Package 'DCEM'

October 12, 2022

Type Package

Title Clustering Big Data using Expectation Maximization Star (EM*) Algorithm

Version 2.0.5

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Description Implements the Improved Expectation Maximisation EM* and the traditional EM algorithm for clustering
big data (gaussian mixture models for both multivariate and univariate datasets). This version implements the faster alternative-
EM* that expedites convergence via structure based data segregation.
The implementation supports both random and K-
means++ based initialization. Reference: Parichit Sharma,
Hasan Kurban, Mehmet Dalkilic (2022) <doi:10.1016/j.softx.2021.100944>. Hasan Kurban,
Mark Jenne, Mehmet Dalkilic (2016) <doi:10.1007/s41060-017-0062-1>.

License GPL-3

Encoding UTF-8

LazyData true

Imports mvtnorm (>= 1.0.7), matrixcalc (>= 1.0.3), MASS (>= 7.3.49),
Rcpp (>= 1.0.2)

LinkingTo Rcpp

RoxygenNote 7.1.2

Depends R(>= 3.2.0)

URL https://github.com/parichit/DCEM

BugReports https://github.com/parichit/DCEM/issues

Suggests knitr, rmarkdown

VignetteBuilder knitr

NeedsCompilation yes

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Repository CRAN

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R topics documented:

`build_heap` *build_heap: Part of DCEM package.*

Description

Implements the creation of heap. Internally called by the `dcem_star_train`.

Usage

```
build_heap(data)
```

Arguments

data	(NumericMatrix): The dataset provided by the user.

Value

A NumericMatrix with the max heap property.

Author(s)

Parichit Sharma <parishar@iu.edu>, Hasan Kurban, Mehmet Dalkilic

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DCEM *DCEM: Clustering Big Data using Expectation Maximization Star (EM*) Algorithm.*

Description

Implements the EM* and EM algorithm for clustering the (univariate and multivariate) Gaussian mixture data.

Demonstration and Testing

Cleaning the data: The data should be cleaned (redundant columns should be removed). For example columns containing the labels or redundant entries (such as a column of all 0's or 1's). See trim_data for details on cleaning the data. Refer: dcem_test for more details.

Understanding the output of dcem_test

The function dcem_test() returns a list of objects. This list contains the parameters associated with the Gaussian(s), posterior probabilities (prob), mean (meu), co-variance/standard-deviation(sigma) ,priors (prior) and cluster membership for data (membership).

Note: The routine dcem_test() is only for demonstration purpose. The function dcem_test calls the main routine dcem_train. See dcem_train for further details.

How to run on your dataset

See dcem_train and dcem_star_train for examples.

Package organization

The package is organized as a set of preprocessing functions and the core clustering modules. These functions are briefly described below.

1. trim_data: This is used to remove the columns from the dataset. The user should clean the dataset before calling the dcem_train routine. **User can also clean the dataset themselves (without using trim_data) and then pass it to the dcem_train function**

2. dcem_star_train and dcem_train: These are the primary interface to the EM* and EM algorithms respectively. These function accept the cleaned dataset and other parameters (number of iterations, convergence threshold etc.) and run the algorithm until:
   (a) The number of iterations is reached.
   (b) The convergence is achieved.

DCEM supports following initialization schemes

1. **Random Initialization:** Initializes the mean randomly. Refer meu_uv and meu_mv for initialization on univariate and multivariate data respectively.
2. **Improved Initialization:** Based on the Kmeans++ idea published in, K-means++: The Advantages of Careful Seeding, David Arthur and Sergei Vassilvitskii. URL http://ilpubs.stanford.edu:8090/778/1/2006-13.pdf. See meu_uv_impr and meu_mv_impr for details.
3. Choice of initialization scheme can be specified as the **seeding** parameter during the training. See dcem_train for further details.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

External Packages: DCEM requires R packages 'mvtnorm'[1], 'matrixcalc'[2] 'RCPP'[3] and 'MASS'[4] for multivariate density calculation, checking matrix singularity, compiling routines written in C and simulating mixture of gaussians, respectively.

[1] Alan Genz, Frank Bretz, Tetsuhisa Miwa, Xuefei Mi, Friedrich Leisch, Fabian Scheipl, Torsten Hothorn (2019). mvtnorm: Multivariate Normal and t Distributions. R package version 1.0-7. URL http://CRAN.R-project.org/package=mvtnorm

[2] Frederick Novomestky (2012). matrixcalc: Collection of functions for matrix calculations. R package version 1.0-3. https://CRAN.R-project.org/package=matrixcalc

[3] Dirk Eddelbuettel and Romain Francois (2011). Rcpp: Seamless R and C++ Integration. Journal of Statistical Software, 40(8), 1-18. URL http://www.jstatsoft.org/v40/i08/.

[4] Venables, W. N. & Ripley, B. D. (2002) Modern Applied Statistics with S. Fourth Edition. Springer, New York. ISBN 0-387-95457-0

[5] K-Means++: The Advantages of Careful Seeding, David Arthur and Sergei Vassilvitskii. URL http://ilpubs.stanford.edu:8090/778/1/2006-13.pdf

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dcem_cluster_mv *dcem_cluster (multivariate data): Part of DCEM package.*

Description

Implements the Expectation Maximization algorithm for multivariate data. This function is called by the dcem_train routine.

Usage

```
dcem_cluster_mv(data, meu, sigma, prior, num_clusters, iteration_count,
threshold, num_data)
```

Arguments

`data`	A matrix: The dataset provided by the user.
`meu`	(matrix): The matrix containing the initial meu(s).
`sigma`	(list): A list containing the initial covariance matrices.
`prior`	(vector): A vector containing the initial prior.
`num_clusters`	(numeric): The number of clusters specified by the user. Default value is 2.
`iteration_count`	(numeric): The number of iterations for which the algorithm should run, if the convergence is not achieved then the algorithm stops. Default: 200.
`threshold`	(numeric): A small value to check for convergence (if the estimated meu are within this specified threshold then the algorithm stops and exit). **Note: Choosing a very small value (0.0000001) for threshold can increase the runtime substantially and the algorithm may not converge. On the other hand, choosing a larger value (0.1) can lead to sub-optimal clustering. Default: 0.00001**.
`num_data`	(numeric): The total number of observations in the data.

Value

A list of objects. This list contains parameters associated with the Gaussian(s) (posterior probabilities, meu, co-variance and prior)

1. (1) Posterior Probabilities: **prob** :A matrix of posterior-probabilities.
2. (2) Meu: **meu**: It is a matrix of meu(s). Each row in the matrix corresponds to one meu.
3. (3) Sigma: Co-variance matrices: **sigma**
4. (4) prior: **prior**: A vector of prior.
5. (5) Membership: **membership**: A vector of cluster membership for data.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

dcem_cluster_uv *dcem_cluster_uv (univariate data): Part of DCEM package.*

Description

Implements the Expectation Maximization algorithm for the univariate data. This function is internally called by the dcem_train routine.

Usage

```
dcem_cluster_uv(data, meu, sigma, prior, num_clusters, iteration_count,
threshold, num_data, numcols)
```

Arguments

data	(matrix): The dataset provided by the user (converted to matrix format).
meu	(vector): The vector containing the initial meu.
sigma	(vector): The vector containing the initial standard deviation.
prior	(vector): The vector containing the initial prior.
num_clusters	(numeric): The number of clusters specified by the user. Default is 2.
iteration_count	(numeric): The number of iterations for which the algorithm should run. If the convergence is not achieved then the algorithm stops. Default: 200.
threshold	(numeric): A small value to check for convergence (if the estimated meu(s) are within the threshold then the algorithm stops). **Note: Choosing a very small value (0.0000001) for threshold can increase the runtime substantially and the algorithm may not converge. On the other hand, choosing a larger value (0.1) can lead to sub-optimal clustering. Default: 0.00001**.
num_data	(numeric): The total number of observations in the data.
numcols	(numeric): Number of columns in the dataset (After processing the missing values).

Value

A list of objects. This list contains parameters associated with the Gaussian(s) (posterior probabilities, meu, standard-deviation and prior)

1. (1) Posterior Probabilities: **prob**: A matrix of posterior-probabilities.
2. (2) Meu(s): **meu**: It is a vector of meu. Each element of the vector corresponds to one meu.
3. (3) Sigma: Standard-deviation(s): **sigma**: A vector of standard deviation.
4. (4) prior: **prior**: A vector of prior.
5. (5) Membership: **membership**: A vector of cluster membership for data.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

`dcem_predict` *dcem_predict: Part of DCEM package.*

Description

Predict the cluster membership of test data based on the learned parameters i.e, output from `dcem_train` or `dcem_star_train`.

Usage

```
dcem_predict(param_list, data)
```

Arguments

`param_list`	(list): List of distribution parameters. The list contains the learned parameteres of the distribution.
`data`	(vector or dataframe): A vector of data for univariate data. A dataframe (rows represent the data and columns represent the features) for multivariate data.

Value

A list containing the cluster membership for the test data.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

Examples

```
# Simulating a mixture of univariate samples from three distributions
# with meu as 20, 70 and 100 and standard deviation as 10, 100 and 40 respectively.
sample_uv_data = as.data.frame(c(rnorm(100, 20, 5), rnorm(70, 70, 1), rnorm(50, 100, 2)))

# Select first few points from each distribution as test data
test_data = as.vector(sample_uv_data[c(1:5, 101:105, 171:175),])

# Remove the test data from the training set
sample_uv_data = as.data.frame(sample_uv_data[-c(1:5, 101:105, 171:175), ])

# Randomly shuffle the samples.
sample_uv_data = as.data.frame(sample_uv_data[sample(nrow(sample_uv_data)),])

# Calling the dcem_train() function on the simulated data with threshold of
```

```
# 0.000001, iteration count of 1000 and random seeding respectively.
sample_uv_out = dcem_train(sample_uv_data, num_clusters = 3, iteration_count = 100,
threshold = 0.001)

# Predict the membership for test data
test_data_membership <- dcem_predict(sample_uv_out, test_data)

# Access the output
print(test_data_membership)
```

`dcem_star_cluster_mv` *dcem_star_cluster_mv (multivariate data): Part of DCEM package.*

Description

Implements the EM* algorithm for multivariate data. This function is called by the dcem_star_train routine.

Usage

```
dcem_star_cluster_mv(data, meu, sigma, prior, num_clusters, iteration_count, num_data)
```

Arguments

`data`	(matrix): The dataset provided by the user.
`meu`	(matrix): The matrix containing the initial meu(s).
`sigma`	(list): A list containing the initial covariance matrices.
`prior`	(vector): A vector containing the initial priors.
`num_clusters`	(numeric): The number of clusters specified by the user. Default value is 2.
`iteration_count`	(numeric): The number of iterations for which the algorithm should run, if the convergence is not achieved then the algorithm stops and exits. Default: 200.
`num_data`	(numeric): Number of rows in the dataset.

Value

A list of objects. This list contains parameters associated with the Gaussian(s) (posterior probabilities, meu, co-variance and priors)

1. (1) Posterior Probabilities: **prob** A matrix of posterior-probabilities for the points in the dataset.
2. (2) Meu: **meu**: A matrix of meu(s). Each row in the matrix corresponds to one meu.
3. (3) Sigma: Co-variance matrices: **sigma**: List of co-variance matrices.
4. (4) Priors: **prior**: A vector of prior.
5. (5) Membership: **membership**: A vector of cluster membership for data.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

`dcem_star_cluster_uv` *dcem_star_cluster_uv (univariate data): Part of DCEM package.*

Description

Implements the EM* algorithm for the univariate data. This function is called by the dcem_star_train routine.

Usage

```
dcem_star_cluster_uv(data, meu, sigma, prior, num_clusters, num_data,
iteration_count)
```

Arguments

`data`	(matrix): The dataset provided by the user.
`meu`	(vector): The vector containing the initial meu.
`sigma`	(vector): The vector containing the initial standard deviation.
`prior`	(vector): The vector containing the initial priors.
`num_clusters`	(numeric): The number of clusters specified by the user. Default is 2.
`num_data`	(numeric): number of rows in the dataset (After processing the missing values).
`iteration_count`	(numeric): The number of iterations for which the algorithm should run. If the convergence is not achieved then the algorithm stops. Default is 100.

Value

A list of objects. This list contains parameters associated with the Gaussian(s) (posterior probabilities, meu, standard-deviation and priors)

1. (1) Posterior Probabilities: **prob** A matrix of posterior-probabilities
2. (2) Meu: **meu**: It is a vector of meu. Each element of the vector corresponds to one meu.
3. (3) Sigma: Standard-deviation(s): **sigma**
   For univariate data: Vector of standard deviation.
4. (4) Priors: **prior**: A vector of priors.
5. (5) Membership: **membership**: A vector of cluster membership for data.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

dcem_star_train *dcem_star_train: Part of DCEM package.*

Description

Implements the improved EM* ([1], [2]) algorithm. EM* avoids revisiting all but high expressive data via structure based data segregation thus resulting in significant speed gain. It calls the dcem_star_cluster_uv routine internally (univariate data) and dcem_star_cluster_mv for (multivariate data).

Usage

```
dcem_star_train(data, iteration_count,  num_clusters, seed_meu, seeding)
```

Arguments

data	(dataframe): The dataframe containing the data. See trim_data for cleaning the data.
iteration_count	(numeric): The number of iterations for which the algorithm should run, if the convergence is not achieved then the algorithm stops and exit. **Default: 200**.
num_clusters	(numeric): The number of clusters. Default: **2**
seed_meu	(matrix): The user specified set of meu to use as initial centroids. Default: **None**
seeding	(string): The initialization scheme ('rand', 'improved'). Default: **rand**

Value

A list of objects. This list contains parameters associated with the Gaussian(s) (posterior probabilities, meu, sigma and priors). The parameters can be accessed as follows where sample_out is the list containing the output:

1. (1) Posterior Probabilities: **sample_out$prob** A matrix of posterior-probabilities.
2. (2) Meu(s): **sample_out$meu**
   For multivariate data: It is a matrix of meu(s). Each row in the matrix corresponds to one mean.
   For univariate data: It is a vector of meu(s). Each element of the vector corresponds to one meu.
3. (3) Co-variance matrices: **sample_out$sigma**
   For multivariate data: List of co-variance matrices.
   Standard-deviation: **sample_out$sigma**
   For univariate data: Vector of standard deviation.
4. (4) Priors: **sample_out$prior** A vector of priors.
5. (5) Membership: **sample_out$membership**: A dataframe of cluster membership for data. Columns numbers are data indices and values are the assigned clusters.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

Examples

```
# Simulating a mixture of univariate samples from three distributions
# with mean as 20, 70 and 100 and standard deviation as 10, 100 and 40 respectively.
sample_uv_data = as.data.frame(c(rnorm(100, 20, 5), rnorm(70, 70, 1), rnorm(50, 100, 2)))

# Randomly shuffle the samples.
sample_uv_data = as.data.frame(sample_uv_data[sample(nrow(sample_uv_data)),])

# Calling the dcem_star_train() function on the simulated data with iteration count of 1000
# and random seeding respectively.
sample_uv_out = dcem_star_train(sample_uv_data, num_clusters = 3, iteration_count = 100)

# Simulating a mixture of multivariate samples from 2 gaussian distributions.
sample_mv_data = as.data.frame(rbind(MASS::mvrnorm(n=2, rep(2,5), Sigma = diag(5)),
MASS::mvrnorm(n=5, rep(14,5), Sigma = diag(5))))

# Calling the dcem_star_train() function on the simulated data with iteration count of 100 and
# random seeding method respectively.
sample_mv_out = dcem_star_train(sample_mv_data, iteration_count = 100, num_clusters=2)

# Access the output
sample_mv_out$meu
sample_mv_out$sigma
sample_mv_out$prior
sample_mv_out$prob
print(sample_mv_out$membership)
```

`dcem_test` *dcem_test: Part of DCEM package.*

Description

For demonstrating the execution on the bundled dataset.

Usage

```
dcem_test()
```

Details

The dcem_test performs the following steps in order:

1. Read the data from the disk (from the file data/ionosphere_data.csv). The data folder is under the package installation folder.

2. The dataset details can be see by typing ionosphere_data in R-console or at http://archive.ics.uci.edu/ml/datasets/Ionosphere.
3. Clean the data (by removing the columns). **The data should be cleaned before use.** Refer trim_data to see what columns should be removed and how. The package provides the basic interface for removing columns.
4. Call the dcem_star_train on the cleaned data.

Accessing the output parameters

The function dcem_test() calls the dcem_star_train. It returns a list of objects as output. This list contains estimated parameters of the Gaussian (posterior probabilities, meu, sigma and prior). The parameters can be accessed as follows where sample_out is the list containing the output:

1. (1) Posterior Probabilities: **sample_out$prob** A matrix of posterior-probabilities
2. (2) Meu: **meu**

   For multivariate data: It is a matrix of meu(s). Each row in the matrix corresponds to one meu.
3. (3) Co-variance matrices: **sample_out$sigma**

   For multivariate data: List of co-variance matrices for the Gaussian(s).

   Standard-deviation: **sample_out$sigma**

   For univariate data: Vector of standard deviation for the Gaussian(s))
4. (4) Priors: **sample_out$prior** A vector of prior.
5. (5) Membership: **sample_out$membership**: A dataframe of cluster membership for data. Columns numbers are data indices and values are the assigned clusters.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

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dcem_train *dcem_train: Part of DCEM package.*

Description

Implements the EM algorithm. It calls the relevant clustering routine internally dcem_cluster_uv (univariate data) and dcem_cluster_mv (multivariate data).

Usage

```
dcem_train(data, threshold, iteration_count,  num_clusters, seed_meu, seeding)
```

Arguments

data	(dataframe): The dataframe containing the data. See trim_data for cleaning the data.
threshold	(decimal): A value to check for convergence (if the meu are within this value then the algorithm stops and exit). **Default: 0.00001**.
iteration_count	(numeric): The number of iterations for which the algorithm should run, if the convergence is not achieved within the specified count then the algorithm stops and exit. **Default: 200**.
num_clusters	(numeric): The number of clusters. Default: **2**
seed_meu	(matrix): The user specified set of meu to use as initial centroids. Default: **None**
seeding	(string): The initialization scheme ('rand', 'improved'). Default: **rand**

Value

A list of objects. This list contains parameters associated with the Gaussian(s) (posterior probabilities, meu, sigma and priors). The parameters can be accessed as follows where sample_out is the list containing the output:

1. (1) Posterior Probabilities: **sample_out$prob**: A matrix of posterior-probabilities
2. (2) Meu: **sample_out$meu**
   For multivariate data: It is a matrix of meu(s). Each row in the matrix corresponds to one meu.
   For univariate data: It is a vector of meu(s). Each element of the vector corresponds to one meu.
3. (3) Sigma: **sample_out$sigma**
   For multivariate data: List of co-variance matrices for the Gaussian(s).
   For univariate data: Vector of standard deviation for the Gaussian(s).
4. (4) Priors: **sample_out$prior**: A vector of priors.
5. (5) Membership: **sample_out$membership**: A dataframe of cluster membership for data. Columns numbers are data indices and values are the assigned clusters.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

Examples

```
# Simulating a mixture of univariate samples from three distributions
# with meu as 20, 70 and 100 and standard deviation as 10, 100 and 40 respectively.
sample_uv_data = as.data.frame(c(rnorm(100, 20, 5), rnorm(70, 70, 1), rnorm(50, 100, 2)))

# Randomly shuffle the samples.
sample_uv_data = as.data.frame(sample_uv_data[sample(nrow(sample_uv_data)),])

# Calling the dcem_train() function on the simulated data with threshold of
```

```
# 0.000001, iteration count of 1000 and random seeding respectively.
sample_uv_out = dcem_train(sample_uv_data, num_clusters = 3, iteration_count = 100,
threshold = 0.001)

# Simulating a mixture of multivariate samples from 2 gaussian distributions.
sample_mv_data = as.data.frame(rbind(MASS::mvrnorm(n=100, rep(2,5), Sigma = diag(5)),
MASS::mvrnorm(n=50, rep(14,5), Sigma = diag(5))))

# Calling the dcem_train() function on the simulated data with threshold of
# 0.00001, iteration count of 100 and random seeding method respectively.
sample_mv_out = dcem_train(sample_mv_data, threshold = 0.001, iteration_count = 100)

# Access the output
print(sample_mv_out$meu)
print(sample_mv_out$sigma)
print(sample_mv_out$prior)
print(sample_mv_out$prob)
print(sample_mv_out$membership)
```

`expectation_mv` *expectation_mv: Part of DCEM package.*

Description

Calculates the probabilistic weights for the multivariate data.

Usage

```
expectation_mv(data, weights, meu, sigma, prior, num_clusters, tolerance)
```

Arguments

`data`	(matrix): The input data.
`weights`	(matrix): The probability weight matrix.
`meu`	(matrix): The matrix of meu.
`sigma`	(list): The list of sigma (co-variance matrices).
`prior`	(vector): The vector of priors.
`num_clusters`	(numeric): The number of clusters.
`tolerance`	(numeric): The system epsilon value.

Value

Updated probability weight matrix.

`expectation_uv` *expectation_uv: Part of DCEM package.*

Description

Calculates the probabilistic weights for the univariate data.

Usage

```
expectation_uv(data, weights, meu, sigma, prior, num_clusters, tolerance)
```

Arguments

`data`	(matrix): The input data.
`weights`	(matrix): The probability weight matrix.
`meu`	(vector): The vector of meu.
`sigma`	(vector): The vector of sigma (standard-deviations).
`prior`	(vector): The vector of priors.
`num_clusters`	(numeric): The number of clusters.
`tolerance`	(numeric): The system epsilon value.

Value

Updated probability weight matrix.

`get_priors` *get_priors: Part of DCEM package.*

Description

Initialize the priors.

Usage

```
get_priors(num_priors)
```

Arguments

`num_priors`	(numeric): Number of priors one corresponding to each cluster.

Details

For example, if the user specify 2 priors then the vector will have 2 entries (one for each cluster) where each will be 1/2 or 0.5.

Value

A vector of uniformly initialized prior values (numeric).

`insert_nodes` *insert_nodes: Part of DCEM package.*

Description

Implements the node insertion into the heaps.

Usage

```
insert_nodes(heap_list, heap_assn, data_probs, leaves_ind, num_clusters)
```

Arguments

`heap_list`	(list): The nested list containing the heaps. Each entry in the list is a list maintained in max-heap structure.
`heap_assn`	(numeric): The vector representing the heap assignments.
`data_probs`	(string): A vector containing the probability for data.
`leaves_ind`	(numeric): A vector containing the indices of leaves in heap.
`num_clusters`	(numeric): The number of clusters. Default: **2**

Value

A nested list. Each entry in the list is a list maintained in the max-heap structure.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

`ionosphere_data` *Ionosphere data: A dataset of 351 radar readings*

Description

This dataset contains 351 entries (radar readings from a system in goose bay laboratory) and 35 columns. The 35th columns is the label columns identifying the entry as either good or bad. Additionally, the 2nd column only contains 0's.

Usage

```
ionosphere_data
```

Format

A file with 351 rows and 35 columns of multivariate data in a csv file. All values are numeric.

Source

Space Physics Group Applied Physics Laboratory Johns Hopkins University Johns Hopkins Road Laurel, MD 20723 Web URL: http://archive.ics.uci.edu/ml/datasets/Ionosphere

References: Sigillito, V. G., Wing, S. P., Hutton, L. V., & Baker, K. B. (1989). Classification of radar returns from the ionosphere using neural networks. Johns Hopkins APL Technical Digest, 10, 262-266.

`maximisation_mv` *maximisation_mv: Part of DCEM package.*

Description

Calculates meu, sigma and prior based on the updated probability weight matrix.

Usage

```
maximisation_mv(data, weights, meu, sigma, prior, num_clusters, num_data)
```

Arguments

`data`	(matrix): The input data.
`weights`	(matrix): The probability weight matrix.
`meu`	(matrix): The matrix of meu.
`sigma`	(list): The list of sigma (co-variance matrices).
`prior`	(vector): The vector of priors.
`num_clusters`	(numeric): The number of clusters.
`num_data`	(numeric): The total number of observations in the data.

Value

Updated values for meu, sigma and prior.

`maximisation_uv` *maximisation_uv: Part of DCEM package.*

Description

Calculates meu, sigma and prior based on the updated probability weight matrix.

Usage

```
maximisation_uv(data, weights, meu, sigma, prior, num_clusters, num_data)
```

Arguments

`data`	(matrix): The input data.
`weights`	(matrix): The probability weight matrix.
`meu`	(vector): The vector of meu.
`sigma`	(vector): The vector of sigma (standard-deviations).
`prior`	(vector): The vector of priors.
`num_clusters`	(numeric): The number of clusters.
`num_data`	(numeric): The total number of observations in the data.

Value

Updated values for meu, sigma and prior.

`max_heapify` *max_heapify: Part of DCEM package.*

Description

Implements the creation of max heap. Internally called by the `dcem_star_train`.

Usage

```
max_heapify(data, index, num_data)
```

Arguments

`data`	(NumericMatrix): The dataset provided by the user.
`index`	(int): The index of the data point.
`num_data`	(numeric): The total number of observations in the data.

Value

A NumericMatrix with the max heap property.

Author(s)

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`meu_mv` *meu_mv: Part of DCEM package.*

Description

Initialize the meus(s) by randomly selecting the samples from the dataset. This is the **default** method for initializing the meu(s).

Usage

```
# Randomly seeding the mean(s).
meu_mv(data, num_meu)
```

Arguments

`data`	(matrix): The dataset provided by the user.
`num_meu`	(numeric): The number of meu.

Value

A matrix containing the selected samples from the dataset.

`meu_mv_impr` *meu_mv_impr: Part of DCEM package.*

Description

Initialize the meu(s) by randomly selecting the samples from the dataset. It uses the proposed implementation from K-means++: The Advantages of Careful Seeding, David Arthur and Sergei Vassilvitskii. URL http://ilpubs.stanford.edu:8090/778/1/2006-13.pdf.

Usage

```
# Randomly seeding the meu.
meu_mv_impr(data, num_meu)
```

Arguments

data	(matrix): The dataset provided by the user.
num_meu	(numeric): The number of meu.

Value

A matrix containing the selected samples from the dataset.

---

meu_uv *meu_uv: Part of DCEM package.*

Description

This function is internally called by the dcem_train to initialize the meu(s). It randomly selects the meu(s) from the range min(data):max(data).

Usage

```
# Randomly seeding the meu.
meu_uv(data, num_meu)
```

Arguments

data	(matrix): The dataset provided by the user.
num_meu	(number): The number of meu.

Value

A vector containing the selected samples from the dataset.

---

meu_uv_impr *meu_uv_impr: Part of DCEM package.*

Description

This function is internally called by the dcem_train to initialize the meu(s). It uses the proposed implementation from K-means++: The Advantages of Careful Seeding, David Arthur and Sergei Vassilvitskii. URL http://ilpubs.stanford.edu:8090/778/1/2006-13.pdf.

Usage

```
# Seeding the meu using the K-means++ implementation.
meu_uv_impr(data, num_meu)
```

Arguments

data	(matrix): The dataset provided by the user.
num_meu	(number): The number of meu.

Value

A vector containing the selected samples from the dataset.

---

separate_data *separate_data: Part of DCEM package.*

Description

Separate leaf nodes from the heaps.

Usage

```
separate_data(heap_list, num_clusters)
```

Arguments

heap_list	(list): The nested list containing the heaps. Each entry in the list is a list maintained in max-heap structure.
num_clusters	(numeric): The number of clusters. Default: **2**

Value

A nested list where,

First entry is the list of heaps with leaves removed.

Second entry is the list of leaves.

References

Parichit Sharma, Hasan Kurban, Mehmet Dalkilic DCEM: An R package for clustering big data via data-centric modification of Expectation Maximization, SoftwareX, 17, 100944 URL https://doi.org/10.1016/j.softx.2021.100

sigma_mv *sigma_mv: Part of DCEM package.*

Description

Initializes the co-variance matrices as the identity matrices.

Usage

```
sigma_mv(num_sigma, numcol)
```

Arguments

num_sigma	(numeric): Number of covariance matrices.
numcol	(numeric): The number of columns in the dataset.

Value

A list of identity matrices. The number of entries in the list is equal to the input parameter (num_cov).

sigma_uv *sigma_uv: Part of DCEM package.*

Description

Initializes the standard deviation for the Gaussian(s).

Usage

```
sigma_uv(data, num_sigma)
```

Arguments

data	(matrix): The dataset provided by the user.
num_sigma	(number): Number of sigma (standard_deviations).

Value

A vector of standard deviation value(s).

trim_data *trim_data: Part of DCEM package. Used internally in the package.*

Description

Removes the specified column(s) from the dataset.

Usage

```
trim_data(columns, data)
```

Arguments

columns	(string): A comma separated list of column(s) that needs to be removed from the dataset. Default: ”
data	(dataframe): Dataframe containing the input data.

Value

A dataframe with the specified column(s) removed from it.

update_weights *update_weights: Part of DCEM package.*

Description

Update the probability values for specific data points that change between the heaps.

Usage

```
update_weights(temp_weights, weights, index_list, num_clusters)
```

Arguments

temp_weights	(matrix): A matrix of probabilistic weights for leaf data.
weights	(matrix): A matrix of probabilistic weights for all data.
index_list	(vector): A vector of indices.
num_clusters	(numeric): The number of clusters.

Value

Updated probabilistic weights matrix.

validate_data *validate_data: Part of DCEM package. Used internally in the package.*

Description

Implements sanity check for the input data. This function is for internal use and is called by the dcem_train.

Usage

```
validate_data(columns, numcols)
```

Arguments

columns	(string): A comma separated list of columns that needs to be removed from the dataset. Default: ”
numcols	(numeric): Number of columns in the dataset.

Details

An example would be to check if the column to be removed exist or not? trim_data internally calls this function before removing the column(s).

Value

boolean: TRUE if the columns exists otherwise FALSE.

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