

Package ‘tensorApp’

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Type Package

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Description

High-order SVD approximation of a tensor by Tucker or CP decomposition and rank selection.

License GPL (>= 2)

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tensorApp-package	<i>High-order SVD approximation of a tensor \mathcal{Y} by Tucker or CP decomposition and selection of ranks</i>
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Description

High-order SVD approximation of a tensor \mathcal{Y} by Tucker decomposition or CANDECOMP/PARAFAC (CP) decomposition and selection of ranks. Alternating Least Squares algorithm is applied to Tucker decomposition, and both Alternating Least Squares algorithm or Tensor Power Method are applied to CP decomposition. This package provides several generator functions, which generate low-rank tensor or low-rank semi-symmetric tensor.

Details

High-order SVD approximation of a tensor \mathcal{Y} by Tucker decomposition or CANDECOMP/PARAFAC (CP) decomposition and selection of ranks.

Author(s)

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References

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cpals	<i>High-order SVD approximation of a tensor \mathcal{Y} by CP decomposition</i>
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Description

High-order SVD approximation of a tensor \mathcal{Y} by CANDECOMP/PARAFAC (CP) decomposition with rank preseted or to be selected. The Alternating Least Squares (als) algorithm is applied.

Usage

```
cpals(Y=NULL, d0=NULL, dims=NULL, dr=10, isfixr=FALSE,
      D0=NULL, eps=1e-4, max_step=50, thresh=1e-6)
```

Arguments

Y	An array with dimension <code>dims</code> , or a $n_{d0} \times N/n_{d0}$ numeric matrix of responses that is the mode <code>d0</code> -unfolding of tensor in $\mathcal{R}^{n_1 \times \dots \times n_d}$, where $N = n_1 \times \dots \times n_d$.
d0	<code>d0</code> is the mode. Y is the mode- <code>d0</code> unfolding of the tensor. <code>d0</code> can be <code>NULL</code> (the default) if Y is an array with dimension <code>dims</code> .
dims	The size of tensor Y, which is a d -vector (n_1, \dots, n_d) . <code>dims</code> can be <code>NULL</code> (the default) if Y is an array with dimension <code>dims</code> . If the length of <code>dims</code> is 2, it is the ordinary SVD decomposition of a matrix.
dr	The user-specified rank for CP decomposition. Default is 10.
isfixr	A logical value indicating whether the rank is fixed. The rank is selected automatically if it is <code>FALSE</code> . Default is <code>FALSE</code> .
D0	A user-specified list of initial matrices of U_1, U_2, \dots, U_d and core tensor S , <code>D0=list($U_1 = U_1, \dots, U_d = U_d, S = S$)</code> . By default, initial matrices are provided by random.
eps	Convergence threshold. The algorithm iterates until the relative change in any coefficient is less than <code>eps</code> . Default is <code>1e-4</code> .
max_step	Maximum number of iterations. Default is 50.
thresh	Convergence threshold in the outer loop. The algorithm iterates until the relative change in any coefficient is less than <code>eps</code> . Default is <code>1e-6</code> .

Details

This function gives a $n_{d0} \times N/n_{d0}$ matrix, which is the mode-`d0` unfolding, and approximates Y.

Value

Tnew	Approximation of Y.
Tn	A list of estimated matrices of U_1, U_2, \dots, U_d and core tensor S , <code>Tn=list($U_1 = U_1, \dots, U_d = U_d, S = S$)</code> .
ranks	The ranks of estimated tensor Tnew. It is an integer.

See Also

`hosvd_dr`

Examples

```

dims <- c(8,8,10,10,6)
N <- length(dims)
ranks <- rep(2,N)
S0 <- matrix(runif(prod(ranks),3,7),ranks[N])
T1 <- matrix(rnorm(dims[1]*ranks[1]),nrow = dims[1])
tmp <- qr.Q(qr(T1))
for(k in 2:(N-1)){
  T1 <- matrix(rnorm(dims[k]*ranks[k]),nrow = dims[k])
  tmp <- kronecker(qr.Q(qr(T1)),tmp)
}
T1 <- matrix(rnorm(dims[N]*ranks[N]),nrow = dims[N])
U <- qr.Q(qr(T1))

```

```

Y <- U%*%S0%*%t(tmp)

fit <- cpals(Y,N,dims)
Tnew <- fit$Tnew
ranks1 <- fit$ranks
U1 <- fit$Tn[[1]]
TNew1 <- ttu(Tnew,N,1,dims)

```

cpsym2

High-order SVD approximation of a tensor Y by CP decomposition

Description

High-order SVD approximation of a semi-symmetric tensor Y by CANDECOMP/PARAFAC (CP) decomposition with rank preseted or to be selected. The Tensor Power Method is applied. The semi-symmetric tensor means that both mode-r1 and mode-r2 unfoldings are equal, that is, $Y_{(r1)} = Y_{(r2)}$. For semi-symmetric tensor approximation, the r1th and r2th dimensions must be smaller than others.

Usage

```

cpsym2(Y=NULL, r1=1, r2=2, d0=NULL, dims=NULL, dr=10, D0=NULL, isfixr=FALSE,
       isOrth=FALSE, eps=1e-4, max_step=50, thresh=1e-6)

```

Arguments

Y	An array with dimension dims, or a $n_{d0} \times N/n_{d0}$ numeric matrix of responses that is the mode d0-unfolding of tensor in $\mathcal{R}^{n_1 \times \dots \times n_d}$, where $N = n_1 \times \dots \times n_d$.
r1	Both r1 and r2 are the user-specified modes, which means that both mode-r1 and mode-r2 unfoldings are equal. Default is r1 = 1 and r2 = 2.
r2	Both r1 and r2 are the user-specified modes, which means that both mode-r1 and mode-r2 unfoldings are equal. Default is r1 = 1 and r2 = 2.
d0	d0 is the mode. Y is the mode-d0 unfolding of the tensor. d0 can be NULL (the default) if Y is an array with dimension dims.
dims	The size of tensor Y, which is a d -vector (n_1, \dots, n_d) . dims can be NULL (the default) if Y is an array with dimension dims. If the length of dims is 2, it is the ordinary SVD decomposition of a matrix.
dr	The user-specified rank for CP decomposition. Default is 10.
D0	A user-specified list of initial matrices of U_1, U_2, \dots, U_d and core tensor S , $D0=list(U_1 = U_1, \dots, U_d = U_d, S = S)$. By default, initial matrices are provided by random.
isfixr	A logical value indicating whether the rank is fixed. The rank is selected automatically if it is FALSE. Default is FALSE.
isOrth	A logical value indicating whether it outputs orthonognal PCs if CP decomposition is used. Default is FALSE.
eps	Convergence threshold. The algorithm iterates until the relative change in any coefficient is less than eps. Default is 1e-4.
max_step	Maximum number of iterations. Default is 50.
thresh	Convergence threshold in the outer loop. The algorithm iterates until the relative change in any coefficient is less than eps. Default is 1e-6.

Details

This function gives a $n_{d0} \times N/n_{d0}$ matrix, which is the mode-d0 unfolding, and approximates Y .

Value

Tnew	Approximation of Y .
Tn	A list of estimated matrices of U_1, U_2, \dots, U_d and core tensor S , $Tn = list(U_1 = U_1, \dots, U_d = U_d, S = S)$.
ranks	The ranks of estimated tensor Tnew. It is an integer.

See Also

hosvd_dr

Examples

```

dims <- c(6,6,8,7,7)
N <- length(dims)
ranks <- rep(2,N)
dm <- prod(ranks)
r1 <- 1
r2 <- 2
S1 <- matrix(runif(dm,3,7),nrow = ranks[r1])
S2 <- ttu(S1,r1,r2,ranks)
S1 <- (S1+S2)/2
S0 <- ttu(S1,r1,N,ranks)

T1 <- matrix(rnorm(dims[1]*ranks[1]),nrow = dims[1])
tmp <- qr.Q(qr(T1))
Uj <- kronecker(tmp,tmp)
for(k in 3:(N-1)){
  T1 <- matrix(rnorm(dims[k]*ranks[k]),nrow = dims[k])
  tmp <- qr.Q(qr(T1))
  Uj <- kronecker(tmp,Uj)
}
T1 <- matrix(rnorm(dims[N]*ranks[N]),nrow = dims[N])
U <- qr.Q(qr(T1))
Y <- U%*%S0%*%t(Uj)

fit <- cpsym2(Y,r1=1,r2=2,d0=N,dims=dims)
Tnew <- fit$Tnew
ranks1 <- fit$ranks
U1 <- fit$Tn[[r1]]
U2 <- fit$Tn[[r2]]
TNew1 <- ttu(Tnew,N,r1,dims)
TNew2 <- ttu(Tnew,N,r2,dims)

```

gtcp	<i>Generate a low-rank tensor characterizing the form of CP decomposition</i>
------	---

Description

This function generates a low-rank tensor characterizing the form of CP decomposition with dimension `dims` and factors `lambda`.

Usage

```
gtcp(dims, lambda=NULL, d0=NULL, dr=NULL, seed_id=2)
```

Arguments

<code>dims</code>	The size of the tensor, which is a vector (n_1, \dots, n_d) . <code>dims</code> must be specified.
<code>lambda</code>	The factors of CP decomposition. It is an vector. Factors <code>lambda</code> will be given randomly if it is <code>NULL</code> .
<code>d0</code>	<code>d0</code> is the mode. The output tensor is the mode- <code>d0</code> unfolding of the tensor. <code>d0</code> can be <code>NULL</code> (the default) if the output tensor is an array with dimension <code>dims</code> .
<code>dr</code>	The user-specified rank. Default is 10.
<code>seed_id</code>	A positive integer, the seed for generating the random numbers. Default is 2.

Details

This function generates a low-rank tensor characterizing the form of CP decomposition with dimension `dims` and factors `lambda`.

Value

<code>Dn</code>	the output mode- <code>d0</code> -unfolding, $D_{(d_0)}$. Or an array with dimension <code>dims</code> if <code>d0</code> is <code>NULL</code> .
-----------------	---

See Also

`gtcpsem`, `gtt`

Examples

```
dims <- c(8,8,10,10,6)
N <- length(dims)
lambda <- seq(6,1,by=-1)
dr <- 5

T1 <- gtcp(dims=dims,lambda=lambda,d0=1,dr=dr)
T2 <- ttu(T1,1,2,dims)
```

gtcpsem	<i>Generate a low-rank semi-symmetric tensor characterizing the form of CP decomposition</i>
---------	--

Description

This function generates a low-rank semi-symmetric tensor characterizing the form of CANDECOMP/PARAFAC (CP) decomposition with the dimension `dims` and factors `lambda`. The semi-symmetric tensor means that both mode-`r1` and mode-`r2` unfoldings are equal, that is, $T_{(r1)} = T_{(r2)}$ for the output tensor T .

Usage

```
gtcpsem(dims, lambda=NULL, r1=1, r2=2, d0=NULL, dr=NULL, seed_id=2)
```

Arguments

<code>dims</code>	The size of the tensor, which is a vector (n_1, \dots, n_d) . <code>dims</code> must be specified.
<code>lambda</code>	The factors of CP decomposition. It is an vector. Factors <code>lambda</code> will be given randomly if it is <code>NULL</code> .
<code>r1</code>	Both <code>r1</code> and <code>r2</code> are the user-specified modes, which means that both mode- <code>r1</code> and mode- <code>r2</code> unfoldings are equal. Default is <code>r1 = 1</code> and <code>r2 = 2</code> .
<code>r2</code>	Both <code>r1</code> and <code>r2</code> are the user-specified modes, which means that both mode- <code>r1</code> and mode- <code>r2</code> unfoldings are equal. Default is <code>r1 = 1</code> and <code>r2 = 2</code> .
<code>d0</code>	<code>d0</code> is the mode. The output tensor is the mode- <code>d0</code> unfolding of the tensor. <code>d0</code> can be <code>NULL</code> (the default) if the output tensor is an array with dimension <code>dims</code> .
<code>dr</code>	The user-specified rank. Default is 10.
<code>seed_id</code>	A positive integer, the seed for generating the random numbers. Default is 2.

Details

This function generates a low-rank semi-symmetric tensor characterizing the form of CP decomposition with dimension `dims` and factors `lambda`.

Value

<code>Dn</code>	the output mode- <code>d0</code> -unfolding, $D_{(d_0)}$. Or an array with dimesion <code>dims</code> if <code>d0</code> is <code>NULL</code> .
-----------------	--

See Also

`gtcp`, `gttsem`

Examples

```
dims <- c(8,6,10,6,7)
N <- length(dims)
lambda <- seq(6,1,by=-1)
r1 <- 2
r2 <- 4
```

```
dr <- 5

T1 <- gtcpsem(dims=dims,lambda=lambda,r1=r1,r2=r2,d0=r1,dr=dr)
T2 <- ttu(T1,r1,r2,dims)
```

gtt	<i>Generate a low-rank tensor characterizing the form of Tucker decomposition</i>
-----	---

Description

This function generates a low-rank tensor characterizing the form of Tucker decomposition with dimension `dims` and core tensor `S`.

Usage

```
gtt(dims, S=NULL, d0=NULL, ranks=NULL, seed_id=2)
```

Arguments

<code>dims</code>	The size of the tensor, which is a vector (n_1, \dots, n_d) . <code>dims</code> must be specified.
<code>S</code>	The core tensor. An array with dimension <code>dims</code> , or a mode-d1-unfolding of core tensor with size $n_1 \times \dots \times n_d$. Core tensor <code>S</code> will be given randomly if it is <code>NULL</code> .
<code>d0</code>	<code>d0</code> is the mode. The output tensor is the mode-d0 unfolding of the tensor. <code>d0</code> can be <code>NULL</code> (the default) if the output tensor is an array with dimension <code>dims</code> .
<code>ranks</code>	The user-specified ranks. It is a vector with length d . If <code>ranks</code> is <code>NULL</code> (the default), this function outputs a tensor without low-rank.
<code>seed_id</code>	A positive integer, the seed for generating the random numbers. Default is 2.

Details

This function generates a low-rank tensor characterizing the form of Tucker decomposition with dimension `dims` and core tensor `S`.

Value

<code>Dn</code>	the output mode-d0-unfolding, $D_{(d_0)}$. Or an array with dimesion <code>dims</code> if <code>d0</code> is <code>NULL</code> .
-----------------	---

See Also

`gtcp`, `gttsem`

Examples

```
dims <- c(8,8,10,10,6)
N <- length(dims)
ranks <- rep(2,N)

T1 = gtt(dims=dims,d0=1,ranks=ranks)
T2 <- ttu(T1,1,2,dims)
```

gttsem	<i>Generate a low-rank semi-symmetric tensor characterizing the form of Tucker decomposition</i>
--------	--

Description

This function generates a low-rank semi-symmetric tensor characterizing the form of Tucker decomposition with dimension `dims` and core tensor `S`. The semi-symmetric tensor means that both mode-`r1` and mode-`r2` unfoldings are equal, that is, $T_{(r1)} = T_{(r2)}$ for the output tensor T , where the absolute difference of `r1` and `r2` is restricted to no more than 3.

Usage

```
gttsem(dims, S=NULL, r1=1, r2=2, d0=NULL, ranks=NULL, seed_id=2)
```

Arguments

<code>dims</code>	The size of the tensor, which is a vector (n_1, \dots, n_d) . <code>dims</code> must be specified.
<code>S</code>	The core tensor. An array with dimension <code>dims</code> , or a mode- <code>d1</code> -unfolding of core tensor with size $n_1 \times \dots \times n_d$. Core tensor <code>S</code> will be given randomly if it is <code>NULL</code> .
<code>r1</code>	Both <code>r1</code> and <code>r2</code> are the user-specified modes, which means that both mode- <code>r1</code> and mode- <code>r2</code> unfoldings are equal. Default is <code>r1 = 1</code> and <code>r2 = 2</code> .
<code>r2</code>	Both <code>r1</code> and <code>r2</code> are the user-specified modes, which means that both mode- <code>r1</code> and mode- <code>r2</code> unfoldings are equal. Default is <code>r1 = 1</code> and <code>r2 = 2</code> .
<code>d0</code>	<code>d0</code> is the mode. The output tensor is the mode- <code>d0</code> unfolding of the tensor. <code>d0</code> can be <code>NULL</code> (the default) if the output tensor is an array with dimension <code>dims</code> .
<code>ranks</code>	The user-specified ranks. It is a vector with length d . If <code>ranks</code> is <code>NULL</code> (the default), this function outputs a semi-symmetric tensor without low-rank.
<code>seed_id</code>	A positive integer, the seed for generating the random numbers. Default is 2.

Details

This function generates a low-rank semi-symmetric tensor characterizing the form of Tucker decomposition with dimension `dims` and core tensor `S`.

Value

<code>Dn</code>	the output mode- <code>d0</code> -unfolding, $D_{(d_0)}$. Or an array with dimension <code>dims</code> if <code>d0</code> is <code>NULL</code> .
-----------------	---

See Also

`gtt`, `gtcpsem`

Examples

```

dims <- c(8,6,8,6,7)
N <- length(dims)
ranks <- rep(2,N)
r1 <- 2
r2 <- 4

T1 <- gttsem(dims=dims,r1=r1,r2=r2,d0=r1,ranks=ranks)
T2 <- ttu(T1,r1,r2,dims)

```

hosvd	<i>High-order SVD approximation of a tensor Y by Tucker or CP decomposition</i>
-------	---

Description

High-order SVD approximation of a tensor Y by Tucker decomposition or CANDECOMP/PARAFAC (CP) decomposition with preseted rank. Alternating Least Squares algorithm is applied to Tucker decomposition, and Tensor Power Method is applied to CP decomposition.

Usage

```

hosvd(Y=NULL, d0=NULL, dims=NULL, isCP=TRUE, ranks=NULL, dr=20,
      D0=NULL,isOrth=FALSE, eps=1e-6, max_step=100)

```

Arguments

Y	An array with dimension dims, or a $n_{d0} \times N/n_{d0}$ numeric matrix of responses that is the mode d0-unfolding of tensor in $\mathcal{R}^{n_1 \times \dots \times n_d}$, where $N = n_1 \times \dots \times n_d$.
d0	d0 is the mode. Y is the mode-d0 unfolding of the tensor. d0 can be NULL (the default) if Y is an array with dimension dims.
dims	The size of tensor Y, which is a d -vector (n_1, \dots, n_d) . dims can be NULL (the default) if Y is an array with dimension dims. If the length of dims is 2, it is the ordinary SVD decomposition of a matrix.
isCP	A logical value indicating whether CP decomposition will be used. Default is TRUE.
ranks	The user-specified ranks. It is a vector with length d . Default is $(2, \dots, 2)$.
dr	The user-specified rank for CP decomposition. It is useless if Tucker decomposition is used. Default is 20.
D0	A user-specified list of initial matrices of U_1, U_2, \dots, U_d and the mode- $d0$ unfolding $S_{(d0)}$ of the core tensor S , $D0=list(U_1 = U_1, \dots, U_d = U_d, S = S_{(d0)})$. By default, initial matrices are provided randomly.
isOrth	A logical value indicating whether it outputs orthonognal PCs if CP decomposition is used. Default is FALSE.
eps	Convergence threshold. The algorithm iterates until the relative change in any coefficient is less than eps. Default is $1e-6$.
max_step	Maximum number of iterations. Default is 100.

Details

This function gives a $n_{d0} \times N/n_{d0}$ matrix, which is the mode- $d0$ unfolding, and approximates Y .

Value

Tnew	Approximation of Y .
Tn	A list of estimated matrices of U_1, U_2, \dots, U_d and the mode- $d0$ unfolding $S_{(d0)}$ of the core tensor S , $Tn = list(U_1 = U_1, \dots, U_d = U_d, S = S_{(d0)})$.
ranks	The ranks of estimated tensor Tnew. It is a vector with the same length as <code>dims</code> if Tucker decomposition is used, or an integer if CP decomposition is used.

See Also

hosvd_dr

Examples

```
# Example 1
dims <- c(8,8,10,10,6)
N <- length(dims)
ranks <- rep(2,N)
S0 <- matrix(runif(prod(ranks),3,7),ranks[N])
T1 <- matrix(rnorm(dims[1]*ranks[1]),nrow = dims[1])
tmp <- qr.Q(qr(T1))
for(k in 2:(N-1)){
  T1 <- matrix(rnorm(dims[k]*ranks[k]),nrow = dims[k])
  tmp <- kronecker(qr.Q(qr(T1)),tmp)
}
T1 <- matrix(rnorm(dims[N]*ranks[N]),nrow = dims[N])
U <- qr.Q(qr(T1))
Y <- U%*%S0%*%t(tmp)

fit <- hosvd(Y,N,dims,isCP=TRUE)
Tnew <- fit$Tnew
ranks1 <- fit$ranks
lambda <- fit$Tn[[N+1]]
U1 <- fit$Tn[[1]]
TNew1 <- ttu(Tnew,N,1,dims)

# Example 2
library(png)
bat = readPNG(system.file("bat", "bat.jpg", package="tensorApp"))
writePNG(bat,target = "bat.png")

Tn = hosvd(bat,dr=20,dims=dim(bat))
writePNG(Tn$Tnew,target = "batCP.png")
Tn = hosvd(bat,dr=50,dims=dim(bat),isCP=F,ranks = c(20,20,3))
writePNG(Tn$Tnew,target = "batTucker.png")

# Example 3
img = readPNG(system.file("img", "Rlogo.png", package="png"))
writePNG(img,target = "Rlog.png")
```

```

Tn = hosvd(img,dr=20,dims=dim(img))
writePNG(Tn$Tnew,target = "RlogCP.png")
Tn = hosvd(img,dr=20,dims=dim(img),isCP=F,ranks = c(20,20,4))
writePNG(Tn$Tnew,target = "RlogTucker.png")

```

hosvd_dr

High-order SVD approximation of a tensor Y by Tucker or CP decomposition and selection of ranks

Description

High-order SVD approximation of a tensor Y by Tucker decomposition or CANDECOMP/PARAFAC (CP) decomposition and selection of ranks. Alternating Least Squares algorithm is applied to Tucker decomposition, and Tensor Power Method is applied to CP decomposition.

Usage

```

hosvd_dr(Y=NULL, d0=NULL, dims=NULL, isCP=TRUE, ranks=NULL, dr=100,
         D0=NULL, isOrth=FALSE, eps=1e-6, max_step=100, thresh=1e-6)

```

Arguments

Y	An array with dimension dims, or a $n_{d0} \times N/n_{d0}$ numeric matrix of responses that is the mode d0-unfolding of tensor in $\mathcal{R}^{n_1 \times \dots \times n_d}$, where $N = n_1 \times \dots \times n_d$.
d0	d0 is the mode. Y is the mode-d0 unfolding of the tensor. d0 can be NULL (the default) if Y is an array with dimension dims.
dims	The size of tensor Y, which is a d -vector (n_1, \dots, n_d) . dims can be NULL (the default) if Y is an array with dimension dims. If the length of dims is 2, it is the ordinary SVD decomposition of a matrix.
isCP	A logical value indicating whether CP decomposition will be used. Default is TRUE.
ranks	The user-specified ranks. It is a vector with length d. Default is $(2, \dots, 2)$.
dr	The user-specified rank for CP decomposition. The maximum rank $dm = \min(dr, \max(ranks))$ if Tucker decomposition is used. Default is 100.
D0	A user-specified list of initial matrices of U_1, U_2, \dots, U_d and the mode-d0 unfolding $S_{(d0)}$ of the core tensor S , $D0 = \text{list}(U_1 = U_1, \dots, U_d = U_d, S = S_{(d0)})$. By default, initial matrices are provided randomly.
isOrth	A logical value indicating whether it outputs orthonormal PCs if CP decomposition is used. Default is FALSE.
eps	Convergence threshold in the inner loop. The algorithm iterates until the relative change in any coefficient is less than eps. Default is $1e-6$.
max_step	Maximum number of iterations. Default is 100.
thresh	Convergence threshold in the outer loop. The algorithm iterates until the relative change in any coefficient is less than thresh. Default is $1e-6$.

Details

This function gives a $n_{d0} \times N/n_{d0}$ matrix, which is the mode-d0 unfolding, and approximates Y.

Value

Tnew	Approximation of Y .
Tn	A list of estimated matrices of U_1, U_2, \dots, U_d and the mode- d_0 unfolding $S_{(d_0)}$ of the core tensor S , $Tn = \text{list}(U_1 = U_1, \dots, U_d = U_d, S = S_{(d_0)})$.
ranks	The ranks of estimated tensor Tnew. It is a vector with the same length as dims if Tucker decomposition is used, or an integer if CP decomposition is used.

See Also

hosvd

Examples

```

dims <- c(8,8,10,10,6)
N <- length(dims)
ranks <- rep(2,N)
S0 <- matrix(runif(prod(ranks),3,7),ranks[N])
T1 <- matrix(rnorm(dims[1]*ranks[1]),nrow = dims[1])
tmp <- qr.Q(qr(T1))
for(k in 2:(N-1)){
  T1 <- matrix(rnorm(dims[k]*ranks[k]),nrow = dims[k])
  tmp <- kronecker(qr.Q(qr(T1)),tmp)
}
T1 <- matrix(rnorm(dims[N]*ranks[N]),nrow = dims[N])
U <- qr.Q(qr(T1))
Y <- U%*%S0%*%t(tmp)

fit_dr <- hosvd_dr(Y,N,dims,isCP=TRUE)
Tnew <- fit_dr$Tnew
ranks1 <- fit_dr$ranks
lambda <- fit_dr$Tn[[N+1]]
U1 <- fit_dr$Tn[[1]]
TNew1 <- ttu(Tnew,N,1,dims)

```

tmp

*Modal Product***Description**

Modal product calculates the product an order d tensor S and a matrix M , that is $T = S \times_{d_0} M$ that means $T_{(d_0)} = M \cdot S_{(d_0)}$, where $S_{(d_0)}$ is the mode- d_0 unfolding of the tensor S .

Usage

```
tmp(S=NULL, M=NULL, d0=NULL, dims=NULL)
```

Arguments

<code>S</code>	An order d tensor with dimension <code>dims</code> , where <code>dims</code> is (n_1, \dots, n_d) .
<code>M</code>	A matrix with K rows and n_{d0} columns. The modal product produces a new order d tensor with dimension <code>dims</code> replaced the $d0$ th dimension by K .
<code>dims</code>	The dimension of tensor Y , which is a d -vector (n_1, \dots, n_d) .
<code>d0</code>	$d0$ is the mode. M multiplies the mode- $d0$ unfoldings of S .

Details

This function gives the modal product of tensor S and matrix M , which is the product of M and the mode- $d0$ unfolding of tensor S , that is $S \times_{d0} M = MS_{(d0)}$, where $S_{(d0)}$ is the mode- $d0$ unfolding of the tensor S . The modal product produce a new order d tensor with dimension `dims` replaced the $d0$ dimension by K , where K is the number of rows of matrix M .

Value

<code>Tnew</code>	Product of S and M .
-------------------	--------------------------

See Also

`TransUnfoldingsT`

Examples

```

dims <- c(8,8,10,10,6)
N <- length(dims)
ranks <- rep(2,N)
S0 <- matrix(runif(prod(ranks),3,7),ranks[N])
T1 <- matrix(rnorm(dims[1]*ranks[1]),nrow = dims[1])
tmp <- qr.Q(qr(T1))
for(k in 2:(N-1)){
  T1 <- matrix(rnorm(dims[k]*ranks[k]),nrow = dims[k])
  tmp <- kronecker(qr.Q(qr(T1)),tmp)
}
T1 <- matrix(rnorm(dims[N]*ranks[N]),nrow = dims[N])
U <- qr.Q(qr(T1))
Y <- U%*%S0%*%t(tmp)
Y1 <- array(ttU(Y,N,1,dims),dims)
M <- matrix(1:(4*dims[3]),4)

X1 <- tmp(Y1,M,3,dims)
X <- ttU(matrix(X1,dims[1]),1,N,dims)

dim(Y1)
dim(X1)
print(Y[,1])
print(X[,1])

```

ttu	<i>Transfer a tensor's modal unfolding to another.</i>
-----	--

Description

Transfer a tensor's modal unfolding to another.

Usage

```
ttu(S=NULL, d1=NULL, d2=0, dims=NULL)
```

Arguments

S	An array with dimension <code>dims</code> , or a mode-d1-unfolding of a tensor with size $n_1 \times \cdots \times n_d$.
d1	An integer, the mode of unfolding $S_{(d_1)}$. d1 can be NULL (the default) if S is an array with dimension <code>dims</code> .
d2	An integer, the mode of output unfolding $S_{(d_2)}$. It transfers S to an array with dimension <code>dims</code> if d2=0. The default is 0.
dims	The size of tensor S , which is a vector (n_1, \dots, n_d) . <code>dims</code> can be NULL (the default) if S is an array with dimension <code>dims</code> .

Details

This function transfers an input mode-d1-unfolding $S_{(d_1)}$ to mode-d2-unfolding $S_{(d_2)}$

Value

Td2 the output mode-d2-unfolding, $S_{(d_2)}$.

Examples

```
T1 <- matrix(1:24,nrow = 4) # A tensor unfolding with size 4*6
T2 <- ttu(T1,1,2,c(4,3,2))

T0 <- ttu(T2,2,dims=c(4,3,2))
```

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