
Contents

1	Introduction	1
1.1	Background	1
1.2	Organization	2
1.3	Features	7
 Part I Fundamental Algorithms for Computer Vision		
2	Ellipse Fitting	11
2.1	Representation of Ellipses	11
2.2	Least-Squares Approach	12
2.3	Noise and Covariance Matrices	13
2.4	Algebraic Methods	15
2.4.1	Iterative Reweight	15
2.4.2	Renormalization and the Taubin Method	16
2.4.3	Hyper-Renormalization and HyperLS	17
2.4.4	Summary of Algebraic Methods	18
2.5	Geometric Methods	19
2.5.1	Geometric Distance and Sampson Error	19
2.5.2	FNS	19
2.5.3	Geometric Distance Minimization	20
2.5.4	Hyper-Accurate Correction	22
2.6	Ellipse-Specific Methods	23
2.6.1	Ellipse Condition	23
2.6.2	Method of Fitzgibbon et al.	23
2.6.3	Method of Random Sampling	24
2.7	Outlier Removal	25
2.8	Examples	26
2.9	Supplemental Note	27
	Problems	29
	References	31
3	Fundamental Matrix Computation	33
3.1	Fundamental Matrices	33
3.2	Covariance Matrices and Algebraic Methods	34

3.3	Geometric Distance and Sampson Error	37
3.4	Rank Constraint	38
3.5	A Posteriori Correction	39
3.6	Hidden Variables Approach	41
3.7	Extended FNS	45
3.8	Geometric Distance Minimization	46
3.9	Outlier Removal	48
3.10	Examples	49
3.11	Supplemental Note	50
	Problems	53
	References	56
4	Triangulation	59
4.1	Perspective Projection	59
4.2	Camera Matrix and Triangulation	60
4.3	Triangulation from Noisy Correspondence	62
4.4	Optimal Correction of Correspondences	63
4.5	Examples	65
4.6	Supplemental Note	66
	Problems	66
	References	68
5	3D Reconstruction from Two Views	69
5.1	Camera Modeling and Self-calibration	69
5.2	Expression of the Fundamental Matrix	72
5.3	Focal Length Computation	73
5.4	Motion Parameter Computation	75
5.5	3D Shape Computation	76
5.6	Examples	77
5.7	Supplemental Note	78
	Problems	79
	References	80
6	Homography Computation	81
6.1	Homographies	81
6.2	Noise and Covariance Matrices	83
6.3	Algebraic Methods	85
6.4	Geometric Distance and Sampson Error	88
6.5	FNS	89
6.6	Geometric Distance Minimization	90
6.7	Hyperaccurate Correction	92
6.8	Outlier Removal	93
6.9	Examples	94
6.10	Supplemental Note	95
	Problems	96
	References	97

7	Planar Triangulation	99
7.1	Perspective Projection of a Plane	99
7.2	Planar Triangulation	101
7.3	Procedure of Planar Triangulation.	101
7.4	Examples	103
7.5	Supplemental Note	104
	Problems.	105
	References.	105
8	3D Reconstruction of a Plane	107
8.1	Self-calibration with a Plane	107
8.2	Computation of Surface Parameters and Motion Parameters	108
8.3	Selection of the Solution.	109
8.4	Examples	112
8.5	Supplemental Note	113
	Problems	113
	References.	115
9	Ellipse Analysis and 3D Computation of Circles	117
9.1	Intersections of Ellipses	117
9.2	Ellipse Centers, Tangents, and Perpendiculars	119
9.3	Projection of Circles and 3D Reconstruction	120
9.4	Center of Circle	123
9.5	Front Image of the Circle	124
9.6	Examples	125
9.7	Supplemental Note	126
	Problems.	128
	References.	129

Part II Multiview 3D Reconstruction Techniques

10	Multiview Triangulation	133
10.1	Trilinear Constraint.	133
10.2	Triangulation from Three Views.	134
10.2.1	Optimal Correspondence Correction	134
10.2.2	Solving Linear Equations.	136
10.2.3	Efficiency of Computation	138
10.2.4	3D Position Computation.	138
10.3	Triangulation from Multiple Views.	140
10.4	Examples	144
10.5	Supplemental Note	144
	Problems.	146
	References.	147

11	Bundle Adjustment	149
11.1	Principle of Bundle Adjustment	149
11.2	Bundle Adjustment Algorithm	151
11.3	Derivative Computation	153
11.3.1	Gauss-Newton Approximation	153
11.3.2	Derivatives with Respect to 3D Positions	154
11.3.3	Derivatives with Respect to Focal Lengths	154
11.3.4	Derivatives with Respect to Principal Points	154
11.3.5	Derivatives with Respect to Translations	154
11.3.6	Derivatives with Respect to Rotations	155
11.3.7	Efficient Computation and Memory Use	155
11.4	Efficient Linear Equation Solving	156
11.5	Examples	158
11.6	Supplemental Note	160
	Problems	160
	References	161
12	Self-calibration of Affine Cameras	163
12.1	Affine Cameras	163
12.2	Factorization and Affine Reconstruction	164
12.3	Metric Condition for Affine Cameras	167
12.4	Description in the Camera Coordinate System	168
12.5	Symmetric Affine Camera	169
12.6	Self-calibration of Symmetric Affine Cameras	172
12.7	Self-calibration of Simplified Affine Cameras	175
12.7.1	Paraperspective Projection Model	175
12.7.2	Weak Perspective Projection Model	177
12.7.3	Orthographic Projection Model	178
12.8	Examples	179
12.9	Supplemental Note	181
	Problems	182
	References	182
13	Self-calibration of Perspective Cameras	183
13.1	Homogeneous Coordinates and Projective Reconstruction	183
13.2	Projective Reconstruction by Factorization	185
13.2.1	Principle of Factorization	185
13.2.2	Primary Method	187
13.2.3	Dual Method	190
13.3	Euclidean Upgrading	192
13.3.1	Principle of Euclidean Upgrading	192
13.3.2	Computation of Ω	194
13.3.3	Modification of K_K	196
13.3.4	Computation of H	198
13.3.5	Procedure for Euclidean Upgrading	198

13.4	3D Reconstruction Computation	199
13.5	Examples	201
13.6	Supplemental Notes	202
	Problems	207
	References	210
 Part III Mathematical Foundation of Geometric Estimation		
14	Accuracy of Geometric Estimation.	213
14.1	Constraint of the Problem	213
14.2	Noise and Covariance Matrices	214
14.3	Error Analysis	214
14.4	Covariance and Bias	216
14.5	Bias Elimination and Hyper-Renormalization	218
14.6	Derivations	219
14.7	Supplemental Note	228
	Problems	228
	References	229
15	Maximum Likelihood of Geometric Estimation	231
15.1	Maximum Likelihood	231
15.2	Sampson Error	232
15.3	Error Analysis	233
15.4	Bias Analysis and Hyper-Accurate Correction	235
15.5	Derivations	236
15.6	Supplemental Note	241
	Problems	242
	References	242
16	Theoretical Accuracy Limit	243
16.1	Kanatani-Cramer-Rao (KCR) Lower Bound	243
16.2	Structure of Constraints	244
16.3	Derivation of the KCR Lower Bound	246
16.4	Expression of the KCR Lower Bound	249
16.5	Supplemental Note	251
	Problems	253
	References	254
	Solutions	255
	Index	319

Guide to 3D Vision Computation

Geometric Analysis and Implementation

Kanatani, K.; Sugaya, Y.; Kanazawa, Y.

2016, XI, 321 p. 54 illus., 10 illus. in color., Hardcover

ISBN: 978-3-319-48492-1