

Contents

1	Introduction	1
2	The Mobile Robot MARVIN	3
2.1	Mobile Platform	4
2.2	Active Stereo Camera System	4
2.3	Hardware Environment	5
2.4	Software Environment	5
3	Visual Information Processing	8
3.1	Tracking Approaches for Gaze Holding	8
3.1.1	Gaze Control for Pursuit Camera Movements	8
3.1.1.1	Introduction and Motivation	8
3.1.1.2	The Biological Model	9
3.1.1.3	Concept and Computational Theory	11
3.1.1.4	How it Works	15
3.1.1.5	System Description and Performance	20
3.1.1.6	Discussion and Future Prospects	22
3.1.2	Structure-Based Optical Flow for Gaze Holding	25
3.1.2.1	Correspondence Measurement in Image Sequences	25
3.1.2.2	A Modified Correlation Algorithm	27
3.1.2.3	Implementation	28
3.1.2.4	Application to a Gaze Holding Task	32
3.1.2.5	Elimination of Background Motion	33
3.1.2.6	Results and Conclusion	35
3.2	Preattentive and Cognitive Gaze Control by Saccades	36
3.2.1	Saccadic Object Recognition with a Foveal Vision System	36
3.2.1.1	System Survey	36
3.2.1.2	Preattentive Feature Analysis	38
3.2.1.3	Cognitive Object Recognition	41
3.2.1.4	Interest Map and Camera Control	43

3.2.1.5	Implementation and Results	44
3.2.2	Visual Attention and Saccadic Scene Recognition	45 14
3.2.2.1	Introduction	45 15
3.2.2.2	Visual Saliency	47 15
3.2.2.3	Pattern Recognition	48 17
3.2.2.4	Models for Saccadic Recognition	48 18
3.2.2.5	A Model for Visual Attention and Saccadic Recognition	53 18
3.2.2.6	Interest Map	55 53
3.2.2.7	Some Results	56 55
3.2.2.8	Conclusion	57 56
3.3	Vergence Guided Disparity Estimation Using a Phase Method	58 57
3.3.1	Introduction	58 58
3.3.2	Two-Dimensional Phase Method	59 58
3.3.3	Accumulation of Disparity Estimates in Scale Space	62 59
3.3.4	Vergence and Accommodation	64 52
3.3.5	Vergence Calibration	67 54
3.3.6	Application to Vergence Control and Disparity Maps	67 57
3.3.7	Discussion of Results	68 67
3.3.8	Conclusion	70 68
3.4	Depth Segmentation and Depth Recovery	71 7C
3.4.1	Depth Segmentation	71 71
3.4.1.1	Panum's Fusional Area Segmentation	71 71
3.4.1.2	Target selection	71 71
3.4.1.3	Experiments	71 71
3.4.2	Depth Recovery from Area-Based Stereo Algorithms	71 71
3.4.2.1	Projective Geometry for Local, Area-Based Stereo Algorithms	8T
3.4.2.2	Interpretation of Stereo Data	88
3.4.2.3	Experiments	88
3.5	Motion Parallax	98
3.5.1	Viewer-Centered Coordinate System	99
3.5.2	Method to Recover Three-Dimensional Structure by Fixation	9f
3.5.2.1	Fixation	9f
3.5.2.2	Estimation of Robot Motion Parameters	9f
3.5.3	Results	9f
3.6	Visual Obstacle Detection by Inverse Perspective Mapping	11
3.6.1	Inverse Perspective Mapping	11
3.6.2	Design Principles and Assumptions	11
3.6.3	A Monocular Optical Flow-Based Obstacle Detection Approach	11

3.6.4	The Correlation-Based Optical Flow Algorithm	109
3.6.5	Stereo Obstacle Detection Scheme with Inverse Perspective Mapping	111
3.7	Image Recognition Based on Higher Order Autocorrelations	113
3.7.1	From Images to Features	114
3.7.1.1	Scale Invariance by means of Scale Space Data	114
3.7.1.2	Features: Autocorrelation Functions	116
3.7.2	Classification	117
3.7.2.1	Optimal Linear Classification	118
3.7.2.2	Linear Discriminant Analysis (LDA)	119
3.7.3	Experimental Results	121
3.7.4	Summary	122
4	Planning and Control for Autonomous Systems	124
4.1	Path Planning with Dynamic Fields	127
4.1.1	The Planning Dynamics	127
4.1.2	The Dynamic Field Approach	129
4.1.3	Experimental Results	132
4.2	Integration with Dynamic Neural Fields	135
4.2.1	Neural Field Architecture: An Example	139
4.2.2	Results	142
4.3	Behavior-Based Visual Navigation: Theory	145
4.3.1	Methods	148
4.3.2	Making and Stabilization of Decisions	152
4.3.3	Estimation of Robot's Position	157
5	Adaptation of the Information Processing Structure	163
5.1	Early Visual Processing: Discrete Parametric Representations	163
5.2	Self-Organization of Binocular Cells	168
5.2.1	Biological Findings	168
5.2.2	Self-Organization	169
5.2.3	Producing Binocular Pattern	169
5.2.4	Developing Maps of Binocular Cells	172
5.2.5	Representation of Disparity and Orientation	174
5.2.6	Functional Aspects	178
6	Aspects of a Neural Architecture	181
6.1	Principles	181
6.2	Structure of the system	183
6.3	Coupling of Behavioral Modules	186

7 Demonstration of Results	188
7.1 Behavior-Based Visual Navigation: Experiment	188
7.2 Demonstration in a Maze Like Environment	192
7.3 Concurrent Active Vision and Depth Reconstruction	195
7.3.1 Saccadic Scene Exploration and Recognition	196
7.3.2 Stereoscopic Tracking	198
7.3.3 Depth Segmentation and Reconstruction	200
Acknowledgements	205
Bibliography	206