

Package ‘dcTensor’

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Type Package

Title Discrete Matrix/Tensor Decomposition

Version 1.3.0

Depends R (>= 3.4.0)

Imports methods, MASS, fields, rTensor, nnTensor

Suggests knitr, rmarkdown, testthat

Description Semi-Binary and Semi-Ternary Matrix Decomposition are performed based on Non-negative Matrix Factorization (NMF) and Singular Value Decomposition (SVD). For the details of the methods, see the reference section of GitHub README.md <<https://github.com/rikenbit/dcTensor>>.

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URL <https://github.com/rikenbit/dcTensor>

VignetteBuilder knitr

NeedsCompilation no

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dcTensor-package

*Discrete Matrix/Tensor Decomposition***Description**

Semi-Binary and Semi-Ternary Matrix Decomposition are performed based on Non-negative Matrix Factorization (NMF) and Singular Value Decomposition (SVD). For the details of the methods, see the reference section of GitHub README.md <<https://github.com/rikenbit/dcTensor>>.

Details

The DESCRIPTION file:

```
Package:      dcTensor
Type:         Package
Title:        Discrete Matrix/Tensor Decomposition
Version:      1.3.0
Authors@R:    c(person("Koki", "Tsuyuzaki", role = c("aut", "cre"), email = "k.t.the-answer@hotmail.co.jp"))
Depends:      R (>= 3.4.0)
Imports:      methods, MASS, fields, rTensor, nnTensor
Suggests:     knitr, rmarkdown, testthat
Description:   Semi-Binary and Semi-Ternary Matrix Decomposition are performed based on Non-negative Matrix Factorization
License:      MIT + file LICENSE
URL:          https://github.com/rikenbit/dcTensor
VignetteBuilder: knitr
Author:       Koki Tsuyuzaki [aut, cre]
Maintainer:   Koki Tsuyuzaki <k.t.the-answer@hotmail.co.jp>
```

Index of help topics:

dNMF	Discretized Non-negative Matrix Factorization Algorithms (dNMF)
dNMTF	Discretized Non-negative Matrix Tri-Factorization Algorithms (dNMTF)
dNTD	Discretized Non-negative Tucker Decomposition Algorithms (dNTD)
dNTF	Discretized Non-negative CP Decomposition Algorithms (dNTF)
dPLS	Discretized Partial Least Squares (dPLS)
dSVD	Discretized Singular Value Decomposition (dSVD)
dcTensor-package	Discrete Matrix/Tensor Decomposition
djNMF	Discretized Joint Non-negative Matrix Factorization Algorithms (djNMF)
dsiNMF	Discretized Simultaneous Non-negative Matrix

	Factorization Algorithms (dsinMF)
toyModel	Toy model data for using dNMF, dSVD, dsinMF, djNMF, dPLS, dNTF, and dNTD

Author(s)

NA

Maintainer: NA

References

Z. Zhang, T. Li, C. Ding and X. Zhang, (2007). Binary Matrix Factorization with Applications, *Seventh IEEE International Conference on Data Mining (ICDM 2007)*, 391-400

See Also

[toyModel, dNMF, dSVD](#)

Examples

```
ls("package:dcTensor")
```

djNMF	<i>Discretized Joint Non-negative Matrix Factorization Algorithms (djNMF)</i>
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Description

This function is the discretized version of nnTensor::jNMF. The input data objects are assumed to be a list containing multiple non-negative matrices ($X_1, X_2, \dots, X_K$), and decomposed to multiple matrix products $((W + V_1) H_1', (W + V_2) H_2', \dots, (W + V_K) H_K')$, where W is common across all the data matrices but each V_k or H_k ($k=1..K$) is specific in each X_k . Unlike regular jNMF, in djNMF, W , V_k , and H_k are estimated by adding binary regularization so that the values are 0 or 1 as much as possible. Likewise, W , V_k , and H_k are estimated by adding ternary regularization so that the values are 0, 1, or 2 as much as possible.

Usage

```
djNMF(X, M=NULL, pseudocount=.Machine$double.eps,
      initW=NULL, initV=NULL, initH=NULL,
      fixW=FALSE, fixV=FALSE, fixH=FALSE,
      Bin_W=1e-10, Bin_V=rep(1e-10, length=length(X)), Bin_H=rep(1e-10, length=length(X)),
      Ter_W=1e-10, Ter_V=rep(1e-10, length=length(X)), Ter_H=rep(1e-10, length=length(X)),
      L1_W=1e-10, L1_V=rep(1e-10, length=length(X)), L1_H=rep(1e-10, length=length(X)),
      L2_W=1e-10, L2_V=rep(1e-10, length=length(X)), L2_H=rep(1e-10, length=length(X)),
      J = 3, w=NULL, algorithm = c("Frobenius", "KL", "IS", "PLTF"), p=1,
      thr = 1e-10, num.iter = 100,
      viz = FALSE, figdir = NULL, verbose = FALSE)
```

Arguments

<code>X</code>	A list containing input matrices (X_k , $\langle N \times M_k \rangle$, $k=1..K$).
<code>M</code>	A list containing the mask matrices (X_k , $\langle N \times M_k \rangle$, $k=1..K$). If the input matrix has missing values, specify the element as 0 (otherwise 1).
<code>pseudocount</code>	The pseudo count to avoid zero division, when the element is zero (Default: Machine Epsilon).
<code>initW</code>	The initial values of factor matrix W , which has N -rows and J -columns (Default: NULL).
<code>initV</code>	A list containing the initial values of multiple factor matrices (V_k , $\langle N \times J \rangle$, $k=1..K$, Default: NULL).
<code>initH</code>	A list containing the initial values of multiple factor matrices (H_k , $\langle M_k \times J \rangle$, $k=1..K$, Default: NULL).
<code>fixW</code>	Whether the factor matrix W is updated in each iteration step (Default: FALSE).
<code>fixV</code>	Whether the factor matrices V_k are updated in each iteration step (Default: FALSE).
<code>fixH</code>	Whether the factor matrices H_k are updated in each iteration step (Default: FALSE).
<code>Bin_W</code>	Paramter for binary (0,1) regularitation (Default: $1e-10$).
<code>Bin_V</code>	A K -length vector containing the paramters for binary (0,1) regularitation (Default: $\text{rep}(1e-10, \text{length}=\text{length}(\text{dim}(X)))$).
<code>Bin_H</code>	A K -length vector containing the paramters for binary (0,1) regularitation (Default: $\text{rep}(1e-10, \text{length}=\text{length}(\text{dim}(X)))$).
<code>Ter_W</code>	Paramter for terary (0,1,2) regularitation (Default: $1e-10$).
<code>Ter_V</code>	A K -length vector containing the paramters for terary (0,1,2) regularitation (Default: $\text{rep}(1e-10, \text{length}=\text{length}(\text{dim}(X)))$).
<code>Ter_H</code>	A K -length vector containing the paramters for terary (0,1,2) regularitation (Default: $\text{rep}(1e-10, \text{length}=\text{length}(\text{dim}(X)))$).
<code>L1_W</code>	Paramter for L1 regularitation (Default: $1e-10$). This also works as small positive constant to prevent division by zero, so should be set as 0.
<code>L1_V</code>	A K -length vector containing the paramters for L1 regularitation (Default: $\text{rep}(1e-10, \text{length}=\text{length}(\text{dim}(X)))$). This also works as small positive constant to prevent division by zero, so should be set as 0.
<code>L1_H</code>	A K -length vector containing the paramters for L1 regularitation (Default: $\text{rep}(1e-10, \text{length}=\text{length}(\text{dim}(X)))$). This also works as small positive constant to prevent division by zero, so should be set as 0.
<code>L2_W</code>	Paramter for L2 regularitation (Default: $1e-10$).
<code>L2_V</code>	A K -length vector containing the paramters for L2 regularitation (Default: $\text{rep}(1e-10, \text{length}=\text{length}(\text{dim}(X)))$).
<code>L2_H</code>	A K -length vector containing the paramters for L2 regularitation (Default: $\text{rep}(1e-10, \text{length}=\text{length}(\text{dim}(X)))$).
<code>J</code>	Number of low-dimension ($J < N, M_k$).

w	Weight vector (Default: NULL)
algorithm	Divergence between X and X_bar. "Frobenius", "KL", and "IS" are available (Default: "KL").
p	The parameter of Probabilistic Latent Tensor Factorization (p=0: Frobenius, p=1: KL, p=2: IS)
thr	When error change rate is lower than thr, the iteration is terminated (Default: 1E-10).
num.iter	The number of iteration step (Default: 100).
viz	If viz == TRUE, internal reconstructed matrix can be visualized.
figdir	the directory for saving the figure, when viz == TRUE.
verbose	If verbose == TRUE, Error change rate is generated in console windos.

Value

W : A matrix which has N-rows and J-columns ($J < N$, Mk). V : A list which has multiple elements containing N-rows and J-columns ($J < N$, Mk). H : A list which has multiple elements containing Mk-rows and J-columns matrix ($J < N$, Mk). RecError : The reconstruction error between data matrix and reconstructed matrix from W and H. TrainRecError : The reconstruction error calculated by training set (observed values specified by M). TestRecError : The reconstruction error calculated by test set (missing values specified by M). RelChange : The relative change of the error.

Author(s)

Koki Tsuyuzaki

References

- Liviu Badea, (2008) Extracting Gene Expression Profiles Common to Colon and Pancreatic Adenocarcinoma using Simultaneous nonnegative matrix factorization. *Pacific Symposium on Biocomputing* 13:279-290
- Shihua Zhang, et al. (2012) Discovery of multi-dimensional modules by integrative analysis of cancer genomic data. *Nucleic Acids Research* 40(19), 9379-9391
- Zi Yang, et al. (2016) A non-negative matrix factorization method for detecting modules in heterogeneous omics multi-modal data, *Bioinformatics* 32(1), 1-8
- Y. Kenan Yilmaz et al., (2010) Probabilistic Latent Tensor Factorization, *International Conference on Latent Variable Analysis and Signal Separation* 346-353
- N. Fujita et al., (2018) Biomarker discovery by integrated joint non-negative matrix factorization and pathway signature analyses, *Scientific Report*

Examples

```
matdata <- toyModel(model = "dsiNMF_Hard")
out <- djNMF(matdata, J=2, num.iter=2)
```

Description

This function is the discretized version of `nnTensor::NMF`. The input data X is assumed to be a non-negative matrix and decomposed to a matrix product $U V'$. Unlike regular NMF, in dNMF, U and V are estimated by adding binary regularization so that the values are 0 or 1 as much as possible. Likewise, U and V are estimated by adding ternary regularization so that the values are 0, 1, or 2 as much as possible.

Usage

```
dNMF(X, M=NULL, pseudocount=.Machine$double.eps,
      initU=NULL, initV=NULL, fixU=FALSE, fixV=FALSE,
      Bin_U=1e-10, Bin_V=1e-10, Ter_U=1e-10, Ter_V=1e-10,
      L1_U=1e-10, L1_V=1e-10, L2_U=1e-10, L2_V=1e-10, J = 3,
      algorithm = c("Frobenius", "KL", "IS", "Beta"), Beta = 2,
      thr = 1e-10, num.iter = 100,
      viz = FALSE, figdir = NULL, verbose = FALSE)
```

Arguments

<code>X</code>	The input matrix which has N-rows and M-columns.
<code>M</code>	The mask matrix which has N-rows and M-columns. If the input matrix has missing values, specify the element as 0 (otherwise 1).
<code>pseudocount</code>	The pseudo count to avoid zero division, when the element is zero (Default: Machine Epsilon).
<code>initU</code>	The initial values of factor matrix U , which has N-rows and J-columns (Default: NULL).
<code>initV</code>	The initial values of factor matrix V , which has M-rows and J-columns (Default: NULL).
<code>fixU</code>	Whether the factor matrix U is updated in each iteration step (Default: FALSE).
<code>fixV</code>	Whether the factor matrix V is updated in each iteration step (Default: FALSE).
<code>Bin_U</code>	Paramter for binary (0,1) regularitation (Default: 1e-10).
<code>Bin_V</code>	Paramter for binary (0,1) regularitation (Default: 1e-10).
<code>Ter_U</code>	Paramter for terary (0,1,2) regularitation (Default: 1e-10).
<code>Ter_V</code>	Paramter for terary (0,1,2) regularitation (Default: 1e-10).
<code>L1_U</code>	Paramter for L1 regularitation (Default: 1e-10). This also works as small positive constant to prevent division by zero, so should be set as 0.
<code>L1_V</code>	Paramter for L1 regularitation (Default: 1e-10). This also works as small positive constant to prevent division by zero, so should be set as 0.
<code>L2_U</code>	Paramter for L2 regularitation (Default: 1e-10).

L2_V	Paramter for L2 regularitation (Default: 1e-10).
J	The number of low-dimension ($J < \{N, M\}$, Default: 3)
algorithm	dNMF algorithms. "Frobenius", "KL", "IS", and "Beta" are available (Default: "Frobenius").
Beta	The parameter of Beta-divergence.
thr	When error change rate is lower than thr, the iteration is terminated (Default: 1E-10).
num.iter	The number of iteration step (Default: 100).
viz	If viz == TRUE, internal reconstructed matrix can be visualized.
figdir	The directory for saving the figure, when viz == TRUE.
verbose	If verbose == TRUE, Error change rate is generated in console window.

Value

U : A matrix which has N-rows and J-columns ($J < \{N, M\}$). V : A matrix which has M-rows and J-columns ($J < \{N, M\}$). RecError : The reconstruction error between data tensor and reconstructed tensor from U and V. TrainRecError : The reconstruction error calculated by training set (observed values specified by M). TestRecError : The reconstruction error calculated by test set (missing values specified by M). RelChange : The relative change of the error.

Author(s)

Koki Tsuyuzaki

References

Z. Zhang, T. Li, C. Ding and X. Zhang, (2007). Binary Matrix Factorization with Applications, *Seventh IEEE International Conference on Data Mining (ICDM 2007)*, 391-400

Examples

```
# Test data
matdata <- toyModel(model = "dNMF")

# Simple usage
out <- dNMF(matdata, J=5)
```

dNMTF	<i>Discretized Non-negative Matrix Tri-Factorization Algorithms (dN-MTF)</i>
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Description

This function is the discretized version of nnTensor::NMTF. The input data is assumed to be non-negative matrix. dNMTF decompose the matrix to three low-dimensional factor matices.

Usage

```
dNMTF(X, M=NULL, pseudocount=.Machine$double.eps,
      initU=NULL, initS=NULL, initV=NULL,
      fixU=FALSE, fixS=FALSE, fixV=FALSE,
      Bin_U=1e-10, Bin_S=1e-10, Bin_V=1e-10,
      Ter_U=1e-10, Ter_S=1e-10, Ter_V=1e-10,
      L1_U=1e-10, L1_S=1e-10, L1_V=1e-10,
      L2_U=1e-10, L2_S=1e-10, L2_V=1e-10,
      rank = c(3, 4),
      algorithm = c("Frobenius", "KL", "IS", "Beta"),
      Beta = 2, root = FALSE, thr = 1e-10, num.iter = 100,
      viz = FALSE, figdir = NULL, verbose = FALSE)
```

Arguments

X	The input matrix which has N-rows and M-columns.
M	The mask matrix which has N-rows and M-columns. If the input matrix has missing values, specify the elements as 0 (otherwise 1).
pseudocount	The pseudo count to avoid zero division, when the element is zero (Default: Machine Epsilon).
initU	The initial values of factor matrix U, which has N-rows and J1-columns (Default: NULL).
initS	The initial values of factor matrix S, which has J1-rows and J2-columns (Default: NULL).
initV	The initial values of factor matrix V, which has M-rows and J2-columns (Default: NULL).
fixU	Whether the factor matrix U is updated in each iteration step (Default: FALSE).
fixS	Whether the factor matrix S is updated in each iteration step (Default: FALSE).
fixV	Whether the factor matrix V is updated in each iteration step (Default: FALSE).
Bin_U	Paramter for binary (0,1) regularitation (Default: 1e-10).
Bin_S	Paramter for binary (0,1) regularitation (Default: 1e-10).
Bin_V	Paramter for binary (0,1) regularitation (Default: 1e-10).
Ter_U	Paramter for terary (0,1,2) regularitation (Default: 1e-10).
Ter_S	Paramter for terary (0,1,2) regularitation (Default: 1e-10).
Ter_V	Paramter for terary (0,1,2) regularitation (Default: 1e-10).
L1_U	Paramter for L1 regularitation (Default: 1e-10).
L1_S	Paramter for L1 regularitation (Default: 1e-10).
L1_V	Paramter for L1 regularitation (Default: 1e-10).
L2_U	Paramter for L2 regularitation (Default: 1e-10).
L2_S	Paramter for L2 regularitation (Default: 1e-10).
L2_V	Paramter for L2 regularitation (Default: 1e-10).
rank	The number of low-dimension (J1 (< N) and J2 (< M)) (Default: c(3,4)).

algorithm	dNMTF algorithms. "Frobenius", "KL", "IS", and "Beta" are available (Default: "Frobenius").
Beta	The parameter of Beta-divergence (Default: 2, which means "Frobenius").
root	Whether square root is calculated in each iteration (Default: FALSE).
thr	When error change rate is lower than thr, the iteration is terminated (Default: 1E-10).
num.iter	The number of iteration step (Default: 100).
viz	If viz == TRUE, internal reconstructed matrix can be visualized.
figdir	The directory for saving the figure, when viz == TRUE.
verbose	If verbose == TRUE, Error change rate is generated in console window.

Value

U : A matrix which has N-rows and J1-columns ($J1 < N$). S : A matrix which has J1-rows and J2-columns. V : A matrix which has M-rows and J2-columns ($J2 < M$). rank : The number of low-dimension ($J1 < N$ and $J2 < M$). RecError : The reconstruction error between data tensor and reconstructed tensor from U and V. TrainRecError : The reconstruction error calculated by training set (observed values specified by M). TestRecError : The reconstruction error calculated by test set (missing values specified by M). RelChange : The relative change of the error. algorithm: algorithm specified.

Author(s)

Koki Tsuyuzaki

References

Fast Optimization of Non-Negative Matrix Tri-Factorization: Supporting Information, Andrej Copar, et. al., *PLOS ONE*, 14(6), e0217994, 2019

Co-clustering by Block Value Decomposition, Bo Long et al., *SIGKDD'05*, 2005

Orthogonal Nonnegative Matrix Tri-Factorizations for Clustering, Chris Ding et. al., *12th ACM SIGKDD*, 2006

Examples

```
if(interactive()){
  # Test data
  matdata <- toyModel(model = "dNMF")

  # Simple usage
  out <- dNMTF(matdata, rank=c(4,4))
}
```

Description

This function is the discretized version of `nnTensor::NTD`. The input data X is assumed to be a non-negative tensor and decomposed to a product of a dense core tensor (S) and low-dimensional factor matrices (A_k , $k=1..K$). Unlike regular NTD, in dNTD, each A_k is estimated by adding binary regularization so that the values are 0 or 1 as much as possible. Likewise, each A_k are estimated by adding ternary regularization so that the values are 0, 1, or 2 as much as possible.

Usage

```
dNTD(X, M=NULL, pseudocount=.Machine$double.eps,
      initS=NULL, initA=NULL, fixS=FALSE, fixA=FALSE,
      Bin_A=rep(1e-10, length=length(dim(X))),
      Ter_A=rep(1e-10, length=length(dim(X))),
      L1_A=rep(1e-10, length=length(dim(X))),
      L2_A=rep(1e-10, length=length(dim(X))),
      rank = rep(3, length=length(dim(X))),
      modes = seq_along(dim(X)),
      algorithm = c("Frobenius", "KL", "IS", "Beta"),
      init = c("dNMF", "Random"),
      Beta = 2, thr = 1e-10, num.iter = 100,
      viz = FALSE,
      figdir = NULL, verbose = FALSE)
```

Arguments

<code>X</code>	K-order input tensor which has $I_1, I_2, \dots$, and I_K dimensions.
<code>M</code>	K-order mask tensor which has $I_1, I_2, \dots$, and I_K dimensions. If the mask tensor has missing values, specify the element as 0 (otherwise 1).
<code>pseudocount</code>	The pseudo count to avoid zero division, when the element is zero (Default: Machine Epsilon).
<code>initS</code>	The initial values of core tensor which has $I_1, I_2, \dots$, and I_K dimensions (Default: NULL).
<code>initA</code>	A list containing the initial values of K factor matrices (A_k , $\langle I_k \times J_k \rangle$, $k=1..K$, Default: NULL).
<code>fixS</code>	Whether the core tensor S is updated in each iteration step (Default: FALSE).
<code>fixA</code>	Whether the factor matrices A_k are updated in each iteration step (Default: FALSE).
<code>Bin_A</code>	A K -length vector containing the parameters for binary (0,1) regularization (Default: <code>rep(1e-10, length=length(dim(X)))</code>).
<code>Ter_A</code>	A K -length vector containing the parameters for ternary (0,1,2) regularization (Default: <code>rep(1e-10, length=length(dim(X)))</code>).

L1_A	A K-length vector containing the paramters for L1 regularitation (Default: rep(1e-10, length=length(dim(X)))). This also works as small positive constant to prevent division by zero, so should be set as 0.
L2_A	A K-length vector containing the paramters for L2 regularitation (Default: rep(1e-10, length=length(dim(X)))).
rank	The number of low-dimension in each mode (Default: 3 for each mode).
modes	The vector of the modes on which to perform the decomposition (Default: 1:K <all modes>).
algorithm	dNTD algorithms. "Frobenius", "KL", "IS", and "Beta" are available (Default: "Frobenius").
init	The initialization algorithms. "NMF", "ALS", and "Random" are available (Default: "NMF").
Beta	The parameter of Beta-divergence.
thr	When error change rate is lower than thr1, the iteration is terminated (Default: 1E-10).
num.iter	The number of iteration step (Default: 100).
viz	If viz == TRUE, internal reconstructed tensor can be visualized.
figdir	the directory for saving the figure, when viz == TRUE (Default: NULL).
verbose	If verbose == TRUE, Error change rate is generated in console windos.

Value

S : K-order tensor object, which is defined as S4 class of rTensor package. A : A list containing K factor matrices. RecError : The reconstruction error between data tensor and reconstructed tensor from S and A. TrainRecError : The reconstruction error calculated by training set (observed values specified by M). TestRecError : The reconstruction error calculated by test set (missing values specified by M). RelChange : The relative change of the error.

Author(s)

Koki Tsuyuzaki

References

- Yong-Deok Kim et. al., (2007). Nonnegative Tucker Decomposition. *IEEE Conference on Computer Vision and Pattern Recognition*
- Yong-Deok Kim et. al., (2008). Nonnegative Tucker Decomposition With Alpha-Divergence. *IEEE International Conference on Acoustics, Speech and Signal Processing*
- Anh Huy Phan, (2008). Fast and efficient algorithms for nonnegative Tucker decomposition. *Advances in Neural Networks - ISNN2008*
- Anh Huy Phan et. al. (2011). Extended HALS algorithm for nonnegative Tucker decomposition and its applications for multiway analysis and classification. *Neurocomputing*

See Also

[plotTensor3D](#)

Examples

```

tensordata <- toyModel(model = "dNTD")
out <- dNTD(tensordata, rank=c(2,2,2), algorithm="Frobenius",
  init="Random", num.iter=2)

```

dNTF

Discretized Non-negative CP Decomposition Algorithms (dNTF)

Description

This function is the discretized version of `nnTensor::NTF`. The input data X is assumed to be a non-negative tensor and decomposed to a product of a diagonal core tensor (S) and low-dimensional factor matrices (A_k , $k=1..K$). Unlike regular NTF, in dNTF, each A_k is estimated by adding binary regularization so that the values are 0 or 1 as much as possible. Likewise, each A_k are estimated by adding ternary regularization so that the values are 0, 1, or 2 as much as possible.

Usage

```

dNTF(X, M=NULL, pseudocount=.Machine$double.eps,
  initA=NULL, fixA=FALSE,
  Bin_A=rep(1e-10, length=length(dim(X))),
  Ter_A=rep(1e-10, length=length(dim(X))),
  L1_A=rep(1e-10, length=length(dim(X))),
  L2_A=rep(1e-10, length=length(dim(X))),
  rank = 3,
  algorithm = c("Frobenius", "KL", "IS", "Beta"),
  init = c("dNMF", "Random"),
  Beta = 2, thr = 1e-10, num.iter = 100, viz = FALSE, figdir = NULL,
  verbose = FALSE)

```

Arguments

<code>X</code>	K-order input tensor which has $I_1, I_2, \dots$, and I_K dimensions.
<code>M</code>	K-order mask tensor which has $I_1, I_2, \dots$, and I_K dimensions. If the mask tensor has missing values, specify the element as 0 (otherwise 1).
<code>pseudocount</code>	The pseudo count to avoid zero division, when the element is zero (Default: Machine Epsilon).
<code>initA</code>	A list containing the initial values of K factor matrices (A_k , $\langle I_k \times J_k \rangle$, $k=1..K$, Default: NULL).
<code>fixA</code>	Whether the factor matrices A_k are updated in each iteration step (Default: FALSE).
<code>Bin_A</code>	A K -length vector containing the paramters for binary (0,1) regularitaton (Default: <code>rep(1e-10, length=length(dim(X)))</code>).
<code>Ter_A</code>	A K -length vector containing the paramters for terary (0,1,2) regularitaton (Default: <code>rep(1e-10, length=length(dim(X)))</code>).

L1_A	A K-length vector containing the paramters for L1 regularitation (Default: rep(1e-10, length=length(dim(X)))). This also works as small positive constant to prevent division by zero, so should be set as 0.
L2_A	A K-length vector containing the paramters for L2 regularitation (Default: rep(1e-10, length=length(dim(X)))).
rank	The number of low-dimension in each mode (Default: 3).
algorithm	dNTF algorithms. "Frobenius", "KL", "IS", and "Beta" are available (Default: "Frobenius").
init	The initialization algorithms. "dNMF", and "Random" are available (Default: "dNMF").
Beta	The parameter of Beta-divergence.
thr	When error change rate is lower than thr1, the iteration is terminated (Default: 1E-10).
num.iter	The number of iteration step (Default: 100).
viz	If viz == TRUE, internal reconstructed tensor can be visualized.
figdir	the directory for saving the figure, when viz == TRUE (Default: NULL).
verbose	If verbose == TRUE, Error change rate is generated in console windos.

Value

S : K-order tensor object, which is defined as S4 class of rTensor package. A : A list containing K factor matrices. RecError : The reconstruction error between data tensor and reconstructed tensor from S and A. TrainRecError : The reconstruction error calculated by training set (observed values specified by M). TestRecError : The reconstruction error calculated by test set (missing values specified by M). RelChange : The relative change of the error.

Author(s)

Koki Tsuyuzaki

References

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See Also

[plotTensor3D](#)

Examples

```

tensordata <- toyModel(model = "dNTF")
out <- dNTF(tensordata, rank=3, num.iter=2)

```

dPLS

Discretized Partial Least Squares (dPLS)

Description

This function is the discretized version of PLS. The input data objects are assumed to be a list containing multiple matrices ($X_1, X_2, \dots, X_K$), and decomposed to multiple matrix products ($U_1 V_1', U_2 V_2', \dots, U_K V_K'$), where each U_k and V_k ($k=1..K$) is specific in each X_k . Unlike regular PLS, in dPLS, U_k and V_k are estimated by adding ternary regularization so that the values are -1, 0, or 1 as much as possible.

Usage

```

dPLS(X, M=NULL, pseudocount=.Machine$double.eps,
      initV=NULL, fixV=FALSE, Ter_V=1e-10,
      L1_V=1e-10, L2_V=1e-10, eta=1e+10, J = 3,
      thr = 1e-10, num.iter = 100,
      viz = FALSE, figdir = NULL, verbose = FALSE)

```

Arguments

X	The input matrix which has N-rows and M-columns.
M	The mask matrix which has N-rows and M-columns. If the input matrix has missing values, specify the element as 0 (otherwise 1).
pseudocount	The pseudo count to avoid zero division, when the element is zero (Default: Machine Epsilon).
initV	The initial values of factor matrix V, which has M-rows and J-columns (Default: NULL).
fixV	Whether the factor matrix V is updated in each iteration step (Default: FALSE).
Ter_V	Paramter for ternary (-1,0,1) regularization (Default: 1e-10).
L1_V	Paramter for L1 regularization (Default: 1e-10). This also works as small positive constant to prevent division by zero, so should be set as 0.
L2_V	Paramter for L2 regularization (Default: 1e-10).
eta	Stepsize of gradient descent algorithm (Default: 1e+10).
J	The number of low-dimension ($J < \{N, M\}$, Default: 3)
thr	When error change rate is lower than thr, the iteration is terminated (Default: 1E-10).
num.iter	The number of iteration step (Default: 100).
viz	If viz == TRUE, internal reconstructed matrix can be visualized.
figdir	The directory for saving the figure, when viz == TRUE.
verbose	If verbose == TRUE, Error change rate is generated in console window.

Value

U : A matrix which has N-rows and J-columns ($J < \{N, M\}$). V : A matrix which has M-rows and J-columns ($J < \{N, M\}$). RecError : The reconstruction error between data tensor and reconstructed tensor from U and V. TrainRecError : The reconstruction error calculated by training set (observed values specified by M). TestRecError : The reconstruction error calculated by test set (missing values specified by M). RelChange : The relative change of the error.

Author(s)

Koki Tsuyuzaki

Examples

```
# Test data
matdata <- toyModel(model = "dPLS_Easy")

# Simple usage
out <- dPLS(matdata, J=2, num.iter=2)
```

dsiNMF

Discretized Simultaneous Non-negative Matrix Factorization Algorithms (dsiNMF)

Description

This function is the discretized version of nnTensor::siNMF. The input data objects are assumed to be a list containing multiple non-negative matrices ($X_1, X_2, \dots, X_K$), and decomposed to multiple matrix products ($W H_1', W H_2', \dots, W H_K'$), where W is common across all the data matrices but each H_k ($k=1..K$) is specific in each X_k . Unlike regular siNMF, in dsiNMF, W and H_k are estimated by adding binary regularization so that the values are 0 or 1 as much as possible. Likewise, W and H_k are estimated by adding ternary regularization so that the values are 0, 1, or 2 as much as possible.

Usage

```
dsiNMF(X, M=NULL, pseudocount=.Machine$double.eps,
       initW=NULL, initH=NULL,
       fixW=FALSE, fixH=FALSE,
       Bin_W=1e-10, Bin_H=rep(1e-10, length=length(X)),
       Ter_W=1e-10, Ter_H=rep(1e-10, length=length(X)),
       L1_W=1e-10, L1_H=rep(1e-10, length=length(X)),
       L2_W=1e-10, L2_H=rep(1e-10, length=length(X)),
       J = 3, w=NULL, algorithm = c("Frobenius", "KL", "IS", "PLTF"), p=1,
       thr = 1e-10, num.iter = 100,
       viz = FALSE, figdir = NULL, verbose = FALSE)
```

Arguments

<code>X</code>	A list containing the input matrices (X_k , $\langle N \times M_k \rangle$, $k=1..K$).
<code>M</code>	A list containing the mask matrices (X_k , $\langle N \times M_k \rangle$, $k=1..K$). If the input matrix has missing values, specify the element as 0 (otherwise 1).
<code>pseudocount</code>	The pseudo count to avoid zero division, when the element is zero (Default: Machine Epsilon).
<code>initW</code>	The initial values of factor matrix W , which has N -rows and J -columns (Default: NULL).
<code>initH</code>	A list containing the initial values of multiple factor matrices (H_k , $\langle M_k \times J \rangle$, $k=1..K$, Default: NULL).
<code>fixW</code>	Whether the factor matrix W is updated in each iteration step (Default: FALSE).
<code>fixH</code>	Whether the factor matrices H_k are updated in each iteration step (Default: FALSE).
<code>Bin_W</code>	Paramter for binary (0,1) regularitation (Default: $1e-10$).
<code>Bin_H</code>	A K -length vector containing the paramters for binary (0,1) regularitation (Default: <code>rep(1e-10, length=length(dim(X)))</code>).
<code>Ter_W</code>	Paramter for terary (0,1,2) regularitation (Default: $1e-10$).
<code>Ter_H</code>	A K -length vector containing the paramters for terary (0,1,2) regularitation (Default: <code>rep(1e-10, length=length(dim(X)))</code>).
<code>L1_W</code>	Paramter for L1 regularitation (Default: $1e-10$). This also works as small positive constant to prevent division by zero, so should be set as 0.
<code>L1_H</code>	A K -length vector containing the paramters for L1 regularitation (Default: <code>rep(1e-10, length=length(dim(X)))</code>). This also works as small positive constant to prevent division by zero, so should be set as 0.
<code>L2_W</code>	Paramter for L2 regularitation (Default: $1e-10$).
<code>L2_H</code>	A K -length vector containing the paramters for L2 regularitation (Default: <code>rep(1e-10, length=length(dim(X)))</code>).
<code>J</code>	Number of low-dimension ($J < N, M_k$).
<code>w</code>	Weight vector (Default: NULL)
<code>algorithm</code>	Divergence between X and X_{bar} . "Frobenius", "KL", and "IS" are available (Default: "KL").
<code>p</code>	The parameter of Probabilistic Latent Tensor Factorization ($p=0$: Frobenius, $p=1$: KL, $p=2$: IS)
<code>thr</code>	When error change rate is lower than <code>thr</code> , the iteration is terminated (Default: $1E-10$).
<code>num.iter</code>	The number of interation step (Default: 100).
<code>viz</code>	If <code>viz == TRUE</code> , internal reconstructed matrix can be visualized.
<code>figdir</code>	the directory for saving the figure, when <code>viz == TRUE</code> .
<code>verbose</code>	If <code>verbose == TRUE</code> , Error change rate is generated in console windos.

Value

W : A matrix which has N-rows and J-columns ($J < N, M_k$). H : A list which has multiple elements containing M_k -rows and J-columns matrix ($J < N, M_k$). RecError : The reconstruction error between data matrix and reconstructed matrix from W and H. TrainRecError : The reconstruction error calculated by training set (observed values specified by M). TestRecError : The reconstruction error calculated by test set (missing values specified by M). RelChange : The relative change of the error.

Author(s)

Koki Tsuyuzaki

References

- Liviu Badea, (2008) Extracting Gene Expression Profiles Common to Colon and Pancreatic Adenocarcinoma using Simultaneous nonnegative matrix factorization. *Pacific Symposium on Biocomputing* 13:279-290
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- Y. Kenan Yilmaz et al., (2010) Probabilistic Latent Tensor Factorization, *International Conference on Latent Variable Analysis and Signal Separation* 346-353
- N. Fujita et al., (2018) Biomarker discovery by integrated joint non-negative matrix factorization and pathway signature analyses, *Scientific Report*

Examples

```
matdata <- toyModel(model = "dsiNMF_Easy")
out <- dsiNMF(matdata, J=2, num.iter=2)
```

dSVD

Discretized Singular Value Decomposition (dSVD)

Description

This function is the discretized version of SVD. The input data X is decomposed to a matrix product $U V^T$. Unlike regular SVD, in dSVD, U and V are estimated by adding binary regularization so that the values are 0 or 1 as much as possible. Likewise, U and V are estimated by adding ternary regularization so that the values are -1, 0, or 1 as much as possible.

Usage

```
dSVD(X, M=NULL, pseudocount=.Machine$double.eps,
      initU=NULL, initV=NULL, fixU=FALSE, fixV=FALSE,
      Ter_U=1e-10, L1_U=1e-10, L2_U=1e-10, eta=1e+10, J = 3,
      thr = 1e-10, num.iter = 100,
      viz = FALSE, figdir = NULL, verbose = FALSE)
```

Arguments

<code>X</code>	The input matrix which has N-rows and M-columns.
<code>M</code>	The mask matrix which has N-rows and M-columns. If the input matrix has missing values, specify the element as 0 (otherwise 1).
<code>pseudocount</code>	The pseudo count to avoid zero division, when the element is zero (Default: Machine Epsilon).
<code>initU</code>	The initial values of factor matrix U, which has N-rows and J-columns (Default: NULL).
<code>initV</code>	The initial values of factor matrix V, which has M-rows and J-columns (Default: NULL).
<code>fixU</code>	Whether the factor matrix U is updated in each iteration step (Default: FALSE).
<code>fixV</code>	Whether the factor matrix V is updated in each iteration step (Default: FALSE).
<code>Ter_U</code>	Paramter for terary (-1,0,1) regularitation (Default: 1e-10).
<code>L1_U</code>	Paramter for L1 regularitation (Default: 1e-10). This also works as small positive constant to prevent division by zero, so should be set as 0.
<code>L2_U</code>	Paramter for L2 regularitation (Default: 1e-10).
<code>eta</code>	Stepsize of gradient descent algorithm (Default: 1e+10).
<code>J</code>	The number of low-dimension ($J < \{N, M\}$, Default: 3)
<code>thr</code>	When error change rate is lower than thr, the iteration is terminated (Default: 1E-10).
<code>num.iter</code>	The number of iteration step (Default: 100).
<code>viz</code>	If viz == TRUE, internal reconstructed matrix can be visualized.
<code>figdir</code>	The directory for saving the figure, when viz == TRUE.
<code>verbose</code>	If verbose == TRUE, Error change rate is generated in console window.

Value

`U` : A matrix which has N-rows and J-columns ($J < \{N, M\}$). `V` : A matrix which has M-rows and J-columns ($J < \{N, M\}$). `RecError` : The reconstruction error between data tensor and reconstructed tensor from U and V. `TrainRecError` : The reconstruction error calculated by training set (observed values specified by M). `TestRecError` : The reconstruction error calculated by test set (missing values specified by M). `RelChange` : The relative change of the error.

Author(s)

Koki Tsuyuzaki

Examples

```
# Test data
matdata <- toyModel(model = "dSVD")

# Simple usage
out <- dSVD(matdata, J=2, num.iter=2)
```

toyModel	<i>Toy model data for using dNMF, dSVD, dsiNMF, djNMF, dPLS, dNTF, and dNTD</i>
----------	---

Description

The data is used to confirm that the algorithm are properly working.

Usage

```
toyModel(model = "dNMF", seeds=123)
```

Arguments

model	Single character string is specified. "dNMF", "dSVD", "dsiNMF_Easy", "dsiNMF_Hard", "dPLS_Easy", "dPLS_Hard", "dNTF", and "dNTD" are available (Default: "dNMF").
seeds	Random number for setting set.seeds in the function (Default: 123).

Value

If model is specified as "dNMF" or "dSVD" a matrix is generated. If model is specified as "dsiNMF_Easy", "dsiNMF_Hard", "dPLS_Easy", or "dPLS_Hard" three matrices are generated. Otherwise, a tensor is generated.

Author(s)

Koki Tsuyuzaki

See Also

[dNMF](#), [dSVD](#)

Examples

```
matdata <- toyModel(model = "dNMF", seeds=123)
```

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