

CONTENTS

Preface	ix
1 Image Analysis: A Perspective	1
1.1 Main Biomedical Imaging Modalities, 3	
1.2 Biomedical Image Analysis, 7	
1.3 Current Trends in Biomedical Imaging, 12	
1.4 About This Book, 15	
References, 17	
2 Survey of Fundamental Image Processing Operators	23
2.1 Statistical Image Description, 24	
2.2 Brightness and Contrast Manipulation, 28	
2.3 Image Enhancement and Restoration, 29	
2.4 Intensity-Based Segmentation (Thresholding), 42	
2.5 Multidimensional Thresholding, 50	
2.6 Image Calculations, 54	
2.7 Binary Image Processing, 58	
2.8 Biomedical Examples, 63	
References, 68	
3 Image Processing in the Frequency Domain	70
3.1 The Fourier Transform, 71	
3.2 Fourier-Based Filtering, 82	

vi CONTENTS

3.3	Other Integral Transforms: The Discrete Cosine Transform and the Hartley Transform, 91	
3.4	Biomedical Examples, 94	
	References, 100	
4	The Wavelet Transform and Wavelet-Based Filtering	103
4.1	One-Dimensional Discrete Wavelet Transform, 106	
4.2	Two-Dimensional Discrete Wavelet Transform, 112	
4.3	Wavelet-Based Filtering, 116	
4.4	Comparison of Frequency-Domain Analysis to Wavelet Analysis, 128	
4.5	Biomedical Examples, 130	
	References, 135	
5	Adaptive Filtering	138
5.1	Adaptive Noise Reduction, 139	
5.2	Adaptive Filters in the Frequency Domain: Adaptive Wiener Filters, 155	
5.3	Segmentation with Local Adaptive Thresholds and Related Methods, 157	
5.4	Biomedical Examples, 164	
	References, 170	
6	Deformable Models and Active Contours	173
6.1	Two-Dimensional Active Contours (Snakes), 180	
6.2	Three-Dimensional Active Contours, 193	
6.3	Live-Wire Techniques, 197	
6.4	Biomedical Examples, 205	
	References, 209	
7	The Hough Transform	211
7.1	Detecting Lines and Edges with the Hough Transform, 213	
7.2	Detection of Circles and Ellipses with the Hough Transform, 219	
7.3	Generalized Hough Transform, 223	
7.4	Randomized Hough Transform, 226	
7.5	Biomedical Examples, 231	
	References, 234	
8	Texture Analysis	236
8.1	Statistical Texture Classification, 238	
8.2	Texture Classification with Local Neighborhood Methods, 242	
8.3	Frequency-Domain Methods for Texture Classification, 254	

8.4	Run Lengths, 257	
8.5	Other Classification Methods, 263	
8.6	Biomedical Examples, 265	
	References, 273	
9	Shape Analysis	276
9.1	Cluster Labeling, 278	
9.2	Spatial-Domain Shape Metrics, 279	
9.3	Statistical Moment Invariants, 285	
9.4	Chain Codes, 287	
9.5	Fourier Descriptors, 291	
9.6	Topological Analysis, 295	
9.7	Biomedical Examples, 301	
	References, 307	
10	Fractal Approaches to Image Analysis	310
10.1	Self-Similarity and the Fractal Dimension, 311	
10.2	Estimation Techniques for the Fractal Dimension in Binary Images, 319	
10.3	Estimation Techniques for the Fractal Dimension in Gray-Scale Images, 327	
10.4	Fractal Dimension in the Frequency Domain, 331	
10.5	Local Hölder Exponent, 337	
10.6	Biomedical Examples, 340	
	References, 345	
11	Image Registration	350
11.1	Linear Spatial Transformations, 352	
11.2	Nonlinear Transformations, 355	
11.3	Registration Quality Metrics, 360	
11.4	Interpolation Methods for Image Registration, 371	
11.5	Biomedical Examples, 379	
	References, 382	
12	Image Storage, Transport, and Compression	386
12.1	Image Archiving, DICOM, and PACS, 389	
12.2	Lossless Image Compression, 392	
12.3	Lossy Image Compression, 400	
12.4	Biomedical Examples, 408	
	References, 411	
13	Image Visualization	413
13.1	Gray-Scale Image Visualization, 413	

viii CONTENTS

13.2	Color Representation of Gray-Scale Images,	416
13.3	Contour Lines,	422
13.4	Surface Rendering,	422
13.5	Volume Visualization,	427
13.6	Interactive Three-Dimensional Rendering and Animation,	433
13.7	Biomedical Examples,	434
	References,	438
14	Image Analysis and Visualization Software	441
14.1	Image Processing Software: An Overview,	443
14.2	ImageJ,	447
14.3	Examples of Image Processing Programs,	452
14.4	Crystal Image,	456
14.5	OpenDX,	461
14.6	Wavelet-Related Software,	466
14.7	Algorithm Implementation,	466
	References,	473
	Appendix A: Image Analysis with Crystal Image	475
	Appendix B: Software on DVD	497
	Index	499