

# Contents

	<i>Preface</i>	page ix
	<i>Acknowledgements</i>	xiii
<b>Part I</b>	<b>Introduction to image processing</b>	<b>1</b>
<b>1</b>	<b>Introduction</b>	<b>3</b>
	1.1 Imaging systems	3
	1.2 Objects and images	7
	1.3 The digital image processing system	10
	1.4 Applications of digital image processing	13
	Exercises	15
<b>2</b>	<b>Imaging systems</b>	<b>16</b>
	2.1 The human visual pathway	16
	2.2 Photographic film	20
	2.3 Other sensors	26
	2.4 Digitizing an image	27
	2.5 The quality of a digital image	34
	2.6 Color images	40
	Computer-based activities	43
	Exercises	45
<b>3</b>	<b>Medical images obtained with ionizing radiation</b>	<b>47</b>
	3.1 Medical imaging modalities	47
	3.2 Images from x-rays	48
	3.3 Images from $\gamma$ -rays	77
	3.4 Dose and risk	84
	Computer-based activities	86
	Exercises	87

vi	<b>Contents</b>	
<b>4</b>	<b>Medical images obtained with non-ionizing radiation</b>	90
	4.1 Ultrasound imaging	91
	4.2 Magnetic resonance imaging	100
	4.3 Picture archiving and communication systems (PACS)	115
	Computer-based activities	118
	Exercises	120
	<b>Part II Fundamental concepts of image processing</b>	121
<b>5</b>	<b>Fundamentals of digital image processing</b>	123
	5.1 The gray-level histogram	123
	5.2 Histogram transformations and look-up tables	135
	Computer-based activities	148
	Exercises	151
<b>6</b>	<b>Image enhancement in the spatial domain</b>	155
	6.1 Algebraic operations	156
	6.2 Logical (Boolean) operations	159
	6.3 Geometric operations	162
	6.4 Convolution-based operations	170
	Computer-based activities	189
	Exercises	191
<b>7</b>	<b>Image enhancement in the frequency domain</b>	194
	7.1 The Fourier domain	195
	7.2 The Fourier transform	198
	7.3 Properties of the Fourier transform	205
	7.4 Sampling	207
	7.5 Cross-correlation and autocorrelation	217
	7.6 Imaging systems – point spread function and optical transfer function	219
	7.7 Frequency domain filters	223
	7.8 Tomographic reconstruction	231
	Computer-based activities	237
	Exercises	243
<b>8</b>	<b>Image restoration</b>	246
	8.1 Image degradation	246
	8.2 Noise	247
	8.3 Noise-reduction filters	252
	8.4 Blurring	258

<b>Contents</b>		vii
8.5	Modeling image degradation	260
8.6	Geometric degradations	263
	Computer-based activities	268
	Exercises	269
<b>Part III Image analysis</b>		<b>271</b>
<b>9</b>	<b>Morphological image processing</b>	<b>273</b>
9.1	Mathematical morphology	273
9.2	Morphological operators	275
9.3	Extension to grayscale images	295
	Computer-based activities	301
	Exercises	305
<b>10</b>	<b>Image segmentation</b>	<b>309</b>
10.1	What is segmentation?	309
10.2	Thresholding	311
10.3	Region-based methods	321
10.4	Boundary-based methods	324
10.5	Other methods	326
	Computer-based activities	335
	Exercises	338
<b>11</b>	<b>Feature recognition and classification</b>	<b>339</b>
11.1	Object recognition and classification	340
11.2	Connected components labeling	340
11.3	Features	342
11.4	Object recognition and classification	348
11.5	Statistical classification	351
11.6	Structural/syntactic classification	364
11.7	Applications in medical image analysis	364
	Computer-based activities	367
	Exercises	367
<b>12</b>	<b>Three-dimensional visualization</b>	<b>369</b>
12.1	Image visualization	369
12.2	Surface rendering	370
12.3	Volume rendering	374
12.4	Virtual reality	376
	Computer-based activities	377
	Exercises	377

---

<b>Part IV Medical applications and ongoing developments</b>	379
<b>13 Medical applications of imaging</b>	381
13.1 Computer-aided diagnosis in mammography	381
13.2 Tumor imaging and treatment	385
13.3 Angiography	386
13.4 Bone strength and osteoporosis	388
13.5 Tortuosity	389
<b>14 Frontiers of image processing in medicine</b>	395
14.1 Trends	395
14.2 The last word	398
<i>Appendix A</i> The Fourier series and Fourier transform	399
<i>Appendix B</i> Set theory and probability	405
<i>Appendix C</i> Shape and texture	423
<i>Bibliography</i>	432
<i>Index</i>	440

The color plates are situated between pages 178 and 179.