

Contents

Abbreviations	viii
About the Companion Website	ix
1 Introduction to Structure from Motion in the Geosciences	1
1.1 The Geosciences and Related Disciplines	1
1.2 Aim and Scope of this Book	3
1.3 The Time and the Place	4
1.4 What Is Structure from Motion?	5
1.5 Structure of this Book	6
References	8
2 The Place of Structure from Motion: A New Paradigm in Topographic Surveying?	9
2.1 Introduction	10
2.2 Direct Topographic Surveying	10
2.3 Remote Digital Surveying	16
2.4 Summary	29
References	31
Further Reading/Resources	36
3 Background to Structure from Motion	37
3.1 Introduction	37
3.2 Feature Detection	39
3.3 Keypoint Correspondence	44
3.4 Identifying Geometrically Consistent Matches	46
3.5 Structure from Motion	48
3.6 Scale and Georeferencing	50
3.7 Refinement of Parameter Values	51
3.8 Clustering for MVS	52
3.9 MVS Image Matching Algorithms	53
3.10 Summary	55
References	55
Further Reading/Resources	59
4 Structure from Motion in Practice	60
4.1 Introduction	61
4.2 Platforms	62
4.3 Sensors	69

4.4	Acquiring Images and Control Data	71
4.5	Software	75
4.6	Point Cloud Viewers	83
4.7	Filtering	84
4.8	Generating Digital Elevation Models from Point Clouds	88
4.9	Key Issues	89
4.10	Summary	90
	References	92
	Associated Reference	96
	Further Reading/Resources	96
5	Quality Assessment: Quantifying Error in Structure from Motion-Derived Topographic Data	97
5.1	Introduction	97
5.2	Validation Data Sets	98
5.3	Validation Methods	101
5.4	Survey Platform	104
5.5	Survey Range and Scale	105
5.6	Error Metrics	111
5.7	Distribution of Ground Control Points	112
5.8	Terrain	113
5.9	Software	114
5.10	Camera	119
5.11	Summary	119
	References	121
	Further Reading/Resources	123
6	Current Applications of Structure from Motion in the Geosciences	124
6.1	Introduction	124
6.2	Use of SfM-MVS-Derived Orthophotograph Mosaics	125
6.3	Use of SfM-MVS for 3D Point Clouds	133
6.4	Use of SfM-MVS for Gridded Topography	134
6.5	Combined Orthophotograph and Point Cloud Analysis	137
6.6	Crossing Temporal Scales: Examples of Change Detection to Suggest Process Dynamics	145
6.7	Practitioner-Based SfM-MVS	152
6.8	Summary	153
	References	154
	Further Reading/Resources	158
7	Developing Structure from Motion in the Geosciences: Future Directions	159
7.1	Introduction	160
7.2	Developments in Hardware	161
7.3	Progressive Automation of Acquisition	163

7.4	Efficient Management and Manipulation of Photographs	178
7.5	Point Cloud Generation and Decimation	179
7.6	Real-Time SfM-MVS and Instant Maps: Simultaneous Localisation and Mapping	181
7.7	Augmented Reality	182
7.8	Detection of Object or Surface Motion: Non-Rigid SfM	183
7.9	Summary	185
	References	186
	Further Reading/Resources	189
8	Concluding Recommendations	190
8.1	Key Recommendation 1: Get “Under the Bonnet” of SfM-MVS to Become More Critical End Users	190
8.2	Key Recommendation 2: Get Co-ordinated to Understand the Sources and Magnitudes of Error	191
8.3	Key Recommendation 3: Focus on the Research Question	192
8.4	Key Recommendation 4: Focus Your Efforts on Data Processing	192
8.5	Key Recommendation 5: Learn from Other Disciplines	193
8.6	Key Recommendation 6: Harness the Democratising Power of SfM-MVS	194
	Index	195