

Contents

1	Cybernetic View of Robot Cognition and Perception	1
1.1	Introduction to the Model of Cognition	1
1.1.1	Various States of Cognition	3
1.1.2	Cycles of Cognition.....	5
1.2	Visual Perception.....	7
1.2.1	Human Visual System.....	7
1.2.2	Vision for Mobile Robots.....	8
1.3	Visual Recognition.....	10
1.3.1	Template Matching	11
1.3.2	Feature-Based Model	11
1.3.3	Fourier Model.....	12
1.3.4	Structural Model.....	12
1.3.5	The Computational Theory of Marr	13
1.4	Machine Learning	13
1.4.1	Properties and Issues in Machine Learning.....	13
1.4.2	Classification of Machine Learning	15
1.5	Soft Computing Tools and Robot Cognition	17
1.5.1	Modeling Cognition Using ANN	17
1.5.2	Fuzzy Logic in Robot Cognition	19
1.5.3	Genetic Algorithms in Robot Cognition	19
1.6	Summary.....	20
2	Map Building.....	21
2.1	Introduction.....	21
2.2	Constructing a 2D World Map.....	22
2.2.1	Data Structure for Map Building.....	22
2.2.2	Explanation of the Algorithm.....	26
2.2.3	An Illustration of Procedure Traverse Boundary..	27
2.2.4	An Illustration of Procedure Map Building	29
2.2.5	Robot Simulation.....	31
2.3	Execution of the Map Building Program.....	33
2.4	Summary.....	38

3.	Path Planning.....	39
3.1	Introduction.....	39
3.2	Representation of the Robot’s Environment.....	39
3.2.1	GVD Using Cellular Automata.....	40
3.3	Path Optimization by the Quadtree Approach.....	41
3.3.1	Introduction to the Quadtree.....	41
3.3.2	Definition.....	42
3.3.3	Generation of the Quadtree.....	42
3.4	Neighbor-Finding Algorithms for the Quadtree.....	47
3.5	The A* Algorithm for Selecting the Best Neighbor.....	52
3.6	Execution of the Quadtree-Based Path Planner Program.....	54
3.7	Summary.....	58
4	Navigation Using a Genetic Algorithm.....	59
4.1	Introduction.....	59
4.2	Genetic Algorithms.....	60
4.2.1	Encoding of a Chromosome.....	61
4.2.2	Crossover.....	62
4.2.3	Mutation.....	62
4.2.4	Parameters of a GA.....	63
4.2.5	Selection.....	63
4.3	Navigation by a Genetic Algorithm.....	64
4.3.1	Formulation of Navigation.....	64
4.4	Execution of the GA-Based Navigation Program.....	67
4.5	Replanning by Temporal Associative Memory.....	68
4.5.1	Introduction to TAM.....	68
4.5.2	Encoding and Decoding Process in a Temporal Memory.....	70
4.5.3	An Example in a Semi-dynamic Environment.....	71
4.5.4	Implications of Results.....	74
4.6	Summary.....	75
5	Robot Programming Packages.....	77
5.1	Introduction.....	77
5.2	Robot Hardware and Software Resources.....	78
5.2.1	Components.....	79
5.3	ARIA.....	79
5.3.1	ARIA Client–Server.....	80
5.3.2	Robot Communication.....	84
5.3.3	Opening the Connection.....	84
5.3.4	ArRobot.....	85
5.3.5	Range Devices.....	87
5.3.6	Commands and Actions.....	88

5.4	Socket Programming	95
5.4.1	Socket Programming in ARIA	96
5.5	BotSpeak Speech System.....	98
5.5.1	Functions	98
5.6	Small Vision System (SVS).....	100
5.6.1	SVS C++ Classes	101
5.6.2	Parameter Classes.....	102
5.6.3	Stereo Image Class	102
5.6.4	Acquisition Classes	106
5.7	Multithreading	112
5.8	Client Front-End Design Using Java	113
5.9	Summary	113
6	Robot Parameter Display	115
6.1	Introduction.....	115
6.2	Flow Chart and Source Code for Robot Parameter Display	115
6.3	Summary	125
7	Program for BotSpeak	127
7.1	Introduction.....	127
7.2	Flow Chart and Source Code for BotSpeak Program	127
7.3	Summary	136
8	Gripper Control Program.....	137
8.1	Introduction.....	137
8.2	Flow Chart and Source Code for Gripper Control Program	137
8.3	Summary	150
9	Program for Sonar Reading Display	151
9.1	Introduction.....	151
9.2	Flow Chart and Source Code for Sonar Reading Display on Client	151
9.3	Summary	161
10	Program for Wandering Within the Workspace	163
10.1	Introduction.....	163
10.2	Algorithm and Source Code for Wandering Within the Workspace	163
10.3	Summary	173

11	Program for Tele-operation.....	175
	11.1 Introduction.....	175
	11.2 Algorithm and Source Code for Tele-operation	175
	11.3 Summary.....	188
12	A Complete Program for Autonomous Navigation	189
	12.1 Introduction.....	189
	12.2 The ImageServer Program.	190
	12.3 The MotionServer Program	192
	12.4 The Navigator Client Program.....	195
	12.5 Summary.....	199
13	Imaging Geometry	201
	13.1 Introduction.....	201
	13.2 Necessity for 3D Reconstruction	201
	13.3 Building Perception	202
	13.3.1 Problems of Understanding 3D Objects from 2D Imagery	203
	13.3.2 Process of 3D Reconstruction	203
	13.4 Imaging Geometry	205
	13.4.1 Image Formation	205
	13.4.2 Perspective Projection in One Dimension.....	206
	13.4.3 Perspective Projection in 3D.....	207
	13.5 Global Representation	211
	13.6 Transformation to Global Coordinate System	217
	13.7 Summary.....	220
14	Image Capture Program	221
	14.1 Introduction.....	221
	14.2 Algorithm for Image Capture	221
	14.3 Summary.....	225
15	Building 3D Perception Using a Kalman Filter	227
	15.1 Introduction.....	227
	15.2 Minimal Representation.....	227
	15.3 Recursive Kalman Filter	229
	15.4 Experiments and Estimation	231
	15.4.1 Reconstruction of 3D Points	237
	15.4.2 Reconstruction of a 3D Line	242
	15.4.3 Reconstruction of a 3D Plane.....	246
	15.5 Correspondence Problem in 3D Recovery.....	249
	15.6 Summary.....	250

16 Program for 3D Perception.....251
 16.1 Introduction.....251
 16.2 Flow Chart and Source Code for 3D Perception251
 16.3 Summary.....262

17 Perceptions of Non-planar Surfaces.....263
 17.1 Introduction.....263
 17.2 Methods of Edge Detection263
 17.3 Curve Tracking and Curve Fitting266
 17.4 Program for Curve Detector270
 17.5 Summary.....275

18 Intelligent Garbage Collection.....277
 18.1 Introduction.....277
 18.2 Algorithms and Source Code for Garbage Collection277
 18.3 Summary.....281

References.....283

Index.....289