

# Contents

<b>1</b>	<b>Similarity and Granulation</b> . . . . .	1
1.1	Introduction . . . . .	1
1.2	Similarity . . . . .	2
1.2.1	Graded Similarity . . . . .	3
1.3	Granulation . . . . .	4
1.4	On Selected Approaches to Granulation . . . . .	7
1.4.1	Granules from Binary Relations . . . . .	8
1.4.2	Granules in Information Systems from Indiscernibility . . . . .	8
1.4.3	Granules from Generalized Descriptors . . . . .	9
1.5	A General Approach to Similarity Based Granules . . . . .	9
1.5.1	Operations on Granules . . . . .	10
1.5.2	An Example of Granule Fusion: Assembling . . . . .	10
	References . . . . .	12
<b>2</b>	<b>Mereology and Rough Mereology: Rough Mereological Granulation</b> . . . . .	17
2.1	Mereology . . . . .	17
2.1.1	Mereology of Leśniewski . . . . .	17
2.2	Rough Mereology . . . . .	21
2.2.1	Rough Inclusions . . . . .	22
2.3	Granules from Rough Inclusions . . . . .	25
2.3.1	Rough Inclusions on Granules . . . . .	27
2.4	General Properties of Rough Mereological Granules . . . . .	28
2.5	Ramifications of Rough Inclusions . . . . .	29
	References . . . . .	30
<b>3</b>	<b>Learning Data Classification: Classifiers in General and in Decision Systems</b> . . . . .	33
3.1	Learning by Machines: A Concise Introduction . . . . .	33
3.1.1	Bayes Classifier . . . . .	34

- 3.1.2 Nearest Neighbor Classifier: Asymptotic Properties . . . 35
- 3.1.3 Metrics for kNN . . . . . 37
- 3.2 Classifiers: Concept Learnability . . . . . 39
  - 3.2.1 The VC Dimension and PAC Learning . . . . . 40
- 3.3 Rough Set Approach to Data: Classifiers in Decision Systems . . . . . 41
- 3.4 Decision Systems . . . . . 44
- 3.5 Decision Rules . . . . . 46
  - 3.5.1 Exhaustive Rules . . . . . 47
  - 3.5.2 Minimal Sets of Rules: LEM2 . . . . . 51
  - 3.5.3 Quality Evaluations for Decision Rules . . . . . 52
- 3.6 Dependencies . . . . . 55
- 3.7 Granular Processing of Data . . . . . 55
- 3.8 Validation Methods: CV . . . . . 57
- References. . . . . 59
  
- 4 Methodologies for Granular Reflections . . . . . 63**
  - 4.1 Granules: Granular Reflections . . . . . 63
    - 4.1.1 The Standard Rough Inclusion . . . . . 64
    - 4.1.2  $\epsilon$ -Modification of the Standard Rough Inclusion . . . . . 64
    - 4.1.3 Residual Rough Inclusions . . . . . 65
    - 4.1.4 Metrics for Rough Inclusions . . . . . 65
    - 4.1.5 A Ranking of Metrics . . . . . 67
  - 4.2 Granular Coverings . . . . . 68
  - 4.3 Granular Reflections . . . . . 70
  - 4.4 Ramifications of Granulation: Concept-Dependent and Layered . . . . . 75
  - 4.5 Granular Approximations to Decision Function . . . . . 77
  - 4.6 Validation of Proposed Algorithms on Real Data Sets . . . . . 91
  - 4.7 Concept-Dependent and Layered Granulation on Real Data: Granulation as a Compression Tool . . . . . 93
    - 4.7.1 Layered Learning . . . . . 99
  - 4.8 Applications of Granular Reflections to Missing Values . . . . . 100
  - References. . . . . 103
  
- 5 Covering Strategies . . . . . 105**
  - 5.1 Description of the Chosen Classifier . . . . . 105
  - 5.2 Parameter Estimation in kNN Classifier . . . . . 107
  - 5.3 Granular Covering Methods . . . . . 107
    - 5.3.1 Order-Preserving Coverings: Cov1 . . . . . 108
    - 5.3.2 Random Coverings: Cov2 . . . . . 109
    - 5.3.3 Coverings by Granules of a Minimal Size: Cov3 . . . . . 109
    - 5.3.4 Coverings by Granules of Average Size: Cov4 . . . . . 110
    - 5.3.5 Coverings by Granules of Maximal Size: Cov5 . . . . . 111

- 5.3.6 Coverings by Granules Which Transfer the Smallest  
Number of New Objects: Cov6. . . . . 112
- 5.3.7 Coverings by Granules Which Transfer an Average  
Number of New Objects: Cov7 . . . . . 112
- 5.3.8 Coverings by Granules Which Transfer Maximal  
Number of New Objects: Cov8. . . . . 113
- 5.3.9 Order-Preserving Coverings Proportional  
to the Size of Decision Classes: Cov9 . . . . . 113
- 5.3.10 Random Coverings Proportional to the Size  
of Decision Classes: Cov10 . . . . . 113
- 5.3.11 Coverings Proportional to the Size of Decision  
Classes by Granules of a Minimal Size: Cov11 . . . . . 114
- 5.3.12 Coverings Proportional to the Size of Decision  
Classes by Granules of the Average Size: Cov12 . . . . . 114
- 5.3.13 Coverings Proportional to the Size of Decision  
Classes by Granules of a Maximal Size: Cov13 . . . . . 115
- 5.3.14 Coverings Proportional to the Size of Decision  
Classes, by Granules Which Transfer the Smallest  
Number of New Objects: Cov14. . . . . 116
- 5.3.15 Coverings Proportional to the Size of Decision  
Classes, by Granules Which Transfer the Average  
Number of New Objects: Cov15. . . . . 116
- 5.3.16 Coverings Proportional to the Size of Decision  
Classes, by Granules Which Transfer a Maximal  
Number of New Objects: Cov16. . . . . 117
- 5.4 Experimental Session with Real World Data Sets . . . . . 117
- 5.5 Summary of Results for Discrete Data Sets from UCI  
Repository . . . . . 118
- 5.6 Validation of Results: Combined Average Accuracy  
with Percentage of Reduction of Object Number,  
and,  $5 \times CV5$  Accuracy Bias. . . . . 151
- 5.7 Best Result Based on CombAGS and the Error  
( $acc_{r=1} - acc$ )  $\leq 0.02$  . . . . . 185
- 6 Layered Granulation . . . . . 221**
  - 6.1 Introduction . . . . . 221
    - 6.1.1 An Example of Multiple Granulation. . . . . 222
    - 6.1.2 Experiments with Real Data. . . . . 227
  - 6.2 Results of Experiments for Symbolic Data from UCI  
Repository . . . . . 228
  - 6.3 In Search for the Optimal Granulation Radius . . . . . 253
    - 6.3.1 Results Pointed to by the Two-layered Granulation. . . . . 255
    - 6.3.2 Comparison of Results Pointed by Double  
Granulation and Best *CombAGS*. . . . . 261

6.3.3	A Comparison for Accuracy Error $acc_{r=1} - acc \leq 0.01$ of <i>CombAGS</i> and $GranSize_{l_{i-1}} - GranSize_{l_i}$ . . . . .	275
	References. . . . .	276
<b>7</b>	<b>Naive Bayes Classifier on Granular Reflections: The Case of Concept-Dependent Granulation.</b> . . . . .	277
7.1	Naive Bayes Classifier. . . . .	277
7.1.1	An Example of Bayes Classification . . . . .	279
7.2	Results of an Experimental Session with Real Data. . . . .	282
7.2.1	Examined Variants of Bayes Classifier . . . . .	282
7.2.2	Evaluation of Results . . . . .	282
7.2.3	A Discussion of Results. . . . .	282
	References. . . . .	301
<b>8</b>	<b>Granular Computing in the Problem of Missing Values</b> . . . . .	303
8.1	Introduction . . . . .	303
8.1.1	A Survey of Strategies. . . . .	303
8.1.2	Examples of Basic Strategies . . . . .	306
8.2	The Experimental Session . . . . .	310
8.2.1	The Methodology of the Experiment. . . . .	310
8.2.2	Evaluation of Results . . . . .	311
8.2.3	The Results of Experiments for Data Sets Damaged in 5 and 10 % . . . . .	311
	References. . . . .	347
<b>9</b>	<b>Granular Classifiers Based on Weak Rough Inclusions.</b> . . . . .	349
9.1	Introduction . . . . .	349
9.2	Results of Experiments with Classifiers 5_v1, 6_v1, 7_v1, 8_v1–8_v5 Based on the Parameter $\varepsilon$ . . . . .	349
9.3	Results of Experiments with Classifiers Based on Parameters $\varepsilon$ and $r_{catch}$ . . . . .	355
9.4	Results of Experiments with Classifiers 5_v3, 6_v3, 7_v3 Based on the Parameter $\varepsilon$ . . . . .	390
	References. . . . .	398
<b>10</b>	<b>Effects of Granulation on Entropy and Noise in Data.</b> . . . . .	399
10.1	On Entropy Behavior During Granulation . . . . .	399
10.2	On Noise in Data During Granulation . . . . .	400
10.3	On Characteristics of Data Sets Bearing on Granulation. . . . .	409
<b>11</b>	<b>Conclusions</b> . . . . .	417
	References. . . . .	422

**Appendix A: Data Characteristics Bearing on Classification . . . . . 423**

**Author Index . . . . . 443**

**General Index . . . . . 447**

**Symbols . . . . . 451**



<http://www.springer.com/978-3-319-12879-5>

Granular Computing in Decision Approximation

An Application of Rough Mereology

Polkowski, L.; Artiemjew, P.

2015, XV, 452 p. 230 illus., Hardcover

ISBN: 978-3-319-12879-5