

Package ‘EigenR’

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Type Package

Title Complex Matrix Algebra with 'Eigen'

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Description Matrix algebra using the 'Eigen' C++ library: determinant, rank, inverse, pseudo-inverse, kernel and image, QR decomposition, Cholesky decomposition, Schur decomposition, Hessenberg decomposition, linear least-squares problems. Also provides matrix functions such as exponential, logarithm, power, sine and cosine. Complex matrices are supported.

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URL <https://github.com/stla/EigenR>

BugReports <https://github.com/stla/EigenR/issues>

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Eigen_absdet	<i>Absolute value of the determinant</i>
--------------	--

Description

Absolute value of the determinant of a real matrix.

Usage

Eigen_absdet(M)

Arguments

M a *real* square matrix

Value

The absolute value of the determinant of M.

Note

‘Eigen_absdet(M)’ is not faster than ‘abs(Eigen_det(M))’.

Examples

```
set.seed(666L)
M <- matrix(rpois(25L, 1), 5L, 5L)
Eigen_absdet(M)
```

Eigen_chol

*Cholesky decomposition of a matrix***Description**

Cholesky decomposition of a symmetric or Hermitian matrix.

Usage

```
Eigen_chol(M)
```

Arguments

M a square symmetric/Hermitian positive-definite matrix or [SparseMatrix](#), real/complex

Details

Symmetry is not checked; only the lower triangular part of M is used.

Value

The upper triangular factor of the Cholesky decomposition of M.

Examples

```
M <- rbind(c(5,1), c(1,3))
U <- Eigen_chol(M)
t(U) %*% U # this is `M`
# a Hermitian example:
A <- rbind(c(1,1i), c(1i,2))
( M <- A %*% t(Conj(A)) )
try(chol(M)) # fails
U <- Eigen_chol(M)
t(Conj(U)) %*% U # this is `M`
# a sparse example
M <- asSparseMatrix(diag(1:5))
Eigen_chol(M)
```

Eigen_complexSchur	<i>Complex Schur decomposition</i>
--------------------	------------------------------------

Description

Complex Schur decomposition of a square matrix.

Usage

```
Eigen_complexSchur(M)
```

Arguments

M real or complex square matrix

Details

See [Eigen::ComplexSchur](#).

Value

A list with the T and U matrices.

Examples

```
library(EigenR)
M <- cbind(c(3, 2i, 1+3i), c(1, 1i, 1), c(5, 0, -2i))
schur <- Eigen_complexSchur(M)
T <- schur$T
U <- schur$U
M - U %*% T %*% t(Conj(U))
```

Eigen_cos	<i>Matrix cosine</i>
-----------	----------------------

Description

Matrix cosine of a real or complex square matrix.

Usage

```
Eigen_cos(M)
```

Arguments

M a square matrix, real or complex

Value

The matrix cosine of M.

Examples

```
library(EigenR)
M <- toeplitz(c(1,2,3))
cosM <- Eigen_cos(M)
sinM <- Eigen_sin(M)
cosM %*% cosM + sinM %*% sinM # identity matrix
```

Eigen_cosh	<i>Matrix hyperbolic cosine</i>
------------	---------------------------------

Description

Matrix hyperbolic cosine of a real or complex square matrix.

Usage

```
Eigen_cosh(M)
```

Arguments

M a square matrix, real or complex

Value

The matrix hyperbolic cosine of M.

Examples

```
library(EigenR)
M <- toeplitz(c(1,2,3))
Eigen_cosh(M)
(Eigen_exp(M) + Eigen_exp(-M)) / 2 # identical
```

Eigen_det	<i>Determinant of a matrix</i>
-----------	--------------------------------

Description

Determinant of a real or complex matrix.

Usage

```
Eigen_det(M)
```

Arguments

M a square matrix or [SparseMatrix](#), real or complex

Value

The determinant of M.

Examples

```
set.seed(666)
M <- matrix(rpois(25, 1), 5L, 5L)
Eigen_det(M)
# determinants of complex matrices are supported:
Eigen_det(M + 1i * M)
# as well as determinants of sparse matrices:
Eigen_det(asSparseMatrix(M))
Eigen_det(asSparseMatrix(M + 1i * M))
```

Eigen_exp	<i>Exponential of a matrix</i>
-----------	--------------------------------

Description

Exponential of a real or complex square matrix.

Usage

```
Eigen_exp(M)
```

Arguments

M a square matrix, real or complex

Value

The exponential of M.

Eigen_Hessenberg	<i>Hessenberg decomposition</i>
------------------	---------------------------------

Description

Hessenberg decomposition of a square matrix.

Usage

```
Eigen_Hessenberg(M)
```

Arguments

M real or complex square matrix

Details

See [Eigen::HessenbergDecomposition](#).

Value

A list with the H and Q matrices.

Examples

```
library(EigenR)
M <- cbind(c(3, 2i, 1+3i), c(1, 1i, 1), c(5, 0, -2i))
Eigen_Hessenberg(M)
```

Eigen_inverse	<i>Inverse of a matrix</i>
---------------	----------------------------

Description

Inverse of a real or complex matrix.

Usage

```
Eigen_inverse(M)
```

Arguments

M an invertible square matrix, real or complex

Value

The inverse matrix of M.

Eigen_isInjective	<i>Check injectivity</i>
-------------------	--------------------------

Description

Checks whether a matrix represents an injective linear map (i.e. has trivial kernel).

Usage

```
Eigen_isInjective(M)
```

Arguments

M	a matrix, real or complex
---	---------------------------

Value

A Boolean value indicating whether M represents an injective linear map.

Examples

```
set.seed(666L)
M <- matrix(rpois(35L, 1), 5L, 7L)
Eigen_isInjective(M)
```

Eigen_isInvertible	<i>Check invertibility</i>
--------------------	----------------------------

Description

Checks whether a matrix is invertible.

Usage

```
Eigen_isInvertible(M)
```

Arguments

M	a matrix, real or complex
---	---------------------------

Value

A Boolean value indicating whether M is invertible.

Examples

```
set.seed(666L)
M <- matrix(rpois(25L, 1), 5L, 5L)
Eigen_isInvertible(M)
```

Eigen_isSurjective	<i>Check surjectivity</i>
--------------------	---------------------------

Description

Checks whether a matrix represents a surjective linear map.

Usage

```
Eigen_isSurjective(M)
```

Arguments

M	a matrix, real or complex
---	---------------------------

Value

A Boolean value indicating whether M represents a surjective linear map.

Examples

```
set.seed(666L)
M <- matrix(rpois(35L, 1), 7L, 5L)
Eigen_isSurjective(M)
```

Eigen_kernel	<i>Kernel of a matrix</i>
--------------	---------------------------

Description

Kernel (null-space) of a real or complex matrix.

Usage

```
Eigen_kernel(M, method = "COD")
```

Arguments

M	a matrix, real or complex
method	one of "COD" or "LU"; the faster method depends on the size of the matrix

Value

A basis of the kernel of M. With method = "COD", the basis is orthonormal, while it is not with method = "LU".

See Also

[Eigen_kernelDimension](#).

Examples

```
set.seed(666)
M <- matrix(rgamma(30L, 12, 1), 10L, 3L)
M <- cbind(M, M[,1]+M[,2], M[,2]+2*M[,3])
# basis of the kernel of `M`:
Eigen_kernel(M, method = "LU")
# orthonormal basis of the kernel of `M`:
Eigen_kernel(M, method = "COD")
```

Eigen_kernelDimension *Dimension of kernel*

Description

Dimension of the kernel of a matrix.

Usage

```
Eigen_kernelDimension(M)
```

Arguments

M a matrix, real or complex

Value

An integer, the dimension of the kernel of M.

See Also

[Eigen_isInjective](#), [Eigen_kernel](#).

Examples

```
set.seed(666L)
M <- matrix(rpois(35L, 1), 5L, 7L)
Eigen_kernelDimension(M)
```

Eigen_log	<i>Logarithm of a matrix</i>
-----------	------------------------------

Description

Logarithm of a real or complex square matrix, when possible.

Usage

Eigen_log(M)

Arguments

M a square matrix, real or complex

Details

The logarithm of a matrix does not always exist. See [matrix logarithm](#).

Value

The logarithm of M.

Eigen_logabsdet	<i>Logarithm of the absolute value of the determinant</i>
-----------------	---

Description

Logarithm of the absolute value of the determinant of a real matrix.

Usage

Eigen_logabsdet(M)

Arguments

M a *real* square matrix

Value

The logarithm of the absolute value of the determinant of M.

Note

‘Eigen_logabsdet(M)’ is not faster than ‘log(abs(Eigen_det(M)))’.

Examples

```
set.seed(666L)
M <- matrix(rpois(25L, 1), 5L, 5L)
Eigen_logabsdet(M)
```

Eigen_lsSolve	<i>Linear least-squares problems</i>
---------------	--------------------------------------

Description

Solves a linear least-squares problem.

Usage

```
Eigen_lsSolve(A, b, method = "cod")
```

Arguments

A	a n*p matrix, real or complex
b	a vector of length n or a matrix with n rows, real or complex
method	the method used to solve the problem, either "svd" (based on the SVD decomposition) or "cod" (based on the complete orthogonal decomposition)

Value

The solution X of the least-squares problem $AX \approx b$ (similar to `lm.fit(A, b)$coefficients`). This is a matrix if b is a matrix, or a vector if b is a vector.

Examples

```
set.seed(129)
n <- 7; p <- 2
A <- matrix(rnorm(n * p), n, p)
b <- rnorm(n)
lsfit <- Eigen_lsSolve(A, b)
b - A %*% lsfit # residuals
```

Eigen_pinverse	<i>Pseudo-inverse of a matrix</i>
----------------	-----------------------------------

Description

Pseudo-inverse of a real or complex matrix (Moore-Penrose generalized inverse).

Usage

```
Eigen_pinverse(M)
```

Arguments

M a matrix, real or complex, not necessarily square

Value

The pseudo-inverse matrix of M.

Examples

```
library(EigenR)
M <- rbind(
  toeplitz(c(3, 2, 1)),
  toeplitz(c(4, 5, 6))
)
Mplus <- Eigen_pinverse(M)
all.equal(M, M %*% Mplus %*% M)
all.equal(Mplus, Mplus %*% M %*% Mplus)
#' a complex matrix
A <- M + 1i * M[, c(3L, 2L, 1L)]
Aplus <- Eigen_pinverse(A)
Aplus <- A %*% Aplus
all.equal(Aplus, t(Conj(Aplus))) #' `A %*% Aplus` is Hermitian
AplusA <- Aplus %*% A
all.equal(AplusA, t(Conj(AplusA))) #' `Aplus %*% A` is Hermitian
```

Eigen_pow	<i>Matricial power</i>
-----------	------------------------

Description

Matricial power of a real or complex square matrix, when possible.

Usage

```
Eigen_pow(M, p)
```

Arguments

- M a square matrix, real or complex
- p a number, real or complex, the power exponent

Details

The power is defined with the help of the exponential and the logarithm. See [matrix power](#).

Value

The matrix M raised at the power p.

Eigen_QR	<i>QR decomposition of a matrix</i>
----------	-------------------------------------

Description

QR decomposition of a real or complex matrix.

Usage

Eigen_QR(M)

Arguments

- M a matrix, real or complex

Value

A list with the Q matrix and the R matrix.

Examples

```
M <- cbind(c(1,2,3), c(4,5,6))
x <- Eigen_QR(M)
x$Q %*% x$R
```

Eigen_range*Range of a matrix*

Description

Range (column-space, image, span) of a real or complex matrix.

Usage

```
Eigen_range(M, method = "QR")
```

Arguments

M	a matrix, real or complex
method	one of "LU", "QR", or "COD"; the "LU" method is faster

Value

A basis of the range of M. With method = "LU", the basis is not orthonormal, while it is with method = "QR" and method = "COD".

Eigen_rank*Rank of a matrix*

Description

Rank of a real or complex matrix.

Usage

```
Eigen_rank(M)
```

Arguments

M	a matrix, real or complex
---	---------------------------

Value

The rank of M.

Eigen_realSchur	<i>Real Schur decomposition</i>
-----------------	---------------------------------

Description

Real Schur decomposition of a square matrix.

Usage

```
Eigen_realSchur(M)
```

Arguments

M real square matrix

Details

See [Eigen::RealSchur](#).

Value

A list with the T and U matrices.

Examples

```
library(EigenR)
M <- cbind(c(3, 2, 3), c(1, 1, 1), c(5, 0, -2))
schur <- Eigen_realSchur(M)
T <- schur$T
U <- schur$U
M - U %*% T %*% t(U)
```

Eigen_sin	<i>Matrix sine</i>
-----------	--------------------

Description

Matrix sine of a real or complex square matrix.

Usage

```
Eigen_sin(M)
```

Arguments

M a square matrix, real or complex

Value

The matrix sine of M.

Eigen_sinh

Matrix hyperbolic sine

Description

Matrix hyperbolic sine of a real or complex square matrix.

Usage

```
Eigen_sinh(M)
```

Arguments

M a square matrix, real or complex

Value

The matrix hyperbolic sine of M.

Examples

```
library(EigenR)
M <- toeplitz(c(1,2,3))
Eigen_sinh(M)
(Eigen_exp(M) - Eigen_exp(-M)) / 2 # identical
```

Eigen_sqrt

Square root of a matrix

Description

Square root of a real or complex square matrix, when possible.

Usage

```
Eigen_sqrt(M)
```

Arguments

M a square matrix, real or complex

Details

See [matrix square root](#).

Value

A square root of M.

Examples

```
# Rotation matrix over 60 degrees:
M <- cbind(c(cos(pi/3), sin(pi/3)), c(-sin(pi/3), cos(pi/3)))
# Its square root, the rotation matrix over 30 degrees:
Eigen_sqrt(M)
```

Eigen_UtDU

'UtDU' decomposition of a matrix

Description

Cholesky-'UtDU' decomposition of a symmetric or Hermitian matrix.

Usage

```
Eigen_UtDU(M)
```

Arguments

M a square symmetric/Hermitian positive or negative semidefinite matrix, real/complex

Details

Symmetry is not checked; only the lower triangular part of M is used.

Value

The Cholesky-'UtDU' decomposition of M in a list (see example).

Examples

```
x <- matrix(c(1:5, (1:5)^2), 5, 2)
x <- cbind(x, x[, 1] + 3*x[, 2])
M <- crossprod(x)
UtDU <- Eigen_UtDU(M)
U <- UtDU$U
D <- UtDU$D
perm <- UtDU$perm
UP <- U[, perm]
t(UP) %*% diag(D) %*% UP # this is `M`
```

SparseMatrix	<i>Sparse matrix</i>
--------------	----------------------

Description

Constructs a sparse matrix, real or complex.

Usage

```
SparseMatrix(i, j, Mij, nrows, ncols)
```

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

```
asSparseMatrix(M)
```

Arguments

i, j	indices of the non-zero coefficients
Mij	values of the non-zero coefficients; must be a vector of the same length as i and j or a single number which will be recycled
nrows, ncols	dimensions of the matrix
x	a SparseMatrix object
...	ignored
M	a matrix, real or complex

Value

A list with the class SparseMatrix.

Examples

```
set.seed(666)  
( M <- matrix(rpois(50L, 1), 10L, 5L) )  
asSparseMatrix(M)
```

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