



## SAS/IML<sup>®</sup> SOFTWARE

A powerful, interactive matrix programming language for a wide range of applications

### What does SAS/IML<sup>®</sup> software do?

SAS/IML provides a powerful and flexible matrix programming language in a dynamic, interactive environment. A new interface provides interactive programming and exploratory data analysis. In addition, simple syntax makes it easy to translate mathematical formulas into program statements. You can program easily and efficiently with the many features for arithmetic and character expressions.

### Why is SAS/IML<sup>®</sup> software important?

You can apply SAS/IML software to problems ranging from simple matrix manipulations to estimation techniques, linear programming and nonlinear optimization. An extensive set of mathematical and matrix operators make the possibilities endless.

### For whom is SAS/IML<sup>®</sup> software designed?

This product is designed for programmers, statisticians, researchers and high-end data analysts who need a versatile computing environment that enables them to apply innovative statistical methods and to understand the multivariate relationships found in complex data.

SAS/IML software is a complete programming language with a dynamic, interactive environment for programmers, statisticians, researchers and high-end analysts. You can use SAS<sup>®</sup> solutions and products for data manipulation and statistical analysis, and then employ the SAS/IML matrix language for more specialized analyses and data exploration.

SAS/IML software makes it possible to design effective user interfaces for complex tasks that require matrix manipulations. In addition, you can create your own SAS/IML modules or use routines from a predefined library of modules. You can develop large applications piece by piece, and store modules and matrices in your own library of tools. All SAS/IML applications can be run both interactively and in batch. Exploratory analyses can be performed interactively while running production jobs in batch mode.

SAS Stat Studio, a new interactive interface for SAS/IML, enables you to debug and execute programs interactively and adds dynamic graphics for exploratory data analysis. Designed for users who've made a significant investment in learning the SAS language, SAS Stat Studio provides a statistical programming environment integrated with interactive data analysis that has the flexibility to implement customized methods that go beyond the standard functionality available in SAS analytical procedures.

Users can move seamlessly between intensive computing and interactive analysis to solve challenging problems and add business value for their company. With an optimized client/server language, multithreaded workspaces, and high-speed data transport between

client and server, SAS Stat Studio provides the performance and reliability that customers expect from SAS.

### Key benefits

- Program easily and efficiently.** Simple syntax makes it easy to translate mathematical formulas into program statements, and there are many features for arithmetic and character expressions.
- Create your own modules or use routines from a predefined library.** A complete set of control statements gives you the commands necessary for execution control and program modularization. Access to a wide range of built-in subroutines makes your programming fast, easy and efficient, and you can build your own module library to extend the functionality of the software.
- Perform interactive exploratory analyses.** Data analysts often begin an analysis by graphically exploring the data. Dynamically linked graphics are a valuable part of this exploration because they enable the discovery of relationships between variables and an understanding of outliers and unusual features in the data.
- Formulate and implement genetic algorithm optimizations.** You have the flexibility to write your own modules to specify the objective function and genetic operators or to use standard functions and operators provided by SAS/IML.
- Take advantage of automatic memory management and matrix sizing.** You do not need to declare, dimension or allocate storage for a data matrix; SAS/IML software does this automatically.



## SAS/IML® product overview

### Dynamic matrix functions

The fundamental data element in SAS/IML is the matrix, a two-dimensional (row-by-column) array of numeric or character values. You do not need to declare, dimension or allocate storage for a data matrix; SAS/IML software does this automatically. You can change the dimension or type of a matrix and reset options or replace modules at any time. You can open multiple files or access many libraries. New subroutines have been added to make sorting of matrices easier and to improve the efficiency of random number generation.

### Data processing

You can read all observations (or conditionally selected observations) from a SAS data set into a matrix, creating multiple vectors (one for each variable in the data set) or a matrix containing a column for each data set variable. You can create a new SAS data set

or append observations to an existing SAS data set in addition to editing an existing SAS data set.

### BY group processing for matrices

A new function, UNIQUEBY, makes it easier to retrieve and process BY groups in a sorted matrix. You can use the SORT and SORTNDX calls to sort a matrix, and then call the UNIQUEBY function to get a vector of indices of the first row of each unique BY group in the input matrix.

### Control statements

A complete set of control statements gives you the commands necessary for execution control and program modularization. These statements direct the flow of execution of IML statements, and enable program modularization.

### Specialized functions and call routines

The software includes built-in functions and call routines that enable you to compute determinants, eigenvalues, eigenvectors and generalized inverses;

generate design matrices and plotting data; and solve systems of linear equations and ordinary differential equations. In addition, you can compute roots of polynomials, perform numerical integration and solve both linear and nonlinear programming problems.

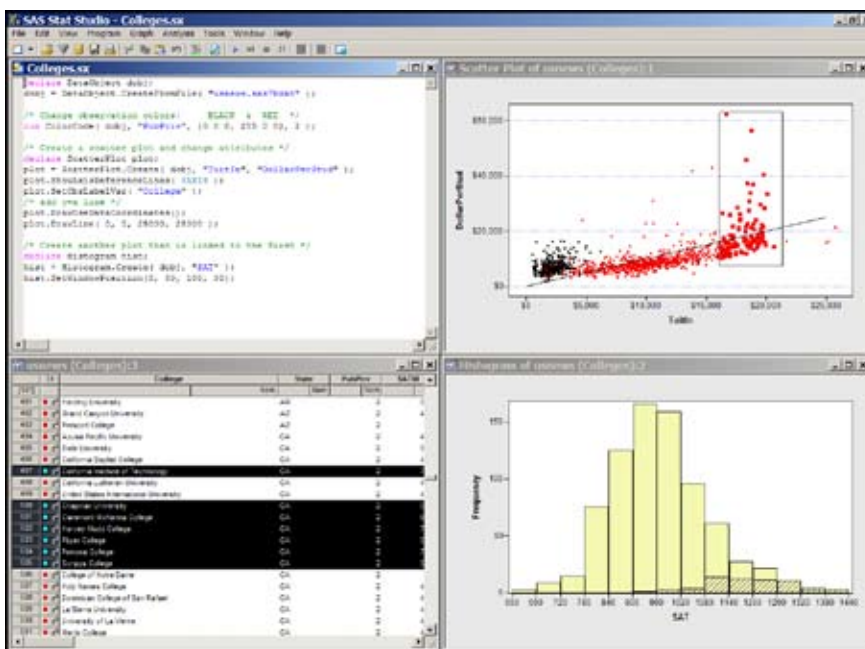
SAS/IML contains collections of routines extremely useful for certain application areas. For instance, routines for times series analysis analyze and forecast univariate and multivariate time series. Also included is a set of routines for Kalman filtering and smoothing. Routines for nonlinear optimization put state-of-the-art techniques at your fingertips.

### Modules and subroutines

You can extend SAS/IML by writing your own functions and routines and storing them as modules in libraries. SAS/IML automatically loads, resolves and executes a module when you use it. The IMLMLIB Module Library contains several modules that may be used as though they were built-in functions of SAS/IML software.

### Genetic algorithms

Genetic algorithms are a family of search algorithms that seek optimal solutions to problems using an approach that parallels the principles of natural selection and evolution in nature. There are several new experimental subroutines and functions that enable you to formulate and implement genetic algorithm optimizations. You have the flexibility either to write your own modules to specify the objective function and genetic operators or to use standard functions and operators provided by SAS/IML.



**SAS® Stat Studio provides a new, dynamic, interactive interface to SAS/IML® software. It provides access to a wide range of graphics commands, allowing you to create customized displays and visually explore relationships in data.**

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## Interactive data analysis with SAS® Stat Studio

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SAS Stat Studio is a dynamic new interactive interface in SAS/IML 9.2 that is designed to meet the needs of high-end data analysts—innovative problem solvers who are familiar with SAS/IML and SAS/STAT® but who need more versatility to try out new methods. SAS Stat Studio provides a rich programming environment that blends SAS/IML with the ability to call SAS procedures as functions and to create customized dynamic graphics.

With SAS Stat Studio, you can build on your familiarity with SAS/STAT or SAS/IML to write programs that explore data, fit models and relate the results to the data with linked graphics. You can programmatically add legends, curves, maps or other custom features to plots, and you can develop interactive analyses that use dialog boxes. You have access to a wide range of graphics commands, allowing you to create customized displays and visually explore relationships in data.

If your programs are computationally intense, you can run them simultaneously in multiple workspaces, possibly connected to multiple SAS servers, and you can move seamlessly between programs and interactive analysis.

SAS Stat Studio includes an integrated development environment for writing, debugging and executing IML programs. The enhanced IML language (called IMLPlus) provides new features such as the ability to call SAS procedures and external C, FORTRAN or Java functions. (SAS Stat Studio runs on Microsoft Windows only.)

## SAS/IML® Key Features

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### Extensive set of mathematical and matrix operators

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- BY-group processing for matrices.

### Control statements

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- Direct the flow of execution of IML statements.
- Enable program modularization.

### General matrix functions

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- Absolute values, exponentials, remainders and powers of matrix elements.
- Find elements in a matrix satisfying given conditions.
- Cumulative sums, horizontal direct product and trace.
- Create block diagonal, identity, diagonal and transposed matrices.
- Reshape a matrix.
- Find set difference, set union or set intersection of matrices; remove duplicates from matrices.

### Linear algebraic and statistical functions

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- Solve an ordinary differential equation.
- Perform numerical integration.
- Compute eigenvalues and eigenvectors for symmetric and unsymmetric matrices; create orthonormal eigenvectors.
- Compute inverses, generalized inverses, Moore-Penrose inverses and determinants.
- Compute Gram-Schmidt orthonormal factorization.
- Perform Cholesky, singular value and complete orthogonal decomposition.
- Perform QR decomposition by Householder rotation or the Gram-Schmidt process.
- Solve linear programs, linear systems and systems of linear equations.
- Compute the first nonzero roots of a Bessel function of the first kind and the derivative of the Bessel function at each root.
- Perform discrete sequential tests.

### Time series functions

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- Compute ARMA model autocovariance sequence, log likelihood and residuals.
- Simulate a univariate ARMA time series.
- Compute autocovariance estimates for time series.
- Generate a Hankel, Toeplitz or block Toeplitz matrix.
- Perform finite Fourier transformations and inverse FFTs.
- Kalman filtering.
- TIMSAC (TIME Series Analysis and Control) routines (developed by the Institute of Statistical Mathematics, Japan).

### Numerical analysis functions

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- Solve ordinary differential equations.
- Perform numerical integration.
- Nonlinear optimization.

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## SAS/IML® Software Technical Requirements

### Supported platforms

- AIX: Release 5.3 on POWER architectures
- HP-UX PA-RISC: HP-UX 11iv2 (11.23), 11iv3 (11.31)
- HP-UX Itanium: HP-UX 11iv2 (11.23), 11iv3 (11.31)
- Linux for x86 (x86-32): RHEL 4, SuSE SLES 9
- Linux for x64 (EM64T/AMD64): RHEL 4, SuSE SLES 9
- Microsoft Windows (x86-32): Windows XP Professional, Windows Vista\*, Windows Server 2003 family
- Microsoft Windows on x64 (EM64T/AMD64): Windows XP Professional for x64, Windows Vista\* for x64, Windows Server 2003 for x64
- Microsoft Windows (on Itanium): Windows Server 2003 for Itanium-based systems
- OpenVMS for HP Integrity Servers (Itanium) 8.3
- Solaris on SPARC: Version 9, 10
- Solaris on x64: Version 10
- z/OS: V1R7, z/OS V1R8, z/OS V1R9 and higher

\* NOTE: Windows Vista editions that are supported include Enterprise, Business and Ultimate.

### Required software

Base SAS®

## SAS® Stat Studio Technical Requirements

SAS Stat Studio runs only on Microsoft Windows and requires Base SAS®, SAS/IML® and SAS /STAT® software.

## SAS® Stat Studio Key Features

### Interactive data analysis with SAS® Stat Studio

- Data exploration:
  - Identify observations in plots.
  - Select observations in linked data tables and graphics.
  - Exclude observations from graphs and analyses.
  - Search, sort, subset and extract data.
  - Transform variables.
- Distribution analysis:
  - Compute descriptive statistics.
  - Create quantile-quantile plots.
  - Create mosaic plots of cross-classified data.
  - Fit parametric and kernel density estimates for distributions.
  - Detect outliers in contaminated Gaussian data.
- Parametric and nonparametric regression:
  - Fit general linear models, logistic regression models and robust regression models.
  - Smooth two-dimensional data by using polynomials, loess curves and thin-plate splines.
  - Create residual and influence diagnostic plots.
  - Include classification effects in logistic and generalized linear models.
- Multivariate analysis
  - Create correlation matrices and scatter plot matrices with confidence ellipses.
  - Principal components analysis.
  - Discriminant analysis.
  - Factor analysis.
  - Correspondence analysis.

### Integrated programming environment

- Write, debug and execute IMLPlus programs in an integrated development environment.
- Execute SAS procedure or DATA step code from within your IMLPlus program.
- Call SAS procedures as functions.
- Create customized, dynamically linked graphics.
- Develop interactive data analysis programs that use dialog boxes.
- Call functions from libraries written in C/C++, FORTRAN and Java.
- Seamless integration between intensive computing and interactive data analysis.
- High-speed data transport between client and server.
- Multithreaded workspace.



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