

Contents

Preface	ix
Introduction	1
1 Basic Concepts	5
1.1 Analysis of data	5
1.2 Cluster analysis	8
1.3 Objective function-based cluster analysis	11
1.4 Fuzzy analysis of data	17
1.5 Special objective functions	20
1.6 A principal clustering algorithm	28
1.7 Unknown number of clusters problem	31
2 Classical Fuzzy Clustering Algorithms	35
2.1 The fuzzy c-means algorithm	37
2.2 The Gustafson-Kessel algorithm	43
2.3 The Gath-Geva algorithm	49
2.4 Simplified versions of GK and GG	54
2.5 Computational effort	58
3 Linear and Ellipsoidal Prototypes	61
3.1 The fuzzy c-varieties algorithm	61
3.2 The adaptive fuzzy clustering algorithm	70
3.3 Algorithms by Gustafson/Kessel and Gath/Geva	74
3.4 Computational effort	75
4 Shell Prototypes	77
4.1 The fuzzy c-shells algorithm	78
4.2 The fuzzy c-spherical shells algorithm	83
4.3 The adaptive fuzzy c-shells algorithm	86

4.4	The fuzzy c-ellipsoidal shells algorithm	92
4.5	The fuzzy c-ellipses algorithm	99
4.6	The fuzzy c-quadratic shells algorithm	101
4.7	The modified FCQS algorithm	107
4.8	Computational effort	113
5	Polygonal Object Boundaries	115
5.1	Detection of rectangles	117
5.2	The fuzzy c-rectangular shells algorithm	132
5.3	The fuzzy c-2-rectangular shells algorithm	145
5.4	Computational effort	155
6	Cluster Estimation Models	157
6.1	AO membership functions	158
6.2	ACE membership functions	159
6.3	Hyperconic clustering (dancing cones)	161
6.4	Prototype defuzzification	165
6.5	ACE for higher-order prototypes	171
6.6	Acceleration of the Clustering Process	177
6.6.1	Fast Alternating Cluster Estimation (FACE)	178
6.6.2	Regular Alternating Cluster Estimation (rACE) . .	182
6.7	Comparison: AO and ACE	183
7	Cluster Validity	185
7.1	Global validity measures	188
7.1.1	Solid clustering validity measures	188
7.1.2	Shell clustering validity measures	198
7.2	Local validity measures	200
7.2.1	The compatible cluster merging algorithm	201
7.2.2	The unsupervised FCSS algorithm	207
7.2.3	The contour density criterion	215
7.2.4	The unsupervised (M)FCQS algorithm	221
7.3	Initialization by edge detection	233
8	Rule Generation with Clustering	239
8.1	From membership matrices to membership functions	239
8.1.1	Interpolation	240
8.1.2	Projection and cylindrical extension	241
8.1.3	Convex completion	243
8.1.4	Approximation	244
8.1.5	Cluster estimation with ACE	247

8.2	Rules for fuzzy classifiers	248
8.2.1	Input space clustering	249
8.2.2	Cluster projection	250
8.2.3	Input output product space clustering	261
8.3	Rules for function approximation	261
8.3.1	Input ouput product space clustering	261
8.3.2	Input space clustering	266
8.3.3	Output space clustering	268
8.4	Choice of the clustering domain	268
Appendix		271
A.1	Notation	271
A.2	Influence of scaling on the cluster partition	271
A.3	Overview on FCQS cluster shapes	274
A.4	Transformation to straight lines	274
References		277
Index		286