
Computational Intelligence
in Complex
Decision Systems

Edited by Da Ruan

Atlantis Computational Intelligence Systems
Series Editor Da Ruan



Contents

Preface	v
1. Computational Intelligence: Past, Today, and Future	1
<i>C. Kahraman, İ. Kaya, and D. Çınar</i>	
1.1 Introduction	1
1.2 Neural Networks	5
1.2.1 Network Architectms	6
1.2.2 Learning processes	9
1.3 Fuzzy Set Theory	12
1.4 Evolutionary Computation	14
1.4.1 Genetic algorithms	14
1.4.2 Genetic programming	18
1.4.3 Evolution strategies	19
1.4.4 Evolutionary programming	19
1.4.5 Classifier systems	20
1.4.6 Ant colony optimization	21
1.4.7 Particle swarm optimization	23
1.5 Hybrid Systems	24
1.6 Literature Review	24
1.6.1 Computational intelligence in complex decision systems	29
1.7 Computational Intelligence Journals	34
1.8 Computational Intelligence’s Future and Conclusions	36
Bibliography	38

2. Uncertainty in Dynamically Changing Input Data 47

T.C. Pais, R.A. Ribeiro, and L.F. Simões

2.1	Problem Statement	47
2.2	Description of Methodology	49
2.2.1	Phase A. Data Preparation in Dynamic Environments	50
2.2.2	Phase B. Decision Evaluation Process with Feedback	52
2.3	Example in Practice	54
2.3.1	Background about Landing Site Selection	54
2.3.2	Phase A. Data Preparation in Dynamic Environments	55
2.3.3	Phase B. Decision Evaluation Process with Feedback	64
2.4	Future Research Directions	65
	Bibliography	65

3. Decision Making under Uncertainty by Possibilistic Linear Programming Problems 67

P. Guo

3.1	Introduction	67
3.2	Fuzzy Decisions in Possibility Linear Programming Problems	68
3.2.1	Triangular Possibility Distributions of Fuzzy Decision Variables	69
3.2.2	Exponential Possibility Distributions of Fuzzy Decision Variables	73
3.3	Numerical Examples	79
3.4	Conclusions	82
	Bibliography	83

4. Intelligent Decision Making in Training Based on Virtual Reality 85

L. dos Santos Machado and R. Marcos de Moraes

4.1	Training Aspects	85
4.2	Virtual Reality	87
4.2.1	Interaction Devices	88
4.2.2	Haptic Devices	89
4.3	Training in Virtual Reality Systems	91
4.4	Collecting and Using Data from VR Simulators	93
4.4.1	Online and Offline Evaluation	94

4.5	Evaluation Based on Expert Systems	95
4.5.1	Using Classical Logic	95
4.5.2	Using Fuzzy Logic	96
4.5.3	Combining Expert Systems	98
4.6	Evaluation Based on Mixture Models	100
4.6.1	Gaussian Mixture Models	100
4.6.2	Fuzzy Gaussian Mixture Models	103
4.6.3	Sequential Methods	105
4.7	Evaluation Methods Based on Hidden Markov Models	108
4.7.1	Discrete Hidden Markov Models (DHMM)	108
4.7.2	Continuous Hidden Markov Models	109
4.7.3	Comparison of Hidden Markov Models	110
4.7.4	Fuzzy Hidden Markov Models	110
4.8	Evaluation Methods Based on Bayesian Models	111
4.8.1	Maximum Likelihood	111
4.8.2	Fuzzy Bayes Rule	113
4.8.3	Naive Bayes	113
4.8.4	Quantitative and Qualitative Evaluation Based on Naive Bayes	115
4.8.5	Bayesian Networks	116
4.9	Considerations About Evaluation Methods	118
4.10	Future Trends and Conclusions	119
	Bibliography	120

5. A Many-Valued Temporal Logic and Reasoning Framework for

Decision Making

125

Z. Lu, J. Liu, J.C. Augusto, and H. Wang

5.1	Introduction	125
5.1.1	Problem Description: a Realistic Scenario	127
5.1.2	Relevant Works	128
5.2	Many-valued Temporal Propositional Logic Systems	129
5.2.1	Syntax and Semantics	130
5.2.2	Inference Rules	132
5.2.3	Logical Calculus	134
5.2.4	Soundness and Completeness Theorems	136

5.3	Practical Many-valued Temporal Reasoning	138
5.3.1	Forward Reasoning Algorithm	138
5.3.2	Backward Reasoning Algorithm	139
5.4	Scenarios	140
5.5	Discussions	144
5.6	Conclusions	144
	Bibliography	145
6.	A Statistical Approach to Complex Multi-Criteria Decisions	147
	<i>P.L. Kunsch</i>	
6.1	Background	147
6.2	Basic Elements of the MCDM Methodology	149
6.2.1	An ordinal procedure for finding the Rank Matrix	149
6.2.2	The maximum number of criteria	155
6.2.3	The inverse procedure for finding preference weights	158
6.3	2-D and 3-D Visualisation in the Ordinal Case	160
6.3.1	The 2-D case	160
6.3.2	The 3-D Case	162
6.4	An Extension of the Approach to Cardinal Scales	165
6.4.1	A MCDM procedure	165
6.4.2	An application of the cardinal procedure	170
6.5	Conclusions and Outlook	173
	Appendix A	176
	A.1 Properties of the space of n -vectors	176
	A.2 Projection in the XY -plane of the 74 ranking vectors ($n = 4$) on the unit sphere in $\mathbb{R}^3$	180
	Bibliography	181
7.	A Web Based Assessment Tool via the Evidential Reasoning Approach	183
	<i>D.-L. Xu</i>	
7.1	Introduction	183
7.2	The ER Approach	185
7.3	Illustration of the ER Approach	186
7.4	Interfaces for Data Input	192

7.5	Interfaces for Outcome Display	197
7.6	Applications	199
7.7	Concluding Remarks	199
	Bibliography	203
8.	An Intelligent Policy Simulator for Supporting Strategic Nuclear Policy Decision Making	205
	<i>S. Rao</i>	
8.1	Introduction	205
8.2	Existing Intelligence Methods in Discerning Proliferation Intentions of Nation-states	207
8.3	A Suggested Policy Simulator Based on the Genetic Evolution of Altruism	208
8.3.1	Inspiration from Nature: The Genetic Evolution of Altruism . . .	209
8.3.2	Peace as a State of Dynamic Equilibrium: Altruism in the Nuclear World	209
8.3.3	DiNI Policy Simulator: Validity and Verification	210
8.4	Modeling Basis for DiNI - Nature's Altruism Model in NetLogo	211
8.5	DiNI Model Construction	212
8.5.1	Calculating Parameter Values c , b , h and d for DiNI	212
8.6	DiNI Model Simulation and Results	215
8.7	Policy Simulation on DiNI: The Experience of USA vis-à-vis India under the Atoms for Peace program	216
8.7.1	Nuclear Cooperation Between USA and India - A Brief Background	216
8.7.2	Construction of the DiNI Atoms for Peace Policy Simulator . . .	217
8.7.3	Calculating Parameter Values for c , b , h and d for the DiNI Atoms for peace policy simulator	218
8.7.4	The AfP Experience of USA vis-à-vis India - Base Case	219
8.7.5	Evaluating the AfP Experience of USA vis-à-vis India - The 1960s	221
8.7.6	DiNI Atoms for Peace Simulation and Results	225
8.7.7	Atoms for Peace: Some Policy Options for the USA	227
8.8	Advantages of the DiNI Policy Simulator	228
8.9	Ethical and Security Aspects of DiNI Policy Simulator	229

8.10	Further Research Directions	229
8.11	Conclusions	230
	Bibliography	230
9.	Computing with Words for Hierarchical and Distributed Decision-Making	233
	<i>J.M. Mendel and D. Wu</i>	
9.1	Introduction	233
9.2	The Journal Publication Judgment Advisor (JPJA)	237
9.3	Perceptual Computing for the JPJA	239
9.3.1	Modified Paper Review Form	239
9.3.2	Encoder	240
9.3.3	CWW Engine	242
9.3.4	Decoder	243
9.4	Examples	245
9.4.1	Aggregation of Technical Merit Sub-criteria	245
9.4.2	Aggregation of Presentation Sub-criteria	249
9.4.3	Aggregation at the Reviewer Level	252
9.4.4	Aggregation at the AE Level	253
9.4.5	Complete Reviews	258
9.5	Conclusions	262
	Appendix A	265
A.1	Interval Type-2 Fuzzy Sets (IT2 FSs)	265
A.2	Linguistic Weighted Average (LWA)	266
	Bibliography	270
10.	Realizing Policies by Projects Using FMCDM	273
	<i>C. Kahraman and İ. Kaya</i>	
10.1	Introduction	273
10.2	Multiple Criteria Decision Making	275
10.3	The Proposed Methodology	279
10.4	An Application	287
10.5	Conclusions	297
	Bibliography	299

**11. Evolutionary Computation Methods for Fuzzy Decision Making
on Load Dispatch Problems 301**

G. Zhang, G. Zhang, Y. Gao, and J. Lu

11.1 Models for Day-ahead Markets 301

11.1.1 Introduction 302

11.1.2 A Load Dispatch Model for a Day-ahead Market 302

11.1.3 An Uncertain Environment/Economic Load Dispatch Model . . 304

11.2 Evolutionary Computation Methods and Fuzzy Decision Making 305

11.2.1 Evolutionary Computation 306

11.2.2 A Fuzzy Multi-object Non-linear Optimization Method 313

11.3 Illustrations on Load Dispatch for Day-ahead Market 316

11.3.1 An example of load dispatch in a day-ahead market 316

11.3.2 An Example of Uncertain Environment/Economic Load Dispatch 317

11.4 Conclusions and Further Research 321

Bibliography 322

**12. Intelligent Decision-Making for a Smart Home Environment with
Multiple Occupants 325**

A. Muñoz, J.A. Botía, and J.C. Augusto

12.1 Introduction 325

12.2 SmartTV System Architecture 329

12.2.1 Information Module 330

12.2.2 Decision Module 332

12.3 Arguments in the SmartTV System 334

12.4 Domain Criteria in the SmartTV System 343

12.4.1 Same Conclusion Supported by Different Type of Information . . 344

12.4.2 Inconsistent Conclusions Supported by Different Type
of Information 347

12.4.3 Inconsistent Conclusions Supported by the Same Type
of Information 350

12.5 Decision Mechanism: Two Approaches 352

12.5.1 A Centralized Approach 352

12.5.2 A Distributed Approach 353

12.5.3 SmartTV Scenarios	356
12.6 Comparing Decision Mechanisms in the SmartTV System	365
12.7 Conclusions and Further Research Directions	367
Bibliography	369
 13. Applying a Choquet Integral Based Decision to Evaluate Agile Supply Chain Strategies	 373
<i>G. Büyüközkan</i>	
13.1 Introduction	373
13.2 Multi Criteria Decision Making with Choquet Integral	375
13.2.1 Background and Notation	376
13.2.2 Elucidation of the Aggregation Result	377
13.3 Evaluation of Agile Supply Chain Strategies	379
13.4 Concluding Remarks	384
Bibliography	384
 Subject Index	 387