SAS/IML® Software
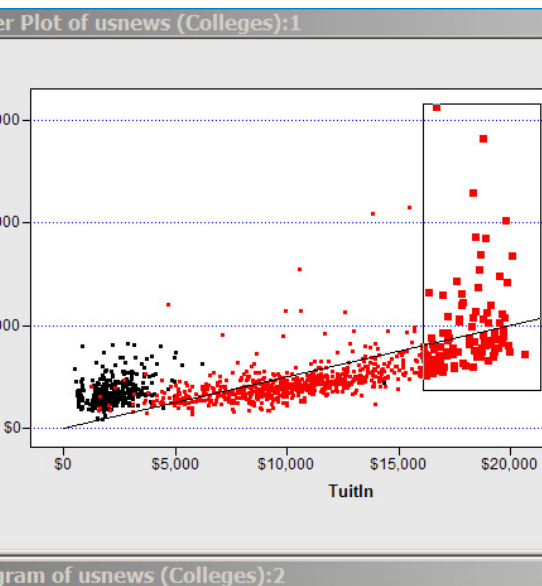
An interactive matrix programming language for creating custom analyses with integration to R

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THE POWER TO KNOW®

What does SAS/IML® do?

SAS/IML software can be used to extend the capabilities of SAS® software. A high-level matrix language makes it easy to translate mathematical formulas into innovative programs.

Why is SAS/IML® important?

You can write arbitrarily complex programs using an extensive library of functions for data analysis, optimization, simulation, matrix computations, numerical analysis and more. The applications are endless. SAS/IML Studio enables you to use exploratory data analysis to understand relationships in complex data.

For whom is SAS/IML® designed?

SAS/IML software is designed for programmers, statisticians, researchers and high-end data analysts who need a versatile computing environment so they can program innovative statistical methods and explore multivariate data.

Do you need to compute statistics or perform analyses that aren't available from any SAS procedure? Reach for SAS/IML software! You can use hundreds of functions in the SAS/IML matrix language to implement specialized analyses and algorithms. As part of your SAS/IML program, you can also call SAS procedures and submit R code. Share your programs and libraries by uploading them to the SAS/IML File Exchange, or download programs written by others.

SAS/IML Studio is an interface that enables you to interactively debug and execute SAS/IML programs. It includes dynamic graphics for exploratory data analysis. SAS/IML Studio is designed for power users who implement customized methods that go beyond the standard functionality available in SAS analytical procedures. Move seamlessly between intensive computing and interactive analysis to solve challenging problems.

Benefits

- **Program easily and efficiently.** A simple syntax and extensive function library make it easy to translate mathematical formulas into program statements.

- **Create and share user-defined modules.** You can build your own module library to extend SAS functionality. You share your functions with others by writing packages, and you can download packages written by others.

- **Perform interactive exploratory analyses.** Data analysts often begin an analysis by graphically exploring the data. Dynamically linked graphics in SAS/IML Studio enable the discovery of relationships between variables and an understanding of outliers and unusual features in the data.

- **Take advantage of automatic memory management**. You do not need to declare or allocate storage for a data matrix – SAS/IML software does this automatically.

- **Optimize functions.** Many statistical methods require optimization of nonlinear functions. Find optimum values for objective functions subject to constraints.

- **Simulate data.** Generate random samples from univariate and correlated multivariate distributions to efficiently simulate data for evaluating statistical techniques.

- **Visualize results.** Use ODS statistical graphics or the interactive linked graphics in SAS/IML Studio.

- **Submit SAS code and R code.** Call any SAS procedure or macro from within your SAS/IML program. On Windows and Linux systems, you can call R functions and packages to apply methods not yet implemented in SAS. Easily transfer data between SAS and R.

SAS/IML® Overview

Matrix computations

The fundamental data element in SAS/IML is the matrix – a two-dimensional array of numeric or character values. You do not need to declare 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 replace elements at any time. Matrix operations, solving linear systems and matrix decompositions are supported.

Figure 1: SAS/IML software supports ODS statistical graphics, including heat maps to visualize matrices.

Figure 2: SAS/IML Studio provides a dynamic, interactive interface to SAS/IML software.

Nonmatrix data types

SAS/IML now supports tables (a rectangular structure that is an in-memory version of a SAS data set, which can contain either numeric or character data) and lists (a nonrectangular data structure that can contain objects of different sizes and types: numeric matrices, character matrices, tables, and other lists).
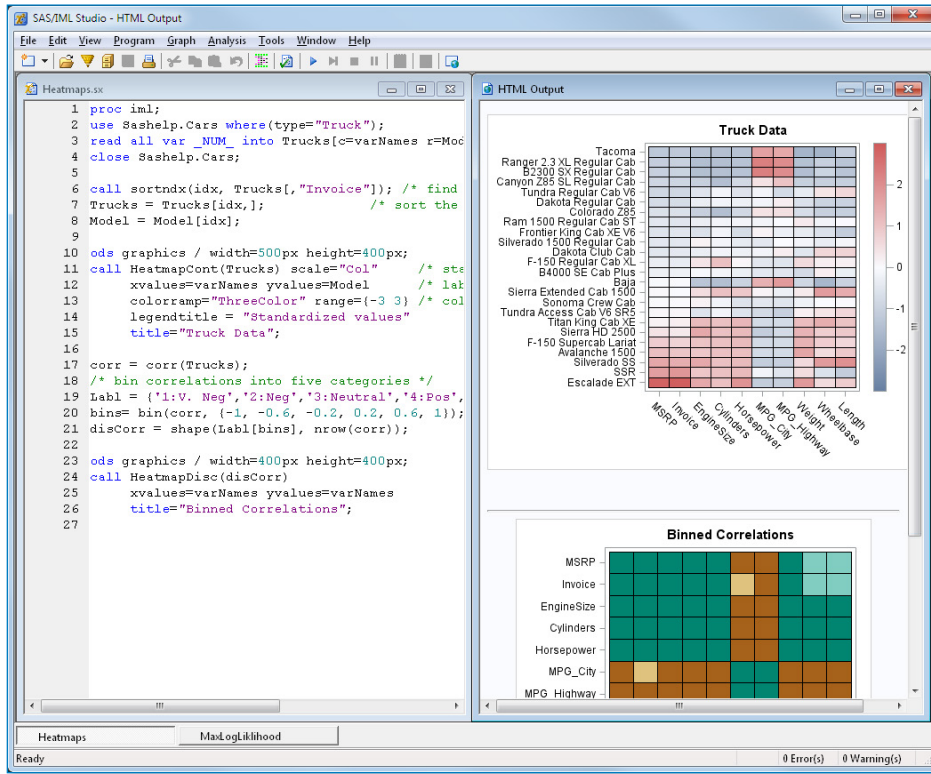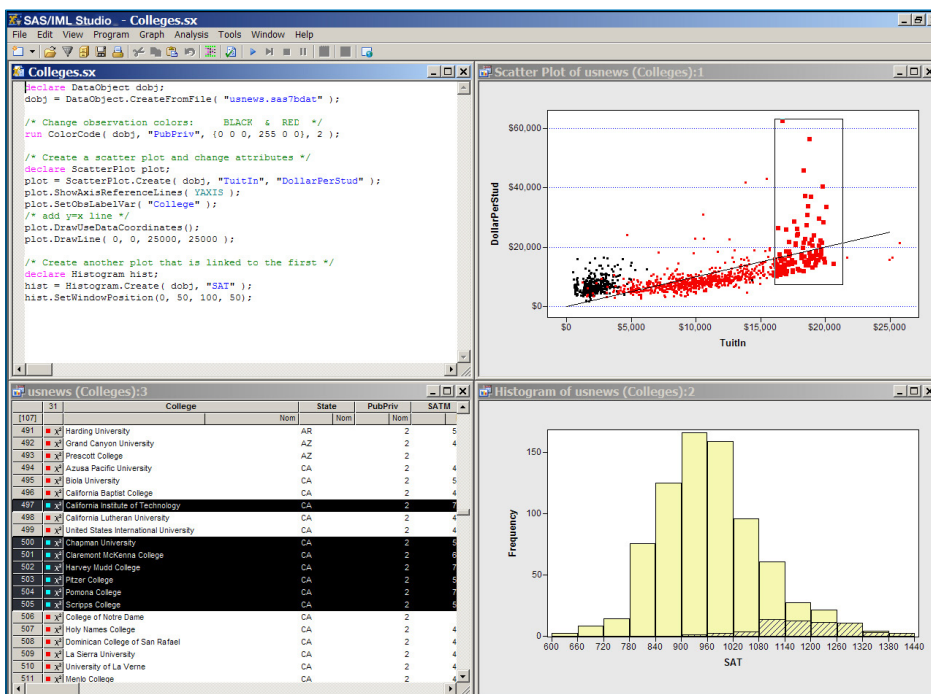
Data processing

SAS/IML enables you to 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 edit an existing SAS data set.

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. The syntax is similar to that of the SAS DATA step.

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 and executes a module when you use it. You can define, install and load packages of functions.

Numerical analysis and statistical functions

With SAS/IML, you can find roots of nonlinear functions, compute numerical integrals and derivatives, solve ordinary differential equations and optimize functions subject to constraints. The software includes built-in functions for numerical linear algebra, including determinants, eigenvalues and singular values. You can

compute classical and robust descriptive statistics for univariate and multivariate data.

Time series functions

SAS/IML software contains collections of routines that analyze and forecast univariate and multivariate time series. Also included is a set of routines for Kalman filtering, wavelet analysis and Fourier transforms.

Optimization algorithms

With SAS/IML, you can define nonlinear objective functions and use optimization algorithms to find optimal solutions subject to parameter constraints. Solve mixed-integer linear programming problems and call genetic algorithms.

Data visualization

Visualize data by using static ODS statistical graphics such as histograms, scatter plots and heat maps. Create dynamically linked graphics in SAS/IML Studio that enable you to select observations in one graph and see those same observations highlighted in all other views of the data.

Data simulation

Generate random samples from standard univariate and multivariate probability distributions. You can combine elementary distributions and sample from complex distributions such as finite mixtures or flexible families of distributions. You can implement bootstrap methods and permutations tests.

SAS/IML® Studio Overview

SAS/IML Studio is an 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 a versatile programming environment to try out new methods.

SAS/IML Studio blends SAS/IML software with the ability to create customized dynamically linked graphics and run standard statistical analyses. SAS/IML Studio is client software that runs on Microsoft Windows; it can connect to a local or remote SAS workspace server.

Key Features

Matrix functions
- Use matrix operations such as multiplication, direct products and factorizations.
- Apply mathematical operators and functions to each element of a matrix.
- Use multithreaded computations for large matrices.
- Find elements in a matrix that satisfy given conditions.
- Compute descriptive statistics for each column of a matrix.
- Create matrices with structure, such as diagonal, banded, block diagonal and Toeplitz matrices.
- Reshape, transpose and concatenate matrices.
- Compute correlation and covariance matrices.
- Count, identify or remove missing values or other special values from matrices.

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

Numerical analysis and statistical functions
- Find roots of polynomials and general nonlinear functions.
- Compute inverses and generalized inverses, and solve sparse systems of linear equations.
- Compute numerical integrals and derivatives; compute eigenvalues and eigenvectors.
- Perform Cholesky, singular value and complete orthogonal decompositions.
- Perform QR decomposition by Householder rotation or the Gram-Schmidt process.
- Perform discrete sequential tests.

Time series functions
- Analyze ARMA models and their generalizations.
- Simulate a univariate ARMA time series or multivariate correlated time series.
- Compute autocovariance estimates for time series.
- Perform finite Fourier transformations and inverse FFTs, Kalman filtering and wavelet analysis.

Numerical analysis functions
- Perform numerical integration.
- Use nonlinear optimization.

Optimization algorithms
- Solve linear programming and mixed-integer linear programming problems.
- Use multiple methods for constrained and unconstrained nonlinear optimization.
- Specify linear or nonlinear constraints.
- Apply genetic algorithms.

Data visualization
- Create standard ODS statistical graphics such as histograms and scatter plots.
- Create heat maps to visualize data in matrices.
- Call ODS statistical procedures directly to create complex graphs.

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 use linked graphics to explore the results. 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. 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 (IMLPlus) provides features such as the ability to call SAS procedures, R, C, FORTRAN or Java.

TO LEARN MORE »

SAS/IML takes advantage of the SAS®9 engine, part of the SAS Platform. Many SAS procedures have been enhanced so code launched from SAS 9 can run in SAS Viya™, the SAS Platform's new distributed, in-memory engine. For more information, visit sas.com/platform.

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

Key Features (continued)

Data simulation
- Generate random samples from standard univariate distributions.
- Generate multivariate samples from standard multivariate distributions.
- Generate random permutations and combinations.
- Generate a random sample from a finite set.

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.
- Enhanced data visualization through ODS graphics.

Distribution analysis:
- Compute descriptive statistics, quantile-quantile plots and 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.
- Perform principal components analysis, discriminant analysis, factor analysis and correspondence analysis.

Efficient handling of large data transfers between client and server:
- Parallel execution of multiple SAS/IML Studio workspaces.
- Client support for 64-bit Windows.

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.
- 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.
- Utilizes a multithreaded workspace.

To contact your local SAS office, please visit: sas.com/offices

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