- **Classes and Methods New to the IMSL C# Numerical Library Version 6.5**

  **Imsl.Math**

  **Error Handling**

  - **NoProgressException**
    - Exception thrown when More's technique is not making any progress.

  **Linear Systems**

  - **ComplexLU.GetL**
    - Returns the lower triangular portion of the LU factorization of input matrix "a".
  - **ComplexLU.GetPermutationMatrix**
    - Returns the permutation matrix which results from the LU factorization of input matrix "a".
  - **ComplexLU.GetU**
    - Returns the unit upper triangular portion of the LU factorization of input matrix "a".

  - **LU.GetL**
    - Returns the lower triangular portion of the LU factorization of input matrix "a".
  - **LU.GetPermutationMatrix**
    - Returns the permutation matrix which results from the LU factorization of input matrix "a".
  - **LU.GetU**
    - Returns the unit upper triangular portion of the LU factorization of input matrix "a".

  **Optimization**

  - **BoundedLeastSquares.Solve**
    - Solves a nonlinear least-squares problem subject to bounds on the variables using a modified Levenberg-Marquardt algorithm. This method is the identical replacement for the deprecated method BoundedLeastSquares.solve.

  **Imsl.Stat**

  **Error Handling**

  - **NoProgressException**
    - Exception thrown when More's technique is not making any progress.

- **Changes in IMSL C# Numerical Numerical Library Version 6.5**

  **General**

  - Changed links to Microsoft SDK webpages for HTML documentation.
  - Added support for the FLEXLM_BATCH FlexNet environment variable. This prevents popups from being displayed for FlexNet errors/warnings.
The properties NumberOfProcessors and/or Parallel have been added to many of the classes/methods which use the Task Parallel Library in .NET 4.0.

**Gallery**

**Imsl.Chart2D**

**General**

Added TCB Spline to the Spline demo.

**Imsl.Math**

**Linear Systems**

- **SuperLU**
- **Cholesky**
- **Matrix.Multiply**
- **ComplexMatrix.Multiply**

Made corrections so that the warning about a singular matrix is printed.

Updated class description with $A = RR^T$.

Overloaded method with processors argument.

Overloaded method with processors argument.

**Optimization**

- **BoundedLeastSquares**
  - **BoundedLeastSquares.solve**
  - **NonlinLeastSquares**

Implemented a fix for a potential infinite loop in More's technique.

This method has been deprecated and replaced by BoundedLeastSquares.Solve.

Updated the documentation for the methods and properties SetXscale, SetFscale, GradientTolerance, and StepTolerance.

Implemented a fix for a potential infinite loop in More's technique.

Modified the write statement in Example 3.

**Imsl.Stat**

**Regression**

- **NonlinearRegression**

Implemented a fix for a potential infinite loop in More's technique.

**Probability Distribution Functions and Inverses**

- **Pdf.NoncentralBeta**
- **GammaDistribution**
- **IDistribution**
- **IProbabilityDistribution**

Corrected an equation in the documentation.

Enhanced the documentation.

Enhanced the documentation.

Enhanced the documentation.
<table>
<thead>
<tr>
<th>LogNormalDistribution</th>
<th>Enhanced the documentation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NormalDistribution</td>
<td>Enhanced the documentation.</td>
</tr>
<tr>
<td>PoissonDistribution</td>
<td>Enhanced the documentation.</td>
</tr>
</tbody>
</table>

**Random Number Generation**

<table>
<thead>
<tr>
<th>Random.CanonicalCorrelation</th>
<th>Changed from a static public method to a static method.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random.NextGaussianCopula</td>
<td>Overloaded version using the k argument has been deprecated.</td>
</tr>
<tr>
<td>Random.NextMultivariateNormal</td>
<td>Overloaded version using the k argument has been deprecated.</td>
</tr>
<tr>
<td>Random.NextStudentsTCopula</td>
<td>Overloaded version using the k argument has been deprecated.</td>
</tr>
</tbody>
</table>

**Probability Distribution Functions and Inverses**

<table>
<thead>
<tr>
<th>Cdf.Beta</th>
<th>A new algorithm is used to improve accuracy in the tails of the distribution.</th>
</tr>
</thead>
</table>

**Time Series and Forecasting**

<table>
<thead>
<tr>
<th>ARMA</th>
<th>Removed extra terms from the difference equation in the documentation.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Implemented a fix for a potential infinite loop in More's technique.</td>
</tr>
</tbody>
</table>

### Classes and Methods New to the IMSL C# Numerical Library Version 6.0

**Error Handling**

<table>
<thead>
<tr>
<th>Imsl.Error Handling</th>
<th>Logs intermediate results and notes from IMSL C# classes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logger</td>
<td>Signals that an unexpected error has occurred.</td>
</tr>
<tr>
<td>IMSLUnexpectedErrorException</td>
<td>Throws an <code>IllegalStateException</code> with a formatted String argument.</td>
</tr>
</tbody>
</table>

**Linear Systems**

<table>
<thead>
<tr>
<th>Imsl.Math.Linear Systems</th>
<th>Returns the inverse of the</th>
</tr>
</thead>
</table>
Matrix.InverseUpperTriangular

Eigensystems Analysis

Eigen

Eigen.MaxIterations

Eigen.Solve

Interpolation and Approximation

CsTCB

Spline2D.Integral

Spline2DLeastSquares

Differential Equations

ODE

FeynmanKac

OdeAdamsGear

lower triangular matrix a. Returns the inverse of the upper triangular matrix a.

A constructor was added. Set or returns the maximum number of iterations.

Solves for the eigenvalues and (optionally) the eigenvectors of a real square matrix.

Extension of the Spline class to handle a tension-continuity-bias (TCB) cubic spline, also known as a Kochanek-Bartels spline and is a generalization of the Catmull-Rom spline.

Returns the value of an integral of a tensor-product spline on a rectangular domain.

Computes a two-dimensional, tensor-product spline approximant using least squares.

ODE represents and solves an initial-value problem for ordinary differential equations.

Solves the generalized Feynman-Kac PDE.

Extension of the ODE class to solve a stiff initial-value problem for ordinary differential equations using the
<table>
<thead>
<tr>
<th><strong>Nonlinear Equations</strong></th>
<th><strong>Adams-Gear methods.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ZerosFunction</td>
<td>Finds the real zeros of a real, continuous, univariate function, f(x).</td>
</tr>
<tr>
<td>ZeroSystem.Logger</td>
<td>Returns the logger object.</td>
</tr>
<tr>
<td><strong>Optimization</strong></td>
<td>Solve a linear least-squares problem with bounds on the variables.</td>
</tr>
<tr>
<td>BoundedVariableLeastSquares</td>
<td>Solves a linear least squares problem with nonnegativity constraints.</td>
</tr>
<tr>
<td>NonNegativeLeastSquares</td>
<td>Compute the Jacobian matrix for a function f(y) with m components in n independent variables.</td>
</tr>
<tr>
<td>NumericalDerivatives</td>
<td><strong>Special Functions</strong></td>
</tr>
<tr>
<td>Sfun.Erfce</td>
<td>Returns the exponentially scaled complementary error function.</td>
</tr>
<tr>
<td>Sfun.GammaIncomplete</td>
<td>Evaluates the incomplete gamma function.</td>
</tr>
<tr>
<td>Sfun.Psi</td>
<td>Returns the logarithmic derivative of the gamma function, also called the digamma function.</td>
</tr>
<tr>
<td>Sfun.Ps1</td>
<td>Returns the ( \psi_1 ) function, also known as the trigamma function.</td>
</tr>
<tr>
<td>Imsl.Stat</td>
<td><strong>Basic Statistics</strong></td>
</tr>
<tr>
<td><strong>Regression</strong></td>
<td><strong>Regression</strong></td>
</tr>
<tr>
<td>StepwiseRegression.Intercept</td>
<td>Returns the intercept.</td>
</tr>
<tr>
<td>StepwiseRegression.SetMeans</td>
<td>Sets the means of the variables.</td>
</tr>
<tr>
<td><strong>Analysis of Variance</strong></td>
<td><strong>Analysis of Variance</strong></td>
</tr>
<tr>
<td>ANCOVA</td>
<td>Analyzes a one-way classification model with covariates.</td>
</tr>
<tr>
<td>ANOVA.GetConfidenceInterval</td>
<td>Computes the confidence</td>
</tr>
</tbody>
</table>
interval associated with the difference of means between two groups using a specified method.

Time Series and Forecasting

AutoARIMA

Automatically identifies time series outliers, determines parameters of a multiplicative seasonal model and produces forecasts that incorporate the effects of outliers whose effects persist beyond the end of the series.

ARMAOutlierIdentification

Detects and determines outliers and simultaneously estimates the model parameters in a time series whose underlying outlier free series follows a general seasonal or nonseasonal ARMA model. Allows computation of forecasts.

LackOfFit

Performs lack-of-fit test for a univariate time series or transfer function given the appropriate correlation function.

Multivariate Analysis

DiscriminantAnalysis.Classify

Classifies a set of observations using the linear or quadratic discriminant functions generated during the training process.

DiscriminantAnalysis.Downdate

Removes a set of observations from the discriminant functions.

DiscriminantAnalysis.NumberOfRowsMissing

Returns the number of rows of data encountered containing missing values (Double.NaN).
Survival and Reliability Analysis

KaplanMeierEstimates
Computes Kaplan-Meier (or product-limit) estimates of survival probabilities for a sample of failure times that possibly contain right censoring.

KaplanMeierECDF
Computes the Kaplan-Meier reliability function estimates or the CDF based on failure data that may be multi-censored.

LifeTables
Computes population (current) or cohort life tables based upon the observed population sizes at the middle (for population table) or the beginning (for cohort table) of some user specified age intervals.

ProportionalHazards
Analyzes survival and reliability data using Cox's proportional hazards model.

Probability Distribution Functions and Inverses

Cdf.NoncentralBeta
Evaluates the noncentral beta cumulative distribution function (CDF).

Cdf.NoncentralF
Evaluates the noncentral F cumulative distribution function (CDF).

Cdf.Logistic
Evaluates the logistic cumulative probability distribution function.

Cdf.Pareto
Evaluates the Pareto cumulative probability distribution function.

InvCdf.Logistic
Returns the inverse of the logistic cumulative probability distribution function.
<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>InvCdf.NoncentralBeta</code></td>
<td>Evaluates the inverse of the noncentral beta cumulative distribution function (CDF).</td>
</tr>
<tr>
<td><code>InvCdf.NoncentralF</code></td>
<td>Evaluates the inverse of the noncentral F cumulative distribution function (CDF).</td>
</tr>
<tr>
<td><code>InvCdf.Pareto</code></td>
<td>Returns the inverse of the Pareto cumulative probability distribution function.</td>
</tr>
<tr>
<td><code>Pdf.Logistic</code></td>
<td>Evaluates the logistic probability density function.</td>
</tr>
<tr>
<td><code>Pdf.NoncentralBeta</code></td>
<td>Evaluates the noncentral beta probability density function (PDF).</td>
</tr>
<tr>
<td><code>Pdf.NoncentralChi</code></td>
<td>Evaluates the noncentral chi-squared probability density function.</td>
</tr>
<tr>
<td><code>Pdf.NoncentralF</code></td>
<td>Evaluates the noncentral F probability density function (PDF).</td>
</tr>
<tr>
<td><code>Pdf.NoncentralStudentsT</code></td>
<td>Evaluates the noncentral Student's t probability density function.</td>
</tr>
<tr>
<td><code>Pdf.Normal</code></td>
<td>Evaluates the normal (Gaussian) probability density function.</td>
</tr>
<tr>
<td><code>Pdf.Pareto</code></td>
<td>Evaluates the Pareto probability density function.</td>
</tr>
<tr>
<td><code>IDistribution</code></td>
<td>Public interface for the user-supplied distribution function.</td>
</tr>
<tr>
<td><code>IProbabilityDistribution</code></td>
<td>Public interface for the user-supplied probability distribution function.</td>
</tr>
<tr>
<td><code>GammaDistribution</code></td>
<td>Evaluates a gamma probability distribution.</td>
</tr>
<tr>
<td><code>LogNormalDistribution</code></td>
<td>Evaluates a lognormal probability distribution.</td>
</tr>
</tbody>
</table>
NormalDistribution
Evaluates a normal (Gaussian) probability distribution.

PoissonDistribution
Evaluates a Poisson probability distribution.

Random Number Generation
Generates a canonical correlation matrix from an arbitrarily distributed multivariate deviate sequence with a Gaussian Copula dependence structure.

Random.CanonicalCorrelation
Generate psedorandom numbers from a Gaussian Copula distribution.

Random.NextGaussianCopula
Generate pseudorandom numbers from a Student's t Copula distribution.

Random.NextStudentsTCopula
Generates pseudorandom numbers using the Ziggurat method.

Random.NextZigguratNormalAR

Imsl.Finance
Component of DayCountBasis. The day count basis consists of a month basis and a yearly basis. Each of these components implements this interface.

Finance
The Day Count Basis. Rules for computing the number or days between two dates or number of days in a year.

BasisPart.GetDaysInYear

DayCountBasis.GetDaysInYear

Imsl.Chart
Draws an annotation.

Chart 2D
Draws an image such that any portion of the image beyond the axis range is clipped.

Annotation

Draw.DrawClippedImage
Treemap creates a chart from two arrays of double precision values or one data array and one array of java.awt.Color values.

Imsl.Datamining

Data Mining

NaiveBayesClassifier

Trains a Naive Bayes Classifier

**Changes in IMSL C# Numerical Numerical Library Version 6.0**

**General**

* ErrorMessage Resource Bundle*

Fixed misspelling, improved consistency and removed extra whitespace.

* Gallery*

The Gallery has been updated.

* Optimization Chapter Introduction*

Clarified documentation by stating that it is the responsibility of the user to ensure that the user-supplied evaluating function always returns valid results.

* Quadrature Chapter Introduction*

Clarified documentation by stating that it is the responsibility of the user to ensure that the user-supplied evaluating function always returns valid results.

**Imsl.Math**

* Linear Systems*

Performance increases can be realized by taking advantage of the MKL-enhanced version of the IMSL C# Numerical Library.

* Matrix.Multiply*

Performance increases can be realized by taking advantage of the MKL-enhanced version of the IMSL C# Numerical Library.

* ComplexMatrix.Multiply*

Performance increases can be realized by taking advantage of the MKL-enhanced version of the IMSL C# Numerical Library.

**Eigensystem Analysis**

* Eigen*

Performance increases can be realized by taking advantage of the MKL-enhanced version of the IMSL C# Numerical Library.

* SymEigen*

Performance increases can be realized by taking advantage of the MKL-enhanced version of the IMSL C# Numerical Library.

**Interpolation and Approximation**

* CsShape*

No longer issues an index out of bounds exception.
Added examples for `RadialBasis.Function`, `RadialBasis.Gaussian` and `RadialBasis.HardyMultiquadric` to highlight the explicit use of different basis functions.

Documentation was added for `RadialBasis.Gaussian` and `RadialBasis.HardyMultiquadric`.

**Transforms**

**FFT**

**ComplexFFT**

**Nonlinear Equations**

**ZeroFunction**

**ZeroSystem**

This class has been deprecated. It has been replaced by the class `ZerosFunction`.

Logging enabled in `ZeroSystem`.

A paragraph was added to the class description.

**Optimization**

**DenseLP**

**MinUncon**

**NonlinLeastSquares**

**QuadraticProgramming**

**Imsl.Finance**

**Finance**

**BasisPart.GetDaysInYear**

**Bond**

**Bond.Accrint**

**Bond.Yearfrac**

**DayCountBasis.GetDaysInYear**

**Finance.Xirr**

**Imsl.Stat**

Performance increases can be realized by taking advantage of the MKL-enhanced version of the IMSL C# Numerical Library.

Performance increases can be realized by taking advantage of the MKL-enhanced version of the IMSL C# Numerical Library.

DenseLP now throws exceptions for infeasible problems.

Fixed resource name so that warnings are printed.

Added warnings for the 4 error types.

A new exception was added to handle inconsistent system exceptions.

Deprecated for this release and replaced by a new `BasisPart.GetDaysInYear`.

Added Monthly and BiMonthly options.

Corrected accrued interest calculation.

Corrected problem where the method gave a wrong result for input days in a leap year.

Deprecated for this release and replaced by a new `DayCountBasis.GetDaysInYear`.

Modified to return better results.
Basic Statistics

**NormOneSample**
Increased accuracy of p-values.

**NormOneSample.ConfidenceMean**
Clarified documentation.

**NormTwoSample**
Increased accuracy of p-values.

**PartialCovariances**
Increased accuracy of p-values.

**TableTwoWay.GetFrequencyTableUsingClassmarks**
Corrected description in documentation.

**TableTwoWay.GetFrequencyTableUsingCutpoints**
Corrected description in documentation.

Regression

**LinearRegression.GetCoefficients**
Replaced the SingularMatrixException exception by a LinearRegression.NotFullRank warning.

**NonlinearRegression**
Added missing NonlinearRegression resource entries.

**RegressorsForGLM**
Added warnings for the 4 error types.

**SelectionRegression**
Increased accuracy of p-values.

**StepwiseRegression**
Modified to correctly account for missing values.

Increased accuracy of p-values.

Analysis of Variance

**ANOVA**
Increased accuracy of p-values.

**ANOVA.GetDunnSidak**
This method has been deprecated and replaced by ANOVA.GetConfidenceInterval.

**ANOVAFactorial**
Increased accuracy of p-values.

Categorical and Discrete Data Analysis

**CategoricalGenLinModel**
Increased accuracy of p-values.

**CategoricalGenLinModel.LowerEndpointColumn**
Corrected implementation.

**ContingencyTable**
Increased accuracy of p-values.

Tests of Goodness of Fit

**ChiSquaredTest**
Increased accuracy of p-values.

**ChiSquaredTest**
Expanded documentation of nParameters and property DegreesOfFreedom.

**NormalityTest.LillieforsTest**
Overloaded the Update method to make the frequencies optional.

Corrected the way ties are identified.
Time Series and Forecasting

**ARMA**
Resolved seg fault and flat forecast issue.
MaxIterations setting now applies to LeastSquares estimation. A TooManyIterationsException is thrown rather than rethrowing ARMA exceptions TooManyIterationsExceptions and TooManyFcnEvaluations which may occur during the LeastSquares estimation.

**ARMAEstimateMissing**

Multivariate Analysis

**ChiSquaredTest**
Increased accuracy of p-values.

**DiscriminantAnalysis**
Increased accuracy of p-values.
This property has been deprecated. It has been replaced by the property NumberOfRowsMissing.
Some Update methods have been deprecated. Each has been replaced by an equivalent Update method.

**DiscriminantAnalysis.Update**
Changed NoDegreesOfFreedomException exception to a warning.

**FactorAnalysis**
Increased accuracy of p-values.

Probability Distribution Functions and Inverses

The Cdf class has been divided into the three classes Cdf, InvCdf, and Pdf. Therefore the methods which have been moved from the Cdf class have been deprecated and replaced by the functionally equivalent versions in the new class. Below is a list of the methods which have been deprecated followed by the functionally equivalent version which has been added.

- Cdf.BinomialProb → Pdf.Binomial
- Cdf.PoissonProb → Pdf.Poisson
- Cdf.BetaProb → Pdf.Beta
- Cdf.FProb → Pdf.F
- Cdf.HypergeometricProb → Pdf.Hypergeometric
- Cdf.GammaProb → Pdf.Gamma
- Cdf.ExponentialProb → Pdf.Exponential
- Cdf.ChiProb → Pdf.Chi
- Cdf.WeibullProb → Pdf.Weibull
- Cdf.LognormalProb → Pdf.Lognormal
Expanded the range of allowable arguments for degrees of freedom.
Improved lower tail accuracy.
Improved lower tail accuracy.
Corrected results for large denominator df.
Corrected calculation of gamma pdf.

Random Number Generation
General
Random.NextNormal

Imsl.Io
Imsl.Datamining.Neural
Neural Nets
<table>
<thead>
<tr>
<th>Package</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ScaleFilter</td>
<td>Corrected possible divide by zero.</td>
</tr>
<tr>
<td>Imsl.Chart</td>
<td><strong>Chart 2D</strong></td>
</tr>
<tr>
<td>AxisLabel.Paint</td>
<td>Added checks to avoid printing labels beyond the extent of the chart window.</td>
</tr>
<tr>
<td>Contour</td>
<td>Modified logic where negative values for Max X and Y data caused distortions.</td>
</tr>
<tr>
<td>Colormap</td>
<td>Renamed the WHITE_BLUE_LINEAR to WB_LINEAR and documented as the reverse of BW_LINEAR. The name WHITE_BLUE_LINEAR no long exists since BLUE_WHITE should be used instead.</td>
</tr>
<tr>
<td>HeatMap</td>
<td>Modified logic where negative values for Max X and Y data caused distortions.</td>
</tr>
</tbody>
</table>