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Contents

dcTensor-package 2
djNMF 3
dNMF 5
dNMTF 7
dNTD 9
dNTF 11
dPLS 13

dsiNMF 14
dSVD 17
toyModel 18

Index **20**

`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

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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 *Discretized Joint Non-negative Matrix Factorization Algorithms (djNMF)*

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, ..., X_K), and decomposed to multiple matrix products ((W + V_1) H_1', (W + V_2) H_2', ..., (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

X	A list containing input matrices (X_k, <N*Mk>, k=1..K).
M	A list containing the mask matrices (X_k, <N*Mk>, k=1..K). 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).
initW	The initial values of factor matrix W, which has N-rows and J-columns (Default: NULL).
initV	A list containing the initial values of multiple factor matrices (V_k, <N*J>, k=1..K, Default: NULL).
initH	A list containing the initial values of multiple factor matrices (H_k, <Mk*J>, k=1..K, Default: NULL).
fixW	Whether the factor matrix W is updated in each iteration step (Default: FALSE).
fixV	Whether the factor matrices Vk are updated in each iteration step (Default: FALSE).
fixH	Whether the factor matrices Hk are updated in each iteration step (Default: FALSE).

Bin_W	Paramter for binary (0,1) regularitation (Default: 1e-10).
Bin_V	A K-length vector containing the paramters for binary (0,1) regularitation (Default: rep(1e-10, length=length(dim(X)))).
Bin_H	A K-length vector containing the paramters for binary (0,1) regularitation (Default: rep(1e-10, length=length(dim(X)))).
Ter_W	Paramter for terary (0,1,2) regularitation (Default: 1e-10).
Ter_V	A K-length vector containing the paramters for terary (0,1,2) regularitation (Default: rep(1e-10, length=length(dim(X)))).
Ter_H	A K-length vector containing the paramters for terary (0,1,2) regularitation (Default: rep(1e-10, length=length(dim(X)))).
L1_W	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.
L1_V	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.
L1_H	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_W	Paramter for L2 regularitation (Default: 1e-10).
L2_V	A K-length vector containing the paramters for L2 regularitation (Default: rep(1e-10, length=length(dim(X)))).
L2_H	A K-length vector containing the paramters for L2 regularitation (Default: rep(1e-10, length=length(dim(X)))).
J	Number of low-dimension (J < N, Mk).
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 interation 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)
```

---

dNMF *Discretized Non-negative Matrix Factorization Algorithms (dNMF)*

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

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).
initU	The initial values of factor matrix U, which has N-rows and J-columns (Default: NULL).
initV	The initial values of factor matrix V, which has M-rows and J-columns (Default: NULL).
fixU	Whether the factor matrix U 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_V	Paramter for binary (0,1) regularitation (Default: 1e-10).
Ter_U	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). This also works as small positive constant to prevent division by zero, so should be set as 0.
L1_V	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.
L2_U	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 interation 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` *Discretized Non-negative Matrix Tri-Factorization Algorithms (dNMTF)*

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 calculed 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 interation 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))
}
```

---

dNTD *Discretized Non-negative Tucker Decomposition Algorithms (dNTD)*

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

X	K-order input tensor which has I_1, I_2, ..., and I_K dimensions.
M	K-order mask tensor which has I_1, I_2, ..., and I_K dimensions. If the mask tensor 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).
initS	The initial values of core tensor which has I_1, I_2, ..., and I_K dimensions (Default: NULL).
initA	A list containing the initial values of K factor matrices (A_k, <Ik*Jk>, k=1..K, Default: NULL).
fixS	Whether the core tensor S is updated in each iteration step (Default: FALSE).
fixA	Whether the factor matrices Ak are updated in each iteration step (Default: FALSE).
Bin_A	A K-length vector containing the paramters for binary (0,1) regularitation (Default: rep(1e-10, length=length(dim(X)))).
Ter_A	A K-length vector containing the paramters for terary (0,1,2) regularitation (Default: rep(1e-10, length=length(dim(X)))).
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 interation 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). Nonneegative 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 Hyu Phan et. al. (2011). Extended HALS algorithm for nonnegative Tucker decomposition and its applications for multiway analysis and classification. *Neurocomputing*

See Also

nnTensor::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

X	K-order input tensor which has I_1, I_2, ..., and I_K dimensions.
M	K-order mask tensor which has I_1, I_2, ..., and I_K dimensions. If the mask tensor 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).
initA	A list containing the initial values of K factor matrices (A_k, <Ik*Jk>, k=1..K, Default: NULL).
fixA	Whether the factor matrices Ak are updated in each iteration step (Default: FALSE).
Bin_A	A K-length vector containing the paramters for binary (0,1) regularitation (Default: rep(1e-10, length=length(dim(X)))).
Ter_A	A K-length vector containing the paramters for terary (0,1,2) regularitation (Default: rep(1e-10, length=length(dim(X)))).
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 interation 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

Andrzej CICHOCKI et. al., (2007). Non-negative Tensor Factorization using Alpha and Beta Divergence. *IEEE ICASSP 2007*

Anh Huy PHAN et. al., (2008). Multi-way Nonnegative Tensor Factorization Using Fast Hierarchical Alternating Least Squares Algorithm (HALS). *NOLTA2008*

Andrzej CICHOCKI et. al., (2008). Fast Local Algorithms for Large Scale Nonnegative Matrix and Tensor Factorizations. *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences*

See Also

nnTensor::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, ..., X_K), and decomposed to multiple matrix products (U_1 V_1', U_2 V_2', ..., 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 terary (-1,0,1) regularitation (Default: 1e-10).
L1_V	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.
L2_V	Paramter for L2 regularitation (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 interation 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, ..., X_K), and decomposed to multiple matrix products (W H_1', W H_2', ..., 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

X	A list containing the input matrices (X_k, <N*Mk>, k=1..K).
M	A list containing the mask matrices (X_k, <N*Mk>, k=1..K). 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).
initW	The initial values of factor matrix W, which has N-rows and J-columns (Default: NULL).
initH	A list containing the initial values of multiple factor matrices (H_k, <Mk*J>, k=1..K, Default: NULL).
fixW	Whether the factor matrix W is updated in each iteration step (Default: FALSE).
fixH	Whether the factor matrices Hk are updated in each iteration step (Default: FALSE).
Bin_W	Paramter for binary (0,1) regularitation (Default: 1e-10).
Bin_H	A K-length vector containing the paramters for binary (0,1) regularitation (Default: rep(1e-10, length=length(dim(X)))).
Ter_W	Paramter for terary (0,1,2) regularitation (Default: 1e-10).
Ter_H	A K-length vector containing the paramters for terary (0,1,2) regularitation (Default: rep(1e-10, length=length(dim(X)))).
L1_W	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.
L1_H	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_W	Paramter for L2 regularitation (Default: 1e-10).
L2_H	A K-length vector containing the paramters for L2 regularitation (Default: rep(1e-10, length=length(dim(X)))).
J	Number of low-dimension (J < N, Mk).
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 interation 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). 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

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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'. 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

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).
initU	The initial values of factor matrix U, which has N-rows and J-columns (Default: NULL).
initV	The initial values of factor matrix V, which has M-rows and J-columns (Default: NULL).
fixU	Whether the factor matrix U is updated in each iteration step (Default: FALSE).
fixV	Whether the factor matrix V is updated in each iteration step (Default: FALSE).
Ter_U	Paramter for terary (-1,0,1) regularitation (Default: 1e-10).
L1_U	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.
L2_U	Paramter for L2 regularitation (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 interation 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 = "dSVD")

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

---

toyModel *Toy model data for using dNMF, dSVD, dsiNMF, djNMF, dPLS, dNTF, and dNTD*

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)
```

Index

∗ **methods**
djNMF, 3
dNMF, 5
dNMTF, 7
dNTD, 9
dNTF, 11
dPLS, 13
dsiNMF, 14
dSVD, 17
toyModel, 18
∗ **package**
dcTensor-package, 2

dcTensor *(*dcTensor-package*)*, 2
dcTensor-package, 2
djNMF, 3
dNMF, *2*, 5, *19*
dNMTF, 7
dNTD, 9
dNTF, 11
dPLS, 13
dsiNMF, 14
dSVD, *2*, 17, *19*

nnTensor::plotTensor3D, *11*, *13*

toyModel, *2*, 18