

Package ‘optR’

May 9, 2026

Type Package

Title Optimization Toolbox for Solving Linear Systems

Version 1.2.5

Date 2016-11-29

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Description Solves linear systems of form $Ax=b$ via Gauss elimination, LU decomposition, Gauss-Seidel, Conjugate Gradient Method (CGM) and Cholesky methods.

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RoxygenNote 5.0.1

Depends graphics, stats

NeedsCompilation no

Repository CRAN

Date/Publication 2016-11-29 15:08:40

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cgm	<i>Optimization & estimation based on Conjugate Gradient Method</i>
-----	---

Description

Function utilizes the Conjugate Gradient Method for optimization to solve equation $Ax=b$

Usage

```
cgm(A, b, x = NULL, iter = 500, tol = 1e-07)
```

Arguments

A	: Input matrix
b	: Response vector
x	: Initial solutions
iter	: Number of Iterations
tol	: Convergence tolerance

Value

optimal : Optimal solutions
initial : initial solution
itr.conv : Number of iterations for convergence
conv : Convergence array

Examples

```
A<-matrix(c(4,-1,1, -1,4,-2,1,-2,4), nrow=3,ncol=3, byrow = TRUE)
b<-matrix(c(12,-1, 5), nrow=3,ncol=1,byrow=TRUE)
Z<-optR(A, b, method="cgm", iter=500, tol=1e-7)
```

choleskiDecomposition *Function for Choleski Decomposition*

Description

Function perform choleski decomposition for positive definite matrix ($A=LL'$)

Usage

```
choleskiDecomposition(A, tol = 1e-07)
```

Arguments

A : Input Matrix
tol : Tolerance

Value

L: Decomposition matrix

Examples

```
A<-matrix(c(4,-2,2, -2,2,-4,2,-4,11), nrow=3,ncol=3, byrow = TRUE)  
chdA<-choleskiDecomposition(A)
```

choleskilm *Function fits linear model using Choleski Decomposition*

Description

Function fits a linear model using Choleski Decomposition for positive definite matrix

Usage

```
choleskilm(A, b, tol = 1e-07)
```

Arguments

A : Input matrix
b : Response matrix
tol : Tolerance

Value

U : Upper part of the triangle is (U) and Lower part of the triangular is L (Diagonal for the L matrix is 1)

c : $Lc=b$ (where $Ux=c$)

beta : Estimates

examples `A<-matrix(c(6,-4,1, -4,6,-4,1,-4,6), nrow=3,ncol=3, byrow = TRUE)` `b<-matrix(c(-14,36, 6), nrow=3,ncol=1,byrow=TRUE)` `Z<-optR(A, b, method="choleski")` # Solve Linear model using Gauss Elimination

`forwardsubstitution.optR`

Function to solve linear system using forward substitution

Description

Function to solve linear system using backsubstitution using Upper Triangular Matrix ($Ux=c$)

Usage

`forwardsubstitution.optR(L, b)`

Arguments

L : Lower triangular matrix

b : response

Value

y : Estimated value

`gaussSeidel`

Gauss-Seidel based Optimization & estimation

Description

Function utilizes the Gauss-Seidel optimization to solve equation $Ax=b$

Usage

`gaussSeidel(A, b, x = NULL, iter = 500, tol = 1e-07, w = 1, witr = NULL)`

Arguments

A : Input matrix
b : Response
x : Initial solutions
iter : Number of Iterations
tol : Convergence tolerance
w : Relaxation paramter used to compute weighted avg. of previous solution. w=1 represent no relaxation
witr : Iteration after which relaxation parameter become active

Value

optimal : Optimal solutions
initial : initial solution
relaxationFactor : relaxation factor

Examples

```

A<-matrix(c(4,-1,1, -1,4,-2,1,-2,4), nrow=3,ncol=3, byrow = TRUE)
b<-matrix(c(12,-1, 5), nrow=3,ncol=1,byrow=TRUE)
Z<-optR(A, b, method="gaussseidel", iter=500, tol=1e-7)
  
```

hatMatrix

Function determines the Hat matrix or projection matrix for given X

Description

Function hatMatrix determines the projection matrix for X from the form $\hat{y} = Hy$. The projection matrix defines the influence of each variable on fitted value. The diagonal elements of the projection matrix are the leverages or influence each sample has on the fitted value for that same observation. The projection matrix is evaluated with I.I.D assumption $\sim N(0, 1)$

Usage

```
hatMatrix(X, covmat = NULL)
```

Arguments

X : Input Matrix
covmat : covariance matrix for error, if the error are correlated for I.I.D covmat will be NULL matrix

Value

X: Projection Matrix

Examples

```
X<-matrix(c(6,-4,1, -4,6,-4,1,-4,6), nrow=3,ncol=3, byrow = TRUE)
covmat <- matrix(rnorm(3 * 3), 3, 3)
H<-hatMatrix(X)
H<-hatMatrix(X, covmat)
diag(H)
```

inv.optR	<i>Invert a matrix using LU decomposition</i>
----------	---

Description

function invert a matrix A using LU decomposition such that $A \cdot \text{inv}(A) = I$

Usage

```
inv.optR(A, tol = 1e-07)
```

Arguments

A : Input matrix
tol : tolerance

Value

A : Inverse of Matrix A

Examples

```
# Invert the matrix using LU decomposition
A<-matrix(c(0.6,-0.4,1, -0.3,0.2,0.5,0.6,-1,0.5), nrow=3,ncol=3, byrow = TRUE)
InvA<-inv.optR(A)
```

jacobian	<i>Function to evaluate jacobian matrix from functions</i>
----------	--

Description

jacobian is function to determine the jacobian matrix for function f for input x

Usage

```
jacobian(f, x)
```

Arguments

f : function to optimize
x : Initial Solution

Value

jacobiabMatrix: Jacobian matrix
f0: Initial solution

LU.decompose	<i>LU decomposition</i>
--------------	-------------------------

Description

The function decomposes matrix A into LU with L lower matrix and U as upper matrix

Usage

```
LU.decompose(A, tol = 1e-07)
```

Arguments

A : Input Matrix
tol : tolerance

Value

A : Transformed matrix with Upper part of the triangle is (U) and Lower part of the triangular is L (Diagonal for the L matrix is 1)

Examples

```
A<-matrix(c(0,-1,1, -1,2,-1,2,-1,0), nrow=3,ncol=3, byrow = TRUE)  
Z<-optR(A, tol=1e-7, method="LU")
```

 LU.optR

Solving system of equations using LU decomposition

Description

The function solves $Ax=b$ using LU decomposition ($LUx=b$). The function handles multiple responses

Usage

```
LU.optR(A, b, tol = 1e-07)
```

Arguments

A : Input Matrix
 b : Response
 tol : tolerance

Value

U : Upper part of the triangle is (U) and Lower part of the triangular is L (Diagonal for the L matrix is 1)

c : $Lc=b$ (where $Ux=c$)

beta : Estimates

Examples

```
A<-matrix(c(0,-1,1, -1,2,-1,2,-1,0), nrow=3,ncol=3, byrow = TRUE)
b<-matrix(c(0,0, 1), nrow=3,ncol=1,byrow=TRUE)
Z<-optR(A, b, method="LU")
```

 LUsplit

Function to extract Lower and Upper matrix from LU decomposition

Description

function to extract Lower and Upper matrix from LU decomposition

Usage

```
LUsplit(A)
```

Arguments

A : Input matrix

Value

U : upper triangular matrix
L : Lower triangular matrix

Examples

```
A<-matrix(c(0,-1,1, -1,2,-1,2,-1,0), nrow=3,ncol=3, byrow = TRUE)
Z<-optR(A, method="LU")
LUsplit(Z$U)
```

machinePrecision *Function to address machine precision error*

Description

function to remove the machine precision error

Usage

```
machinePrecision(A)
```

Arguments

A : Input matrix

Value

A : return matrix

newtonRapson *Function for Newton Rapson roots for given equations*

Description

newtonRapson function perform optimization

Usage

```
newtonRapson(f, x, iteration = 30, tol = 1e-09)
```

Arguments

f : function to optimize
x : Initial Solution
iteration : Iterations
tol : Tolerance

Value

x : optimal roots

nonDiagMultiplication *Non-diagnoal multiplication*

Description

Function for non-diagnoal multiplication

Usage

```
nonDiagMultiplication(i, A, beta)
```

Arguments

i : Column Index of Matrix A
A : Input matrix
beta : Response

Value

asum: Non-diagnoal contribution

opt.matrix.reorder *Function to Re-order the matrix to make dominant diagonals*

Description

Function re-order the matrix to make matrix pivot.diag at each iteration

Usage

```
opt.matrix.reorder(A, tol = 1e-16)
```

Arguments

A : Input Matrix
tol : tolerance

Value

A : Updated Matrix
b.order : Order sequence of A updated matrix

Examples

```
A<-matrix(c(0,-1,1, -1,2,-1,2,-1,0), nrow=3,ncol=3, byrow = TRUE)
b<-matrix(c(0,0, 1), nrow=3,ncol=1,byrow=TRUE)
Z<-optR(A, b, method="gauss")
```

 optR

Optimization & predictive modelling Toolsets

Description

optR function for solving linear systems using numerical approaches. Current toolbox supports Gauss Elimination, LU decomposition, Conjugate Gradient Decent and Gauss-Sideal methods for solving the system of form $AX=b$ For optimization using numerical methods cgm method performed faster in comparison with gaussseidel. For decomposition LU is utilized for multiple responses to enhance the speed of computation.

Usage

```
optR(x, ...)
```

Arguments

```
x          : Input matrix
...        : S3 method
```

Value

```
optR : Return optR class
```

Author(s)

```
PKS Prakash
```

Examples

```
# Solving equation Ax=b
A<-matrix(c(6,-4,1, -4,6,-4,1,-4,6), nrow=3,ncol=3, byrow = TRUE)
b<-matrix(c(-14,36, 6), nrow=3,ncol=1,byrow=TRUE)
Z<-optR(A, b, method="gauss") # Solve Linear model using Gauss Elimination

# Solve Linear model using LU decomposition (Supports Multi-response)
Z<-optR(A, b, method="LU")

# Solve the matrix using Gauss Elimination (1, -1, 2)
A<-matrix(c(2,-2,6, -2,4,3,-1,8,4), nrow=3,ncol=3, byrow = TRUE)
b<-matrix(c(16,0, -1), nrow=3,ncol=1,byrow=TRUE)
Z<-optR(A, b, method="gauss") # Solve Linear model using Gauss Elimination
```

```
require(utils)
set.seed(129)
n <- 10 ; p <- 4
X <- matrix(rnorm(n * p), n, p) # no intercept!
y <- rnorm(n)
Z<-optR(X, y, method="cgm")
```

optR.backsubstitution *Function to solve linear system using backsubstitution*

Description

Function to solve linear system using backsubstitution using Upper Triangular Matrix ($Ux=c$)

Usage

```
## S3 method for class 'backsubstitution'
optR(U, c)
```

Arguments

U : Upper triangular matrix
c : response

Value

beta : Estiamted value

optR.default *Optimization & predictive modelling Toolsets*

Description

soptR is the default function for optimization

Usage

```
## Default S3 method:
optR(x, y = NULL, weights = NULL, method = c("gauss",
      "LU", "gausseidel", "cgm", "choleski"), iter = 500, tol = 1e-07,
      keep.data = TRUE, ...)
```

Arguments

x : Input data frame
 y : Response is data frame
 weights : Observation weights
 method : "gauss" for gaussian elimination and "LU" for LU factorization
 iter : Number of Iterations
 tol : Convergence tolerance
 keep.data : Returns Input dataset in object
 ... : S3 Class

Value

U : Decomposed matrix for Gauss-ELimination $Ax=b$ is converted into $Ux=c$ where U is upper triangular matrix for LU decomposition U contain the values for L & U decomposition $LUx=b$
 c : transformed b & for LU transformation c is y from equation $Ux=y$
 estimates : Return x values for linear system
 seq : sequence of A matrix re-ordered

Examples

```

# Solving equation Ax=b
A<-matrix(c(6,-4,1, -4,6,-4,1,-4,6), nrow=3,ncol=3, byrow = TRUE)
b<-matrix(c(-14,36, 6), nrow=3,ncol=1,byrow=TRUE)
Z<-optR(A, b, method="gauss")

# Solve Linear model using LU decomposition (Supports Multi-response)
Z<-optR(A, b, method="LU")

# Solving the function using numerical method
Z<-optR(A, b, method="cgm")

require(utils)
set.seed(129)
n <- 7 ; p <- 2
X <- matrix(rnorm(n * p), n, p) # no intercept!
y <- rnorm(n)
Z<-optR(X, y, method="LU")

```

 optR.fit

Fitter function for Linear/Non-linear system with form $Ax=b$

Description

optR.fit is fit function for determining x for System with form $Ax=b$

Usage

```
## S3 method for class 'fit'
optR(x, y = NULL, method = c("gauss", LU, gausseidel", "cgm"),
     iter = 500, tol = 1e-07, ...)
```

Arguments

```
x           : Input matrix
y           : Response is matrix
method      : "gauss" for gaussian elimination and "LU" for LU factorization
iter        : Number of Iterations
tol         : Convergence tolerance
...         : S3 Class
```

Value

U : Decomposed matrix for Gauss-ELimination $Ax=b$ is converted into $Ux=c$ where U is upper triangular matrix for LU decomposition U contain the values for L & U decomposition $LUx=b$

c : transformed b & for LU transformation c is y from equation $Ux=y$

estimates : Return x values for linear system

seq : sequence of A matrix re-ordered

Examples

```
# Solving equation Ax=b
A<-matrix(c(6,-4,1, -4,6,-4,1,-4,6), nrow=3,ncol=3, byrow = TRUE)
b<-matrix(c(-14,36, 6), nrow=3,ncol=1,byrow=TRUE)
Z<-optR(A, b, method="gauss")

# Solve Linear model using LU decomposition (Supports Multi-response)
Z<-optR(A, b, method="LU")

# Solving the function using numerical method
Z<-optR(A, b, method="cgm")
```

Description

optR package to perform the optimization using numerical methods

Usage

```
## S3 method for class 'formula'
optR(formula, data = list(), weights = NULL,
      method = c("gauss", "LU", "gaussseidel", "cgm", "choleski"), iter = 500,
      tol = 1e-07, keep.data = TRUE, contrasts = NULL, ...)
```

Arguments

```
formula      : formula to build model
data         : data used to build model
weights      : Observation weights
method       : "gauss" for gaussian elimination and "LU" for LU factorization
iter        : Number of Iterations
tol         : Convergence tolerance
keep.data    : If TRUE returns input data
contrasts    : Data frame contract values
...         : S3 Class
```

Value

U : Decomposed matrix for Gauss-ELimination $Ax=b$ is converted into $Ux=c$ where U is upper triangular matrix for LU decomposition U contain the values for L & U decomposition $LUx=b$

c : transformed b & for LU transformation c is y from equation $Ux=y$

estimates : Return x values for linear system

Author(s)

PKS Prakash

Examples

```
# Solving equation Ax=b
b<-matrix(c(-14,36, 6), nrow=3,ncol=1,byrow=TRUE)
A<-matrix(c(6,-4,1, -4,6,-4,1,-4,6), nrow=3,ncol=3, byrow = TRUE)
Z<-optR(b~A-1, method="gauss") # -1 to remove the constant vector

Z<-optR(b~A-1, method="LU") # -1 to remove the constant vector

require(utils)
set.seed(129)
n <- 10 ; p <- 4
X <- matrix(rnorm(n * p), n, p) # no intercept!
y <- rnorm(n)
data<-cbind(X, y)
colnames(data)<-c("var1", "var2", "var3", "var4", "y")
Z<-optR(y~var1+var2+var3+var4+var1*var2-1, data=data.frame(data), method="cgm")
```

optR.gauss *gauss to solve linear systems*

Description

Function solves linear systems using Gauss Elimination. The function solves equation of form $Ax=b$ to $Ux=c$ (where U is upper triangular matrix)

Usage

```
## S3 method for class 'gauss'
optR(A, b, tol = 1e-07)
```

Arguments

A : Input Matrix
b : Response
tol : Tolerance
method : To be used to perform factorization

Value

U : Upper triangular matrix
c : Transformed b
beta : Estimates

Examples

```
A<-matrix(c(0,-1,1, -1,2,-1,2,-1,0), nrow=3,ncol=3, byrow = TRUE)
b<-matrix(c(0,0, 1), nrow=3,ncol=1,byrow=TRUE)
Z<-optR(A, b, method="gauss")
```

optR.multiplyfactor *Function to estimate lambda*

Description

Function estimates the lambda or multiplier factor for Elimination using the pivot row/column

Usage

```
## S3 method for class 'multiplyfactor'
optR(rowindex, A, pivotindex)
```

Arguments

rowindex : Row Index for the row to be used
A : Input matrix
pivotindex : Column index for the pivot

Value

lambda : Lambda

optRFun

Function based optimization module

Description

Function based optimization module

Usage

```
optRFun(formula, x0, iteration = 30, method = c("newtonrapson"),  
        tol = 1e-09)
```

Arguments

formula : Function to optimize
x0 : Initial Solution
iteration : Number of Iterations
method : Method for solving the optimization
tol : Tolerance

Value

optRFun : Optimal Solution class

optRFun.newtonRapson *Function based optimization module*

Description

Newton Rapshon based optimization

Usage

```
optRFun.newtonRapson(formula, x0, iteration = 30, tol = 1e-09)
```

Arguments

formula : Function to optimize
x0 : Initial Solution
iteration : Number of Iterations
tol : Tolerance

Value

optRFun : Optimal Solution

predict.optR *Prediction function based on optR class*

Description

Function for making predictions using OptR class

Usage

```
## S3 method for class 'optR'  
predict(object, newdata, na.action = na.pass, ...)
```

Arguments

object : optR class fitted object
newdata : data for prediction
na.action : action for missing values
... : S3 class

Value

fitted.val : Predicted values
terms : terms used for fitting

print.optR	<i>print coefficients for optR class</i>
------------	--

Description

optR is the default function for optimization

Usage

```
## S3 method for class 'optR'  
print(x, ...)
```

Arguments

x : Input of optR class
... : S3 class

Examples

```
# Solving equation Ax=b  
A<-matrix(c(6,-4,1, -4,6,-4,1,-4,6), nrow=3,ncol=3, byrow = TRUE)  
b<-matrix(c(-14,36, 6), nrow=3,ncol=1,byrow=TRUE)  
Z<-optR(A, b, method="gauss")  
print(Z)
```

summary.optR	<i>Generate Summary for optR class</i>
--------------	--

Description

summary function generates the summary for the optR class

Usage

```
## S3 method for class 'optR'  
summary(object, ...)
```

Arguments

object : Input of optR class
... : S3 method

Examples

```
# Solving equation Ax=b
A<-matrix(c(6,-4,1, -4,6,-4,1,-4,6), nrow=3,ncol=3, byrow = TRUE)
b<-matrix(c(-14,36, 6), nrow=3,ncol=1,byrow=TRUE)
Z<-optR(A, b, method="cgm")
summary(Z)
```

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