
Index

- absolute error, 97, 109
- accelerated bias-corrected bootstrap, 460
- accuracy (statistical), 40
- ACE (alternating conditional expectation method), 631
- ACM Transactions on Mathematical Software*, 322, 690, 692
- ACM Transactions on Modeling and Computer Simulation*, 690
- action space, 41
- adaptive quadrature, 189
- additivity and variance stabilization (AVAS), 632
- affine transformation, 375
- agglomerative hierarchical clustering, 523–527
- AIC (Akaike information criterion), 617
- Aitken acceleration, 131, 246, 250
- Akaike information criterion (AIC), 617
- algorithm, definition, 130
- almost everywhere, 149
- alternating conditional expectation (ACE), 631
- AMISE (asymptotic mean integrated squared error), 413
- AMS MR classification system, 690
- anaglyph, 353
- Andrews curve, 362
 - grand tour *Exercise 9.5.*, 398
- angle between vectors, 372, 374
- angular separation, 390
- anisometry, 391
- antithetic variates, 195
- API (application program interface), 140
- application program interface (API), 140
- Applied Statistics*, 322, 690, 692
- approximate inference, 51
- approximation of a matrix, 235
- approximation of functions, 147–202
- Archimedean copula, 34
- arcing, 628
- artificial ill-conditioning, 208
- artificial structure in data, 8, 209, 473, 534, 555
- ASCII code, 85
- ASH (average shifted histogram), 498
- aspect ratio, 7
- asymptotic inference, 52
- asymptotic mean integrated squared error (AMISE), 413
- AVAS (additivity and variance stabilization method), 632
- average shifted histogram (ASH), 498
- AVS (graphics system), 367
- axpy, 16
- B-spline, 180, 405
- Bézier curve, 341, 510
- backward error analysis, 109, 114
- bagging, 628
- Banach space, 150
- base, 89
- base point, 88
- basis functions, 160, 161

- basis set, 17, 160
- batch algorithm, 135
- batch means for variance estimation, 420
- Bayes rule, 592, 625
- Bayesian inference, 43
- Bayesian model, 598
- BC_α bootstrap, 460
- Bernstein polynomial, 342
- Bessel's inequality, 20, 163
- beta function, 673
- beta weight function, 173, 342
- beta-binomial distribution, 659
- BFGS (method), 271
- bias, 39
- bias correction, bootstrap, 454–456
- bias correction, jackknife, 444–448
- bias, in exponent of floating-point number, 90
- big O (order), 110, 117
- big omega (order), 111
- bilinear form, 22
- bin smoother, 617
- binary difference, 390
- binning, 138, 577
- bisection method, 246
- bit, 85
- blind source separation, 572
- Boltzmann distribution, 277
- bona fide density estimator, 487
- boosting, 628
- bootstrap, 453–467
 - bias correction, 454–456
 - confidence interval, 457–461
 - regression, 461–462
 - variance estimate, 456–457
- bootstrap, parametric, 424
- Box-Cox transformation, 630
- Box-Tidwell transformation, 630
- branch and bound, 276
- broken-line ECDF, 348
- Brownian motion, 599
- Broyden update, 271
- brushing, 338
- Burr family of distributions, 479
- byte, 85
- C (programming language), 136, 320
- CALGO (Collected Algorithms of the ACM)*, 690, 692
- Canberra distance, 389
- cancellation error, 114
- canonical singular value factorization, 28
- CART (method and software), 621
- casement display, 358
- catastrophic cancellation, 100–101
- categorical variable, 385
- Cauchy sequence, 150
- Cauchy-Schwarz inequality, 12
- CDF (cumulative distribution function), 29, 666
- centered data, 373, 385
- centered matrix, 595
- centroidal tessellation, 531
- characteristic function, 30, 37, 165
- Chebyshev approximation, 154, 178
- Chebyshev norm, 149
- Chebyshev polynomial, 172
- Chebyshev-Hermite polynomial, 174
- Chernoff face, 360
- Cholesky factorization, 218, 219
- Christoffel-Darboux formula, 169
- circular data, 392
- classification, 519–538, 620–628
- classification tree, 474, 521, 621
- claw density, 508
- clustered image map, 351
- clustering, 481, 519–538
 - agglomerative, 523–527
 - divisive, 528
- co-arrays, 141
- Collected Algorithms of the ACM (CALGO)*, 690, 692
- color table, 366
- color, representation of, 365
- column-major, 204
- combinatorial optimization, 275
- Communications in Statistics — Simulation and Computation*, 690
- complete beta function, 673
- complete gamma function, 673
- complete linkage clustering, 524
- complete pivoting, 213
- complete space, 150
- completeness, of system of functions, 163

- COMPSTAT, 689, 691
 computational efficiency, 116–128
 computational feasibility, 137–138
 computational inference, 52, 58, 422
Computational Statistics, 690
Computational Statistics & Data Analysis, 691
 computer experiment, 653
Computing Science and Statistics, 691
 concave function, 21
 concentrated likelihood, 45
 conceptual clustering, 532
 condition (problem or data), 113
 condition number, 113, 116, 206–209, 257, 260
 with respect to computing a sample standard deviation, 116
 with respect to matrix inversion, 206
 condition number of a function with respect to finding a root, 257, 260
 conditional inverse, 25
 conditional likelihood, 45
 conditioning plot, 357
 confidence interval, 54
 confidence interval, bootstrap, 457–461
 conjugate gradient method, 223–272
 conjunctive normal form (CNF), 622
 consistency (statistical), 40
 consistency check, 112, 235
 consistent estimator, 409
 consistent system of equations, 24, 258
 container hull, 542
 contour plot, 351
 control variate, 427
 convergence
 tests for, 129
 convergence (algorithmic) criterion, 129, 243
 convergence (algorithmic) rate, 130
 convergence (distributional) in mean square, 409
 convex function, 21, 49
 convex hull, 542–543
 convex loss, 42
 convolution, 21, 124
 coordinate system, 382–383
 graphics, 338
 coplot (conditioning plot), 358
 copula, 32–34
 random number generation, 316, 330
 correlation, 33, 384
 correlation matrix, 385
 covariance, 32, 384
 CPU, 128
 cross products, computing sum of
 Exercise 3.5c:, 142
 cross validation, 440–442, 617
 crude Monte Carlo, 197
 cumulant generating function, 31, 37, 166
 cumulative distribution function, 29, 666
 curse of dimensionality, 133, 576

 data depth, 543
 data mining, 474
 data partitioning, 435–451
 data structure, 108
 data-based random number generation, 318–320, 324
 data-generating process, 5–58
 DATAPLOT, 8
daxpy, 16
 decision rule, 41
 decision theory, 41
 decomposition of a function, 37, 192, 403, 418
 decomposition of a matrix, 28–29, 215–219
 Delaunay triangulation, 530
 Delta algorithm, 295
 delta method, 51
 Δ^2 -extrapolation, 131
 density estimation, 475–515
 dependence function for extreme value
 copulas, 33
 depth median, 545
 depth of data, 543
 device coordinate system, 338
 device driver, 367
 DFP (method), 271
 diagonal factorization, 27
 Digital Library of Mathematical Functions (DLMF), 199
 Dijkstra’s algorithm, 539
 dimension reduction, 371, 529
 Dirac delta function, 670
 direct volume rendering, 351

- directional data, 392
- Dirichlet tessellation, 529
- discrete Fourier transform (DFT), 124
- discrete Legendre polynomials, 172
- discretization error, 112, 132
- discrimination, 519–538
- disjunctive normal form (DNF), 622
- dissimilarity, 383–397
- dissimilarity measure, 392
- distance, 388
- distributions (table of), 657–663
- divergence measure, 49
- divide and conquer, 121–124
- divisive clustering, 528
- divisive hierarchical clustering, 528
- DLMF (Digital Library of Mathematical Functions), 199
- dot product, 12
- double precision, 94

- ECDF (empirical cumulative distribution function), 59–65, 348, 472, 666
- EDA, 474, 586
- Edgeworth series, 165
- efficiency, computational, 116–128
- eigenvalue, 26
- elemental regression, 627
- elementary operator matrix, 209
 - permutation matrix, 213
- ellipsoid, minimum volume, 543
- EM method, 296–298
 - mixtures, 481–482
- empirical cumulative distribution function, 59–65, 348, 472, 666
- empirical orthogonal functions, 548
- empirical parametric method, 319
- empirical probability density function (EPDF), 60, 472
- empirical quantile, 62
- ensemble methods in classification, 627
- Epanechnikov kernel, 503
- EPDF (empirical probability density function), 60, 472
- error
 - absolute, 109
 - backward error analysis, 109
 - bound, 110
 - cancellation, 114
 - discretization, 112
 - function approximation, 156
 - measures of, 97, 109–110
 - of approximation, 111
 - relative, 109
 - rounding, 109
 - truncation, 112
- error, rounding, models of *Exercise 2.9*., 104
- errors-in-variables, 610
- estimating equation, 46, 48
- estimation of quantile, 64
- Euclidean distance, 15, 388
- Euclidean length, 372
- Euclidean norm, 14
- Euler’s constant *Exercise 2.3*., 103
- even function, 175
- exact inference, 51
- exception, in computer operations, 97
- expected value, 30
- experimental support, 47
- exploratory data analysis, 474, 586
- exponent, 89
- exponential class, 35
- exponential order, 118
- exponentially tilted, 161
- exponentially tilting, 175
- extended precision, 94
- extrapolation, 131, 139, 188
- extreme ranking, 538
- extreme value copula, 33
- eye position, 339, 355

- f -divergence, 49
- factor analysis, 549, 560
- factorization of a matrix, 28–29, 215–219
- fan-in algorithm, 99, 123
- fast Fourier Transform (FFT), 126
- fathoming, 276
- feature space, 572
- FFT (fast Fourier Transform), 126
- field, 84
- fill-in, 226
- filter, 182, 403, 406
- filtered kernel density estimator, 507
- first-order accurate, 40
- Fisher scoring, 295
- Fisher’s linear discriminant, 625

- fixed-point method, 246
- fixed-point numbers, 86–88
- flat, 372
- flipped ECDF, 348
- floating-point numbers, 88–101
- flops (floating-point operations per second), 117
- Fortran, 136, 140
 - random number generation, 320
- forward selection, 615
- forward stepwise selection, 615
- 4-plot, 8
- Fourier basis, 164
- Fourier coefficients, 19, 162
- Fourier series curve, 362
- fractal dimension, 580
- frequency polygon, 498
- Frobenius norm, 14
- full rank, 24
- function approximation, 147–202
- function estimation, 401–415
- functional, 60, 151
- functional data, 387
- fuzzy clustering, 533

- g_4 inverse (see also Moore-Penrose inverse), 24
- g_1 inverse, 25
- g_2 inverse, 25
- gamma function, 673
- gamma weight function, 173
- GAMS (*Guide to Available Mathematical Software*), 158, 322, 692
- GAMS, electronic access, 692
- Gauss-Newton method, 292
- Gauss-Seidel method, 221
- Gaussian copula, 33
- Gaussian elimination, 209–214
- Gaussian quadrature, 190
- generalization error, 435
- generalized feedback shift register (GFSR), 306
- generalized inverse, 24, 26, 217
- generalized jackknife, 446, 447
- generalized lambda family of distributions, 480
- generalized linear model, 591
- generating set, 17, 160

- generation of random number, 305–331
 - software, 320–329, 429–430
- genetic algorithm, 281
- geometric Brownian motion, 600
- geometry, 374
- GGobi (graphics system), 368
- Gibbs method, 313, 317
- Givens rotations, 379
- global optimum, 243
- glyph, 359
- GMRES method, 223
- GNU Scientific Library (GSL), 322, 693
- gnuplot (graphics software), 367
- golden section search, 264
- Goldstein-Armijo method, 265
- GPU, 128
- graceful underflow, 91, 678
- gradient of a function, 258, 261
- gradual underflow, 91
- Gram-Charlier series, 165
- Gram-Schmidt transformation, 18, 162, 167, 219, 221
- Gramian matrix, 25
- grand tour
 - in Andrews curves *Exercise 9.5.*, 398
 - in parallel coordinates plots *Exercise 9.4.*, 398
- graphical methods, 6–10, 337–370
- greedy algorithm, 126, 265
- Grid Graphics, 368
- GSL (GNU Scientific Library), 322, 693
- gs1 package, 322
- Gumbel copula, 33

- halfspace location depth, 543
- Hamiltonian circuit, 541
- Hamming distance, 390
- Harrell-Davis quantile estimator, 65, 77
- Hastings ratio, 314
- Heaviside function, 669
- Hellinger distance, 410
- Hemes formula, 228
- Hermite function, 175
- Hermite polynomial, 174
- Hessian, 261
- hidden bit, 90
- hierarchical clustering, 523–528
 - agglomerative, 523–527
 - divisive, 528

- hierarchical model, 598
- high-performance computing, 127
- Hilbert space, 150
- histogram, 344
- histogram estimator, 490–499
- histospline, 498
- hit-or-miss Monte Carlo, 197
- homogeneous coordinates, 380
- Horner’s method, 120, 169, 198
- Hotelling transform, 554
- Huber estimator, 606
- hull, 542
- hypergeometric distribution, 478
- hypothesis testing, 52, 422–424

- IAE (integrated absolute error), 410, 413
- ICA (independent components analysis), 564, 572
- ideal bootstrap, 456
- idempotent matrix, 26
- IEC standards, 86
- IEEE standards, 86, 94
 - Standard 754, 94, 95
- i.i.d. (independent and identically distributed), 37
- ill-conditioned (problem or data), 113
- ill-conditioned data, 113, 206
- Illinois method, 254
- IMAE (integrated mean absolute error), 412
- image plot, 351
- immersive techniques, 340
- IMPLOM, 357
- importance sampling, 195, 426
- imputation, 425
- IMSE (integrated mean squared error), 411
- IMSL Libraries, 321, 323–325
- incomplete factorization, 226
- incomplete gamma function, 673
- independent components analysis, 549, 564, 572
- indicator function, 669
- induced matrix norm, 14
- Inf (“infinity”), 94
- inference, 37–56
 - approximate, 51
 - asymptotic, 52
 - computational, 52, 58, 422
 - exact, 51
- infinity, floating-point representation, 94
- information theory, 49
- inner product, 11, 12, 148
- inner pseudoinverse, 25
- integer programming, 289
- integer representation, 87
- integrated absolute bias, 411
- integrated absolute error (IAE), 410, 413
- integrated bias, 411
- integrated mean absolute error (IMAE), 412
- integrated mean squared error (IMSE), 411
- integrated squared bias, 411
- integrated squared error (ISE), 410
- integrated variance, 411
- Interface Symposium, 689, 691
- interior-point method, 288
- internal consistency checks, 112
- International Association of Statistical Computing (IASC), 689, 691
- interpolating spline, 180
- interpolation, 154
- interval arithmetic, 102
- invariance property, 374
- inversion formula, 165
- IRLS (iteratively reweighted least squares), 293, 294
- ISE (integrated squared error), 410
- isnan**, 95
- isometric matrix, 391
- isometric transformation, 374, 391, 395
- isotropic transformation, 374
- iterative method, 128, 243
- iterative method for matrix computations, 221–226
- iterative refinement, 226
- iteratively reweighted least squares, 293, 294
- Ito process, 600

- jackknife, 442–448
 - bias correction, 444–448
 - variance estimate, 443–444
- jackknife-after-bootstrap, 462

- Jacobi polynomial, 173, 342
- Jacobian, 259
- Jensen's inequality, 49
- jittering, 339
- Joe copula, 34
- Johnson family of distributions, 479
- Journal of Computational and Graphical Statistics*, 365, 691
- Journal of Statistical Computation and Simulation*, 691
- Journal of Statistical Software*, 691
- k-d-tree*, 546–547
- K-means clustering, 521, 532
- Kadane's algorithm, 679
- Kagomé lattice, 509
- Karhunen-Loève transform, 549, 554
- Karush-Kuhn-Tucker conditions, 290
- KDD (knowledge discovery in databases), 474
- kernel
 - positive definite, 23
 - symmetric, 22
- kernel (function), 182, 406, 500, 618, 626
- kernel density estimation, 499–504
- kernel estimator, 403
- kernel function, 21
- kernel regression, 618
- kernel smoother, 617
- kernel trick, 626
- knowledge discovery in databases (KDD), 474
- Kolmogorov distance, 350, 410, 412
- Kuhn-Tucker conditions, 290
- Kullback-Leibler measure, 49, 410
- Kumaraswamy distribution, 51
- L_2 norm, 150
- L_∞ norm, 150
- L_p norm, 13, 150, 389
- $L^2(D)$, 149, 403
- L_1 consistency, 413
- L_2 consistency, 409, 413
- L_2 metric, 15
- L_2 norm, 14, 389
- Lagrange multiplier, 286, 287
- Lagrange polynomial, 155
- Lagrangian function, 287
- Laguerre-Fourier index, projection pursuit, 570
- Laguerre polynomial, 173
- lambda family of distributions, 480
- Langevin equation, 600
- Laplace approximation, 161, 190
- Laplace transform, 31
- Laplacian operator, 671
- lasso, 608
- latent semantic indexing, 549, 563
- Latin hypercube sampling, 577, 654
- Lattice (graphics system), 368
- learning, 572
- least absolute values estimator, 48
- least angle regression, 615
- least median of squares regression, 607, 636
- least squares, 291–294
- least squares estimator, 48, 67, 229, 604
- least squares/normal drift *Exercise 11.2.*, 431
- least trimmed absolute values, 606
- least trimmed squares, 606
- Legendre polynomial, 171
- Legendre's differential equation, 172
- length of a vector, 17
- Levenberg-Marquardt algorithm, 293
- likelihood equation, 46
- likelihood function, 44, 70, 476
- likelihood principle, 47
- likelihood ratio, 47, 53
- limited-memory quasi-Newton method, 272
- line search, 263
- linear classifier, 623
- linear congruential generator, 306
- linear convergence, 131
- linear estimator, 61
- linear functional, 61
- linear independence, 16, 160
- linear programming, 287
- link function, 591
- little o (order), 111
- little omega (order), 111
- local optimum, 243
- log order, 118
- log-likelihood function, 44, 71
- logit function, 591
- loss function, 41

- absolute-error, 42
 - convex, 42
 - squared-error, 42
- LU* factorization, 219
- M-estimator, 603
- MACHAR, 95
- machine epsilon, 92, 269
- machine learning, 519, 572
- MAE (mean absolute error), 408
- Mahalanobis distance, 15, 592
- Mahalanobis squared distance, 392
- Manhattan distance, 389
- marginal CDF, 30
- Markov chain Monte Carlo, 313
- martingale, 8
- Mathematical Reviews*, 690
- Matlab (software), 321
- matrix factorization (decomposition), 28–29, 215–219
- Matusita distance, 410
- maximal linearly independent subset, 16
- maximum absolute error (SAE), 410
- maximum difference, 389
- maximum likelihood method, 70, 71, 294–298, 476, 488
- MCMC (Markov chain Monte Carlo), 313
- mean absolute error (MAE), 408
- mean integrated absolute error (MIAE), 412, 413
- mean integrated squared error (MISE), 412
- mean square consistent, 413
- mean squared error (MSE), 408, 411
- mean squared error, of series expansion, 20, 162
- mean sup absolute error (MSAE), 412
- median-unbiasedness, 39
- mergesort, 122
- Mersenne twister, 306
- message passing, 141
- method of moments, 60
- metric, 15, 383
 - Euclidean, 15
- Metropolis random walk, 314
- MIAE (mean integrated absolute error), 412, 413
- minimal spanning tree, 538
- minimax approximation, 178
- minimum-volume ellipsoid, 543
- Minkowski distance, 389
- MINRES method, 223
- MISE (mean integrated squared error), 412
- missing data, 425
- mixed integer programming, 289
- mixture distribution, 36, 166, 368, 480, 481, 483, 658
- model, 5, 56–58, 586–587
 - algorithm, 586
 - equation, 586
 - random component, 58, 611
 - systematic component, 58, 611
- model-based clustering, 481
- modified Gram-Schmidt (see also Gram-Schmidt transformation), 221
- moment generating function, 31, 37
- monotone likelihood ratio, 47, 53
- Monte Carlo evaluation of an integral, 192
- Monte Carlo experimentation, 335, 417, 643
- Monte Carlo study, 643–656
- Monte Carlo test, 422–424
- Moore-Penrose inverse, 24, 232
 - and *QR* factorization, 216, 217
 - and SVD, 29
- mountain plot, 348
- MPI (Message Passing Interface), 141
- MR classification system, 690
- MSAE (mean sup absolute error), 412
- MSE (mean squared error), 39, 408, 411
- MST (minimal spanning tree), 538
- MT19937 random number generator, 306, 325
- multidimensional scaling, 396
- multiple imputation, 425
- multiple roots of a function, 256
- multivariate data, ranking, 538–548
- multivariate distributions, 320
- NA (“not-available”), 95
- NaN (“not-a-number”), 95
- natural polynomial spline, 180, 405
- nearest neighbors, 518, 546–547

- Nelder-Mead simplex method, 272, 284
- nested Newton form, 169
- netlib, 322, 690, 692
- neural net, 284, 634
- Newton form, 169
- Newton's method, 258, 266
 - solving a single equation, 249–251
- Newton-Cotes formula, 186
- Newton-Raphson, 266
- noisy function optimization, 275
- nonlinear regression, 293
- nonnegative definite kernel, 23
- nonnegative definite matrix, 23, 218
- nonnegative matrix factorization, 564
- nonparametric density estimation, 487–515
- nonparametric method, 475, 586
- nonparametric regression, 618
- norm, 13
 - (pseudonorm) of a function, 150
 - Chebyshev, 150
 - Euclidean, 14
 - Frobenius, 14
 - L_2 , 14, 150
 - L_∞ , 150
 - L_p , 13, 150, 389
 - of a matrix, 14
 - of a vector, 14
 - uniform, 150
- norm of a functional, 152
- norm of an operator, 152
- normal equations, 230
- normal function, 150
- normalized data, 391
- normalized floating-point numbers, 90
- normalized function, 150
- normalized generalized inverse (see also Moore-Penrose inverse), 25
- normalized vector, 17
- normalizing factor, 167
- not-a-number (“NaN”), 95
- not-available (“NA”), 95
- NP-complete problem, 118
- numerical data, 372

- oblique partitioning, 474
- odd function, 175
- OLS (ordinary least squares), 229
- online algorithm, 135, 137
- online processing, 135
- OpenGL (software), 367
- operator, 151
- optimization, 65–73, 241–304
- optimization of stochastic (noisy) functions, 275
- order
 - big O, 110
 - big omega, 111
 - exponential, 118
 - little o, 111
 - little omega, 111
 - log, 118
 - of the problem, 118
 - polynomial, 118
- order of computations, 117, 137
- order of convergence, 110
- order of error, 110
- order statistic, 62
- ordering of multivariate data, 538–548
- Ornstein-Uhlenbeck process, 600
- orthogonal distance regression, 610
- orthogonal polynomials, 191
- orthogonal projection, 18, 355
- orthogonal transformation, 373
- orthogonal vectors, 17
- orthogonalization transformation, 18, 219
- orthogonalization, Gram-Schmidt, 219
- orthonormal vectors, 17
- out-of-core algorithm, 135, 137
- outer pseudoinverse, 25
- outlier, 395, 559
- overdetermined linear system, 228
- overfitting, 597, 614
- overflow, in computer operations, 88
- overloading, 14

- p -inverse (see also Moore-Penrose inverse), 25
- p -value, 54
- Padé approximation, 153
- parallel coordinates, 360
 - grand tour *Exercise 9.4.*, 398
- parameter space, 34
- parametric bootstrap, 424
- partial pivoting, 212
- partial scatter plot matrix, 357

- PCA (principal components analysis), 548–560
 PDF (probability density function), 29
 PDF decomposition, 162
 PDF decomposition, 37, 192, 403, 407, 418, 426–427
 Pearson family of distributions, 477
 penalized maximum likelihood method, 489
 period of random number generator, 306
 permutation matrix, 213
 perspective plot, 350
 ϕ -divergence, 49
 pivotal value, 55
 pivoting, 212, 217
 pixel, 338, 365, 366
 plug-in estimator, 60, 463
 pointwise properties, 407
 polar coordinates, 382, 392, 535
 polynomial order, 118
 polynomial, evaluation of, 120, 169
 portability, 107
 positive definite kernel, 23
 positive definite matrix, 23, 218
 power of test, 54
 precision, double, 94
 precision, extended, 94
 precision, single, 94
 preconditioning, 225
 prediction, 38, 440, 441
 prediction error, 435
 PRESS, 441
 principal components, 548–560
 principal components regression, 635
 principal curves, 572
 probabilistic error bound, 110, 196
 probabilistic latent semantic indexing, 564
 probability density function, 29
 estimation, 475–515
 probability density function decomposition, 37, 192, 403, 418
 probability distributions (table of), 657–663
 probability plot, 349
 probably approximately correct (PAC) model, 592
Proceedings of the Statistical Computing Section, 691
 product kernel, 184, 501
 profile likelihood, 45, 630
 profiling programs, 136
 programming, 134–137
 projection, 355, 379
 projection matrix, 26, 357
 projection pursuit, 564–571, 618
 projection pursuit guided tour, 364
 projective transformation, 375
 proximity search, 519
 pseudo grand tour, 364
 pseudoinverse (see also Moore-Penrose inverse), 25
 pseudonorm, 149
 pseudo-value, 443

 Q-convergence, 131
 q-q plot, 349
 QR factorization, 216, 219
 quad tree, 546
 quadratic convergence, 131
 quadratic form, 22
 quadratic programming, 290
 quadrature, 184–197
 quantile, 62
 estimation, 64
 quantile plot, 477
 quantile-quantile plot, 349
 quasi-Newton method, 269, 295
 quasirandom numbers, 307, 322
 queue, 108
 Quicksort, 123

 R (software), 140, 693
 graphics, 368
 packages, 134, 141
 random number generation, 321, 325–329
 radial ranking, 538
 radix, 89
rand, 323
 Rand’s statistic, 536
 random forest, 628
 random number generation, 305–331
 software, 320–329, 429–430
 rank correlation, 385
 rank of matrix, 24, 217

- rank reduction, 235
- rank transformation, 385
- rank-one update, 227
- rank-revealing QR , 217
- rank-two update, 271
- ranking of multivariate data, 538–548
- Rao-Blackwell theorem, 40
- raster image, 339
- rate constant, 131
- rate of convergence, 131
- rational approximation, 153
- real numbers, 88
- real-time algorithm, 135
- recursion, 119
- recursion formula for orthogonal polynomials, 168
- recursive partitioning, 474, 521, 528, 622
- reflexive generalized inverse, 25
- registration of data, 387
- regression, 293, 588
 - bootstrapping, 461–462
 - nonlinear, 293
- regression tree, 617, 621
- regression variable selection, 613
- regula falsi, 253
- regularization, 607
- regularization method, 607
- relative error, 97, 109
- relative spacing, 92
- reproducible research, 644
- resampling, 336, 453
- resampling vector, 454
- restarting, 225
- restricted maximum likelihood method, 488
- Richardson extrapolation, 133
 - quadrature, 188
- ridge regression, 607, 635
- risk function, 41, 42
- Robbins-Monro procedure, 256, 284
- robust covariance matrix, 395
- robust method, 395, 606
- robustness (algorithm or software), 114, 134
- Romberg quadrature, 188
- root of a function, 101, 245
- rotation, 234, 362, 375
- roughness of a function, 151, 414, 494
- rounding error, 109
- rounding mode, 94
- row-major, 204
- running smoother, 617
- S, S-Plus (software), 321
 - graphics, 368
 - random number generation, 325–329
- saddlepoint approximation, 165
- SAE (sup absolute error), 410
- sample quantile, 62
- sample variance, computing, 115
- saw-tooth density, 509
- saxpy**, 16
- scaled data, 391
- scaling, 391
- scaling of a vector or matrix, 208
- scaling of an algorithm, 117
- scatter plot, 344, 356
- score function, 46
- scoring, 295
- scree plot, 554
- secant method, 251
- second-order accurate, 40
- section, 357
- seed of a random number generator, 307, 321, 325, 326, 430
- sequential unconstrained minimization techniques, 290
- series estimator, 404
- series expansion, 18, 160, 161
- shape of data, 573
- shearing transformation, 374
- Sherman-Morrison formula, 227, 271
- shrinkage, 607
- SIAM Journal on Scientific Computing*, 691
- side effect, 322
- sieve, 489
- SIGGRAPH, 365
- sign bit, 86
- signal to noise ratio, 589
- significance level, 54
- significand, 89
- signum function, 674
- similarity, 383–397
- similarity measure, 384
- simplex algorithm, linear programming, 288

- simplex method, 272, 284
- simplicial location depth, 578
- Simpson's rule, 186
- simulated annealing, 277–281
- simulation, 336, 643
- single linkage clustering, 524
- single precision, 94
- singular value, 28, 209, 556
- singular value decomposition, 28, 556
- 6-plot, 8
- skinny QR factorization, 216
- Sklar's theorem, 32
- smooth comb density, 509
- smoothing, 179, 320, 341, 405, 617
- smoothing matrix, 500
- smoothing parameter, 183, 320, 442, 502, 507
- smoothing spline, 181, 405
- snowflake, 359
- software engineering, 322
- SOR (method), 223
- sorting, 121–123
- sorting of multivariate data, 538–548
- span(\cdot), 17
- spanning set, 17, 160
- sparse matrix, 205, 226
- spectral decomposition, 549
- spectral radius, 27, 222
- sphered data, 391, 570
- spline, 179, 405
- spline smoothing, 405
- splitting extrapolation, 133, 139
- SPLOM (“scatter plot matrix”), 356
- SPMD, 141
- square root factorization, 219
- square root matrix, 218
- squared-error loss, 42
- stability, 114, 214, 256
- stack, 108
- standard deviation, computing, 115
- standard normal distribution, 657
- standardized data, 392, 518, 548, 549, 551
- star diagram, 359
- statistic, 37
- Statistical Computing & Graphics Newsletter*, 365, 691
- Statistical Computing Section of the American Statistical Association, 689, 691
- statistical function, 31
- statistical learning, 519, 572
- Statistics and Computing*, 691
- statlib**, 322, 466, 690, 692
- steepest descent, 265
- Steffensen acceleration, 132
- Steffensen's method, 246, 251
- step length factor, 263
- stereogram, 353
- Stevens's scale typology, 371
- stiff data, 116
- stochastic approximation, 254, 284
- stochastic integration, 192
- stopping criterion, 129, 243
- storage unit, 85, 89
- stratified sampling, 195
- structure in data, 6, 473
 - artificial, 8, 209, 473, 534, 555
- successive overrelaxation, 223
- sufficiency, 40
- SUMT, 290
- sup absolute error (SAE), 410
- superlinear convergence, 131
- support of a distribution, 30
- support of an hypothesis, 47
- support vector machine, 626
- surface rendering, 351
- SVD (singular value decomposition), 28, 556
- symmetric kernel, 22
- symmetric matrix, 22
- tabu search, 284
- Taylor series approximation, 160
- tensor product, 178
- tessellation, 497, 528, 577
- TESTU01 (test suite for random number generators), 307
- Tikhonov regularization, 607, 635
- timing programs, 136
- total least squares, 610, 612
- transform-both-sides, 631
- transformation of data, 628–634
- transition kernel, 312
- translation transformation, 380
- trapezoid rule, 185

- trapezoidal matrix, 216
- traveling salesperson problem, 281
- trellis display, 359
- triangle inequality, 13, 15
- trigonometric basis, 164
- trimmed least squares, 606
- truncated Newton method, 272
- truncated power function, 179, 405
- truncation error, 112
- trust region, 268
- twofold rule, 621
- twos-complement representation, 86, 87

- UCI Machine Learning Repository, 628
- ulp (“unit in the last place”), 93
- ultrametric inequality, 383, 526
- underflow, in computer operations, 91
- Unicode, 85
- uniform norm, 149
- Uniform Parallel C (UPC), 141
- unit in the last place, 93
- unit roundoff, 92
- unrolling a loop, 134
- UPC (Uniform Parallel C), 141
- updating a solution, 227, 233

- Vandermonde matrix, 172
- variable metric method, 269
- variable selection, 613
- variance, 39
- variance estimation, 419, 420
 - bootstrap, 456–457
 - jackknife, 443–444
- variance reduction, 195, 425–429
 - bootstrap, 462
- variance stabilizing transformation, 629
- variance, computing, 115
- variance-covariance matrix, 384
- vector image, 339
- viewing angle, 339, 355
- virtual reality, 340
- Visualization Toolkit (software), 367
- Voronoi diagram, 529
- Voronoi tessellation, 529
- voxel, 352
- vtk (Visualization Toolkit software), 367

- Ward’s method of clustering, 526
- weak convergence in mean square, 409
- Weierstrass approximation theorem, 167
- weighted least squares, 69
- Weka (software), 628
- white matrix, 392
- Wiener process, 600
- Wilkinson’s polynomial, 113
- window size, 500
- wire frame, 352
- Woodbury formula, 228, 271
- word, computer, 85, 89
- world coordinate system, 338

- xfig (graphics software), 367
- Xnetlib**, 692

- z-buffering, 352
- zero of a function, 101, 245
- 0-1 loss, 42
- zooming window, 7