

Package ‘psvd’

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Title Eigendecomposition, Singular-Values and the Power Method

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Depends R (>= 4.0),

Description For a data matrix with m rows and n columns ($m \geq n$), the power method is used to compute, simultaneously, the eigendecomposition of a square symmetric matrix. This result is used to obtain the singular value decomposition (SVD) and the principal component analysis (PCA) results. Compared to the classical SVD method, the first r singular values can be computed.

License GPL (>= 2)

NeedsCompilation yes

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Contents

psvd-package	2
calcPCA	3
calcSVD	4
eigenV	5
eigenVc	6
mGS	7
mGSc	7

Index	9
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Description

The power method is used to compute simultaneously the eigenvectors of a square symmetric matrix. Using the classical method, all eigenvectors are computed. The method used here allows to compute the first r eigenvectors using only matrix multiplications and the Gram-Schmidt orthogonalization algorithm. The relationships between the eigendecomposition factors, on the one hand, and the PCA factors or SVD factors, on the other hand, are used to get SVD or PCA results).

Details

Package: psvd
 Type: Package
 Version: 0.1-0
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 License: GPL (≥ 2)

Package psvd has the following functions:

calcSVD(): Given a data matrix X of size (m,n) , $m \geq n$, this function allows to compute the singular value decomposition.
 calcPCA(): Given a data matrix X of size (m,n) , $m \geq n$, this function allows to compute the principal component analysis.
 mGS(): Modified Gramf-Schmidt orthogonalization method, R code, internal use.
 mGSc(): Modified Gramf-Schmidt orthogonalization method, C code, internal use.
 eigenV(): Computation of the eigenvectors matrix for a symmetric square matrix using the power method, R Code, internal use.
 eigenVc(): Computation of the eigenvectors matrix for a symmetric square matrix using the power method, C Code, internal use.

Author(s)

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References

Dembele D. (2024), *A Power Method for Computing Singular Value Decomposition*, arXiv:2410.23999

Examples

```
data(iris)
X <- as.matrix(iris[,1:4])
rownames(X) <- iris[,5]
res <- calcSVD(X, r=4)
```

```
res$d
res$v
res$iter
```

calcPCA	<i>Perform principal component analysis</i>
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Description

Given a data matrix, the function allows to perform principal component analysis using a power method to get the eigendecomposition.

Usage

```
calcPCA(X, r, eta, itmax, err, normed, mySeed)
```

Arguments

X	Data matrix of size (m,n), $m \geq n$.
r	Number of principal components, default: $r=2$.
eta	Power method tuning parameter, default: $\eta=10$.
itmax	Maximum number of iteration in the power method, default: $itmax=200$.
err	Tolerance level in the power method, default: $err=1e-8$.
normed	TRUE (default) or FALSE for PCA using standardized data or not.
mySeed	An integer allowing to reproduce results from two different runs, default: mySeed=50.

Details

X is usually a data matrix .

Value

This function returns a data frame containing 5 components

values	Eigenvalues
vectors	Matrix with the eigenvectors.
iter	The number of iterations used in the eigendecomposition.
li	Projection of rows in the r principal components space.
co	Projection of columns in the r principal components space.

Examples

```
data(iris)
X <- as.matrix(iris[,1:4])
rownames(X) <- iris[,5]
res <- calcPCA(X, r=3)
res$values
pcol <- c(rep("cyan",50), rep("red",50), rep("blue",50))
plot(res$li[,1], res$li[,3], col = pcol)
```

calcSVD

Perform singular values decomposition

Description

Given a data matrix, the function allows to perform a singular decomposition using a power method and relationship between SVD factors and the eigendecomposition factors.

Usage

```
calcSVD(X, r, eta, q, itmax, err, mySeed)
```

Arguments

X	Data matrix of size (m,n), $m \geq n$.
r	Rank r approximation, default: $r=2$.
eta	Power method tuning parameter, default: $\eta=10$.
q	Power method tuning parameter, default: $q=2$.
itmax	Maximum number of iteration in the power method, default: $itmax=200$.
err	Tolerance level in the power method, default: $err=1e-8$.
mySeed	An integer allowing to reproduce results from two different runs, default: mySeed=50.

Details

X is usually a data matrix.

Value

This function returns a data frame containing 4 components

d	Singular values.
u	Matrix with the right eigenvectors.
v	Matrix with the right eigenvectors.
iter	The number of iterations used in the eigendecomposition.

Examples

```
data(iris)
X <- as.matrix(iris[,1:4])
rownames(X) <- iris[,5]
res <- calcSVD(X, r=3)
res$d
res$v
res$iter
```

eigenV

*Compute the eigenvectors matrix of a square symmetric matrix***Description**

This is an internal function which uses a R code to calculate an eigendecomposition of a square symmetric matrix. This function is used in the power method allowing to compute singular values and principal component analysis.

Usage

```
eigenV(xmat, wp, itmax, err)
```

Arguments

xmat	Square symmetric matrix of order d.
wp	Columns orthogonal matrix of size (d,r), $r \leq d$.
itmax	Maximum number of iterations.
err	Tolerance level in the iterative search.

Value

This function returns a data frame containing 2 components

wc	Eigenvectors matrix.
iter	Number of iterations by the power method.

Examples

```
d <- 3
w <- matrix(rnorm(d*d,0,1), ncol=d)
wp <- mGS(w)
XtX <- matrix(c(3,2,1,2,1,0,1,0,1), ncol=3)
res <- eigenV(XtX, wp, itmax=100, err=1e-8)
t(res$wc)
```

eigenVc

*Compute the eigenvectors of a square symmetric matrix***Description**

This is an internal function which uses a C code to calculate an eigendecomposition of a square symmetric matrix. This function is used in the power method allowing to compute singular values and principal component analysis.

Usage

```
eigenVc(xmat, wp, d, r, itmax, err)
```

Arguments

xmat	Square symmetric matrix of order d.
wp	Columns orthogonal matrix of size (d,r), $r \leq d$.
d	Number of rows of wp.
r	Number of columns of wp.
itmax	Maximum number of iterations.
err	Tolerance level in the iterative search.

Value

This function returns a data frame containing 2 components

wc	Eigenvectors matrix.
iter	Number of iterations by the power method.

Examples

```
d <- 3
r <- 3
w <- c(rnorm(d*r,0,1))
res <- mGSc(w, d, r)
wp <- res$wp
XtX <- c(3,2,1,2,1,0,1,0,1)
res <- eigenVc(XtX, wp, d, r, itmax=100, err=1e-8)
wc <- matrix(res$wc, d, r)
t(wc)
```

mGS	<i>Modified Gram-Schmidt orthogonalization of a matrix</i>
-----	--

Description

This is an internal function which uses a R code to calculate an orthogonalization of a matrix. This function is used in the power method allowing to compute an eigendecomposition of a symmetric square.

Usage

```
mGS(A)
```

Arguments

A	Matrix in vector form.
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Value

This function returns a matrix which columns are the eigenvectors

wp	Eigenvectors matrix.
----	----------------------

Examples

```
A <- matrix(rnorm(6,0,1), ncol=2)
res <- mGS(A)
t(res)
```

mGSc	<i>Modified Gram-Schmidt orthogonalization of a matrix</i>
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Description

This is an internal function which uses a C code to calculate an orthogonalization of a matrix. This function is used in the power method allowing to compute an eigendecomposition of a symmetric square.

Usage

```
mGSc(amat, m, n)
```

Arguments

amat	Matrix in vector form.
m	Number of rows of the matrix amat.
n	Number of columns of the matrix amat.

Value

This function returns a data frame containing 1 component

wp Eigenvectors matrix.

Examples

```
d <- 3
r <- 2
amat <- c(rnorm(d*r,0,1))
res <- mGSc(amat, d, r)
wp <- matrix(res$wp, nrow=d, ncol=r)
t(wp)
```


Index

calcPCA, [3](#)

calcSVD, [4](#)

eigenV, [5](#)

eigenVc, [6](#)

mGS, [7](#)

mGSc, [7](#)

psvd-package, [2](#)