

Contents

List of Figures	XV
List of Tables	XIX
List of Acronyms	XXI
1 Introduction	1
1.1 Objectives	1
1.2 Motivation	2
1.3 Challenges	4
1.4 Contributions	8
1.4.1 Structure from Motion	9
1.4.2 Ortho-mosaic and Rendering	9
1.4.3 Loop Closure Detection	10
1.4.4 Vertex Selection	10
1.5 Book Outline	10
2 Literature Review	13
2.1 Image Registration	13
2.1.1 Frequency Domain	13
2.1.2 Optical Flow	14
2.1.3 Feature Based	15
2.1.4 Match Propagation	27
2.2 Photo-mosaicing	27
2.3 3D Reconstruction	30
2.4 Discussion	38
3 Direct Structure from Motion	39
3.1 Introduction	39
3.2 Image Features	40
3.3 Model Initialization	42

3.4	Scene Model	45
3.5	Direct Camera Registration	47
3.6	Model Update	49
3.7	Ortho-mosaicing and 3D Representation	51
3.8	Experimental Results	52
3.8.1	Car Scene	57
3.8.2	Water-Tank Sequence	64
3.8.3	Rocks Loop	67
3.8.4	Pool Trials	68
3.8.5	Coral Reef Sequence	74
3.8.6	Mequinenza Sequence	79
3.8.7	Urban Experiment	81
3.9	Discussion	84
4	Online Loop Detection	87
4.1	Introduction	87
4.2	Visual Vocabulary	91
4.2.1	Vocabulary Building	92
4.2.2	Cluster Characterization	93
4.2.3	Cluster Updating	93
4.2.4	Cluster Merging Criterion	94
4.2.5	Convergence Criterion	96
4.2.6	Adding New Clusters	96
4.2.7	Linear Discriminant Analysis	97
4.2.8	Vocabulary Update Criterion	97
4.3	Image Indexing	98
4.3.1	Cluster Association	98
4.3.2	Image Re-indexing	100
4.3.3	Image Similarity	101
4.3.4	Loop-Closure Detection	102
4.3.5	Increasing Vocabulary Efficiency	102
4.4	Experimental Results	102
4.4.1	Laboratory Experiment	103
4.4.2	Large-Scale Mixed Environment	109
4.4.3	Underwater Experiment	111
4.4.4	Coral Reef Experiment	119
4.4.5	Outdoor Experiment	122
4.5	Discussion	125
5	Online 3D Model Simplification	127
5.1	Introduction	127
5.2	Depth Map Computation	130
5.3	Depth Map Derivatives	130
5.4	RoI Extraction	132
5.5	Geometrical Feature Extraction	133

5.6	Selection of 3D Vertices	134
5.7	Experimental Results	134
5.7.1	Rocks Experiment	135
5.7.2	Coral Head Experiment	138
5.7.3	Coral Reef Experiment	138
5.8	Discussion	140
6	Conclusions	143
6.1	Contributions of the Book	145
6.2	Ongoing and Future Work	146
Appendix A	Estimating the Uncertainty of 3D Vertices	147
Appendix B	Loop Closing and 3D Model Correction	149
References		151