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UNSPECIFIED
Cumulative Index to the Applied Statistics Algorithms

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Chapter 1

Introduction

We present an index of all the algorithms which have been published in Applied Statistics between 1968 and 1991 inclusive. The algorithms have been classified using a modified version of the GAMS (Guide to Available Mathematical Software) Problem Classification Scheme given by Boisvert et al. [2]. This is an updated version of the scheme which appeared in Boisvert et al. [1] and has been considerably expanded especially in the statistical area. GAMS is a variable depth classification scheme. The first character, which is always a capital letter, gives the major subject area, further subdivisions are recursively denoted by alternating numbers and lower case letters. Thus, for example, D3a4 is in the main classification area of Linear Algebra (D), subarea Determinants (3), sub-subarea Real Nonsymmetric Matrices (a), sub-sub-subarea Sparse (4). The full classification list is reproduced in Chapter 4.

Although each algorithm has been classified using the full GAMS index, only the first two fields have been used to generate the cumulative index presented in Chapter 2. Each algorithm entry consists of three fields. The first field gives the algorithm number. An asterisk in this field indicates that the algorithm appears in the book of Griffiths and Hill [3]. The second field is the title of the algorithm followed by the implementation language (F for Fortran, A for Algol 60, P for Pascal and PL1 for PL/1). If the algorithm appears in Griffiths and Hill [3] then the implementation language is given as that used in the book. The final field gives all published references to the algorithm: the original publication (in bold) followed by any remarks and corrections to the algorithm which have subsequently been published. All references are of the form ASvolume:page. The full GAMS classification for each algorithm is given in Chapter 3.

The form of the database entries from which the index was generated is described by Hopkins and Morse in [6] and [4]. A short description has been given in Appendix B. The database will be updated at regular intervals and the authors would be pleased to be informed of any errors or omissions.

We have also added a perl script for performing a number of transformations on the original database. This is faster and more easily modified than the original Fortran routines. It is described in more detail in Appendix A.

An earlier version of Chapter 2 of this report appeared as [5]. In addition, this report also contains the full GAMS classification of each algorithm (Chapter 3), the GAMS classification list (Chapter 4), a description of how to obtain tools to operate on the database to generate a number of more useful output forms, where to obtain sources of the algorithms, and details of the database from which the index of algorithms was generated Appendix B.
Chapter 2

Index to the Applied Statistics Algorithms

In this chapter we present a cumulative index classified using the first two fields of the GAMS classification index. All algorithms published in *Applied Statistics* between 1968 and 1991 inclusive are included along with references to any remarks and corrections which may have appeared subsequently. The GAMS index has been slightly modified as follows

- C7 *Gamma* has been changed to *Gamma and Beta distributions*
- C8 *Error functions* has been changed to *Normal distributions and Error functions*
C : Elementary and special functions (search also class L5)

C1 : Integer-valued functions (e.g., floor, ceiling, factorial, binomial coefficient, permutations, combinations)

88 Generation of All $N \choose C_R$ Combinations by Simulating Nested Fortran DO Loops (F) AS24:374
94 Coefficients of the Zonal Polynomials (F) AS25:82
179 Enumeration of All Permutations of Multi-sets with Fixed Repetition Numbers (F) AS31:169
227 Efficient Generation of all Binary Patterns by Gray Code Counting (A60) AS36:245

C3 : Polynomials

10 The Use of Orthogonal Polynomials (F) AS17:283 AS20:117
42 The Use of Orthogonal Polynomials with Equal $x$-values (F) AS20:209

C7 : Gamma and beta

32 The Incomplete Gamma Integral (F) AS19:285 AS34:326 AS38:423
63 The Incomplete Beta Integral (F) AS22:409 AS26:111
64 Inverse of the Incomplete Beta Function Ratio (F) AS22:411 AS26:111
103 Psi (Digamma) Function (F) AS25:315
109 The Incomplete Beta Integral and the Inverse of the Incomplete Beta Function Ratio (F) AS26:111 AS39:309
121 Trigamma Function (F) AS27:97 AS40:514
123 Mixtures of Beta Distributions (F) AS27:104
147 A Simple Series for the Incomplete Gamma Integral (F) AS29:113 AS29:229 AS34:326 AS38:423
187 Derivatives of the Incomplete Gamma Integral (F) AS31:330
226 Computing Noncentral Beta Probabilities (F) AS36:241 AS39:311
239 Chi-squared and Incomplete Gamma Integral (F) AS37:466
245 A Robust and Reliable Algorithm for the Logarithm of the Gamma Function (F) AS38:397

C8 : Normal distributions and error functions

2 The Normal Integral (F) AS17:186 AS18:299
24 From Normal Integral to Deviate (F) AS18:290
66 The Normal Integral (F) AS22:424
70 The Percentage Points of the Normal Distribution (F) AS23:96
111 The Percentage Points of the Normal Distribution (F) AS26:118
195 Multivariate Normal Probabilities with Error Bound (F) AS33:81 AS34:103
241 The Percentage Points of the Normal Distribution (F) AS37:477
D : Linear Algebra

D1 : Elementary vector and matrix operations
11 Normalizing a Symmetric Matrix (F) AS17:287

D2 : Solution of systems of linear equations (including inversion, \textit{LU} and related decompositions)
6 Triangular Decomposition of a Symmetric Matrix (F) AS17:195 AS23:477
7 Inversion of a Positive Semi-definite Symmetric Matrix (F) AS17:198 AS31:336
34 Sequential Inversion of Band Matrices (F) AS19:290
37 Inversion of a Symmetric Matrix (A60) AS20:111 AS23:100

D3 : Determinants
82 The Determinant of an Orthogonal Matrix (F) AS24:150

D4 : Eigenvalues, eigenvectors
60 Latent Roots and Vectors of a Symmetric Matrix (F) AS22:260 AS23:101

D5 : \textit{QR} decomposition, Gram-Schmidt orthogonalization
46 Gram–Schmidt Orthogonalization (F) AS20:335

G : Optimization \textit{(search also classes K, L8)}

G1 : Unconstrained
47 Function Minimization using a Simplex Procedure (F) AS20:338 AS23:252
133 Optimization of One-Dimensional Multimodal Functions (F) AS27:367

G2 : Constrained
13 Minimum Spanning Tree (A60) AS18:103
14 Printing the Minimum Spanning Tree (A60) AS18:105
40 Updating a Minimum Spanning Tree (F) AS20:204
263 Construction of Irredundant Test Sets (F) AS40:213

J : Integral transforms

J1 : Trigonometric transforms including Fast Fourier transforms
83 Complex Discrete Fast Fourier Transform (F) AS24:153
97 Real Discrete Fast Fourier Transform (F) AS25:166
117 The Chirp Discrete Fourier Transform of General Length (F) AS26:351
186 Fast Algorithm of Data Permutation in Discrete Fast Fourier Transform (F) AS31:327
K : Approximation (search also class L8)

K1 : Least squares \( (L_2) \) approximation

164 Least Squares Subject to Linear Constraints (F) AS30:204 AS30:357 AS37:484
225 Minimizing Linear Inequality Constrained Mahalanobis Distances (F) AS36:234
228 Finding \( l \)-Projections Subject to a Finite Set of Linear Inequality Constraints (F) AS36:377

K5 : Smoothing

222 Resistant Smoothing Using the Fast Fourier Transform (F) AS36:104 AS37:316

L : Statistics, probability

L1 : Data summarization

12 Sums of Squares and Products Matrix (F) AS17:289
16 Maximum Likelihood Estimation from Grouped and Censored Normal Data (A60) AS18:110 AS26:122 AS36:119
18 Evaluation of Marginal Means (A60) AS18:197
41 Updating the Sample Mean and Dispersion Matrix (F) AS20:206
52 Calculation of Power Sums of Deviations about the Mean (F) AS21:226
78 The Mediancentre (F) AS23:466 AS24:390
101 Distribution-free Confidence Intervals (F) AS25:309
119 Tabulating Sparse Joint Frequency Distributions (F) AS26:364
131 Tabulating Frequency Distributions for Variables with Structured Code Sets (F) AS27:359 AS38:582
143 The Mediancentre (F) AS28:325
180 A Linear Estimator of Standard Deviation in Symmetrically Trimmed Normal Samples (F) AS31:174
235 Number tally (F) AS37:285
240 Updating the Inverse of the Dispersion Matrix (F) AS37:474

L2 : Data manipulation

267 Probabilities and Standardized Differences for Selecting Subsets Containing the Best Populations (F) AS40:495

L3 : Elementary statistical graphics (search also class Q)

21 Scale Selection for Computer Plots (F) AS18:206 AS20:118 AS23:248
30 Half Normal Plotting (F) AS19:192 AS20:118 AS21:351
44 Scatter Diagram Plotting (F) AS20:327 AS23:248
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**L6 : Random number generation**

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**L8 : Regression** *(search also classes D5, D6, D9, G, K)*

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Chapter 3

Full GAMS Classification

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Chapter 4

The GAMS index

In this chapter we reproduce the full GAMS index produced by Boisvert et al. [2]. We are indebted to Ron Boisvert for providing us with a machine readable copy of this index and for permission to reproduce it.
A Arithmetic, error analysis

A1 Integer
A2 Rational
A3 Real
A3a Standard precision
A3c Extended precision
A3d Extended range
A4 Complex
A4a Standard precision
A4c Extended precision
A4d Extended range
A5 Interval
A5a Real
A5b Complex
A6 Change of representation
A6a Type conversion
A6b Base conversion
A6c Decomposition, construction
A7 Sequences (e.g., convergence acceleration)

B Number theory

C Elementary and special functions (search also class L5)
C1 Integer-valued functions (e.g., floor, ceiling, factorial, binomial coefficient, permutations, combinations)
C2 Powers, roots, reciprocals
C3 Polynomials
C3a Orthogonal
C3a1 Trigonometric
C3a2 Chebyshev, Legendre
C3a3 Laguerre
C3a4 Hermite
C3b Non-orthogonal
C4 Elementary transcendental functions
C4a Trigonometric, inverse trigonometric
C4b Exponential, logarithmic
C4c Hyperbolic, inverse hyperbolic
C4d Integrals of elementary transcendental functions
C5 Exponential and logarithmic integrals
C6 Cosine and sine integrals
C7 Gamma
C7a Gamma, log gamma, reciprocal gamma
C7b Beta, log beta
C7c Psi function
C7d Polygamma function
C7e Incomplete gamma
C7f Incomplete beta
C7g Riemann zeta
C8 Error functions
C8a Error functions, their inverses, integrals, including the normal distribution function
C8b Fresnel integrals
C8c Dawson’s integral
C9 Legendre functions
C10 Bessel functions
C10a $J$, $Y$, $H_1$, $H_2$
C10a Real argument, integer order
C10b Complex argument, integer order
C10c Real argument, real order
C10d Complex argument, complex order
C10e Kelvin functions
C10f Airy and Scorer functions
C10g Struve, Anger, and Weber functions
C10h Confluent hypergeometric functions
C10i Coulomb wave functions
C10j Jacobian elliptic functions, theta functions
C10k Elliptic integrals
C10l Weierstrass elliptic functions
C10m Parabolic cylinder functions
C10n Mathieu functions
C10o Spheroidal wave functions
C10p Other special functions

D Linear Algebra

D1 Elementary vector and matrix operations
D1a Elementary vector operations
D1a1 Set to constant
D1a2 Minimum and maximum components
D1a3 Norm
D1a4 L_1 (sum of magnitudes)
D1a5 L_2 (Euclidean norm)
D1a6 L_\infty (maximum magnitude)
D1a7 Dot product (inner product)
D1a8 Copy or exchange (swap)
D1a9 Multiplication by scalar
D1a10 Triad (\alpha x + y for vectors x, y and scalar \alpha)
D1a11 Elementary rotation (Givens transformation)
D1a12 Elementary reflection (Householder transformation)
D1a13 Convolutions
D1a14 Other vector operations

D1b Elementary matrix operations
D1b1 Set to zero, to identity
D1b2 Norm
D1b3 Transpose
D1b4 Multiplication by vector
D1b5 Addition, subtraction
D1b6 Multiplication
D1b7 Matrix polynomial
D1b8 Copy
D1b9 Storage mode conversion
D1b10 Elementary rotation (Givens transformation)
D1b11 Elementary reflection (Householder transformation)

D2 Solution of systems of linear equations (including inversion, LU and related decompositions)
D2a Real nonsymmetric matrices
D2a1 General
D2a2 Banded
D2a2a Tridiagonal
D2a3 Triangular
D2a4 Sparse
D2b Real symmetric matrices
D2b1 General
D2b1a Indefinite
D2b1b Positive definite
D2b2 Positive definite banded
D2b2a Tridiagonal
D2b4 Sparse
D2c Complex non-Hermitian matrices
D2c1 General
D2c2 Banded
D2c2a Tridiagonal
D2c3 Triangular
D2c4 Sparse
D2d Complex Hermitian matrices
D2d1 General
D2d1a Indefinite
D2d1b Positive definite
D2d2 Positive definite banded
D2d2a Tridiagonal
D2d4 Sparse
D2e Associated operations (e.g., matrix reorderings)
D3 Determinants
D3a Real nonsymmetric matrices
D3a1 General
D3a2 Banded
D3a2a Tridiagonal
D3a3 Triangular
D3a4 Sparse
D3b Real symmetric matrices
D3b1 General
D3b1a Indefinite
D3b1b Positive definite
D3b2 Positive definite banded
D3b2a Tridiagonal
D3b4 Sparse
D3c Complex non-Hermitian matrices
D3c1 General
D3c2 Banded
D3c2a Tridiagonal
D3c3 Triangular
D3c4 Sparse
D3d Complex Hermitian matrices
D3d1 General
D3d1a Indefinite
D3d1b Positive definite
D3d2 Positive definite banded
D3d2a Tridiagonal
D3d4 Sparse
D4 Eigenvalues, eigenvectors
D4a Ordinary eigenvalue problems \((Ax = \lambda x)\)
D4a1 Real symmetric
D4a2 Real nonsymmetric
D4a3 Complex Hermitian
D4a4 Complex non-Hermitian
D4a5 Tridiagonal
D4a6 Banded
D4a7 Sparse
D4b Generalized eigenvalue problems (e.g., $Ax = \lambda Bx$)
D4b1 Real symmetric
D4b2 Real general
D4b3 Complex Hermitian
D4b4 Complex general
D4b5 Banded
D4c Associated operations
D4c1 Transform problem
D4c1a Balance matrix
D4c1b Reduce to compact form
D4c1b1 Tridiagonal
D4c1b2 Hessenberg
D4c1b3 Other
D4c1c Standardize problem
D4c2 Compute eigenvalues of matrix in compact form
D4c2a Tridiagonal
D4c2b Hessenberg
D4c2c Other
D4c3 Form eigenvectors from eigenvalues
D4c4 Back transform eigenvectors
D4c5 Determine Jordan normal form
D5 QR decomposition, Gram-Schmidt orthogonalization
D6 Singular value decomposition
D7 Update matrix decompositions
D7a $LU$
D7b Cholesky
D7c $QR$
D7d Singular value
D8 Other matrix equations (e.g., $AX + XB = C$)
D9 Singular, overdetermined or underdetermined systems of linear equations, generalized inverses
D9a Unconstrained
D9a1 Least squares ($L_2$) solution
D9a2 Chebyshev ($L_\infty$) solution
D9a3 Least absolute value ($L_1$) solution
D9a4 Other
D9b Constrained
D9b1 Least squares ($L_2$) solution
D9b2 Chebyshev ($L_\infty$) solution
D9b3 Least absolute value ($L_1$)
D9b4 Other
D9c Generalized inverses

E Interpolation

E1 Univariate data (curve fitting)
E1a Polynomial splines (piecewise polynomials)
E1b Polynomials
E1c Other functions (e.g., rational, trigonometric)
E2 Multivariate data (surface fitting)
E2a Gridded

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E2b  Scattered
E3  Service routines for interpolation
E3a  Evaluation of fitted functions, including quadrature
E3a1  Function evaluation
E3a2  Derivative evaluation
E3a3  Quadrature
E3b  Grid or knot generation
E3c  Manipulation of basis functions (e.g., evaluation, change of basis)
E3d  Other

F  Solution of nonlinear equations
F1  Single equation
F1a  Polynomial
F1a1  Real coefficients
F1a2  Complex coefficients
F1b  Nonpolynomial
F2  System of equations
F3  Service routines (e.g., check user-supplied derivatives)

G  Optimization (search also classes K, L8)
G1  Unconstrained
G1a  Univariate
G1a1  Smooth function
G1a1a  User provides no derivatives
G1a1b  User provides first derivatives
G1a1c  User provides first and second derivatives
G1a2  General function (no smoothness assumed)
G1b  Multivariate
G1b1  Smooth function
G1b1a  User provides no derivatives
G1b1b  User provides first derivatives
G1b1c  User provides first and second derivatives
G1b2  General function (no smoothness assumed)
G2  Constrained
G2a  Linear programming
G2a1  Dense matrix of constraints
G2a2  Sparse matrix of constraints
G2b  Transportation and assignments problem
G2c  Integer programming
G2c1  Zero/one
G2c2  Covering and packing problems
G2c3  Knapsack problems
G2c4  Matching problems
G2c5  Routing, scheduling, location problems
G2c6  Pure integer programming
G2c7  Mixed integer programming
G2d  Network (for network reliability search class M)
G2d1  Shortest path
G2d2  Minimum spanning tree
G2d3  Maximum flow
G2d3a  Generalized networks
G2d3b  Networks with side constraints
G2d4  Test problem generation
G2e  Quadratic programming
G2e1  Positive definite Hessian (i.e., convex problem)
G2c2 Indefinite Hessian
G2f Geometric programming
G2g Dynamic programming
G2h General nonlinear programming
G2h1 Simple bounds
G2h1a Smooth function
G2h1a1 User provides no derivatives
G2h1a2 User provides first derivatives
G2h1a3 User provides first and second derivatives
G2h1b General function (no smoothness assumed)
G2h2 Linear equality or inequality constraints
G2h2a Smooth function
G2h2a1 User provides no derivatives
G2h2a2 User provides first derivatives
G2h2a3 User provides first and second derivatives
G2h2b General function (no smoothness assumed)
G2h3 Nonlinear constraints
G2h3a Equality constraints only
G2h3a1 Smooth function and constraints
G2h3a1a User provides no derivatives
G2h3a1b User provides first derivatives of function and constraints
G2h3a1c User provides first and second derivatives of function and constraints
G2h3a2 General function and constraints (no smoothness assumed)
G2h3b Equality and inequality constraints
G2h3b1 Smooth function and constraints
G2h3b1a User provides no derivatives
G2h3b1b User provides first derivatives of function and constraints
G2h3b1c User provides first and second derivatives of function and constraints
G2h3b2 General function and constraints (no smoothness assumed)

G2i Global solution to nonconvex problems
G3 Optimal control
G4 Service routines
G4a Problem input (e.g., matrix generation)
G4b Problem scaling
G4c Check user-supplied derivatives
G4d Find feasible point
G4e Check for redundancy
G4f Other

H Differentiation, integration
H1 Numerical differentiation
H2 Quadrature (numerical evaluation of definite integrals)
H2a One-dimensional integrals
H2a1 Finite interval (general integrand)
H2a1a Integrand available via user-defined procedure
H2a1a1 Automatic (user need only specify required accuracy)
H2a1a2 Nonautomatic
H2a1b Integrand available only on grid
H2a1b1 Automatic (user need only specify required accuracy)
H2a1b2 Nonautomatic
H2a2 Finite interval (specific or special type integrand including
weight functions, oscillating and singular integrands, principal
value integrals, splines, etc.)
H2a2a Integrand available via user-defined procedure
H2a2a1 Automatic (user need only specify required accuracy)
H2a2a2 Nonautomatic
H2a2b Integrand available only on grid
H2a2b1 Automatic (user need only specify required accuracy)
H2a2b2 Nonautomatic
H2a3 Semi-infinite interval (including exp $-x$ weight function)
H2a3a Integrand available via user-defined procedure
H2a3a1 Automatic (user need only specify required accuracy)
H2a3a2 Nonautomatic
H2a4 Infinite interval (including exp $-x^2$ weight function)
H2a4a Integrand available via user-defined procedure
H2a4a1 Automatic (user need only specify required accuracy)
H2a4a2 Nonautomatic
H2b Multidimensional integrals
H2b1 One or more hyper-rectangular regions (includes iterated integrals)
H2b1a Integrand available via user-defined procedure
H2b1a1 Automatic (user need only specify required accuracy)
H2b1b Integrand available only on grid
H2b1b1 Automatic (user need only specify required accuracy)
H2b1b2 Nonautomatic
H2b2 n-D quadrature on a nonrectangular region
H2b2a Integrand available via user-defined procedure
H2b2a1 Automatic (user need only specify required accuracy)
H2b2b Integrand available only on grid
H2b2b1 Automatic (user need only specify required accuracy)
H2b2b2 Nonautomatic
H2c Service routines (e.g., compute weights and nodes for quadrature formulas)

I Differential and integral equations

I1 Ordinary differential equations (ODE’s)
I1a Initial value problems
I1a1 General, nonstiff or mildly stiff
I1a1a One-step methods (e.g., Runge-Kutta)
I1a1b Multistep methods (e.g., Adams’ predictor-corrector)
I1a1c Extrapolation methods (e.g., Bulirsch-Stoer)
I1a2 Stiff and mixed algebraic-differential equations
I1b Multipoint boundary value problems
I1b1 Linear
I1b2 Nonlinear
I1b3 Eigenvalue (e.g., Sturm-Liouville)
I1c Service routines (e.g., interpolation of solutions, error handling, test programs)

I2 Partial differential equations
I2a Initial boundary value problems
I2a1 Parabolic
I2a1a One spatial dimension
I2a1b Two or more spatial dimensions
I2a2 Hyperbolic
I2b Elliptic boundary value problems
I2b1 Linear
I2b1a Second order
I2b1a1 Poisson (Laplace) or Helmholtz equation
I2b1a1a Rectangular domain (or topologically rectangular in the coordinate system)
I2b1a1b Nonrectangular domain
I2b1a2 Other separable problems
I2b1a3 Nonseparable problems
I2b1c Higher order equations (e.g., biharmonic)
I2b2 Nonlinear
I2b3 Eigenvalue
I2b4 Service routines
I2b4a Domain triangulation (search also class P2a2c1)
I2b4b Solution of discretized elliptic equations
I3 Integral equations

J Integral transforms

J1 Trigonometric transforms including Fast Fourier transforms
J1a One-dimensional
J1a1 Real
J1a2 Complex
J1a3 Sine and cosine transforms
J1b Multidimensional
J2 Convolutions
J3 Laplace transforms
J4 Hilbert transforms

K Approximation (search also class L8)

K1 Least squares ($L_2$) approximation
K1a Linear least squares (search also classes D5, D6, D9)
K1a1 Unconstrained
K1a1a Univariate data (curve fitting)
K1a1a1 Polynomial splines (piecewise polynomials)
K1a1a2 Polynomials
K1a1b Other functions (e.g., rational, trigonometric, user-specified)
K1a1b Multivariate data (surface fitting)
K1a2 Constrained
K1a2a Linear constraints
K1a2b Nonlinear constraints
K1b Nonlinear least squares
K1b1 Unconstrained
K1b1a Smooth functions
K1b1a1 User provides no derivatives
K1b1a2 User provides first derivatives
K1b1a3 User provides first and second derivatives
K1b1b General functions
K1b2 Constrained
K1b2a Linear constraints
K1b2b Nonlinear constraints
K2 Minimax ($L_{\infty}$) approximation
K3 Least absolute value ($L_1$) approximation
K4 Other analytic approximations (e.g., Taylor polynomial, Pade)
K5 Smoothing
K6 Service routines for approximation
K6a Evaluation of fitted functions, including quadrature
K6a1 Function evaluation
K6a2 Derivative evaluation
K6a3 Quadrature
K6b Grid or knot generation
K6c Manipulation of basis functions (e.g., evaluation, change of basis)
K6d    Other

L    Statistics, probability

L1    Data summarization
L1a    One-dimensional data
L1a1   Raw data
L1a1a  Location
L1a1b  Dispersion
L1a1c  Shape
L1a1d  Frequency, cumulative frequency
L1a1e  Ties
L1a3   Grouped data
L1b    Two dimensional data (*search also class L1c*)
L1c    Multi-dimensional data
L1c1   Raw data
L1c1b  Covariance, correlation
L1c1d  Frequency, cumulative frequency
L1c2   Raw data containing missing values (*search also class L1c*)

L2    Data manipulation
L2a    Transform (*search also classes L1a, N6, and N8*)
L2b    Tally data
L2c    Subset
L2d    Merge (*search also class N7*)
L2e    Construct new variables (e.g., indicator variables)

L3    Elementary statistical graphics (*search also class Q*)
L3a    One-dimensional data
L3a1   Histograms
L3a2   Frequency, cumulative frequency, percentile plots
L3a3   EDA (e.g., box-plots, stem-and-leaf plots)
L3a4   Bar charts
L3a5   Pie charts
L3a6   \( X_i \) vs. \( i \) (including symbol plots)
L3a7   Lag plots (e.g., plots of \( X_i \) vs. \( X_{i-1} \))
L3b    Two-dimensional data (*search also class L3e*)
L3b1   Histograms (superimposed and bivariate)
L3b2   Frequency, cumulative frequency
L3b3   EDA
L3b4   Scatter diagrams
L3b4a  \( Y \) vs. \( X \)
L3b4b  Symbol plots
L3b4c  Lag plots (i.e., plots of \( X_i \) vs. \( Y_{i-j} \))
L3c    Three-dimensional data (*search also class L3e*)
L3e    Multi-dimensional data
L3e1   Histograms
L3e2   Frequency, cumulative frequency, percentile plots
L3e3   Scatter diagrams
L3e3a  Superimposed scatter diagrams of two or more \( Y \)-variables vs. one or more \( X \)-variables
L3e3c  Superimposed scatter diagrams of \( X_i \) vs. \( i \) for two or more \( X \)-variables
L3e3d  Matrices of bivariate scatter diagrams
L3e4   EDA

L4    Elementary data analysis
L4a    One-dimensional data
L4a1   Raw data
L4a1a  Parametric analysis
L4a1a1 Plots of empirical and theoretical density and distribution functions
L4a1a2 Parameter estimates and hypothesis tests
L4a1a2b Beta, binomial
L4a1a2c Cauchy, chi-squared
L4a1a2d Double exponential
L4a1a2e Exponential, extreme value type 1, extreme value type 2
L4a1a2f F distribution
L4a1a2g Gamma, geometric
L4a1a2h Halfnormal
L4a1a2l Lambda, logistic, lognormal
L4a1a2n Negative binomial, normal
L4a1a2p Pareto, Poisson
L4a1a2s Semicircular
L4a1a2t t distribution, triangular
L4a1a2u Uniform
L4a1a2w Weibull
L4a1a3 Probability plot correlation coefficient plots
L4a1a3c Chi-squared
L4a1a3e Extreme value type 2
L4a1a3g Gamma, geometric
L4a1a3l Lambda
L4a1a3n Normal
L4a1a3p Pareto, Poisson
L4a1a3t t distribution
L4a1a3w Weibull
L4a1a4 Parameter estimates and tests
L4a1a4b Binomial
L4a1a4e Extreme value
L4a1a4n Normal
L4a1a4p Poisson
L4a1a4u Uniform
L4a1a4w Weibull
L4a1a5 Transformation selection (e.g., for normality)
L4a1a6 Tail and outlier analysis
L4a1a7 Tolerance limits
L4a1b Distribution-free (nonparametric) analysis
L4a1b1 Estimates and tests regarding location (e.g., median), dispersion, and shape
L4a1b2 Density function estimation
L4a1c Goodness-of-fit tests
L4a1d Analysis of a sequence of numbers (search also class L10a)
L4a3 Grouped (and/or censored) data
L4a4 Data sampled from a finite population
L4a5 Categorical data
L4b Two dimensional data (search also class L4c)
L4b1 Pairwise independent data
L4b1a Parametric analysis
L4b1a1 Plots of empirical and theoretical density and distribution functions
L4b1a4 Parameter estimates and hypothesis tests
L4b1b Distribution-free analysis (e.g., tests based on ranks)
L4b1c Goodness-of-fit tests
L4b3 Pairwise dependent data
L4b4 Pairwise dependent grouped data
L4b5 Data sampled from a finite population
L4c Multi-dimensional data (search also classes L4b and L7a1)
L4c1 Independent samples
L4c1a Parametric analysis
L4c1b Distribution-free analysis (e.g., tests based on ranks)
L4e Multiple multi-dimensional data sets
L5 Function evaluation (search also class C)
L5a Univariate
L5a1 Cumulative distribution functions, probability density functions
L5a1b Beta, binomial
L5a1c Cauchy, chi-squared
L5a1d Double exponential
L5a1e Error function, exponential, extreme value
L5a1f F distribution
L5a1g Gamma, general, geometric
L5a1h Halfnormal, hypergeometric
L5a1k Kendall F statistic, Kolmogorov-Smirnov
L5a1l Lambda, logistic, lognormal
L5a1n Negative binomial, normal
L5a1p Pareto, Poisson
L5a1t t distribution
L5a1u Uniform
L5a1v Von Mises
L5a1w Weibull
L5a2 Inverse distribution functions, sparsity functions
L5a2b Beta, binomial
L5a2c Cauchy, chi-squared
L5a2d Double exponential
L5a2e Error function, exponential, extreme value
L5a2f F distribution
L5a2g Gamma, general, geometric
L5a2h Halfnormal
L5a2l Lambda, logistic, lognormal
L5a2n Negative binomial, normal, normal order statistics
L5a2p Pareto, Poisson
L5a2t t distribution
L5a2u Uniform
L5a2w Weibull
L5b Multivariate
L5b1 Cumulative multivariate distribution functions, probability density functions
L5b1n Normal
L5b2 Inverse cumulative distribution functions
L5b2n Normal
L6 Random number generation
L6a Univariate
L6a2 Beta, binomial, Boolean
L6a3 Cauchy, chi-squared
L6a4 Double exponential
L6a5 Exponential, extreme value
L6a6 F distribution
L6a7 Gamma, general (continuous, discrete), geometric
L6a8 Halfnormal, hypergeometric
L6a12 Lambda, logistic, lognormal
L6a14 Negative binomial, normal, normal order statistics
L6a16 Pareto, Pascal, permutations, Poisson
L6a19 Samples, stable distribution
L6a20 t distribution, time series, triangular
L6a21 Uniform (continuous, discrete), uniform order statistics

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L6a22 Von Mises
L6a23 Weibull
L6b Multivariate
L6b3 Contingency table, correlation matrix
L6b5 Experimental designs
L6b12 Discrete linear $L_1$ (least absolute value) approximation test problem
L6b13 Multinomial
L6b14 Normal
L6b15 Orthogonal matrix
L6b21 Uniform
L6c Service routines (e.g., seed)
L7 Analysis of variance (including analysis of covariance)
L7a One-way
L7a1 Parametric
L7a2 Distribution-free
L7b Two-way (search also class L7d)
L7c Three-way (e.g., Latin squares) (search also class L7d)
L7d Multi-way
L7d1 Balanced complete data (equal number of observations in every cell, e.g., factorial designs)
L7d2 Balanced incomplete data (equal number of observations in cells containing data, e.g., fractional factorial designs)
L7d3 General linear models (unbalanced data)
L7e Multivariate
L7f Generate experimental designs
L7g Service routines
L8 Regression (search also classes D5, D6, D9, G, K)
L8a Simple linear (i.e., $y = b_0 + b_1 x$) (search also class L8h)
L8a1 Ordinary least squares
L8a1a Parameter estimation
L8a1a1 Unweighted data
L8a1a2 Weighted data
L8a1c Inference (e.g., calibration) (search also class L8a1a)
L8a2 $L_p$ for $p$ different from 2 (e.g., least absolute values, minimax)
L8a3 Robust least squares
L8a4 Errors in variables
L8b Polynomial (e.g., $y = b_0 + b_1 x + b_2 x^2$) (search also class L8c)
L8b1 Ordinary least squares
L8b1a Degree determination
L8b1b Parameter estimation
L8b1b1 Not using orthogonal polynomials
L8b1b2 Using orthogonal polynomials
L8b1c Analysis (search also class L8b1b)
L8b1d Inference (search also class L8b1b)
L8c Multiple linear (i.e., $y = b_0 + b_1 x_1 + \ldots + b_p x_p$)
L8c1 Ordinary least squares
L8c1a Variable selection
L8c1a1 Using raw data
L8c1a2 Using correlation or covariance data
L8c1a3 Using other data
L8c1b Parameter estimation (search also class L8c1a)
L8c1b1 Using raw data
L8c1b2 Using correlation data
L8c1c Analysis (search also classes L8c1a and L8c1b)
L8c1d Inference (search also classes L8c1a and L8c1b)
Several multiple regressions

$L_p$, for $p$ different from 2

Robust least squares

Measurement error models

Models based on ranks

Polynomial in several variables analysis

Nonlinear (i.e., $y = F(X; \beta)$) (search also class L8e)

Ordinary least squares

Variable selection

Parameter estimation (search also class L8e1a)

Unweighted data, user provides no derivatives

Unweighted data, user provides derivatives

Weighted data, user provides no derivatives

Weighted data, user provides derivatives

Ridge

Measurement error models

Simultaneous (i.e., $Y = X\beta + \epsilon$)

Spline (i.e., piecewise polynomial)

EDA (e.g., smoothing)

Service routines (e.g., matrix manipulation for variable selection)

Categorical data analysis

2-by-2 tables

Two-way tables (search also class L9d)

Log-linear model

EDA (e.g., median polish)

Time series analysis (search also class J)

Univariate (search also classes L3a6 and L3a7)

Transformations

Elementary (search also class L2a)

Stationarity (search also class L8e1)

Filters (search also class K5)

Difference filters (nonseasonal and seasonal)

Symmetric linear filters (e.g., moving averages)

Autoregressive linear

Other

Taper

Time domain analysis

Summary statistics

Autocovariances and autocorrelations

Partial autocorrelations

Stationarity analysis (search also class L10a2a)

Autoregressive models

Model identification

Parameter estimation

ARMA and ARIMA models (including Box-Jenkins methods)

Model identification

Parameter estimation

Forecasting

State-space analysis (e.g., Kalman filtering)

Analysis of a locally stationary series

Frequency domain analysis (search also class J1)

Spectral analysis

Pilot analysis

Periodogram analysis

Spectrum estimation using the periodogram

Spectrum estimation using the Fourier transform of the autocorrelation function
Spectrum estimation using autoregressive models
Spectral windows
Complex demodulation
Two time series (search also classes L3b3c, L10c, and L10d)
Time domain analysis
Summary statistics (e.g., cross-correlations)
Transfer function models
Frequency domain analysis (search also class J1)
Cross-spectral analysis
Cross-periodogram analysis
Cross-spectrum estimation using the cross-periodogram
Cross-spectrum estimation using the Fourier transform of the
cross-correlation or cross-covariance function
Multivariate time series (search also classes J1, L3e3 and L10c)
Two multi-channel time series
Correlation analysis (search also classes L4 and L13c)
Discriminant analysis
Covariance structure models
Factor analysis
Principal components analysis
Canonical correlation
Cluster analysis
One-way
Unconstrained
Nested
Joining (e.g., single link)
Divisive
Switching
Predict missing values
Non-nested
Constrained
Two-way
Service routines (e.g., compute distance matrix)
Life testing, survival analysis
Multidimensional scaling
Statistical data sets
Simulation, stochastic modelling (search also classes L6 and L10)
Simulation
Discrete
Continuous (Markov models)
Queueing
Reliability
Quality control
Electrical network
Project optimization (e.g., PERT)
Data handling (search also class L2)
Input, output
Bit manipulation
Character manipulation
Storage management (e.g., stacks, heaps, trees)
Searching
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>N5a</td>
<td>Extreme value</td>
</tr>
<tr>
<td>N5b</td>
<td>Insertion position</td>
</tr>
<tr>
<td>N5c</td>
<td>On a key</td>
</tr>
<tr>
<td>N6</td>
<td>Sorting</td>
</tr>
<tr>
<td>N6a</td>
<td>Internal</td>
</tr>
<tr>
<td>N6a1</td>
<td>Passive (i.e. construct pointer array, rank)</td>
</tr>
<tr>
<td>N6a1a</td>
<td>Integer</td>
</tr>
<tr>
<td>N6a1b</td>
<td>Real</td>
</tr>
<tr>
<td>N6a1c</td>
<td>Character</td>
</tr>
<tr>
<td>N6a2</td>
<td>Active</td>
</tr>
<tr>
<td>N6a2a</td>
<td>Integer</td>
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<tr>
<td>N6a2b</td>
<td>Real</td>
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<tr>
<td>N6a2c</td>
<td>Character</td>
</tr>
<tr>
<td>N6b</td>
<td>External</td>
</tr>
<tr>
<td>N7</td>
<td>Merging</td>
</tr>
<tr>
<td>N8</td>
<td>Permuting</td>
</tr>
<tr>
<td>O</td>
<td>Symbolic computation</td>
</tr>
<tr>
<td>P</td>
<td>Computational geometry (search also classes G and Q)</td>
</tr>
<tr>
<td>Q</td>
<td>Graphics (search also class L3)</td>
</tr>
<tr>
<td>R</td>
<td>Service routines</td>
</tr>
<tr>
<td>R1</td>
<td>Machine-dependent constants</td>
</tr>
<tr>
<td>R2</td>
<td>Error checking (e.g., check monotonicity)</td>
</tr>
<tr>
<td>R3</td>
<td>Error handling</td>
</tr>
<tr>
<td>R3a</td>
<td>Set criteria for fatal errors</td>
</tr>
<tr>
<td>R3b</td>
<td>Set unit number for error messages</td>
</tr>
<tr>
<td>R3c</td>
<td>Other utilities</td>
</tr>
<tr>
<td>R4</td>
<td>Documentation retrieval</td>
</tr>
<tr>
<td>S</td>
<td>Software development tools</td>
</tr>
<tr>
<td>S1</td>
<td>Program transformation tools</td>
</tr>
<tr>
<td>S2</td>
<td>Static program analysis tools</td>
</tr>
<tr>
<td>S3</td>
<td>Dynamic program analysis tools</td>
</tr>
<tr>
<td>Z</td>
<td>Other</td>
</tr>
</tbody>
</table>
Appendix A

Availability of Data, Tools and Algorithm Sources

In addition to the Fortran code described in Appendix B there is a perl script for transforming the original database files into a number of more useful formats. Currently the perl script will generate

1. a \texttt{BibTeX} database entry for each algorithm,
2. a cumulative index based on the \texttt{SHARE} classification like the one in [6],
3. a cumulative index based on the \texttt{GAMS} classification like the one in [7].

The algorithm databases available are

1. The \texttt{CALGO} algorithms published in Communications of the ACM from 1960–1975 and in ACM Transactions on Mathematical Software from 1975–,

The databases and software are available via electronic mail or anonymous ftp from \texttt{unix.hensa.ac.uk}.

The files are

- \texttt{acm.dbase} – the \texttt{CALGO} algorithms database,
- \texttt{acm.bib} – \texttt{BibTeX} database of the \texttt{CALGO} algorithms,
- \texttt{as.dbase} – the Applied Statistics algorithms database,
- \texttt{as.bib} – \texttt{BibTeX} database of the Applied Statistics algorithms,
- \texttt{bibeg.f}, \texttt{lib.f}, \texttt{shared.f} – Fortran 77 codes for operating on the database files. These codes are described in Appendix B,
- \texttt{bibop.sh} – a shar file containing the perl script, data files and man page as described above.

To obtain these files by electronic mail send mail of the form

\texttt{send misc/netlib/bib/file}

to \texttt{archive@unix.hensa.ac.uk} where file is replaced by the name of the file you require.
To obtain files via anonymous ftp, connect to unix.hensa.ac.uk (129.12.21.7) – the files are in the directory misc/netlib/bib. Compressed PostScript versions of [6] and [7] are also available for ftp in misc/ukc.reports/reports/64 and misc/ukc.reports/reports/71 respectively.

Please send bug reports, extensions to the perl script or further algorithm databases to trh@ukc.ac.uk.

Availability of algorithms

The sources to all algorithms published in TOMS and a number of those published in the Communications to the ACM are available via both e-mail and ftp.

To obtain copies via e-mail send a message of the form

send number from apstat

where number is the number of the algorithm you require, e.g., to obtain algorithm 276 the message would be

send 276 from apstat

to statlib@unix.hensa.ac.uk (UK/Europe) or statlib@temper.stat.cmu.edu (US).

Using anonymous ftp connect to unix.hensa.ac.uk (129.12.21.7) from the UK and Europe or lib.stat.cmu.edu (US) log in as anonymous to unix.hensa.ac.uk and statlib to lib.stat.cmu.edu. In both cases use your e-mail address as a password. To access the Applied Statistics algorithms cd statlib/apstat on unix.hensa.ac.uk and cd apstat on lib.stat.cmu.edu.

The algorithms currently available are

We report on an enhanced version of the database originally reported in [10]. In this new version we have included all the information necessary to generate full bibliographic references. Extra information includes the author’s name (including any accents), the page range of the original reference (rather than just the starting page), the month and year of publication and an abbreviated journal name. The programming language used to code the algorithm is also given. Any mathematical notation used within the algorithm title and accents in the author’s name have been defined using \TeX[8]. Following the practice used with \TeX[9], all letters within the title which need to remain capitalised in a printed version of the reference (e.g., Fortran, Bessel) are enclosed in braces.

The keywords and SHARE classification associated with each algorithm have been included with the main entry information rather than in a separate list as in [10]. Finally we have included references to all published remarks for each algorithm. These are in a compressed form which provides type (Remark or Certification), journal in which it appeared, volume, number, month and year of publication, page range and author.

The entry for each algorithm consists of either four or five records depending on whether there have been any published remarks. Each line in the file is restricted to 80 characters; records longer than this are continued on successive lines using a + in the first character position to denote that the line is a continuation line. Only the first record begins in character position one.

The first record gives details of the primary reference. The second and third are the author’s name and title of the algorithm respectively. The keywords make up the fourth record. The first four records are always present. The final record provides details of remarks; individual fields within each remark reference are separated by commas and a semicolon is used to terminate each reference. Multiple remark references are treated as a single record.

As an example, the following entry is for algorithm 487

487 cacom 703 704 12 17 December 1974 s14 F
J. Pomeranz;
Exact Cumulative Distribution of the \{K\}olmogorov-{S}mirnov Statistic for
+ Small Samples
  goodnes-of-fit testing; k-s statistic; k-s test; Kolmogorov-Smirnov test;
R,toms,111,2,1,March,1976,J. Pomeranz;

The first line should be interpreted as ‘ACM CALGO Algorithm 487 appeared in Commun. ACM, Volume 17, Number 12, December 1974, pages 703–704’. The algorithm was implemented in Fortran and the modified SHARE classification is S14 (a sub-classification of the Special Functions).
The title spans two lines and contains two letters which must remain in upper case. The second remark is interpreted as being a Remark which appeared in ACM TOMS, Volume 3, Number 3 (second of the threes) in September 1977, pages 285–294. The author was R. Kallman.

We have provided Fortran routines which read in a reference in this compressed form and split the information up into a number of variables stored in a pair of common blocks. A template showing how to use these routines is given in Figure B.1. The two common blocks CREFNO and CREFST,

```
* * TEMPLATE FOR USE OF GETREF *
* LOGICAL GETREF *
* Insert COMMON block definitions here *
* Set up i/o channels and open data file *
* (This routine contains a possibly machine dependent *
* OPEN statement)
* CALL SETUP *
* Set up output file -- application dependent routine
* CALL OUTFIL *
* Initialize input buffer for references *
* a call to initrf must precede calls to getref
* CALL INITRF *
* Process all references
10 IF (GETREF()) THEN
* process current reference
   GO TO 10
END IF
* *
```

Figure B.1: Template code for processing references

holding numerical and character data respectively, are defined by

```
INTEGER NUMBER, PAGEND, PAGEST, VOLUME, YEAR
COMMON /CREFNO/VOLUME, NUMBER, YEAR, PAGEST, PAGEND

INTEGER AUTLEN, TITLEN, KEYLEN, OTHLEN
PARAMETER (AUTLEN=80, TITLEN=160, KEYLEN=400
+ OTHLEN=300)
CHARACTER AUTHOR(AUTLEN), KEYWDS(KEYLEN),
+ OTHERS(OTHLEN), TITLE(TITLEN)
CHARACTER ALABEL* (6), JOURNL* (4), MONTH* (9),
+ LANG* (3), SHARE* (3)
```

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COMMON /CREFST/ALABEL, JOURNL, MONTH, LANG, SHARE, AUTHOR, 
+ TITLE, KEYWDS, OTHERS

where

- **JOURNL** contains the journal in which the algorithm was published (possible values are cacm, toms or topl),

- **VOLUME, NUMBER, MONTH and YEAR** store the volume, number, month and year of publication of the main reference,

- **PAGEST** and **PAGEND** give the page range of the main reference,

- the author and title are stored in the arrays **AUTHOR** and **TITLE**,

- the algorithm number (in two instances this contains a letter), implementation language (**F** = Fortran, **A60** = Algol 60, **PLI** = PL1, **R** = Ratfor, **N** = None), and the Share index are placed in **ALABEL**, **LANG** and **SHARE** respectively;

- **KEYWDS** is an array containing the list of keywords separated by semicolons,

- the array **OTHERS** stores associated Remarks and Certifications. Each remark is separated by a semicolon and contains, as a list separated by commas
  - type of remark (**R** = Remark, **C** = Certification),
  - journal of publication (**cacm** or toms)
  - page range – either a pair of number separated by -- or a single integer for a one page remark,
  - the volume, number, month and year of the publication,
  - the author.

Two example programs are included which use these routines to generate a **BIBTEX** database and a cumulative index sorted by the **SHARE** index.
Bibliography


