Cambridge University Press 978-1-107-15978-5 — Fundamentals of Medical Imaging Paul Suetens Index More Information

# Index

absorbed dose (D), 28-30 absorption efficiency, 19 acoustic impedance (Z), 148, 154, 156 acoustic intensity, wave propagation, 149, 150 acoustic pressure, wave propagation, 148-152 acoustic wave physics, ultrasound imaging, 147-156 acoustic window, 157, 171 acquisition time (TA) blood flow and tissue deformation, ultrasound, 165-166 magnetic resonance imaging, 89 multi-slice imaging, 89 parallel magnetic resonance imaging, 91 three-dimensional MRI, 88, 89 ultrasound imaging, 158 active appearance model, 211 active matrix flat panel detector, 21-22 active shape models, 211-213 ADC, see apparent diffusion coefficient ALARA, radiation dosage, 30-31 aliasing, see also artifacts CT artifacts, 56 CT sampling, 34, 44 MRI artifacts, 107 MRI sampling, 106 parallel MRI, 91 ultrasound artifacts, 168-170 ambient light, surface rendering, 226-228 A-mode transmission imaging, 156-157 Anger scintillation camera, 120 angiography, 25, 27, 31 computed tomography (CTA), 64, 69 magnetic resonance angiography (MRA), 96-99 subtraction angiography, 5-7 three-dimensional rotational angiography (3DRA), 24-27 angular momentum, magnetic resonance imaging, 71-74 anode, X-ray tube, 15 anti-scatter grid in radiography, 23-24 in CT, 35, 59 apparent diffusion coefficient (ADC), diffusion imaging, 101, 102 apparent diffusion tensor, 101-102 arterial spin labeling (ASL), 99-100 artifacts automated image computing, 185 computed tomography, 56-58 digital images, 3, 24

MRI image quality, 107, 108, 110 nuclear medicine, 132-134 ultrasound imaging, 168-170 ASL, see arterial spin labeling (ASL) augmented reality, 242-248 avalanche photodiodes (APD) nuclear medicine, 124 PET-MRI hybrid imaging, 140 averaging linear filter, 8-13 multi-image noise reduction, 5-6 axial scanning cardiac applications, 49-50 circular computed tomography, 44 axial transverse tomography, 33-34 axial volume scan, cardiac imaging, 49-50 backprojection fan-beam filtered backprojection, 34, 42 - 44filtered backprojection, 39-42 image reconstruction, 38-39 projection theorem, 39-40 time-of-flight PET (positron emission tomography), 137-138 backscatter, 154, 155 back-to-back symmetric bipolar pulses, moving spin dephasing, 95 barium fluoroscopy, 25, 27 Bayesian approach iterative reconstruction, 47-48 model fitting, 198-216 nuclear medicine, 128 beam hardening, 24–26 computed tomography, 56 becquerel unit (Bq), 122-123 beta (β)-particles, nuclear medicine, 121 - 123bias field, MRI image quality, 107, 108, 110 biomarkers, automated image computing, 195-199 bipolar pulses back-to-back symmetric pulses, 95 phase-contrast (PC) MRA, 97-98 blood flow acquisition and reconstruction time, 165-166 ultrasound imaging, 159, 160, 165, 166, 176, 178, 180, 182 blood oxygenation level dependent imaging (BOLD), 102-104 blooming artifact, computed tomography, 58-63 B-mode imaging, 157-160

bremstrahlung, 15 brightness, color, 1, 4, see also B-mode imaging Brownian motion, diffusion imaging, 100 - 102cardiac imaging augmented reality, 242-245, 247 computed tomography, 49-50 electron beam tomography, 62-63, 65 ultrasound imaging, 174, 180 CASL, see continuous arterial spin labeling cathode, X-ray tube, 15 celestial mechanics, 71, 72 CE MRA, see contrast-enhanced (CE) magnetic resonance angiography central slice theorem, see projection theorem CF Doppler, see color flow Doppler characteristic radiation, 15-17 chemical shift, 73-74 chemical shift imaging (CSI), 93-94 MRI artifacts, 108, 109 phase-based imaging, 92-94 susceptibility-weighted imaging (SWI), 93 Ci, see curie unit circular computed tomography, 44-45 cardiac applications, 49-50 circular cone-beam reconstruction, 46-47 CNR, see contrast-to-noise ratio coherent scattering, 17 coil sensitivity, 91 collimation, nuclear medicine, 125 collimator resolution, nuclear medicine, 131 color Doppler, 163-165 data acquisition, 159-160 image reconstruction, 163-165 color flow Doppler, 164 compression waves, 147 Compton scatter, 17-18, 51-55 nuclear medicine, 126, 129, 130, 132 computed tomography angiography (CTA), 54, 64, 69 computer-assisted intervention, 222 cone-beam collimators, nuclear medicine, 129 dedicated CT scanners, 42-44, 62 volumetric computed tomography, 46

BOLD, see blood oxygenation level

dependent imaging

Boltzmann's constant, 107

Cambridge University Press 978-1-107-15978-5 — Fundamentals of Medical Imaging Paul Suetens Index More Information

tore information

### Index

continuous arterial spin labeling (CASL), continuous wave (CW) Doppler aliasing, 168-170 axial resolution, 167-168 data acquisition, 159-160 image reconstruction, 161-162 lateral and elevation resolution, 167-169 contouring, digital images, 2 contrast, 23 computed tomography, 56 digital image, 2-4 of film, 19-20 magnetic resonance imaging, 105, 106 in nuclear medicine, 131 ultrasound imaging, 168 contrast agents MRI, 99, 112-113 X-ray imaging, 26-27, 50, 52, 54 contrast echography, 177, 182 contrast-enhanced (CE) magnetic resonance angiography, 97, 99 contrast-to-noise ratio (CNR), digital image, 3 conversion efficiency, 19 convolution continuous wave Doppler, 161 fast imaging MRI, 90 filtered backprojection, 41 linear filters, 8 count rate, nuclear medicine, 126 cross-correlation, linear filter, 8-13 cross-talk, multi-slice MRI, 89 CSI, see chemical shift imaging CT, see computed tomography CT dose index (CDTI), 65-67, 70 CT number, 34 CTA, see computed tomography angiography curie unit (Ci), 122-123 curve fitting basic models, 204-205 deterministic flexibility modeling, 209-212 flexible models, 208-213 probabilistic flexibility modeling, 211-213 CW Doppler, see continuous wave (CW) Doppler D, see absorbed dose data classification/regression automated image computing, 189, 192 - 198pixel labeling, 192-195 DCE-MRI imaging, see dynamic contrast-enhanced magnetic resonance imaging deoxyhemoglobin, functional magnetic

resonance imaging, 102–103 dephasing phenomena diffusion imaging, 100–102 moving spins, 94–96

phase-based imaging, 92-94

static spins, 84 depth cueing, surface rendering, 228, 229 derivative filters, 9-13 detective quantum efficiency (DQE), 22, 24 deterministic modeling automated image computing, 188 curve fitting, 209-212 flexible model fitting, 206-208 graph matching, 213-214 deterministic radiation effects, 28 difference of Gaussians (DoG), 9 differential operators edge detection, 189, 191 linear filters, 9–13 diffraction interference, 149, 150 scattering patterns, 154, 155 diffuse reflection, surface rendering, 226-228 diffusion coefficient, diffusion imaging, 101, 102 diffusion imaging, 100-102, 112, 115, 117-119 diffusion tensor imaging (DTI), 101-103 digital mammography, 24, 26, 29 dimensionality reduction, pattern recognition, 195-198 direct Fourier reconstruction, two-dimensional imaging, 40 direct X-ray conversion, 22 photon counting detectors, 36 discrete backprojection, 38-39 discrete convolution operators, linear filters, 9-13 DoG, see difference of Gaussian Doppler effect, wave propagation, 154 - 156Doppler tissue imaging (DTI), 163-165 Doppler ultrasound axial resolution, 167-168 color Doppler, 159-160 continuous wave (CW) Doppler, 159-160 historical evolution of, 147 pulsed-wave (PW) Doppler, 159-160 DQE, see detective quantum efficiency drive fields, magnetic particle imaging, 103-105 DSC MRI, see dynamic susceptibility contrast-enhanced (DSC) MRI DSR, see dynamic spatial reoconstructor DTI, see diffusion tensor imaging; Doppler tissue imaging dual-energy CT (DECT), see multi-energy computed tomography dual-source computed tomography, 44 cardiac imaging, 49-50 dynamic computed tomography, 49-51 dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI), 99, 116, 118, 140, 141, 143 dynamic equilibrium net magnetization vector of matter, 74-75

relaxation, 76-78

dynamic focusing, 172 dynamic programming,  $F^*$  algorithm, 213 - 215dynamic reference frame, intraoperative navigation, 236-238, 244 dynamic spatial reoconstructor (DSR), 61, 64,65 dynamic susceptibility contrast-enhanced (DSC) MRI, 99-100 E, see effective dose EBT, see electron beam tomography EC, see electron capture echogenic reflection, ultrasound imaging, 168 echo planar imaging (EPI), 90, 91 blood oxygenation level dependent imaging, 102-103 diffusion imaging, 100-102 echo time (TE), 84, 90, 105-107, 110 echo train length (ETL), multiple echoes per excitation, 90 edge detection curve fitting, 204–205 low-level automated image computing, 189, 191 edge enhancement, unsharp masking, 10 - 13effective dose (E), 28-30 eigenvalue decomposition, diffusion tensor imaging, 101-102 eigenvectors/eigenfaces/eigenimages/ eigenshapes model fitting, 202-203 pattern recognition, 195-198 elasticity imaging blood flow and tissue deformation, 176 Doppler data acquisition, 159-160 image reconstruction, 164, 167 elastography, see elasticity imaging electromagnetic spectrum, 16 electromagnetic waves, X-rays as, 15 electron beam tomography (EBT), 62-63, 65 electron capture (EC), 121 electron ( $\beta^{-}$ ) emission, nuclear medicine, 121 elevation resolution, ultrasound imaging, 167-169 EM algorithm, see expectation-maximization algorithm energy integrating detectors, 35 energy resolution, nuclear medicine, 126 energy separation, multi-energy CT, 54 envelope detection, ultrasound imaging, 157, 161 EPL, see echo planar imaging equivalent dose  $(H_T)$ , 28–30 ETL, see echo train length excitation field, magnetic particle imaging, 103-105 expectation-maximization (EM) algorithm, 129, 130, 132 unsupervised learning, 193-195

RF field disturbance, 75-76

Cambridge University Press 978-1-107-15978-5 — Fundamentals of Medical Imaging Paul Suetens Index More Information

exponential decay, nuclear medicine, 122 - 123exposure (E) of film, 20 FA, see fractional anisotropy F\* algorithm, graph matching, 213–214 fan angle, 42 fan-beam filtered backprojection, 34, 42 - 44fan-beam geometry, computed tomography, 33-34, 42-44 far field ultrasonic waves, 151 fast imaging sequences, MRI, 89-92 FBP, see filtered backprojection FDK algorithm, circular cone-beam construction, 46 feature vector, 189 FFP, see field-free point fiber tracking, see tractography field-free point (FFP), magnetic particle imaging, 103-105 field of view (FOV) circular computed tomography, 44 equipment, 59-64, 110-111, 135-136, 140, 166, 173 fan-beam filtered backprojection, 42-44 MRI gradient system, 110-112 projections, 36-37 ultrasound acquisition and reconstruction time, 165-166 film (X-ray), properties of, 19-20 filtered backprojection (FBP), 40-42 circular cone-beam reconstruction, 46-47 helical cone-beam reconstruction, 46 nuclear medicine, 130, 131 time-of-flight PET (positron emission tomography), 137-138 filters digital images, 8-13 linear filters, 8-13 nonllinear filters, 11, 13 FLAIR sequence, see fluid attenuated inversion recovery sequence flat-field image, 3 flat panel digital X-ray detectors, 21-22, 26, 31, 58-61 flexible geometric model fitting, 191, 205-216 deterministic description, 206-208 graph matching, 213-216 image pattern/shape fitting, 216, 217 image registration, 206-208 probabilistic description, 208-210 shape fitting, 208–216 statistical atlas, 208, 210-212 flip angles, 75-77, 79 gradient-echo pulse sequence, 87-88 image quality, 107, 110 flow compensation, moving spin dephasing, 95, 96 fluid attenuated inversion recovery (FLAIR) sequence, inversion recovery, 77 fluorescence, 19

<sup>18</sup>FDG (fluoro-deoxyglucose) imaging, tumors, 140, 141, 143 fluoroscopy, 20 clinical applications, 27-28, 30-32 fMRI, see functional magnetic resonance imaging Fourier rebinning, nuclear medicine, 131 Fourier transform (FT) diffusion imaging, 101 k-theorem, position encoding, 80-83 nuclear medicine, 127 point transfer function, 2-4 projections, 37-39 FOV, see field of view fractional anisotropy (FA), diffusion tensor imaging, 101-102 frequency-encoding gradient, pulse sequence, 85-87 frequency shift, Doppler effect, 154-156 FT, see Fourier transform full width at half maximum (FWHM) energy resolution, nuclear medicine, 126 MRI resolution, 106 single-slice CT, 44 spatial resolution, 2-4, 131 time-of-flight PET (positron emission tomography), 137-138 functional imaging functional magnetic resonance imaging (fMRI), 102-104 nuclear medicine, 120 pixel labeling, 192-195 fuzzy segmentation pixel labeling, 192-193 position-dependent volume rendering, 231-232, 237, 238 FWHM, see full width at half maximum gamma, of film, 20 gamma camera, SPECT imaging and, 134-135 gamma (y)-photons detection of, 124-125 particle interaction, 123-124 gamma (γ)-rays, nuclear medicine, 121-123 Gaussian kernel, linear filters, 8-10 GE, see gradient-echo Generalized Hough Transform, curve fitting, 204-205 geometric operations digital imaging, 7-8 fan-beam geometry, 33-34 intraoperative navigation, 238-242, 245 model fitting, 191, 200-205 multitemporal analysis, 186-188 parallel-beam geometry, 33-34 surface rendering, 225-227 ghosting, MRI artifacts, 108-109 Gibbs artifact, MRI images, 107, 109, 110 energy, 48, 129 measure, 199-200

### Index

Gouraud shading, surface rendering, 228, 229 gradient-echo (GE), 84 gradient-echo (GE) pulse sequence, 84-88, 88 contrast quality, 105 moving spin dephasing, 95, 96 TurboGE, 90 gradient moment nulling, moving spin dephasing, 95, 96 gradient moment rephasing, moving spin dephasing, 95, 96 gradient operators, linear filters, 9-13 gradient system, MRI equipment, 110-112 graininess, of film, 19-20 graph matching flexible geometric model fitting, 213 - 214model fitting, 203, 204 gray level transformation, digital images, 4 gray (Gy) units, 28 gyromagnetic ratio, 72 half Fourier imaging, spin echo pulse sequence, 86, 87 half-life, nuclear medicine, 122-123 Hamming window, filtered backprojection, 41, 42 Hanning window, filtered backprojection, 41, 42 hard radiation, 24 HARDI, see high angular diffusion imaging harmonics, wave propagation, 151-152, 157 HASTE (half Fourier single shot turboSE) sequences, 111 head mounted display (HMD) augmented reality, 242-246 virtual reality, 233, 236, 239 helical computed tomography, 44, 45 cardiac applications, 49-50 helical cone-beam construction, 46 helical interpolation, in computed tomography images, 56, 58 HIFU, see high intensity focused ultrasound high angular diffusion imaging (HARDI), 102, 104 high intensity focused ultrasound (HIFU), 115-118 high-pass filters, 8-10 Hilbert transformation, 157, 161 histogram digital images, 2 window/level operation, 4, 5, 7 HMD, see head mounted display Hounsfield units (HU), 34 hue, color, 1, 2 Huygens' principle, 153-154 hybrid imaging techniques, 115-118 nuclear medicine, 138-140 hypogenic ultrasound imaging, 168

Cambridge University Press 978-1-107-15978-5 — Fundamentals of Medical Imaging Paul Suetens Index More Information

ore information

#### Index

ICP algorithm, see iterative closest point algorithm ICRP, see International Commission on Radiological Protection image intensifier, 20, 21 image operations, 4 low-level automated image computing, 189 image quality basic principles, 23-24 computed tomography, 55-58 digital images, 2-4 magnetic resonance imaging, 105-110 nuclear medicine, 132 radiography, 23 ultrasound imaging, 166-170 image registration flexible image patterns/shape fitting, 216, 217 flexible model fitting, 206-208 model fitting, transformation matrix, 201-202 multitemporal analysis, 186-188 image segmentation, 185 flexible shape fitting, 213-215 fuzzy segmentation, 192-193 low-level automated image computing, 189-190 iMRI, see interventional MRI indirect X-ray conversion, 21-22 inflow magnetic resonance angiography, 96, 97 interference, wave propagation, 149, 150 International Commission on Radiological Protection (ICRP), 28-31,144 inter-observer variability, medical image computing, 185 interpolation, pixel grid, 7-8 interventional computed tomography, 61-64 interventional fluoroscopy, 25, 27, 30 interventional MRI (iMRI), 110 intra-observer variability, medical image computing, 185 intraoperative navigation computer-assisted intervention, 234-242 geometric transformation calculation, 238-242 surgical space coordinates, 236-238, 243, 244 intravascular ultrasound (IVUS), 171-173 intrinsic broadening, continuous wave Doppler, 161 inverse Fourier transform MRI acquisition and reconstruction times, 89 multiple echoes per excitation, 90 inversion recovery, 77 inversion time, 77 isotopes, 72, 75, 116, 120-121 iterative closest point (ICP) algorithm, intraoperative navigation, 238-242, 245 iterative reconstruction

maximum-likelihood (ML) approach, 48 nuclear medicine, 127-130 time-of-flight PET (positron emission tomography), 137-138 volumetric computed tomography, 47 - 48IVUS, see intravascular ultrasound K-edge, 18 multi-energy CT, 51-55 kernel, linear filter, 8-13 k-space contrast-enhanced MRA, 97 echo planar imaging (EPI), 90, 91 k-theorem, 82 multi-slice imaging, 89 resolution in, 106-107 spin echo pulse sequence, 85-87 three-dimensional imaging, 88 undone dephasing, magnetic field gradients, 84 k-theorem MRI resolution, 106-107 multiple echoes per excitation, 90 multi-slice imaging, 89 phase-based imaging, 92-94 position encoding, 80-83 pulse sequences, 85-88 Laplacian of a Gaussian (LoG), 9-13 Laplacian operator, linear filters, 9-13 Larmor frequency, 72-74 chemical shift imaging, 73-74, 93-94 RF field disturbance, 75-76 slice or slab selection, 80 LCD shutter glasses, virtual reality, 233, 236, 239 LINAC-MRI, 115-118 linear-array transducers, 171-173 linear attenuation coefficient, 17-18, 34, 52, 127, 139 linear filters, basic properties, 8-13 linear magnetic field gradient, 80 linear partial volume, see partial volume effect linear tomography, 33-34 linear wave equation, 148-149 line of response (LOR), time-of-flight PET (positron emission tomography), 137-138 line spread function, resolution, 2-4 LoG, see Laplacian of a Gaussian log-compression, ultrasound imaging, 157, 161 Lorentz forces, 113-114 loudness, acoustic intensity, 149, 150 low-level methods, model-to-data tuning, 189 low-pass filters, 8-10 LSF, see line spread function luminescence, 19

Bayesian approach, 47-48

machine learning, data classification/regression, 192-198 magnetic field gradients biological effects, 113-114 dephasing, 84 undo dephasing, 84 magnetic field inhomogeneities, 84 phase-based imaging, 92-94 undo dephasing, 84 magnetic moments, magnetic resonance imaging, 71-74 magnetic particle imaging (MPI), 103-105 magnetic resonance angiography (MRA), 96-99 artifacts, 107, 109, 110 contrast-enhanced (CE) MRA, 97, 99 inflow MRA, 96, 97 phase-contrast (PC) MRA, 97-99 magnetic susceptibility phase-based imaging, 92-94 mammography, 17, 21-23, 27-28, 31-32, 61, 64, 177 MAP, see maximum-a-posteriori probability marching cubes algorithm, surface rendering, 225-227 mask, linear filter, 8-13 mass attenuation coefficient, 18 maximum a-posteriori probability (MAP) CT, 47-48 nuclear medicine, 128, 129 maximum intensity projection (MIP), 96-99 MRA imaging, 112, 113 nuclear medicine artifacts, 133 volume rendering, 229-238 maximum-likelihood (ML) CT, 48 nuclear medicine, 127-132 mean diffusivity, diffusion tensor imaging, 101-102 mean transit time (MTT) perfusion computed tomography, 50-52 perfusion MRI, 99-100 metal artifacts, computed tomography, 58-63 metastable state, electron ( $\beta^-$ ) emission, 121 MIP, see maximum intensity projection ML, see maximum-likelihood M-mode imaging, 157, 161 modulation transfer function (MTF), 2-4 molecular imaging, 144-146 motion equation angular momentum, 73 quantum mechanics, 72-73 MPI, see magnetic particle imaging MPR, see multiplanar reformatting MRA, see magnetic resonance angiography MRI, see magnetic resonance imaging MTF, see modulation transfer function MTT, see mean transit time multi-energy computed tomography, 51-55 multi-image operations, 5-6

Cambridge University Press 978-1-107-15978-5 — Fundamentals of Medical Imaging Paul Suetens Index More Information

multimodal analysis, 186-188 multiplanar reformatting (MPR), 223, 224 user interaction, 234, 239 multiple echoes per excitation, fast imaging sequences, 90 multiscale image processing, 4, 11, 13-14 multi-slice computed tomography, 44-46 multi-slice magnetic resonance imaging, 89, 107, 108, 110 multitemporal analysis, 186-188 mutual information, image registration, 201 - 202navigation system, computer-assisted intervention, 234-242 near field, ultrasonic waves, 149, 150 net magnetization density, contrast quality, 105 net magnetization vector of matter, 79 magnetic resonance imaging, 74-75 static spin dephasing, 84 90-degree pulse, 76 spin echo pulse sequence, 85-86 noise power spectrum (NPS), 3 nonlinearity, wave propagation, 151-152 nonlinear filters, 11, 13 nonlinear partial volume effect, see partial volume effect nucleon emission/capture, 121 Nyquist criterion circular computed tomography, 44 MRI resolution, 106-107 sampling distances, 37-38 ultrasound aliasing, 168-170 objective function, model fitting, 198-216 180-degree pulse, 76 spin echo pulse sequence, 85-86 optical density, 19-20 optical transfer function (OTF) resolution, 2-4 orbital angular momentum, 71, 72 PACS, see picture archiving and communication systems pair production, 17-18 parallel beam forming, one-dimensional array transducers, 171-173 parallel-beam geometry computed tomography, 33-34

projections, 36–37 parallel magnetic resonance imaging (pMRI), 91

- Parker weighting, 43
- partial volume effect (PVE), 56, 57 linear, automated image computing, 185–186
- nonlinear, computed tomography, 57 PASL, *see* pulsed arterial spin labeling pattern classification, automated image computing, 195–199
- pattern recognition, automated image computing, 189, 195–198

PCA, see principal component analysis

pCASL, see pseudo-continuous arterial spin labeling (pCASL) PC MRA, see phase-contrast magnetic resonance angiography perfusion computed tomography, 50-52 perfusion magnetic resonance imaging, 99-100, 112, 115, 116 PET, see positron emission tomography PET-MRI, 115-118 PGSE, see pulsed gradient spin-echo phase-based imaging, 92-94 phase cancellation, MRI artifacts, 109, 110 phase-contrast (PC) magnetic resonance angiography, 97-99 phased-array transducers one-dimensional transducers, 171-173 two-dimensional transducers, 173 phase-encoding gradient pulse sequence, 85-87 three-dimensional MRI, 88 phase transfer function (PTF), 2-4 phon, acoustic intensity, 149-150 Phong shading, surface rendering, 228, 229 phosphorescence, 19 storage phosphors, 20 photoconductor, nuclear medicine, 124 photoelectric absorption, 17-18 multi-energy CT, 51-55 photomultiplier tube (PMT) gamma camera, 134-135 photon detection, 124-125 photon position, 125-126 photon counting, 23 count rate, 126 detectors, 35-36 multi-energy computed tomography, 52 - 55nuclear medicine, 126 photon pairs randoms, positron emission tomography, 135-136 SPECT scanner, 120 photostimulable phosphor, 20 photostimulated luminescence, 20 picture archiving and communication systems (PACS), 21 piezoelectric crystal ultrasonic wave generation, 147 ultrasound wave generation and detection, 156 piezoelectric effect, 147 pin-cushion distortion, 20 pitch ratio helical CT, 44, 45 multi-slice computed tomography, 44 - 46pixel labeling automated image computing, 189 data classification/regression, 192-195 planar imaging, nuclear medicine, 127 Planck's constant, 15, 73-74 plane waves, ultrasonography, 148 pMRI, see parallel magnetic resonance imaging

PMT, see photomultiplier tubes

3D-to-3D matching, 238-245, 247 intraoperative navigation, 234-242 point scatter, 154, 155 Doppler effect, 154-156 point spread function (PSF) axial resolution, ultrasound imaging, 167-168 backprojection, 38-39 lateral and elevation resolution, ultrasound imaging, 167-169 resolution, 2-4, 106 Poisson distribution maximum-likelihood (ML), 48 noise, computed tomography, 56, 57 nuclear medicine, 122-123 photon detection, 23-24 Poisson noise, nuclear medicine, 126 position-dependent transfer functions, volume rendering, 230-238 position encoding, MRI, 80-82 position errors, MRI artifacts, 108-109 position-independent transfer functions, volume rendering, 230-232 positron emission ( $\beta^+$  decay), nuclear medicine, 122 positron range, spatial resolution, nuclear medicine, 131 precession frequency, 73, 75, 78 MRI, 72-73, 75 PRF, see pulse repetition frequency principal component analysis (PCA) active shape models, 211-213 eigenfaces/eigenimages fitting, 202-203 pattern recognition, 195-198 probabilistic flexible geometric model fitting, 208–210 probabilistic description curve fitting, 211-213 flexible geometric model fitting, 208-210 graph matching, 214-216 projection theorem, 39-40 nuclear medicine, 127 volumetric computed tomography, 46 pseudo-continuous arterial spin labeling (pCASL), 99 PSF, see point spread function PTF, see phase transfer function pulsed arterial spin labeling (PASL), 99 pulsed gradient spin-echo (PGSE), diffusion imaging, 100-102 pulsed-wave (PW) Doppler aliasing, 168-170 data acquisition, 159-160 lateral and elevation resolution, 167-169 reconstruction, 161-164 pulse-echo, ultrasound imaging, 156-157 pulse repetition frequency (PRF) data acquisition, 159-160 pulsed-wave Doppler, 161, 162 pulse sequences, magnetic resonance imaging, 85-88 PVE, see partial volume effect

point matching

Cambridge University Press 978-1-107-15978-5 — Fundamentals of Medical Imaging Paul Suetens Index More Information

PW Doppler, see pulsed-wave Doppler

tore information

#### Index

q-space, diffusion imaging, 101 quadrature detector, MRI, 78 quadrature filter, ultrasound imaging, 157, 161 quadrature transmitter, MRI, 75 quantization, 2 space quantization, 73 quantum noise, 23-24 radiation weighted factor ( $w_R$ ), 28–30 radioactive decay, nuclear medicine, 121-123, 144 radio waves biological effects, 112-113 MRI, 74-78 MRI equipment, 110-112 radiofrequency (RF) waves, see radio waves radionuclides, nuclear medicine, 120 Radon transform data acquisition, 36, 37 projection theorem, 39-40 volumetric computed tomography, 46 Ram-Lak filter, filtered backprojection, 41 randoms, positron emission tomography, 135-136 range gate, 160, 162-164 Rayleigh scattering, 17 rebinning fan-beam filtered backprojection, 42-44 nuclear medicine, 131 reflection scatter reflections, 154, 155 wave propagation, 153-154 reflection coefficient, 153-154 refraction, wave propagation, 153-154 region growing, low-level automated image computing, 189-190 registration, see image registration relaxation, MRI, 76-78 rendering surface rendering, 225-229 three-dimensional rendering, 223-233 volume rendering, 228, 229 repetition time (TR), 79, 105-106 rephasing gradients diffusion imaging, 100-102 gradient-echo pulse sequence, 87-88 moving spins, 95 resolution computed tomography, 55-56 digital images, 2-4 MRI, 106-107 nuclear medicine, 131 ultrasound imaging, 166-168 see also energy resolution see also temporal resolution resonance condition, 73-74 reverberations, ultrasound artifacts, 168 ringing artifact, 107, 109, 110

### 256 sampling

data acquisition systems, 37-38

digital images, 2 parallel magnetic resonance imaging, 91 undersampling, 56-57 saturation color, 1, 2 inflow magnetic resonance angiography, 96, 97 scan conversion, ultrasound imaging, 158 scattering Compton scattering, 17-18, 51-55 in computed tomography images, 56, 57 Rayleigh/coherent scattering, 17 wave propagation, in ultrasound, 154, 155, 157, 161 scintigraphy, 140-142 scintillation crystals, 19 screen-film detector, 19-20 SE, see spin echo (SE) pulse sequence selection field, magnetic particle imaging, 103 - 105selective arterial spin labeling, 99, 100 sensitometric curve, 19-20 shading, surface rendering, 228, 229 shear modulus, elasticity imaging, 164, 167 shear waves, 147 elasticity imaging, 164, 167 shift-invariant transformation, linear filter, 8-13 short TI inversion recovery (STIR), 77 side lobe, ultrasound imaging, 168, 169 sievert (Sv), 28 signal-to-noise ratio (SNR, S/N) CT, 56 digital image, 3 MRI, 107 nuclear medicine, 123 radiography, 23-24 ultrasound, 168 sinogram, 37, 125 slab selection, MRI, 80 slice selection, principles of, 80 slice-selection gradient, 85-86 slice sensitivity profile (SSP) circular computed tomography, 44 MRI image quality, 107, 108, 110 slip rings, 59 Snell's law, 153, 220 SNR, S/N, see signal-to-noise ratio soft radiation, 24 sound level, 149 space quantization, 73 spatial context, medical image model/prototype construction, 188 spatial resolution, see resolution specific absorption rate (SAR), RF waves, 112-115 specific acoustic impedance, wave propagation, 148-152 speckle, 158 speckle tracking echography (STE), 164, 165 axial resolution, 167 data acquisition, 159-160 image reconstruction, 164 SPECT, see single photon emission computed tomography

spectrogram, 161-162 specular reflections, 153-154 surface rendering, 226-228 speed, of film, 19–20 spin angular momentum, 71, 72 spin down state, 73-74 spin echo (SE) pulse sequence, 84-86 TurboSE, 90 spin-lattice relaxation time  $(T_1)$ , 76 spin quantum number, 72-74 spin-spin relaxation time  $(T_2)$ , 77 spin up state, 73-74 SPIO, see superparamagnetic iron oxide spoiler gradients, 87-88 MRI contrast, 105, 106 stairstep artifacts, computed tomography, 56, 58 static magnetic field, MRI imaging, 114-115 static spin dephasing, 84 statistical atlas flexible geometric model fitting, 208, 210-212 model fitting, 202 statistical modeling, automated image computing, 188 step-and-shoot method, cardiac imaging, 49 - 50stereotactic surgery, 221-223, 234 stitching artifacts, 173 stochastic radiation effects, 28 storage phosphors, digital radiography detectors, 20 strain and strain rate, 164-165 subtraction angiography, multi-image operations, 5-7 superconducting magnets, MRI equipment, 110-112 superparamagnetic iron oxide (SPIO) nanoparticles, magnetic particle imaging, 103-105 supervised learning, pixel labeling, 192-193 surface matching, intraoperative navigation, 238-242, 245 surface rendering, 225-229 geometry, 225-227 illumination, 226-228 shading, 228, 229 susceptibility weighted imaging (SWI), 92 - 94T<sub>1</sub>-weighted images, 82, 83 T2-weighted images, 82, 83 table feed (TF), helical CT, 44, 45 Tam-window, 46 targeted contrast agents multi-energy CT, 52, 64 magnetic particle imaging, 105 utrasound, 178-183 TE, see echo time TEE, see transesophageal echocardiography templates linear filter, 8-13

Cambridge University Press 978-1-107-15978-5 — Fundamentals of Medical Imaging Paul Suetens Index More Information

template matching, 202-205 temporal resolution computed tomography, 62 ultrasound imaging, 159, 161, 164, 172-173 three-dimensional rotational angiography (3DRA), 24, 26, 27 thresholding, digital images, 4, 5 tiling, surface rendering, 225-226 tilted plane reconstruction, 45 time gain compensation, ultrasound attenuation correction, 157 time-of-flight (TOF) future expectations, 144-145 hybrid PET-MRI imaging, 140 magnetic resonance angiography, 96-97, 229 positron emission tomography, 137–138 tissue weighting factor ( $w_T$ ), 28–30 tomosynthesis, 58 TR, see repetition time tracer, 121-122 tractography diffusion imaging, 101-104 flexible shape fitting, 213-214 transducers Doppler effect, 154-156 one-dimensional array transducers, 171-173 two-dimensional array transducers, 173

ultrasonic wave generation and detection, 147, 156 transesophageal echocardiography (TEE), 174, 180 transesophageal probes, 171-173 transmission coefficient, 153-154 transparency, surface rendering, 228 triangular mesh, surface rendering, 225-226 triangulation, intraoperative navigation, 236-238, 244 truncated Fourier imaging spin echo pulse sequence, 86, 87 wrap-around artifacts, 107, 109, 110 TurboGE, 90 TurboSE, 90 MRI artifacts, 109 Tuy's data sufficiency condition, 46 unsharp masking, edge enhancement, 10-13 unsupervised learning, pixel labeling, 193-195

virtual reality, computer-assisted diagnosis and intervention, 223 volume rendering, 228, 229 position-dependent transfer functions, 230–235 position-independent transfer functions, 230–232 volumetric computed tomography (CT), 46-48 wavefront, 152-154 wave propagation Doppler effect, 154-156 homogeneous media, 148-152 inhomogeneous media, 152-154 weighted spin density, 82 Wiener spectrum, 3 window/level operation, 4, 5 wrap-around artifacts, MRI images, 107, 109, 110 X-rays basic principles, 15 biological effects and safety, 28-31 history, 15 radioactive decay, nuclear medicine, 121-123

volume selection, see slab selection

121–123 tissue interaction, 17–18 X-ray tube, 15–16 multiple tubes, computed tomography, 61, 64, 65

Young's modulus, elasticity imaging, 164, 167

Zeeman effect, 73-74

### Index