3	Application Examples and Discussion	208
4.4.4	Case Study	216
4.4.5	Conclusions	222
5	Fuzzy Model based Classifiers	
5.1	Fuzzy Model Structures for Classification	227
5.1.1	Classical Bayes Classifier	227
5.1.2	Classical Fuzzy Classifier	228
5.1.3	Bayes Classifier based on Mixture of Density Models	229
5.1.4	Extended Fuzzy Classifier	229
5.1.5	Fuzzy Decision Tree for Classification	230
5.2	Iterative Learning of Fuzzy Classifiers	232
5.2.1	Ensuring Transparency and Accuracy	233
5.2.2	Conclusions	237
5.3	Supervised Fuzzy Clustering	237
5.3.1	Supervised Fuzzy Clustering – the Algorithm	239
5.3.2	Performance Evaluation	240
5.3.3	Conclusions	244
5.4	Fuzzy Classification Tree	245
5.4.1	Fuzzy Decision Tree Induction	247
5.4.2	Transformation and Merging of the Membership Functions	248
5.4.3	Conclusions	252
6	Segmentation of Multivariate Time-series	
6.1	Mining Time-series Data	253
6.2	Time-series Segmentation	255
6.3	Fuzzy Cluster based Fuzzy Segmentation	261
6.3.1	PCA based Distance Measure	263
6.3.2	Modified Gath–Geva Clustering for Time-series Segmentation	264
6.3.3	Automatic Determination of the Number of Segments	266
6.3.4	Number of Principal Components	268
6.3.5	The Segmentation Algorithm	269
6.3.6	Case Studies	270
6.4	Conclusions	273
	Appendix: Hermite Spline Interpolation	275
	Bibliography	279
	Index	301