

Contents

1. Fuzzy Sets and Fuzzy Logic	
1.1 Fuzzy sets	1
1.2 Operations on fuzzy sets	7
1.3 The extension principle	12
1.4 t-norm-based operations on fuzzy numbers	19
1.5 Product-sum of triangular fuzzy numbers	21
1.6 Hamacher-sum of triangular fuzzy numbers	24
1.7 t-norm-based addition of fuzzy numbers	28
1.8 A functional relationship between t-norm-based addition and multiplication	30
1.9 On generalization of Nguyen's theorems	33
1.10 Measures of possibility and necessity	35
1.11 A law of large numbers for fuzzy numbers	38
1.12 Metrics for fuzzy numbers	44
1.13 Possibilistic mean value and variance of fuzzy numbers	46
1.14 Auxiliary lemmas	53
1.15 Fuzzy implications	57
1.16 Linguistic variables	60
2. Fuzzy Multicriteria Decision Making	
2.1 Averaging operators	65
2.2 Obtaining maximal entropy OWA operator weights	73
2.3 OWA Operators for Ph.D. student selection	78
2.4 Possibility and necessity in weighted aggregation	85
2.5 Benchmarking in linguistic importance weighted aggregations	92
3. Fuzzy Reasoning	
3.1 The theory of approximate reasoning	101
3.2 Aggregation in fuzzy system modeling	104
3.3 Multiple fuzzy reasoning schemes	107
3.4 Some properties of the compositional rule of inference	111
3.5 Computation of the compositional rule of inference under t-norms	115
3.6 On the generalized method-of-case inference rule	119

4. Fuzzy Optimization	
4.1 Possibilistic linear equality systems	123
4.2 Sensitivity analysis of $\tilde{a}x = \tilde{b}$ and $\tilde{a}^\delta x = \tilde{b}^\delta$	130
4.3 Possibilistic systems with trapezoid fuzzy numbers	134
4.4 Flexible linear programming	136
4.5 Fuzzy linear programming with crisp relations	142
4.6 Possibilistic linear programming	144
4.7 Possibilistic quadratic programming	148
4.8 Multiobjective possibilistic linear programming	150
5. Fuzzy Reasoning for Fuzzy Optimization	
5.1 Fuzzy reasoning for FMP	157
5.1.1 Extension to nonlinear FMP	161
5.1.2 Relation to classical LP problems	162
5.1.3 Crisp objective and fuzzy coefficients in constraints	163
5.1.4 Fuzzy objective function and crisp constraints	164
5.1.5 Relation to Zimmermann's soft constraints	164
5.1.6 Relation to Buckley's possibilistic LP	166
5.2 Optimization with linguistic variables	170
5.3 Multiobjective optimization with linguistic variables	177
5.4 Interdependent multiple criteria decision making	179
5.4.1 The linear case	184
5.4.2 Application functions	186
5.5 MOP with interdependent objectives	190
5.6 Additive linear interdependences	193
5.7 Additive nonlinear interdependences	199
5.8 Compound interdependences	201
5.9 Biobjective interdependent decision problems	203
6. Applications in Management	
6.1 Nordic Paper Inc.	207
6.1.1 Outline of a macro algorithm	209
6.2 A fuzzy approach to real option valuation	212
6.2.1 Probabilistic real option valuation	213
6.2.2 A hybrid approach to real option valuation	215
6.3 The Woodstrat project	219
6.3.1 Fuzzy hyperknowledge support systems	220
6.3.2 Cognitive maps for hyperknowledge representation	231
6.3.3 Adaptive FCM for strategy formation	232
6.4 Soft computing methods for reducing the bullwhip effect	236
6.4.1 The bullwhip effect, some additional details	240
6.4.2 Explanations for the bullwhip effect: standard results	242
6.4.3 Demand signal processing	243
6.4.4 Order batching	244
6.4.5 Price variations	246

6.4.6 A fuzzy approach to demand signal processing 247
 6.4.7 A fuzzy logic controller to demand signal processing .. 248
 6.4.8 A hybrid soft computing platform for taming the bull-
 whip effect 250

7. Future Trends in Fuzzy Reasoning and Decision Making

7.1 Software agents and agent-based systems 255
 7.2 Intelligence and software agents 261
 7.3 Scenario agents 264
 7.3.1 The scenario agent: basic functionality 267
 7.4 Scenarios and scenario planning: key features 268
 7.5 Forecasting 272
 7.6 Industry foresight 275
 7.7 The scenario agent 278
 7.7.1 Support for OW scenarios 279
 7.7.2 Support for model-based scenarios 281
 7.7.3 Support for scenario building and foresight 285
 7.8 Interpretation agent 287
 7.8.1 The interpretation agent: basic functionality 288
 7.9 Coping with imprecision 290
 7.10 Interpretation in a business environment 293
 7.11 Mental models and cognitive maps 295
 7.12 A preliminary description of an interpretation agent 296
 7.13 An interpretation agent: details 300
 7.13.1 Interpretation support for OW scenarios 302
 7.13.2 Interpretation support for model-based scenarios 305
 7.13.3 Interpretation support for decision models 309
 7.13.4 Interpretation support for data sources 312
 7.13.5 Generic interpretation of agent structures 313
 7.13.6 Approximate reasoning and sense-making 313
 7.13.7 Support for sense-making and interpretation 314

Bibliography 319

Index 337