
Contents

Foreword	V
Preface	VII
Intelligent Machines: An Introduction	
<i>Lakshmi C. Jain, Anas Quteishat, and Chee Peng Lim</i>	1
1 Introduction	1
2 Learning in Intelligent Machines	2
3 Application of Intelligent Machines	3
3.1 Unmanned Aerial Vehicle (UAV)	3
3.2 Underwater Robot	4
3.3 Space Vehicle	4
3.4 Humanoid Robot	5
3.5 Other Attempts in Intelligent Machines	6
4 Chapters Included in this Book	7
5 Summary	7
References	8
Predicting Operator Capacity for Supervisory Control of Multiple UAVs	
<i>M.L. Cummings, Carl E. Nehme, Jacob Crandall, and Paul Mitchell</i> ...	11
1 Introduction	11
2 Previous Experimental Multiple UAV studies	12
3 Predicting Operator Capacity through Temporal Constraints	14
3.1 Wait Times	15
3.2 Experimental Analysis of the Fan-out Equations	16
3.3 Linking Fan-out to Operator Performance	24
3.4 The Overall Cost Function	25
3.5 The Human Model	27
3.6 Optimization through Simulated Annealing	28
3.7 Results of Simulation	29

4	Meta-Analysis of the Experimental and Modeling Prediction methods	33
5	Conclusions	36
	References	36

**Team, Game, and Negotiation based Intelligent Autonomous
UAV Task Allocation for Wide Area Applications**

	<i>P.B. Sujit, A. Sinha, and D. Ghose</i>	39
1	Introduction	39
2	Existing Literature	41
3	Task Allocation Using Team Theory	42
	3.1 Basics of Team Theory	42
	3.2 Problem Formulation	43
	3.3 Team Theoretic Solution	45
	3.4 Simulation Results	47
4	Task Allocation using Negotiation	50
	4.1 Problem Formulation	50
	4.2 Decision-making	53
	4.3 Simulation Results	58
5	Search using Game Theoretic Strategies	61
	5.1 N-person Game Model	62
	5.2 Solution Concepts	63
	5.3 Simulation Results	69
6	Conclusions	72
	References	72

UAV Path Planning Using Evolutionary Algorithms

	<i>Ioannis K. Nikolos, Eleftherios S. Zografos, and Athina N. Brintaki</i>	77
1	Introduction	77
	1.1 Basic Definitions	77
	1.2 Cooperative Robotics	79
	1.3 Path Planning for Single and Multiple UAVs	80
	1.4 Outline of the Current Work	85
2	B-Spline and Evolutionary Algorithms Fundamentals	86
	2.1 B-Spline Curves	86
	2.2 Fundamentals of Evolutionary Algorithms (EAs)	88
	2.3 The Solid Boundary Representation	89
3	Off-line Path Planner for a Single UAV	90
4	Coordinated UAV Path Planning	92
	4.1 Constraints and Objectives	92
	4.2 Path Modeling Using B-Spline Curves	93
	4.3 Objective Function Formulation	94
5	The Optimization Procedure	97
	5.1 Differential Evolution Algorithm	97
	5.2 Radial Basis Function Network for DE Assistance	99

5.3 Using RBFN for Accelerating DE Algorithm 102
 6 Simulation Results 102
 7 Conclusions 107
 7.1 Trends and challenges 108
 References 109

**Evolution-based Dynamic Path Planning
 for Autonomous Vehicles**

Anawat Pongpunwattana and Rolf Rysdyk 113
 1 Introduction 113
 2 Dynamic Path Planning 116
 3 Probability of Intersection 122
 4 Planning Algorithm 125
 4.1 Algorithm for Static Planning 125
 4.2 Algorithm for Dynamic Planning 134
 5 Planning with Timing Constraints 135
 6 Planning in Changing Environment 138
 7 Conclusion 142
 8 Acknowledgments 143
 References 144

Algorithms for Routing Problems Involving UAVs

Sivakumar Rathinam and Raja Sengupta 147
 1 Introduction 147
 2 Single Vehicle Resource Allocation Problem
 in the Absence of Kinematic Constraints 148
 2.1 Problem Formulation 148
 2.2 Relevant Literature 149
 2.3 Algorithms 150
 3 Multiple Vehicle Resource Allocation Problems
 in the Absence of Kinematic Constraints 155
 3.1 Literature Review 155
 3.2 Single Depot, Multiple TSP(SDTSP) 156
 3.3 Multiple Depot, Multiple TSP (MDMTSP) 158
 3.4 Generalized Multiple Depot Multiple TSP (GMTSP) 159
 4 Resource Allocation Problems in the Presence
 of Kinematic Constraints 162
 4.1 Problem Formulation 162
 4.2 Literature Review 163
 4.3 Alternating Algorithm for the Single UAV Case 164
 4.4 Approximation Algorithm for the Multiple UAV Case 165
 5 Summary and Open Problems 169
 References 170

State Estimation for Micro Air Vehicles

<i>Randal W. Beard</i>	173
1 UAV State Variables	174
2 Sensor Models	176
2.1 Rate Gyros	176
2.2 Accelerometers	177
2.3 Pressure Sensors	177
2.4 GPS	179
3 Simulation Environment	180
4 State Estimation via Model Inversion	182
4.1 Low Pass Filters	182
4.2 State Estimation by Inverting the Sensor Model	183
5 The Continuous-Discrete Kalman Filter	188
5.1 Dynamic Observer Theory	189
5.2 Essentials from Probability Theory	189
5.3 Continuous-Discrete Kalman Filter	191
6 Application of the EKF to UAV State Estimation	195
6.1 Roll and Pitch Estimation	195
6.2 Position and Course Estimation	197
7 Summary	198
References	198

Evolutionary Design of a Control Architecture for Soccer-Playing Robots

<i>Steffen Prüter, Hagen Burchardt, and Ralf Salomon</i>	201
1 Introduction	201
2 The Slip Problem	204
2.1 Slip and Friction	204
2.2 Experimental Analysis	205
2.3 Self-Organizing Kohonen Feature Maps and Methods	206
2.4 Results	207
3 Improved Position Prediction	209
3.1 Latency Time	209
3.2 Experimental Analysis	210
3.3 Back-Propagation Networks and Methods	211
4 Local Position Correction	213
4.1 Increased Position Accuracy by Local Sensors	213
4.2 Embedded Back-Propagation Networks	213
4.3 Methods	214
4.4 Results	215
5 Path Planning using Genetic Algorithms	217
5.1 Gene Encoding	218
5.2 Fitness Function	218
5.3 Evolutionary operations	219
5.4 Continous calculation	219
5.5 Calculation Time	220

5.6 Finding a Path in Dynamic Environments 220
 6 Discussion 221
 References 222

Toward Robot Perception through Omnidirectional Vision

*José Gaspar, Niall Winters, Etienne Grossmann,
 and José Santos-Victor* 223

1 Introduction 223
 1.1 State of the Art 225

2 Omnidirectional Vision Sensors: Modelling and Design 226
 2.1 A Unifying Theory for Single Centre of Projection Systems ... 228
 2.2 Model for Non-Single Projection Centre Systems 229
 2.3 Design of Standard Mirror Profiles 230
 2.4 Design of Constant Resolution Cameras 233
 2.5 The Single Centre of Projection Revisited 237

3 Environmental Perception for Navigation 238
 3.1 Geometric Representations for Precise Self-Localisation 239
 3.2 Topological Representations 246

4 Complementing Human and Robot Perceptions
 for HR Interaction 255
 4.1 Interactive Scene Reconstruction 257
 4.2 Human Robot Interface based on 3D World Models 262

5 Conclusion 263
 References 265