

Contents

Acknowledgements	III
Abstract	IX
Kurzfassung	XI
Nomenclature	XIII
1. Introduction	1
1.1. Motivation	1
1.1.1. Automated Vehicles	1
1.1.2. Functional System Architecture	3
1.1.3. Environmental Perception	6
1.2. State of the Art	7
1.2.1. Simultaneous Localization and Mapping	9
1.2.2. Movable Object Detection	14
1.2.3. Movable Object Tracking	16
1.3. Contributions	19
1.4. Overview	21
2. Sensor Data Preprocessing	25
2.1. Introduction	25
2.2. Vehicle Origin/Orientation correction	27
2.3. Scan Undistortion	29
2.4. Sensor Data Representation	30
2.5. Ground Point Classification	32
2.6. Object Segmentation	36
2.7. Movable Object Detection	40
2.8. Landmark Classification	44
2.9. Road Area Identification	45
2.10. Summary	47

3. Volumetric Hybrid Map-based SLAM	49
3.1. Introduction	49
3.2. Estimation technique	50
3.3. Motion Model	55
3.4. Environment Models	57
3.4.1. Grid Map	62
3.4.2. Feature Map	72
3.5. Proposal Distribution	76
3.5.1. Mathematical Formulation	77
3.5.2. Efficient Computation	81
3.5.3. Adaptive Selection	84
3.6. Summary	85
4. Geometric Model-based Tracking with Multiple Motion Models	87
4.1. Introduction	87
4.2. Geometric Model-based Tracking	90
4.2.1. Geometric Shape Extraction	92
4.2.2. Geometric Shape Inference	95
4.3. Multiple Motion Models	99
4.3.1. Constant Velocity (CV) Model	100
4.3.2. Constant Acceleration (CA) Model	101
4.3.3. Coordinated Turn (CT) Model	102
4.4. Fuzzy Interacting Multiple Model Algorithm	103
4.4.1. Elemental Filter Design	103
4.4.2. Common State Vector	105
4.4.3. Hybrid Estimation Scheme	106
4.4.4. Fuzzy Inference System	111
4.5. Data Association	114
4.5.1. Validation Gating	115
4.5.2. Assignment method	116
4.6. Track Management	117
4.6.1. Life Cycle	118
4.6.2. Dynamic State	119
4.7. Summary	120
5. Evaluation	123
5.1. Introduction	123
5.2. Localization and Mapping	124
5.2.1. Hybrid Map-based SLAM	124

5.2.2. Volumetric Hybrid Map-based SLAM	128
5.3. Target Tracking	137
5.3.1. Geometric Model-based Tracking	137
5.3.2. Multiple Motion Model-based Tracking	141
5.4. Runtime Analysis	151
5.5. Summary	154
6. Conclusion	155
6.1. Summary	155
6.2. Outlook	157
A. Appendix	159
A.1. Probability Theory	159
A.1.1. Conditional Probability	159
A.1.2. Product Rule	159
A.1.3. Sum Rule (Marginal Probability)	159
A.1.4. Total Probability Rule	160
A.1.5. Independence Rule	160
A.1.6. Bayes rule	160
A.1.7. Markov Assumption	161
A.2. Gaussian Distribution	161
A.2.1. Partitioned Gaussian Distribution	161
A.2.2. Linear Operation	162
A.2.3. Moments	162
List of Publications	165
Bibliography	167