

## Table of Contents

- Preface p. xv
- About the Authors p. xix
- Chapter 1 Introduction to Image Processing and the Matlab“ Environment
- 1.1 Introduction p. 1
- 1.1.1 What Is an Image? p. 2
- 1.2 Digital Image Definitions: Theoretical Account p. 2
- 1.3 Image Properties p. 5
- 1.3.1 Signal-to-Noise Ratio p. 5
- 1.3.2 Image Bit Resolution p. 5
- 1.4 Matlab p. 7
- 1.4.1 Why Matlab for Image Processing p. 9
- 1.4.2 The Image Processing Toolbox in Matlab p. 10
- 1.5 Algorithmic Account p. 11
- 1.5.1 Sampling p. 11
- 1.5.2 Noisy Image p. 11
- 1.5.3 Bit Resolution p. 12
- 1.6 Matlab Code p. 13
- 1.6.1 Basic Steps p. 13
- 1.6.2 Sampling p. 14
- 1.6.3 Noisy Image p. 14
- 1.6.4 Bit Resolution p. 14
- 1.7 Summary p. 15
- 1.8 Exercises p. 16
- Chapter 2 Image Acquisition, Types, and File I/O p. 19
- 2.1 Image Acquisition p. 19
- 2.1.1 Cameras p. 20
- 2.2 Image Types and File I/O p. 23
- 2.2.1 Bitmap Format p. 24
- 2.2.2 JPEG Format p. 24
- 2.2.3 GIF Format p. 24
- 2.2.4 TIFF Format p. 25
- 2.3 Basics of Color Images p. 25
- 2.4 Other Color Spaces p. 27
- 2.4.1 YIQ Color Space p. 27
- 2.4.2 YC<sub>b</sub>C<sub>r</sub> Color Space p. 28
- 2.4.3 HSV Color Space p. 28
- 2.5 Algorithmic Account p. 29
- 2.5.1 Image Conversions p. 32
- 2.6 Matlab Code p. 32
- 2.7 Summary of Image Types and Numeric p. 36
- 2.8 Exercises p. 38
- Chapter 3 Image Arithmetic p. 39
- 3.3.1 Pixel Addition p. 40
- 3.1 Introduction p. 39

- 3.2 Operator Basics p. 39
- 3.3 Theoretical Treatment p. 40
- 3.3.2 Pixel Subtraction p. 41
- 3.3.3 Pixel Multiplication and Scaling p. 42
- 3.3.4 Pixel Division p. 43
- 3.3.5 Blending p. 43
- 3.4 Algorithmic Treatment p. 44
- 3.4.1 Image Addition p. 44
- 3.4.2 Image Subtraction/Multiplication/Division p. 44
- 3.4.3 Image Blending and Linear Combinations p. 46
- 3.5 Coding Examples p. 48
- 3.5.1 Image Addition p. 48
- 3.5.2 Image Subtraction p. 50
- 3.5.3 Multiplying Images p. 51
- 3.5.4 Dividing Images p. 53
- 3.5.5 Image Blending and Linear Combinations p. 54
- 3.6 Summary p. 56
- 3.7 Exercises p. 56
- Chapter 4 Affine and Logical Operations, Distortions, and Noise in Images p. 59
- 4.1 Introduction p. 59
- 4.2 Affine Operations p. 59
- 4.3 Logical Operators p. 62
- 4.4.3 On-Chip Electronic Noise p. 67
- 4.4 Noise in Images p. 65
- 4.4.1 Photon Noise p. 66
- 4.4.2 Thermal Noise p. 66
- 4.4.4 KTC Noise p. 67
- 4.4.5 Amplifier Noise p. 67
- 4.4.6 Quantization Noise p. 67
- 4.5 Distortions in Images p. 68
- 4.5.1 Linear Motion Blur p. 68
- Uniform Out-of-Focus Blur p. 69
- Atmospheric Turbulence Blur p. 70
- Scatter Blur p. 70
- 4.6 Algorithmic Account p. 70
- Affine Operations p. 70
- Logical Operators p. 72
- Noise in Images p. 77
- Distortions and Noise p. 74
- 4.7 Matlab Code p. 75
- Affine and Logical Operators p. 76
- Blur in Images p. 78
- 4.8 Summary p. 80
- 4.9 Exercises p. 81
- Chapter 5 Image Transforms p. 83
- 5.1 Introduction p. 83

- 5.5 Algorithmic Account p. 94
- 5.2 Discrete Fourier Transform (DFT) in 2D p. 84
- 5.3 Wavelet Transforms p. 85
- 5.4 Hough Transform p. 91
- Fourier Transform p. 94
- Wavelet Transform p. 94
- Hough Transform p. 94
- 5.6 Matlab“ Code p. 95
- Fourier Transform p. 95
- Wavelet Transform p. 98
- Hough Transform p. 99
- 5.7 Summary p. 99
- 5.8 Exercises p. 100
- Chapter 6 Spatial and Frequency Domain Filter Design p. 103
- 6.1 Introduction p. 103
- 6.2 Spatial Domain Filter Design p. 103
- Convolution Operation p. 104
- 6.2.2 Averaging/Mean Filter p. 104
- 6.2.3 Median Filter p. 105
- 6.2.4 Gaussian Smoothing p. 108
- 6.2.5 Conservative Smoothing p. 108
- 6.3 Frequency-Based Filter Design p. 109
- 6.4 Algorithmic Account p. 112
- 6.4.1 Spatial Filtering (Convolution Based) p. 112
- 6.4.2 Spatial Filtering (Case Based) p. 115
- 6.4.3 Frequency Filtering p. 116
- 6.5 Matlab“ Code p. 116
- 6.6 Summary p. 120
- 6.7 Exercises p. 120
- Chapter 7 Image Restoration and Blind Deconvolution p. 123
- 7.1 Introduction p. 123
- 7.2 Image Representation p. 124
- 7.3 Deconvolution p. 127
- 7.4 Algorithmic Account p. 131
- 7.4.1 Lucy-Richardson Method p. 132
- 7.4.2 Wiener Method p. 132
- 7.4.3 Blind Deconvolution p. 133
- 7.5 Matlab Code p. 135
- 7.6 Summary p. 136
- 7.7 Exercises p. 137
- Chapter 8 Image Compression p. 139
- 8.1 Introduction p. 139
- 8.2 Image Compression-Decompression Steps p. 140
- 8.2.1 Error Metrics p. 141
- 8.3 Classifying Image Data p. 142
- 8.3.1 Discrete Cosine Transform p. 142

- 8.4 Bit Allocation p. 143
- 8.5 Quantization p. 145
- 8.6 Entropy Coding p. 149
- 8.7 JPEG Compression p. 149
- 8.7.1 JPEG's Algorithm p. 150
- 8.11 Exercises p. 154
- 8.8 Algorithmic Account p. 151
- 8.9 Matlab“ Code p. 152
- 8.10 Summary p. 153
- Chapter 9 Edge Detection p. 155
- 9.1 Introduction p. 155
- 9.2 The Sobel Operator p. 156
- 9.3 The Prewitt Operator p. 158
- 9.4 The Canny Operator p. 160
- 9.5 The Compass Operator (Edge Template Matching) p. 161
- 9.6 The Zero-Crossing Detector p. 163
- 9.7 Line Detection p. 166
- 9.8 The Unsharp Filter p. 167
- 9.9 Algorithmic Account p. 168
- 9.10 Matlab Code p. 170
- 9.11 Summary p. 172
- 9.12 Exercises p. 173
- Chapter 10 Binary Image Processing p. 175
- 10.1 Introduction p. 175
- 10.2 Dilation p. 177
- 10.3 Erosion p. 179
- 10.4 Opening p. 179
- 10.5 Closing p. 180
- 10.6 Thinning p. 182
- 10.7 Thickening p. 183
- 10.8 Skeletonization/Medial Axis Transform p. 184
- 10.9 Algorithmic Account p. 186
- 10.10 Matlab“ Code p. 186
- 10.11 Summary p. 190
- 10.12 Exercises p. 190
- Chapter 11 Image Encryption and Watermarking p. 193
- 11.1 Introduction p. 193
- 11.2 Watermarking Methodology p. 194
- 11.3 Basic Principle of Watermarking p. 196
- 11.4 Problems Associated With Watermarking p. 197
- 11.4.1 Attacks on Watermarks p. 199
- 11.4.2 What Can Be Done? p. 200
- 11.5 Algorithmic Account p. 201
- 11.6 Matlab“ Code p. 201
- 11.7 Summary p. 203
- 11.8 Exercises p. 204

- Chapter 12 Image Classification and Segmentation p. 205
- 12.1 Introduction p. 205
- 12.1.1 Supervised Classification p. 206
- 12.1.2 Unsupervised Classification p. 206
- 12.2 General Idea of Classification p. 207
- 12.3 Common Intensity-Connected Pixel: Naïve Classifier p. 208
- 12.4 Nearest Neighbor Classifier p. 209
- 12.4.1 Mechanism of Operation p. 211
- 12.5 Unsupervised Classification p. 212
- 12.6 Algorithmic Account p. 213
- 12.7 Matlab“ Code p. 214
- 12.8 Summary p. 218
- 12.9 Exercises p. 219
- Chapter 13 Image-Based Object Tracking p. 221
- 13.1 Introduction p. 221
- 13.2 Methodologies p. 221
- 13.3 Background Subtraction p. 223
- 13.3.1 Artifacts p. 225
- 13.4 Temporal Difference Between Frames p. 226
- 13.4.1 Gradient Difference p. 226
- 13.5 Correlation-Bases Tracking p. 227
- 13.6 Color-Based Tracking p. 229
- 13.7 Algorithmic Account p. 231
- 13.8 Matlab Code p. 231
- 13.9 Summary p. 239
- 13.10 Exercises p. 40
- 14.3 Vector Representation p. 242
- Chapter 14 Face Recognition p. 241
- 14.1 Introduction p. 241
- 14.2 Face Recognition Approaches p. 241
- 14.3.1 Linear (Subspace) Analysis p. 243
- 14.3.2 Principal Components Analysis p. 244
- 14.3.3 Databases and Performance Evaluation p. 244
- 14.4 Process Details p. 46
- 14.5 Algorithmic Account p. 249
- 14.6 Matlab“ Code p. 250
- 14.7 Summary p. 251
- 15.2 Fuzzy Logic in Image Processing p. 255
- 14.8 Exercises p. 252
- Chapter 15 Soft Computing in Image Processing p. 253
- 15.1 Introduction p. 253
- 15.2.1 Why Fuzzy Image Processing? p. 256
- 15.2.2 Fuzzy Classifier p. 258
- 15.2.3 Fuzzy Denoising p. 261
- 15.3 Algorithmic Account p. 263
- 15.4 Matlab Code p. 263

- 15.5 Summary p. 266
- 15.6 Exercises p. 266
- Bibliography p. 269
- Glossary p. 275
- Index p. 283