

Index

Page numbers in *italics* refer to figures and tables

- abdomen
 - pre-/post-contrast CT 252
 - spatial heterogeneity 3
- acoustic impedance, ultrasound 149
- active shape/appearance
 - model-based delineation
 - methods 220–223
- Aequorea victoria* 172, 173
- aequorin 172, 173
- aging, brain structural changes 266–270, 268
- Akt kinase activity 179
- Akt protein 179
- Allen Brain Atlas 238, 239
- aminocyclopentanecarboxylic acid (ACPC), carbon-11 labeling 204
- analog to digital (A/D) converter 40, 40
- analysis of variance (ANOVA) 212
- anaphylaxis, iodine-induced 184–185
- anatomic correspondence 235
- anatomic localization 232
- anatomy, detailed from merged information 231
- Anger gamma camera/scanner 72–73, 73, 123–124, 124, 127
 - single photon imaging 123
- angiogenesis 270
- annexin V 180
- ApoB100 280
- apoptosis, optical imaging 180–181
- area under the curve (AUC) 102–104
- arterial input function (AIF) 270, 271
- arterial spin-labeled perfusion 271–272
- artificial intelligence 106
- aspartate 285
- astronomy 7–8, 36–37, 82
- atlas building 230
 - brain 231–232
 - image registration 232–236
 - diffusion tensor imaging 233
 - statistical atlases 240–249
- atlas warping 232
- atoms 60–62, 117
 - Bohr model 61
 - energy levels 122
- attenuation 120–121
 - Beer–Lambert law 148–149
 - coefficients 184
 - CT 253
 - PET 121, 121
 - SPECT 121, 121
 - ultrasound 148–149
 - x-rays 136–137, 183, 253
- Audubon, John James 2–3, 4
- automated computer feature extraction 109
- avalanche photodiodes 122–123
- barium
 - double contrast 184
 - x-ray contrast 183–185
- Bayes' rule 310
 - segmentation 312–315
- Bayesian observers 88
- Beer–Lambert law of attenuation 148–149
- beetles, spatial variation 17
- beta decay 117
- bias 86
- binding problem 95–96
- binocular vision 94
- bioluminescence 172, 173
- bioluminescence imaging (BLI) 172–173
 - sensitivity 277–279
 - tumor growth monitoring 174–175
- Bloch equation 161
- block detector 124
- blood flow
 - arterial spin-labeled perfusion 271–272
 - assessment 270–271
 - blood oxygen level determination 272–273
- blood oxygen level dependence (BOLD) 272–273
- blood–brain barrier
 - contrast agents 185
 - radiopharmaceuticals crossing 197
- Bohr atomic model 61
- bone scan, ^{99m}Tc-MDP 199
- boundary-based methods of delineation 219–220
- box-car filter 296, 297, 301
- brain
 - blood oxygen level dependence 272–273
 - evolutionary changes 238
 - function imaging 28
 - imaging 95
 - iodine contrast 186
 - MRI 11
 - structural changes with aging 266–270, 268
- brain atlas construction 231–232
 - anatomic variability 232
 - average morphology 231–232
 - challenges 231–232
 - image registration 232–236
 - volume registering 232
- brain hemorrhage, MRI 260
- brain mapping 230–231
 - Cartesian coordinate system 231
 - MRI 230
 - new technology 236–239
 - RAVENS map 267–268, 268
- brain tumor growth 36
- breast, infrared thermography 56
- breast tumor
 - contrast-enhanced MRI 263
 - see also* mammography
 - bremssstrahlung 133–134
 - bright field microscopy 64
 - brightness 263–264
 - Broad Street pump (cholera epidemic, London) 34
- cancer
 - angiogenesis targeting 270
 - apoptosis imaging 180–181
 - hyperspectral imaging 175
 - molecular beacon imaging 179–180
 - multispectral imaging 175
 - optical imaging in research 174–181
 - post-translational modification monitoring 178–179
 - protein–protein interaction monitoring 178–179
 - stem cell imaging 175, 177

Index

- transcriptional activity measurement 175–178
see also metastases; non-Hodgkin's lymphoma; thyroid cancer; tumor(s)
- carbon-11 203, 204
- carbon-13 289
- cardiac motion tracking 238, 268–270
- carfentanil 205
- carotid artery, Doppler ultrasonography 155
- Cartesian coordinate system 90–91, 111, 261
- brain mapping 231
- morphological analysis 260
- Cartesian geography 34
- Cartesian images 80
- cartography 5–6, 6, 32–36
- measurement 41–42
- morphological analysis 260
- certainty measures 311–310
- change 252
- characteristic radiation 134
- charge capture device (CCD) camera 39–40
- Chi-square statistic, classification tasks 102
- cholera epidemic, London 34
- cholesterol esters 280
- choline, carbon-11 labeling 204
- CHOP therapy 285
- tumor response to treatment 286, 287, 288
- classification tasks 100–104, 102
- coelenterazine 172
- bioluminescence imaging 172–173
- cognition, visual search 96–98
- Collider Detector (Fermilab) 39
- collimators 128
- color detection 91
- color vision 89–90
- communication
- biomedical system 85
 - imaging 82–83
 - spatial information 114
 - theoretical system 84
- Compton scattering 63, 120, 120, 139, 145
- x-rays 136–138
- computed radiography (CR) systems 141–142, 142
- computed tomography (CT) 4, 143, 144–146, 185
- 2D images 72
- 3D images 79–81
- acquisition 146
- brain evolutionary changes 238
- brain scan 37
- contrast agents 185
- data projection 5
- direct/indirect image formation 77
- filtered back-projection 145
- heart 24
- high-resolution 49, 254
- image reconstruction 146
- images 145–146
- linear attenuation coefficient 253
- mouse skull/mandible 255–256
- multiple angular projections 80
- phantom 92
- pre-/post-contrast of abdomen 252
- scanner for PET 121
- spatial information 79–81
- spatial resolution 254–255
- tumor progression 266
- computed tomography (CT) scanners 5, 143, 144
- computer-aided visualization and analysis (CAVA) 98–101, 215
- computerized displays, image data manipulation 98–101
- computers, observers 106–109
- conduction band 122
- constellations 82
- non-scientific imaging 83
- continuous systems 49
- continuous/continuous systems 49
- contrast agents
- blood-brain barrier 185
 - CT 185
 - kidney 185
 - MRA 188
 - MRI 185–194
 - radiographic 183–185
 - radiographic density 184
 - ultrasound 156–157, 156, 157, 158
- contrast-to-noise ratio (CNR) 87–88
- MRI 168
 - x-rays 138–140
- convolution, linear systems 296–297, 301
- copper radionuclides, PET 204–206
- correspondence mapping 237
- Crook's tubes 53
- cumulative distribution function (CDF) 309
- darkness 263–264
- Darwin's finches 26
- decision making
- outcomes 210, 211
 - terminology 211, 211
- delineation of images 218, 219
- active shape/appearance model-based methods 220–223
- fuzzy region-based automatic 221–222
- fuzzy region-based human-assisted 223
- hard region-based automatic 221
- hard region-based human-assisted 222–223
- hybrid strategies 223
- approaches 219–223
- boundary-based methods 219–220
- fuzzy automatic 220
- hard human-assisted 220
- primary 219
- delta function 50, 297–298
- depth
- fixed position monocular clues 94
 - perception 94
- dermatologic disease 8
- image 8
- detectability index 213
- detectors, signal 66–81
- arrangement 69
- field-of-view 69–73
- frequency modulation 73–76
- movement 72
- multiple 72–73
- non-projection spatial signal modulation 73–76
- performance 66–67
- sample size 70–73
- signal sampling 68–69
- signal source 67
- signal-to-noise ratio 67
- spatial resolution 70, 72
- x-rays 78
- diagnostic imaging agents 196
- diffusion equation 294–295
- image analysis 300–301
 - one-dimensional 292–293
- diffusion tensor images
- atlas building 233
 - manifolds 244
 - scalar maps 241–242
- digital images
- analysis 11
 - data characteristics 214–215
 - mammography 263
 - processing 214–229
- digital radiography (DR) detectors 142–143, 142
- digital signals 40, 293
- digital subtraction angiography (DSA) 189
- Dirac delta function 50, 297–298

Index

- discrete Fourier transform (DFT) 302, 304–305
 - inverse 306–307
 - sampling scheme 305
- discrete systems 49
- discrete-time systems 300
- discrimination measurement 210–213
 - ideal observer 213
 - receiver operating characteristic 211–213
 - terminology 211, 211
- discrimination tasks 210
- disease 251
 - prevalence 105
- disorder 84–85
- distortion 86
- distribution
 - entropy 311
 - mean 309
- DNA
 - free radical damage 140–141
 - sample contamination 39
- Doppler shift 152–153
- Doppler signal detection 154
- Doppler ultrasonography 152–154, 154, 158
 - carotid artery 155
- d -prime 213
- dsRed protein 173–174
- echo planar imaging (EPI) 165–166
- edge detectors 261, 300–301
- edge enhancement 98
 - visual processing 97
- eigenfunctions 298–299
- electromagnetic energy 14–16
 - human visual system detection 30
 - waves 14
- electromagnetic field, energy density/flow 52–54
- electromagnetic force 117
- electromagnetic radiation 15, 52–53, 117, 134
 - MRI 59
 - NMR spectroscopy 68
 - signals 52
 - x-rays 133
- electrons 60–62, 117
 - K-shell 134
 - L-shell 134
 - x-ray production 133–134
- electro-stimulation 58
- energy (E) 1–2, 8, 13, 14, 17
 - external source 54–57
 - heating 58–59
 - ionizing radiation 59–62
 - imaging process 38
- incident 65
- ionizing radiation 59–62
- measurement 38–42, 39, 47, 49–51
- metabolism pathways 284
- movement 52–57
- potential 13–14
- propagation 52–57
- requirement for imaging 62
- scientific image 22–25
- sources 16
- spatial distribution 18–19
- thermal 58–59
 - see also* electromagnetic energy
- enhancing filters 217
- entropy 84–85, 86, 311, 311
 - conditional 311
 - edge detectors 261
 - map 314, 315
 - voxels 313–315
- error
 - elimination 42
 - image quality 50–51
 - measurement 42–45, 48, 49
- estimation tasks 105–106
- Euclidean geometry 33, 46–47
 - multidimensional measurements 47
- Euclidean space 46–47
- eye
 - multimodality images 9
 - see also* retina; visual system
- facial recognition 100
- false discovery rate (FDR)
 - comparisons 245
- false positive fraction (FPF) 211, 213
 - receiver operating characteristic 102
- fast Fourier transform (FFT) 305–307
 - algorithm 302, 306
 - inverse 306–307
 - see also* discrete Fourier transform (DFT)
- ferromagnetic materials 191
- Ferumoxytol 192
- fetal imaging 10
 - ultrasound 25
- ^{18}F -fluorodeoxyglucose (FDG) 117, 119–120, 202
 - see also* fluorodeoxyglucose PET (FDG-PET)
- field of view (FOV) 70
 - detectors 69–73
 - MRI 163
 - SPECT scanners 128
- filtered back-projection 145
- firefly luciferase 172–173
 - transcriptional activity
- gadolinium
 - interaction with water molecules 187
 - MRI contrast 186–189, 186, 188, 281
 - MRI signal intensity 270–271
- gadolinium-DTPA 186–189, 186
 - adverse effects 189
- Galileo 36–37, 82
 - moons of Jupiter 35, 36, 84
 - notebook 7
- gallium-67 199–200, 201
- gallium-68 199–200
- gallstones, ultrasound 57, 150

Index

- gamma camera/scanner
 - Anger 72–73, 73, 123–124, 123, 124, 127
 - rectilinear 70–73, 71
 - thyroid cancer 57
- gamma radiation 117
- Gaussian distribution 44
 - function 44–45, 313
- Gaussian filter 297
- Gaussian random variable 42
- Gaussian smoothing 301
- Gd-DTPA *see* gadolinium-DTPA
- general kinetic model 270–271
- geometric descriptors 257
- glutamate 285
 - labeling 289
- glutaminolysis 289, 290
- glycerophosphate shuttle 285–289
- glycolysis 285–289, 290
- gradient echo pulse sequences 165
- gravity 13–14
- green fluorescent protein (GFP) 172, 173, 174
 - fluorescence imaging 173–174
- grids, radiographic 143
- group average forming 245–246
- Gulf Stream, seawater flow 20
- half-life 196–197
- hard boundary-based human-assisted delineation methods 220
- heart
 - cardiac motion tracking 269
 - CT 24
 - SPAMM 269
- heart beats 269
- heart rate 269
- HER-2 receptors 192–194, 194
- high-density lipoprotein (HDL) 281
- high-dimensional data, statistical distribution 244–245
- high-dimensional pattern classification 246–249
 - dimensionality 248
 - receiver operating curve 248–249
 - spatial resolution 248
- high-energy particle accelerator 39
- holography 93
- Hotelling's T-square statistic 245
- Hounsfield units 37, 145–146
- human observers 88–96, 207–213
- hyperspectral imaging 175, 177
- hypothesis testing 11
 - estimation tasks 105–106
- image(s) 2–3, 22
 - color 89–90
- contrast 61
- decomposition 95–96
- definition 13
- hard copy 93
- information
 - content 63
 - spatial representation 91–93
- intensity 301
- interpretation 8–10
- media 32
- perception 31–32
- presentation 93
- processing algorithms 214
- reconstruction process 126
- rectangular object 267
- remote 27
- scale 28
- similarity 235
 - measurement 234
- soft copy 93
- spatial components 90–91
- two-dimensional 48
- volume registration 236–237
 - see also* delineation of images; pre-processing of images; registration of images; scientific images
- image analysis 8–10, 215–216, 228–229
 - diffusion equation 300–301
 - human 99
- image data
 - manipulation 98–100, 101
 - segmentation 313–314
- image formation 71
 - direct/indirect 77–81
 - nuclear medicine 125–126
 - PET 125–126
 - reconstruction algorithms 125–126
- image operations
 - analysis 215–216, 228–229
 - classification 215
 - manipulation 215–216, 228
 - pre-processing 215–223
 - visualization 215–216, 223–228
- image operator performance metrics 51
- image quality 50–51, 100, 207
 - expert opinion 209
 - physical measurement 207–209
 - spatial resolution 209
 - subjective measures 209
 - visibility measures 209
- image-based surface rendering 225–226
- image-based volume rendering 226
- imaging 1
 - 2D projection 79–81
 - communication 82–83
- devices 8, 9
- energy requirement 62
- forward problems 77
- human involvement 10
- inverse problems 77
- measurements 47–48
- process 38
- response to therapy 180
- sample effect on signal 62–81
- imaging system
 - components 207
 - discrimination measurement 210–213
 - fundamental properties 207
 - large-scale transfer characteristic 207–208
 - model 49–51
 - modulation transfer function 126–127, 208, 209
 - real 51–62
 - spatial resolution properties 208
 - task-dependent performance 209–210
 - see also* noise; signal-to-noise ratio
- impulse function 297–298
- impulse response 297–298, 300
- indium-111 198–199
 - radiolabeled antibody 200
- individual patient analysis 246–249
- information 83–85
 - density 96
 - merged 231
 - minimization of mutual 312
 - spatial
 - communication 114
 - representation 91–93
 - transfer 82–83
- information theory 310–312
 - concepts 310
 - evidence evaluation 312
 - quantification of information 311–312
 - segmentation 312–315
- infrared signals 54–57
- infrared thermography, breast 56
- input–output transfer characteristic curve 208
- instrumentation 8
- inverse discrete Fourier transform (IDFT) 306–307
- inverse fast Fourier transform (IFFT) 306–307
- inverse Radon transform 80
- iodinated compounds 201–206, 202
- iodine
 - adverse effects 184–185
 - SPECT contrast 200–206
 - x-ray contrast 183–185, 185, 186

Index

- iodine-123 54, 200–201, 201
- iodine-124 204, 205
- iodine-125 200
- iodine-131 200–201
- ionization detectors 67–68
- ionizing radiation 59–62
- iron oxide contrast 189–194, 191, 192
- isosurfacing 219
- isotopes
 - nuclear medicine 119, 120
 - production for SPECT 119
- iterative expansion technique 127
- kernel-based Fischer discriminant analysis (kFDA) 245
- kernel-based principal component analysis (kPCA) 245
- kidney
 - contrast agents 185
 - spatial heterogeneity 3
 - ultrasound 157–158
- kinetic energy 14
- Kronecker delta function 300
- k*-space 77, 161–165, 163, 302–303, 304
 - coordinates 163
 - high-frequency 304
 - image reconstruction 164
 - low-frequency 304
- labeling grid, cardiac motion tracking 269–270
- Laplace transform 299–300
- large-scale transfer characteristic 207–208
- Larmor frequency 75, 160, 161
 - rotating frame of reference 189–190, 190
- lateral geniculate nuclei (LGN) 95
- Leeuwenhoek's microscope 27
- light
 - microscopy signal 62–63
 - properties 133
 - signal 53–54
 - visible 40
- linear attenuation coefficient 63, 253
- linear shift-invariant systems 49–50, 292, 293, 295–296
 - convolution 297
 - eigenfunctions 299
- linear superposition of filtered back-projection (LSFB) 126
- linear systems 292–300
 - convolution 296–297, 301
 - discrete-time 300
 - impulse function/response 297–298
 - scaling 294, 295
 - signals 293
 - superimposition property 295
- linearity 293–295
- lines of response (LORs) 121
 - oblique 125
 - PET 129–131
- lipoproteins, molecular imaging 279–281
- live-wire method 220, 221
- logarithms 311
- low-density lipoprotein (LDL) 279–281
 - structure 280
- low-density lipoprotein receptor (LDLR) 279–281
- luciferase 172
 - bioluminescence imaging 172–173
 - p53-inducible reporter 176–178
 - split molecule 277
- D-luciferin 173
- lungs
 - anatomical variation 237–238
 - display cutoffs of metastases 267
 - metastases 131, 267
 - motion 238
- machine learning 106
- Macroscopic Prism and Reflectance Imaging Spectroscopy System (MACRO-PARISS) 175, 177
- magnetic resonance angiography (MRA) 108, 188–189, 189
 - contrast-enhanced 188, 189
 - maximum intensity projection 224
 - pseudo-color display 225
- magnetic resonance imaging (MRI)
 - 160–171
 - arterial spin-labeled perfusion 272
 - blood flow assessment 270–271
 - blood oxygen level-dependent (BOLD) 272–273
 - brain hemorrhage 260
 - brain mapping 230
 - brain scan 11
 - cardiac motion tracking 268–270
 - cerebrospinal fluid 222
 - contrast agents 185–194
 - particle size 192–194
 - contrast-enhanced 166–168, 263
 - dynamic 270–271, 271
 - contrast-to-noise ratio 168
 - data sampling/reconstruction 162–165
 - decomposition of data
 - acquisition 305
 - dephasing 189–190
 - diffuse hyperintensities 259
 - diffusion tensor images 232
 - manifolds 244
 - scalar maps 241–242
- dynamic contrast-enhanced 270–271, 271
- echo planar imaging 165–166, 165, 166
- external magnetic field 74–75
- field of view 163
- frequency modulation 73–76
- functional 110
- gadolinium contrast 186–189, 186, 188, 281
 - signal intensity 270–271
- gradient echo pulse sequences 165
- gradient subsystem 168–169
- hardware 168–169
- image contrast 167
- image resolution 166–168
- iron oxide contrast 189–194
- k*-space 77, 161–165, 163
 - co-ordinates 163
 - image reconstruction 164
- live-wire method 220, 221
- longitudinal 268
- magnet 168–169
- magnetic field strength 169–170
- magnetization 160, 161
- molecular imaging 279
- noise 169–170
- Nyquist criterion 163
- orbit 169
- phase angle 189–190
- proton density-weighted 218
- protons 185–186
- pulse sequence 188–189
- radiofrequency pulse 166–167, 185–186
- radiofrequency transmit/receive assembly 168–169
- relaxation 74–76, 187–188
- rotating frame of reference 189–190
- scan acquisition speed 165–166
- segmentation 314–315
- sensitivity 277–279
- signal 160–161, 253
 - characteristics 46
 - intensity 247
 - specificity for brain hematoma 262
- signal-to-noise ratio 167–168, 169–170
- spatial encoding 161–165
- spatial frequency 162–163
- spin echo sequence 89, 166–167, 170
- spin warp pulse sequence 163
- thermal energy 59
- time (T_1 and T_2) constants 186, 187–188, 190–192
- tissue resistance 169–170
- T*-weighted images 166–167, 167
- T_1 -weighted images 89, 168, 281, 314

Index

- ventilation–perfusion ratio
 - mapping 237
 - voxels 167–168
 - whole body scan 76
- magnetic resonance spectroscopy (MRS) 279, 284
 - clinical outcomes 114
 - phospholipid metabolite detection 282–290
- magnetite 190, 192, 193
- magnetization 160, 161, 162
 - ferromagnetic materials 191
 - longitudinal 161
- magnocellular system 95, 99
- malate–aspartate shuttle 285–289
- mammography 83
 - communication system 85
 - digital images 263
 - high-resolution digital monitors 96
- manifolds 243–244
 - statistical analysis 244, 246
- manipulation of images 215–216, 228
- mapping 41–42
 - correspondence 237
- maps 6
 - thematic 35–36
- margins, morphological analysis 260, 260
- marker genes 277
- Mars, telescopic images 55
- mass (m) 1–2, 8, 13, 14, 17
 - force 13–14
 - imaging process 38
 - measurement 38–42, 47, 49–51
 - scientific image 22–25
 - spatial distribution 18–19
- mass spectrometry 58, 58
- maximum intensity projection (MIP) 98–101, 106–107, 225
 - magnetic resonance angiography 224
- maximum-entropy evaluation of experimental evidence 312
- m,E dimension 47–48
 - see also* energy (E); mass (m)
- m,E signal 52
 - directionality 63–65
 - measurement 51–52
 - propagation 63–65
- mean of distribution 309
- measurement 41
 - confounding signals 49
 - energy (E) 38–42, 39, 47, 49–51
 - error 42–45, 48, 49
 - imaging 47–48
 - location 47
 - mapping 41–42
 - mass (m) 38–42, 47, 49–51
- m,E dimension 47–48
- m,E signal 51–52
- multidimensional 45–47
- noise 49
- numerical 41
- principles 38–42
- spatial definition 48
- spatial localization 52
- time 47
- types 41
- variability 42–45, 48
- variables 45–46
- mechanical index (MI) 154–155
- memory, visual search 96–98
- metastases
 - lung 131, 267
 - optical imaging 174–175
- microbubbles, ultrasound contrast 156–157, 156
- microscopy 27
 - bright field 64
 - light signal 62–63
 - phase contrast 64
- minimization of mutual information 312
- minimum description length
 - interference 312
- modulation transfer function (MTF) 126–127, 208, 209
- molecular beacon imaging 179–180, 180
 - split luciferase molecule 277
- molecular imaging 252–254, 275–290
 - coordinates 278
 - lipoproteins 279–281
 - microbubbles 156
 - MRI 279
 - nanoparticles 275, 279–281
 - prediction and early detection of therapeutic response 282–290
 - signals 277–279
 - targets 275, 276
 - tissues 279
- Montreal Neurological Atlas 111
- moons of Jupiter 35, 84
- morphological analysis 255–264
 - brightness 263–264
 - darkness 263–264
 - descriptors 256–257
 - margins 260, 260
 - pattern matching 255
 - position 260
 - shape 259–261, 259
 - signals 261–264
 - texture 264
 - volumetric 259
- morphological imaging 251–264
 - spatial dimensions 254
 - spatial resolution 254–255
- morphological variability 111–112
- morphology 251
 - average of brain 231–232
- morphometric analysis 114
- morphometry, voxel-based 268
- mouse skull/mandible, CT 255–256
- multidimensional displays 92
- multimodality 46
 - statistical analysis of data 243–245
- multiparametric data, statistical analysis 243–245
- multi-reader multi-case (MRMC) program 212
- multispectral imaging, tumor vasculature 175, 176
- nanoparticles 275, 279
 - lipoproteins 279–281
- Napoleon’s Russian Campaign, Minard’s graphic 91, 93
- nature *see* universe
- near-infrared fluorophores 275
- near-infrared imaging sensitivity 277–279
- negative predictive values (NPVs) 104
- neuroreceptors/neurotransmitters, PET 278–279
- neutrons 60–61, 117
- nitrogen-13 203–204
- noise 49, 85–88, 208
 - images 87
 - signals 87
 - suppression 98
 - task performance 100
 - visualization 87
 - see also* contrast-to-noise ratio; signal-to-noise ratio
- non-Gaussian distribution 45
- non-Hodgkin’s lymphoma MRS 284
 - treatment 284–285, 284
- non-projection spatial signal modulation 73–76
- nuclear factor- κ B (NF κ B) 178
- nuclear force 117
- nuclear imaging
 - biomedical 54–57
 - signal source 117–120
- nuclear magnetic resonance (NMR)
 - (NMR) 76
 - k -space 161–162
 - signal 160
- nuclear magnetic resonance (NMR) spectroscopy
 - carbon-13 spectra 289
 - irradiating RF signal 67–68

Index

- nuclear medicine 118, 131
 - attenuation 120–121
 - Compton scattering 120, 120
 - gamma production by isotopes 120
 - image formation 125–126
 - isotopes 119
 - gamma production 120
 - iterative expansion technique 127
 - photoelectric effect 120, 120
 - physics 117
 - scanner design 127–131
 - series expansion technique 127
 - signal detection 121–125
 - signal/sample interaction 120
 - transform algorithms 126–127
- nuclear molecular labeling 196–206
 - principles 196–197
- nucleus 117
 - decay 117–119
 - forces 117
- nuclides 61
- Nyquist criterion 163, 252, 254
 - discrete Fourier transform 305
- Nyquist sampling theorem 29
- Nyquist spacing 304–305
- object classification 98–100, 101
 - fuzzy connectedness 103
 - human observer feature extraction 106
 - ROC analysis 103
 - voxel thresholding 108
- object contrast 262–263
- object edges 267
- object signal 262–263
- object-based surface rendering 227, 227
- object-based volume rendering 227, 227
- observers 29–32, 88
 - characteristics 88
 - classification tasks 100–104
 - computers 106–109
 - human 88–96, 207–213
 - ideal 213
 - image presentation 93
 - multidimensional data 91–93
 - pattern extraction 100
 - perception 88–90
 - spatial components of images 90–91
 - task performance 100
 - visual system 29–30, 88–90
- optic chiasm 95
- optical imaging 172–181
 - bioluminescence imaging 172–173
 - cancer research 174–181
 - fluorescence imaging 173–174
 - tumor growth monitoring 174–175
- orbit, MRI 169
- order 84
- ordered subset expectation maximization (OSEM) algorithm 127
- oxidative metabolism 289
- oxygen
 - blood oxygen level determination 272–273
 - consumption rate measurement 290
 - oxygen-15 204
- p53-induced optical reporter 176–178, 178
- pair production 63, 120
- parallax 92–93
- parallel image processing 98
 - human 99
- parallel imaging 73
- Parkinson's disease, fluorine-18 DOPA scan 203
- partial volume effect 71
- parvocellular system 95, 99
- pattern analysis and recognition system 246–248
- pattern building 256
- pattern classification, high-dimensional 246–249
 - dimensionality 248
 - receiver operating curve 248–249
 - spatial resolution 248
- pattern extraction 100
- pattern learning 101
 - visual search 96–98
- pattern matching 256
 - computerized 109
 - facial recognition 100
 - morphological analysis 255
 - radiology 101
- perception
 - human 88–90
 - images 31–32
- phase contrast microscopy 64
- phosphatidylserine 180
- phospholipid metabolites, MRS detection 282–290
- photoacoustic imaging 68
- photocathode, quantum efficiency 122
- photodynamic therapy 275–277
- photoelectric absorption (PEA) 184
- photoelectric effect 63, 120, 139, 145
 - absorption 120
 - x-rays 136–137
- photomultiplier tubes 122–123
 - Anger detector 123
 - collimated 72–73
- photons 14, 16
 - emission from green fluorescent protein 173–174
 - radionuclide decay 65
 - x-rays 184
- photopic vision 89–90, 89
- photoreceptors 30
- photostimulable phosphor (PSP) plate 142
- physiological imaging 251–252, 265–274
 - arterial spin-labeled perfusion 271–272
 - blood flow assessment 270–271
 - blood oxygen level determination 272–273
 - brain structural changes with aging 266–270
 - cardiac motion tracking 268–270
 - change detection in special dimensions over long time scale 265–268
 - dynamic contrast-enhanced MRI 270–271
 - tumor response assessment 265–266
- piezoelectric crystals 57
 - ultrasound 147, 149–150
- pixels, artistic 25
- point response function (PRF) 50–51, 51
- point spread function (PSF) 51, 126–127
- position analysis 260
- positive predictive values (PPVs) 104
- positron emission tomography (PET) 117
 - attenuation 121, 121
 - camera 124
 - carbon-11 203
 - carbon-11 labeled thymidine 205
 - clinical outcomes 114
 - coincidence measurement 129
 - copper radionuclides 204–206
 - CT scanner 121
 - data corrections 129
 - fluorine-18 202–203
 - fluorodeoxyglucose 117, 119–120, 202–203, 203
 - gastrointestinal tumor 204
 - image formation 125–126
 - iodine-124 204, 205
 - isotope production 119
 - lines of response 129–131
 - lung metastases 131
 - neuroreceptors 278–279
 - neurotransmitters 278–279
 - nitrogen-13 203–204
 - oxygen-15 204

Index

- radiolabeled tracers 119, 197, 202–206, 202
- radiometals 204–206
- rubidium chloride 206
- scanners 128–129, 129
 - time-of-flight 129–131, 130
- scintillation detectors 124, 125, 125
- sensitivity 277–279
- signal 253
- post-translational modification
 - monitoring 178–179
- potential energy 13–14
- predictive values, disease
 - prevalence 105
- pre-processing of images 102, 215–223
 - delineation 218, 219
 - approaches 219–223
 - primary 219
 - filtering 216–217
 - interpolation 216
 - image-based 216
 - object-based 216
 - recognition 218, 219
 - human-assisted 219
 - registration 217–218
 - segmentation 218–219
- principal component analysis, kernel-based (kPCA) 245
- probability 43–45
 - Bayes' rule 310
 - conditional 308
 - entropy of distribution 311
 - interpretation 309
 - uncertainty quantification 311–310
- probability density function (PDF) 43, 297–298, 309
 - parameters 43
- probability distribution 43–44, 46
- probability theory 308–310
 - concepts 308–309
- product rule 308
- projection imaging, visible light 75
- promoter activity 175–178
- prostate, ultrasound imaging 157–158
- protein–protein interaction
 - monitoring 178–179
- protons 60–61, 117
 - magnetic perturbation 187
 - MRI 185–186
- Ptolemy 33
- pulse repetition frequency 153
- p*-value maps 245
- quantum efficiency (QE) 122
- radiant energy 14, 16
- radiocarbon dating, natural 56
- radiofrequency (RF) field 160–161
 - MRI 185–186
- radiofrequency (RF) pulse 161, 166–167
 - cardiac motion tracking 269
 - signal modulation 75
- radiographic density, attenuation
 - coefficients 184
- radiography, x-ray signal detection 141–143
- radioiodine *see* iodine
- radiolabeled tracers 119
 - PET 202–206
 - SPECT 119, 197–206, 197
- radiology procedures, effective doses 141
- radiometals, PET 204–206
- radionuclides
 - half-life 196–197
 - PET 119, 197, 202
 - SPECT 119, 197–206, 197
- radiopharmaceuticals 196
 - blood–brain barrier crossing 197
 - iodinated 201–206, 202
 - lipophilicity 197
 - organic solubility 197
 - specific activity 197
 - technetium-99m labeled 200
 - water solubility 197
- RadLex lexicon 256, 259
 - margins 260
 - morphological characteristic 257
 - shape 259
 - size modifiers 258
- Radon transform 145
 - inverse 80
- randomness 84
- RAVENS map 268
 - brain structural change assessment 267–268
- RCHOP therapy 285
 - tumor response to treatment 286, 287, 288
- receiver operating characteristic (ROC)
 - analog systems 105
 - bias 212
 - classification tasks 102–104, 104
 - computer-extracted feature 110
 - detectability 212
 - digital systems 105
 - discrimination measurement 211–213
 - high-dimensional pattern classification 248–249
 - index of detectability 213
 - localized quantitative analysis 107
 - manually extracted features 107
 - methodology 212–213
- RECIST criteria 266, 266
- recognition of images 218, 219
 - human-assisted 219
- reconstruction algorithms, nuclear medicine images 125–126
- dsRed protein 173–174
- reflective imaging 74
- refraction, ultrasound beam 149
- region of interest (ROI)
 - analysis 113
 - scalar maps 242
- registration of images 232–236, 233
 - anatomic labeling 113
 - elastic deformation 235–236
 - image similarity measurement 234
 - image volume 236–237
 - information use 313
 - minimization of mutual information 312
 - multimodality study fusing 236
 - new technology 236–239
 - ROI analysis 113
 - smoothness constraint 234
 - solution estimation 234–235
 - standard template 113
 - volume 236–237
- Renilla* luciferase 172–173
- reproducible kernel Hilbert space (RKHS) 245
- respiratory motion 238
 - cardiac motion tracking 269
- retina 30, 89–90, 89
 - image decomposition 95
- Roentgen, Conrad 4
- Rose–Burger phantom 209, 209, 210–212
- rotating frame of reference (RFR) 189–190
- rubidium chloride 206
- scalar maps
 - diffusion tensor images 241–242
 - regions of interest 242
 - statistical analysis 241–242
 - statistical parametric mapping 242
- scaling, linear systems 294, 295
- scan acquisition speed, MRI 165–166
- scanner design, nuclear medicine 127–131
- scanners
 - PET 128–129
 - time-of-flight 129–131
 - SPECT 127–129
- scenes 17–22
 - scientific images 25–29

Index

- science 1
- scientific images 22
 - analysis 4, 8–10
 - content 22–29
 - Darwin’s finches 26
 - energy 22–25
 - interpretation 8–10
 - mass 22–25
 - measurement 4
 - observers 29–32
 - scenes 25–29
 - space 25–29
 - spatial information 4–6
- scintillation detectors 121–122
 - performance 125, 125
 - PET 124, 125, 125
 - SPECT 125
- scotopic vision 89–90, 89
- seawater flow 20
- segmentation 312–315
 - algorithms 98–101, 101, 314
 - application 314–315
- self-preservation, visual tools 93–95
- serial projection imaging 71
- series expansion technique 127
- shape analysis 217, 259–261, 259, 260, 261
 - shape model-based boundary segmentation 221
- shape-based interpolation 217
- Shepp–Logan phantom 304
- sifting 298
- signal(s) 39–40
 - confounding 49
 - dependence on imaging modality 262
 - digital 293
 - electromagnetic radiation 52
 - external 54–57, 65
 - image quality 50
 - infrared 54–57
 - intensity 65, 313–314
 - intrinsic 65–66
 - light 53–54
 - linear systems 293
 - magnetic resonance 160–161
 - m,E 51–52
 - modified 65–66
 - molecular imaging 277–279
 - sensitivity/specificity 252–253
 - morphological analysis 261–264
 - movement 63–65
 - noise 87
 - non-projection spatial modulation 73–76
 - nuclear magnetic resonance 160
 - object 262–263
- propagation 63–65, 64
 - relating to function 265
- sample effect 62–81
- sampling detectors 68–69
- scattered 65
- source 53–54, 53, 64–65
 - detector design 67
 - nuclear imaging 117–120
- ultrasound 147–148
 - detection 149–151
 - source 57, 147–148
 - spatial encoding 150–151
- x-rays 133–136
 - quantification 138
 - source 133–136
- signal detection 66–81, 66, 121–125, 213
 - theory model 210–211, 213
 - two-alternative forced choice 210–211
 - ultrasound spatial encoding 150–151
 - x-rays 141–143
 - yes–no decision 210
- signal/sample interaction 57–58, 58, 66
 - nuclear medicine 120
 - ultrasound 148–150
 - x-rays 136–141
- signal-to-noise ratio (SNR) 87, 207, 208–209
 - detectors 67
 - MRI 167–168, 169–170
 - x-rays 138
- single photon emission tomography (SPECT) 117
 - Anger detector 123–124
 - attenuation 121, 121
 - collimator arrangements 128
 - field of view 128
 - gallium-67/-68 199–200
 - indium-111 198–199
 - iodine 200–206
 - isotope production 119
 - principles 197
 - radiolabeled tracers 119, 197–206, 197
 - scanners 127–129
 - scintillation detectors 125
 - sensitivity 277–279
 - technetium-99m 197–206
- single photon imaging 123
 - collimators 128
 - smoothing 300–301
 - Gaussian 301
 - Snow, John 35–36
 - sonoelastography 158
 - space 4–6, 17–22
 - scientific images 25–29
- spatial analysis 109–112
 - quantitative 113
- spatial attractors, human 97
- spatial encoding, x-rays 143–144
- spatial frequency 162–163
- spatial heterogeneity 2, 61
- spatial homogeneity 61
- spatial independence, imaging modality 262
- spatial information
 - communication 114
 - representation 91–93
- spatial labeling 109–112
- spatial measurements 8
- spatial modulation of magnetization (SPAMM) 269
- spatial normalization 111–112
- spatial patterns 18
 - non-random 85
- spatial representation of information 91–93
- spatial resolution
 - bar pattern 209
 - CT 254–255
 - detectors 70, 72
 - full width at half maximum 51
 - image quality 209
 - metric 90
 - morphological imaging 254–255
- spatial variation 17
- speckle, ultrasound 151
- statistical analysis
 - high-dimensional data 244–245
 - manifolds 244, 246
 - multimodal data 243–245
 - multiparametric data 243–245
 - scalar maps 241–242
- statistical atlases 240–249
 - group analysis 241
 - group average forming 245–246
 - high-dimensional pattern classification 246–249
 - individual patient analysis 246–249
 - multiparametric statistics 241
 - statistical analysis scalar maps 241–242
 - uses 240
- statistical decision theory 210, 211
- statistical distribution, high-dimensional data 244–245
- statistical parametric mapping (SPM) 107–109, 242
- stereopsis 94
- superimposition property of linear systems 295
- superparamagnetic iron oxide (SPIO) 192–194, 194

Index

- superparamagnetic magnetite 190
 support vector machine (SVM)
 analysis 109
 suppressing filters 216–217
Système International (SI) units 41
 systems 292–293
 mathematical 292–293
 natural 292
 transfer functions 299–300
 see also imaging system; linear systems
- Talairach Brain Atlas 111, 231
 morphological analysis 260
 Talairach Cartesian coordinate system 261
 task performance 100, 112–114
 task-dependent performance 209–210
 technetium-99m 117, 118
 bone scan 199
 chelating agents 198, 199
 production 198
 radiopharmaceuticals 200
 SPECT 197–206
 technology assessment 112–115
 temperature, continuous ratio
 measurement 42
 templates, deformation field 114
 temporal bone, high-resolution CT 254
 tensors 243–244
 teratoma, ultrasound 148
 texture, morphological analysis 264
 thermal energy 58–59
 thermodynamics, laws of 84
 thermography 54–57, 59
 thin-film transistor (TFT) array 142–143
 threshold analysis 106–107
 thresholding 219
 voxels 108
 thymidine, carbon-11 labeling 205
 thyroid, ultrasound 152
 thyroid cancer
 gamma camera scan 57
 iodine-123 diagnostic scan 201
 time
 images as function of 265
 long-scale change detection 265–268
 physiological imaging 252
 wave properties 15
 time-gain compensation, ultrasound 151
 time-of-flight (TOF) scanners 129–131, 130
 tissues
 ischemic and voxel classification 112
 molecular imaging 279
 probabilistic classification 112
- tomography 143
 reconstructions 80
 x-rays 144–146
 see also computed tomography (CT)
 tracers 196
 transcriptional activity measurement 175–178
 transfer functions of systems 208, 299–300
 transferrin receptor 192–194
 transform algorithms, nuclear medicine 126–127
 tricarboxylic acid (TCA) cycle 285, 290
 true positive fraction (TPF) 211, 213
 observer performance 211
 receiver operating characteristic 102
 tumor(s)
 ATP production 289
 metabolic pathways 282–290
 tumor assessment
 blood flow measurement 270
 physiological imaging 265–266
 size 265–266
 tumor growth
 brain 36
 monitoring 174–175
 optical imaging 174–175
 RECIST assessment 266, 266
 WHO assessment 266
 tumor response to treatment 286, 287, 288
 assessment by physiological imaging 265–266
 tumor vasculature imaging 175
 multispectral 175, 176
 two-alternative forced choice 210–211
- ultra-small paramagnetic iron oxide (USPIO) 192, 193
 ultra-small magnetic particles 193
 ultrasound 147–158
 acoustic impedance 149
 acoustic power 151, 154
 applications 157–157
 attenuation 148–149
 bicornuate uterus 153
 biological effects 154–156
 cardiac motion tracking 268–270
 cavitation 154–155
 contrast agents 156–157, 156, 157, 158
 curvilinear array 149–150
 Doppler 152–154, 154, 158
 carotid artery 155
 dynamic range 151–152
 echo amplitude 149–150, 150
 energy reflection 149
- energy transmission 149
 far field 151
 fetal 25
 future developments 157–158
 gallstones 57, 150
 generation 148
 gray-scale images 31, 90, 150
 high-frequency 157–158
 high-frequency, high-resolution scanners 157
 hyper-/hypoechoic areas 150
 image contrast 151–152
 kidney 157–158
 linear array 149–150
 Mechanical Index 154–155
 microbubbles 156–157
 miniaturization of equipment 158
 MRI-guided thermal ablation of uterine fibroid 60
 near field 151
 pathologic areas 158
 piezoelectric crystal 147, 149–150
 prostate vascularity 157–158
 refraction 149
 secondary mechanical effects 154–155
 signals 147–148
 detection 149–151
 source 57, 147–148
 spatial encoding 150–151
 signal/sample interactions 148–150
 spatial resolution of images 150–151
 speckle 151
 teratoma 148
 thermal effects 154
 thermal energy 59
 thyroid 152
 time-gain compensation 151
 transducers 151–152, 154
 waves 148
- unit impulse function 297–298
 universe 1–3, 17–22, 21, 82, 251
 discontinuous 20–22
 Newtonian 19–20
 spatial heterogeneity 2
- uterus
 bicornuate 153
 ultrasound thermal ablation of fibroids 60
- valence band 122
 variability 42–45
 measurement 48
- variables, measurement 45–46
 vector analysis 106
 velocity 13
 Visible Human Project 231

Index

visible light 40
projection imaging 75
visual pathways, parvocellular/magno-cellular 99
visual processing, edge enhancement 97
visual psychophysics, human 93–96
visual system
 energy detection 30
 evolution 93–95
 human 30, 89, 98
 observers 29–30, 88–90
 search 96–100
 self-preservation tools 93–95
 temporal resolution 30–31
visualization of images 215–216, 223–228
challenges 228
image-based methods 223–226
image-based surface rendering 225–226
image-based volume rendering 226
maximum intensity projection 225
modes 102
object-based methods 226–228
object-based surface rendering 227
object-based volume rendering 227
slice mode 224
volume mode 224–226
 voxel projection 226
VisualSonics Vevo 770 157
volumetric analysis 259
voxel-based morphometry 268
voxel-based statistics 106

voxels
 classification 111, 313–315
 ischemic tissue 112
 entropy 313–315
 projection 226
 segmentation 313–314
 signal patterns 234
 spatial analysis 109
 thresholding 108
water, free radical formation 140–141
wavelength 14
x-ray(s) 133–146, 183
 2D projection views 79
 adverse biological effects 141
 anodes 135
 atomic number of tissues 183
 attenuation 136–137, 138, 183
 barium contrast agent 183–185
 bremsstrahlung 133–134
 characteristic radiation 134
 Compton scattering 136–138, 139, 145
 computed radiography systems 141–142
 contrast agents 183–185
 contrast-to-noise ratio 138–140
 detection 78
 digital radiography detectors 142–143
 effective doses 141, 183
 electromagnetic radiation 133
 electron interactions 133–134
 electron-electron interactions 140–141
 generation 53

image production 77–79
interactions with matter 139
iodine contrast agent 183–185
ionization dose 183
linear attenuation coefficient 183, 253
magnification 143–144
mass attenuation coefficients 138
photoelectric effect 136–137, 139, 145
photons 184
pixel values 140
production 136
projection 78, 143–144
projective geometry 143–144
propagation 135
properties 133
radiation dose 141
radiographic grids 143
Roentgen's wife's hand 4
sample effect on signal 136–140
signal 133–136
 detection 141–143
 effect on sample 140–141
 quantification 138
 source 133–136
signal/sample interaction 136–141
signal-to-noise ratio 138
spatial encoding 143–144
thoracic 145
tissue interaction 63
tomography 143, 144–146
x-ray generators 136
x-ray tubes 133, 134–135, 137
 components 134–135
 heat management 135