

- 1 Acquiring Images p. 1
- Human reliance on images for information p. 1
- Video cameras p. 6
- CCD cameras p. 8
- Camera artefacts and limitations p. 11
- Color cameras p. 13
- Camera resolution p. 15
- CMOS cameras p. 17
- Focusing p. 18
- Electronics and bandwidth limitations p. 18
- Pixels p. 20
- Grey-scale resolution p. 23
- Noise p. 24
- High-depth images p. 26
- Color imaging p. 30
- Digital camera limitations p. 36
- Color spaces p. 40
- Color correction p. 47
- Color displays p. 50
- Image types p. 52
- Range imaging p. 54
- Multiple images p. 59
- Stereoscopy p. 64
- Imaging requirements p. 71
- 2 Printing and Storage p. 79
- Printing p. 79
- Dots on paper p. 83
- Color printing p. 88
- Printing hardware p. 93
- Film recorders p. 98
- File storage p. 100
- Storage media p. 101
- Magnetic recording p. 103
- Databases for images p. 104
- Browsing and thumbnails p. 108
- Lossless coding p. 111
- Reduced color palettes p. 117
- JPEG compression p. 118
- Wavelet compression p. 123
- Fractal compression p. 126
- Digital movies p. 128
- 3 Correcting Imaging Defects p. 131
- Contrast expansion p. 131
- Noisy images p. 137
- Neighborhood averaging p. 140
- Neighborhood ranking p. 152

- Other neighborhood noise-reduction methods p. 162
- Defect removal, maximum entropy, and maximum likelihood p. 167
- Nonuniform illumination p. 171
- Fitting a background function p. 174
- Rank leveling p. 179
- Color shading p. 181
- Non-planar views p. 188
- Computer graphics p. 189
- Geometrical distortion p. 191
- Alignment p. 193
- Interpolation p. 197
- Morphing p. 202
- 4 Image Enhancement (Processing in the Spatial Domain) p. 207
  - Contrast manipulation p. 208
  - Histogram equalization p. 211
  - Laplacian p. 219
  - Derivatives p. 229
  - The Sobel and Kirsch operators p. 232
  - Rank operations p. 248
  - Texture p. 257
  - Fractal analysis p. 261
  - Implementation notes p. 263
  - Image math p. 264
  - Subtracting images p. 265
  - Multiplication and division p. 269
- 5 Processing Images in Frequency Space p. 277
  - Some necessary mathematical preliminaries p. 277
  - What frequency space is all about p. 277
  - The Fourier transform p. 278
  - Fourier transforms of real functions p. 281
  - Frequencies and orientations p. 286
  - Measuring images in the frequency domain p. 286
  - Orientation and spacing p. 286
  - Preferred orientation p. 290
  - Texture and fractals p. 295
  - Filtering images p. 297
  - Isolating periodic noise p. 297
  - Masks and filters p. 303
  - Selection of periodic information p. 309
  - Convolution and correlation p. 314
  - Fundamentals of convolution p. 314
  - Imaging system characteristics p. 317
  - Noise and Wiener deconvolution p. 322
  - Motion blur p. 325
  - Template matching and correlation p. 328
  - Autocorrelation p. 331

- Conclusion p. 332
- 6 Segmentation and Thresholding p. 333
  - Thresholding p. 333
  - Multiband images p. 336
  - Two-dimensional thresholds p. 338
  - Multiband thresholding p. 341
  - Thresholding from texture p. 346
  - Multiple thresholding criteria p. 349
  - Textural orientation p. 352
  - Accuracy and reproducibility p. 357
  - Including position information p. 359
  - Selective histograms p. 366
  - Boundary lines p. 367
  - Contours p. 370
  - Image representation p. 374
  - Other segmentation methods p. 377
  - The general classification problem p. 379
- 7 Processing Binary Images p. 383
  - Boolean operations p. 383
  - Combining Boolean operations p. 387
  - Masks p. 389
  - From pixels to features p. 391
  - Boolean logic with features p. 397
  - Selecting features by location p. 402
  - Double thresholding p. 405
  - Erosion and dilation p. 409
  - Opening and closing p. 410
  - Isotropy p. 413
  - Measurements using erosion and dilation p. 417
  - Extension to grey-scale images p. 419
  - Morphology neighborhood parameters p. 420
  - Examples of use p. 421
  - The cluster p. 425
  - Euclidean distance map p. 425
  - Watershed segmentation p. 429
  - Ultimate eroded points p. 434
  - Other EDM-based measurements p. 434
  - Skeletonization p. 435
  - Boundary lines and thickening p. 437
  - Combining skeleton and EDM p. 442
- 8 Global Image Measurements p. 445
  - Global measurements and stereology p. 445
  - Surface area p. 450
  - ASTM Grain Size p. 453
  - Multiple types of surfaces p. 456
  - Length p. 457

- Sampling strategies p. 459
- Determining number p. 461
- Curvature, connectivity, and the disector p. 462
- Anisotropy and gradients p. 466
- Size distributions p. 469
- Classical stereology (unfolding) p. 471
- 9 Feature-Specific Measurements p. 475
  - Brightness measurements p. 475
  - Determining location p. 481
  - Orientation p. 484
  - Neighbor relationships p. 486
  - Alignment p. 491
  - Counting features p. 496
  - Special counting procedures p. 499
  - Feature size p. 502
  - Circles and ellipses p. 505
  - Caliper dimensions p. 507
  - Perimeter p. 509
  - Describing shape p. 512
  - Fractal dimension p. 515
  - Harmonic analysis p. 519
  - Topology p. 522
  - Three-dimensional measurements p. 523
- 10 Feature Recognition and Classification p. 527
  - Template matching and cross-correlation p. 527
  - Parametric description p. 529
  - Decision points p. 534
  - Multidimensional classification p. 536
  - Learning systems p. 541
  - kNN and cluster analysis p. 545
  - Expert systems p. 549
  - Neural nets p. 551
  - Syntactical models p. 553
- 11 3D Image Acquisition p. 555
  - Volume imaging versus sections p. 555
  - Basics of reconstruction p. 558
  - Algebraic reconstruction methods p. 563
  - Maximum entropy p. 567
  - Defects in reconstructed images p. 568
  - Beam hardening p. 573
  - Imaging geometries p. 578
  - Three-dimensional tomography p. 580
  - High-resolution tomography p. 587
- 12 3D Image Visualization p. 591
  - Sources of 3D data p. 591
  - Serial sections p. 592

- Optical sectioning p. 596
- Sequential removal p. 598
- Stereo measurement p. 600
- 3D data sets p. 604
- Slicing the data set p. 606
- Arbitrary section planes p. 611
- The use of color p. 615
- Volumetric display p. 615
- Stereo viewing p. 618
- Special display hardware p. 623
- Ray tracing p. 624
- Reflection p. 628
- Surfaces p. 633
- Multiply connected surfaces p. 639
- Image processing in 3D p. 643
- Measurements on 3D images p. 647
- Conclusion p. 649
- 13 Imaging Surfaces p. 651
- Producing surfaces p. 651
- Devices that image surfaces by physical contact p. 653
- Noncontacting measurements p. 657
- Microscopy of surfaces p. 659
- Surface composition imaging p. 662
- Processing of range images p. 664
- Processing of composition maps p. 668
- Data presentation and visualization p. 669
- Rendering and visualization p. 674
- Analysis of surface data p. 677
- Profile measurements p. 683
- The Birmingham measurement suite p. 687
- New approaches--topographic analysis and fractal dimensions p. 693
- References p. 699
- Index p. 717