



SAS/IML[®] Software

A powerful, interactive matrix programming language for a wide range of applications – with integration to R

What does SAS/IML[®] software do?

SAS/IML provides a powerful and flexible matrix programming language in a dynamic, interactive environment. The SAS/IML Studio interface provides interactive programming and exploratory data analysis. 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. In addition, users can submit R code within SAS, enabling experimentation with new methods not yet implemented in SAS.

Why is SAS/IML[®] 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[®] 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 manipulate and analyze data with many SAS[®] products, and then use 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. Users can also submit R code through the IML server language (PROC IML) on Windows and Linux servers.

SAS/IML Studio is an interface that enables you to interactively debug and execute SAS/IML programs and adds dynamic graphics for exploratory data analysis. SAS/IML Studio also provides integration with R. Designed for users who have made a significant investment in learning the SAS language, SAS/IML Studio provides 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. With an optimized client/server language, multi-threaded workspaces and high-speed data transport between client and server, SAS/IML Studio provides enhanced performance and reliability.

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 set of control statements lets you easily direct execution and program modularization. Access to a wide range of built-in subroutines enables fast, easy and efficient programming. You also can build your own module library to extend functionality.
- 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 software.
- 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.
- Submit R code within the SAS environment.** Using the SAS/IML interface or the IML server language (PROC IML) on Windows and Linux servers, users can try out new methods not yet implemented in SAS.



SAS/IML® Product Overview

General 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 because 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

The UNIQUEBY function 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 provides the commands necessary for execution control and program modularization. These statements direct the flow of execution for SAS/IML statements and enable program modularization.

Modules and subroutines

You can extend SAS/IML software by writing your own functions and routines and storing them as modules in libraries. SAS/IML software 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.

Linear algebraic and statistical functions

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.

Time series functions

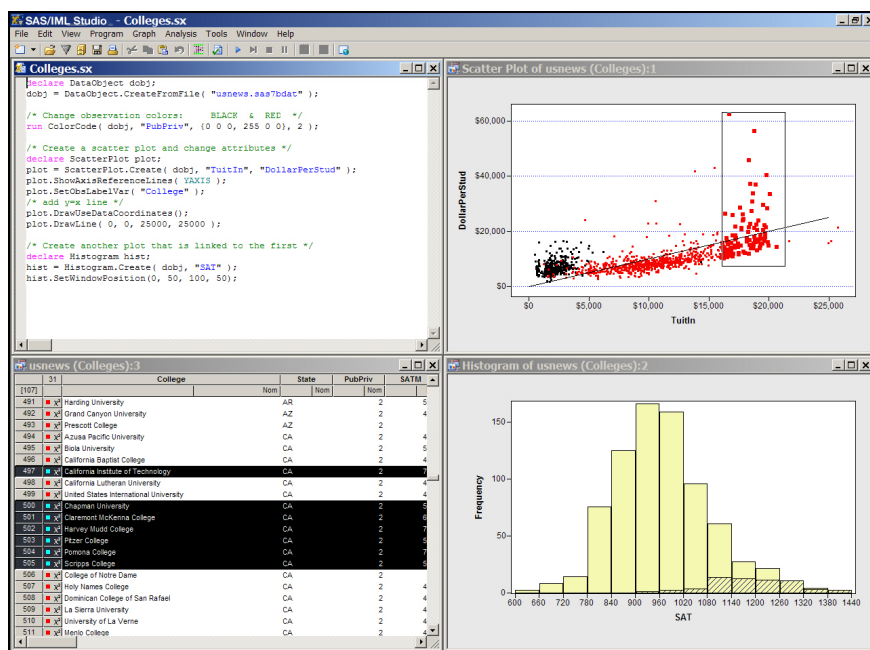
SAS/IML software contains collections of routines that are extremely useful for certain application areas. For instance, routines for time series analysis analyze and forecast univariate and multivariate time series. Also included is a set of routines for Kalman filtering and smoothing. Routines for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

Numerical analysis functions

With SAS/IML, you can compute roots of polynomials, perform numerical integration and solve both linear and nonlinear programming problems.

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 software.



SAS/IML® Studio provides a dynamic, interactive interface to SAS/IML software. A wide range of graphics commands enables you to create customized displays and visually explore relationships in data, as well as execute R through the interface.

Interactive Data Analysis with SAS/IML® Studio

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

With SAS/IML Studio, you can build on your familiarity with SAS/STAT or SAS/IML software 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/IML Studio includes an integrated development environment for writing, debugging and executing IML programs. The enhanced IML language (called IMLPlus) provides features such as the ability to call SAS procedures and external C, FORTRAN or Java functions.

(SAS/IML Studio runs on Microsoft Windows only.)

SAS/IML® Key Features

Extensive set of mathematical and matrix operators

- Provides BY-group processing for matrices.

Control statements

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

General matrix functions

- Provides absolute values, exponentials, remainders and powers of matrix elements.
- Finds elements in a matrix that satisfy given conditions.
- Provides cumulative sums, horizontal direct product and trace.
- Lets you create block diagonal, identity, diagonal and transposed matrices.
- Lets you reshape a matrix.
- Finds set difference, set union or set intersection of matrices; removes duplicates from matrices.

Linear algebraic and statistical functions

- Solve an ordinary differential equation.
- Perform numerical integration.
- Compute eigenvalues and eigenvectors for symmetric and nonsymmetric 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

- 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.
- Perform Kalman filtering.
- Use TIMSAC (TIME Series Analysis and Control) routines (developed by the Institute of Statistical Mathematics, Japan).

Numerical analysis functions

- Perform numerical integration.
- Use nonlinear optimization.

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SAS/IML® Studio Key Features

Interactive data analysis with SAS/IML 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 in SAS/IML Studio

- Write, debug and execute IMLPlus programs in an integrated development environment.
- Execute SAS procedures 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.
- Provides seamless integration between intensive computing and interactive data analysis.
- Provides high-speed data transport between client and server.
- Utilizes multithreaded workspace.
- Quickly and easily apply methods in R while working in SAS, enabling you to obtain new capabilities at no extra cost.

SAS/IML® and SAS/IML® Studio Software System Requirements

To learn more about SAS/IML and SAS/IML Studio system requirements, download white papers, view screenshots and see other related materials, please visit www.sas.com/iml.