Three-Dimensional Computer Vision
A Geometric Viewpoint

The MIT Press
Cambridge, Massachusetts
London, England
Contents

Series Foreword xi
Figures xiii
Tables xxix
Preface xxxi

1 Introduction 1

2 Projective Geometry 7
  2.1 How to read this chapter 8
  2.2 Projective spaces 9
  2.3 The projective line 13
  2.4 The projective plane 14
  2.5 The projective space 23
  2.6 Problems 30

3 Modeling and Calibrating Cameras 33
  3.1 A guide to this chapter 33
  3.2 Modeling cameras 33
  3.3 Changing coordinate systems 41
  3.4 Calibrating cameras 51
  3.5 Problems 66
4 Edge Detection 69
4.1 Introduction and precursors 69
4.2 Computing derivatives and smoothing 77
4.3 One-dimensional edge detection by the maxima of the first derivative 90
4.4 Discrete implementations 104
4.5 Two-dimensional edge detection by the maxima of the gradient magnitude 108
4.6 More references 118
4.7 Problems 119

5 Representing Geometric Primitives and Their Uncertainty 125
5.1 How to read this chapter 126
5.2 Manifolds 127
5.3 The two-dimensional case 130
5.4 The three-dimensional case 135
5.5 Three-dimensional displacements 142
5.6 Computing uncertainty 151
5.7 Problems 162

6 Stereo Vision 165
6.1 Correspondence ambiguity; tokens and features 165
6.2 Constraints 169
6.3 Rectification 188
6.4 Correlation techniques 189
6.5 Relaxation techniques 196
6.6 Dynamic programming 198
6.7 Prediction and verification 201
6.8 Adding the planarity constraint 206
6.9 Using three cameras 211
6.10 Reconstructing points and lines in three dimensions 230
6.11 More references 240
6.12 Problems 240
Contents

7  Determining Discrete Motion from Points and Lines  245
  7.1 How to read this chapter  245
  7.2 Introduction  247
  7.3 Determining camera displacement from point correspondences  247
  7.4 Determining displacement from line correspondences  283
  7.5 Determining the displacement of a planar patch  289
  7.6 Problems  297

8  Tracking Tokens over Time  301
  8.1 Introduction  301
  8.2 Recursive least-squares and Kalman filtering methods  302
  8.3 Two-dimensional token tracking  318
  8.4 Three-dimensional token tracking  326
  8.5 Conclusion and references  338
  8.6 Problems  338

9  Motion Fields of Curves  341
  9.1 How to read this chapter  341
  9.2 Optical flow and the motion field  343
  9.3 The motion fields of a curve  350
  9.4 Rigid motion of a 3-D straight line  369
  9.5 Rigid motion of a 3-D curve  380
  9.6 Some simple examples  387
  9.7 Constraining stereo matches  394
  9.8 More references  399
  9.9 Problems  400

10 Interpolating and Approximating Three-Dimensional Data  403
  10.1 The status of the problem  403
  10.2 How to read this chapter  411
  10.3 Shape topologies  412
  10.4 Delaunay triangulation  415
Contents

C  Differential Geometry  629
   C.1 Plane curves  629
   C.2 Space curves  629
   C.3 Surface patches  630

Bibliography  635

Index  659