

# Package ‘smartid’

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**Title** Scoring and Marker Selection Method Based on Modified TF-IDF

**Version** 1.7.0

**Description** This package enables automated selection of group specific signature, especially for rare population. The package is developed for generating specific lists of signature genes based on Term Frequency-Inverse Document Frequency (TF-IDF) modified methods. It can also be used as a new gene-set scoring method or data transformation method. Multiple visualization functions are implemented in this package.

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'AllGenerics.R' 'gs\_score-methods.R' 'plot.R' 'scale\_mgm.R'  
'smartid-package.R' 'score-methods.R' 'select\_markers.R'  
'top\_markers.R' 'top\_markers-methods.R'

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|           |                                 |
|-----------|---------------------------------|
| cal_score | <i>calculate combined score</i> |
|-----------|---------------------------------|

---

### Description

compute TF (term/feature frequency), IDF (inverse document/cell frequency), IAE (inverse average expression of features) and combine the the final score

### Usage

```
cal_score(
  data,
  tf = c("logtf", "tf"),
  idf = "prob",
  iae = "prob",
  slot = "counts",
  new.slot = "score",
  par.idf = NULL,
  par.iae = NULL
)

## S4 method for signature 'AnyMatrix'
cal_score(
  data,
  tf = c("logtf", "tf"),
  idf = "prob",
  iae = "prob",
  par.idf = NULL,
  par.iae = NULL
)

## S4 method for signature 'SummarizedExperiment'
cal_score(
  data,
  tf = c("logtf", "tf"),
  idf = "prob",
  iae = "prob",
  slot = "counts",
  new.slot = "score",
  par.idf = NULL,
  par.iae = NULL
)
```

### Arguments

|      |                                                                   |
|------|-------------------------------------------------------------------|
| data | an expression object, can be matrix or SummarizedExperiment       |
| tf   | a character, specify the TF method to use, can be "tf" or "logtf" |

|          |                                                                                                                    |
|----------|--------------------------------------------------------------------------------------------------------------------|
| idf      | a character, specify the IDF method to use. Available methods can be accessed using <code>idf_iae_methods()</code> |
| iae      | a character, specify the IAE method to use. Available methods can be accessed using <code>idf_iae_methods()</code> |
| slot     | a character, specify which slot to use when data is se object, optional, default 'counts'                          |
| new.slot | a character, specify the name of slot to save score in se object, optional, default 'score'                        |
| par.idf  | other parameters for specified IDF methods                                                                         |
| par.iae  | other parameters for specified IAE methods                                                                         |

### Value

A list of matrices or se object containing combined score

### Examples

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
cal_score(
  data,
  par.idf = list(label = sample(c("A", "B"), 10, replace = TRUE)),
  par.iae = list(label = sample(c("A", "B"), 10, replace = TRUE))
)
```

---

|                |                                                      |
|----------------|------------------------------------------------------|
| cal_score_init | <i>Calculate score for each feature in each cell</i> |
|----------------|------------------------------------------------------|

---

### Description

Calculate score for each feature in each cell

### Usage

```
cal_score_init(
  expr,
  tf = c("logtf", "tf"),
  idf = "prob",
  iae = "prob",
  par.idf = NULL,
  par.iae = NULL
)
```

**Arguments**

|         |                                                                                                                       |
|---------|-----------------------------------------------------------------------------------------------------------------------|
| expr    | a count matrix, features in row and cells in column                                                                   |
| tf      | a character, specify the TF method to use, can be "tf" or "logtf"                                                     |
| idf     | a character, specify the IDF method to use. Available methods can be accessed using <a href="#">idf_iae_methods()</a> |
| iae     | a character, specify the IAE method to use. Available methods can be accessed using <a href="#">idf_iae_methods()</a> |
| par.idf | other parameters for specified IDF methods                                                                            |
| par.iae | other parameters for specified IAE methods                                                                            |

**Value**

a list of combined score, tf, idf and iae

**Examples**

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
label <- sample(c("A", "B"), 10, replace = TRUE)
smartid::cal_score_init(data,
  par.idf = list(label = label),
  par.iae = list(label = label)
)
```

---

|          |                                                             |
|----------|-------------------------------------------------------------|
| gs_score | <i>compute overall score based on the given marker list</i> |
|----------|-------------------------------------------------------------|

---

**Description**

compute overall score based on the given marker list

**Usage**

```
gs_score(data, features = NULL, slot = "score", suffix = "score")

## S4 method for signature 'AnyMatrix,ANY'
gs_score(data, features = NULL)

## S4 method for signature 'AnyMatrix,list'
gs_score(data, features = NULL, suffix = "score")

## S4 method for signature 'SummarizedExperiment,ANY'
gs_score(data, features = NULL, slot = "score", suffix = "score")
```

**Arguments**

|          |                                                                                          |
|----------|------------------------------------------------------------------------------------------|
| data     | an expression object, can be matrix or SummarizedExperiment                              |
| features | vector or named list, feature names to compute score                                     |
| slot     | a character, specify which slot to use when data is se object, optional, default 'score' |
| suffix   | a character, specify the name suffix to save score when features is a named list         |

**Value**

A vector of overall score for each sample

**Examples**

```
data <- matrix(rnorm(100), 10, dimnames = list(seq_len(10)))
gs_score(data, features = seq_len(3))
```

---

|               |                                                        |
|---------------|--------------------------------------------------------|
| gs_score_init | <i>Calculate scores of each cell on given features</i> |
|---------------|--------------------------------------------------------|

---

**Description**

Calculate scores of each cell on given features

**Usage**

```
gs_score_init(score, features = NULL)
```

**Arguments**

|          |                                               |
|----------|-----------------------------------------------|
| score    | matrix, features in row and samples in column |
| features | vector, feature names to compute score        |

**Value**

a vector of score

**Examples**

```
data <- matrix(rnorm(100), 10, dimnames = list(1:10))
gs_score_init(data, 1:5)
```

---

|     |                                            |
|-----|--------------------------------------------|
| iae | <i>standard inverse average expression</i> |
|-----|--------------------------------------------|

---

**Description**

standard inverse average expression

**Usage**

```
iae(expr, features = NULL, thres = 0)
```

**Arguments**

|          |                                                            |
|----------|------------------------------------------------------------|
| expr     | a matrix, features in row and cells in column              |
| features | vector, feature names or indexes to compute                |
| thres    | numeric, cell only counts when expr > threshold, default 0 |

**Details**

$$\mathbf{IAE}_i = \log\left(1 + \frac{n}{\hat{N}_{i,j} + 1}\right)$$

where  $n$  is the total number of cells,  $\hat{N}_{i,j}$  is the counts of feature  $i$  in cell  $j$ .

**Value**

a vector of inverse average expression score for each feature

**Examples**

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::iae(data)
```

---

|         |                                                                  |
|---------|------------------------------------------------------------------|
| iae_hdb | <i>inverse average expression using hdbscan cluster as label</i> |
|---------|------------------------------------------------------------------|

---

**Description**

inverse average expression using hdbscan cluster as label

**Usage**

```
iae_hdb(expr, features = NULL, multi = TRUE, thres = 0, minPts = 2, ...)
```

**Arguments**

|                       |                                                                                              |
|-----------------------|----------------------------------------------------------------------------------------------|
| <code>expr</code>     | a matrix, features in row and cells in column                                                |
| <code>features</code> | vector, feature names or indexes to compute                                                  |
| <code>multi</code>    | logical, if to compute based on binary (FALSE) or multi-class (TRUE)                         |
| <code>thres</code>    | numeric, cell only counts when <code>expr &gt; threshold</code> , default 0                  |
| <code>minPts</code>   | integer, minimum size of clusters, default 2. Details in <a href="#">dbscan::hdbscan()</a> . |
| <code>...</code>      | parameters for <a href="#">dbscan::hdbscan()</a>                                             |

**Details**

Details as [iae\\_prob\(\)](#).

**Value**

a matrix of inverse average expression score

**Examples**

```
set.seed(123)
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::iae_hdb(data)
```

---

|                      |                                                |
|----------------------|------------------------------------------------|
| <code>iae_igm</code> | <i>labeled inverse average expression: IGM</i> |
|----------------------|------------------------------------------------|

---

**Description**

labeled inverse average expression: IGM

**Usage**

```
iae_igm(expr, features = NULL, label, lambda = 7, thres = 0)
```

**Arguments**

|                       |                                                                             |
|-----------------------|-----------------------------------------------------------------------------|
| <code>expr</code>     | a matrix, features in row and cells in column                               |
| <code>features</code> | vector, feature names or indexes to compute                                 |
| <code>label</code>    | vector, group label of each cell                                            |
| <code>lambda</code>   | numeric, hyperparameter for IGM                                             |
| <code>thres</code>    | numeric, cell only counts when <code>expr &gt; threshold</code> , default 0 |

## Details

$$\mathbf{IGM}_i = \log(1 + \lambda \frac{\max(\text{mean}(N_{i,j \in D})_k)}{\sum_k^K (\text{mean}(N_{i,j \in D})_k * r_k) + e^{-8}})$$

where  $\lambda$  is the hyper parameter,  $N_{i,j \in D}$  is the counts of feature  $i$  in cell  $j$  within class  $D$ , and  $r_k$  is the rank of  $\text{mean}(N_{i,j \in D})$ .

## Value

a vector of inverse gravity moment score for each feature

## Examples

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::iae_igm(data, label = sample(c("A", "B"), 10, replace = TRUE))
```

---

|       |                                        |
|-------|----------------------------------------|
| iae_m | <i>inverse average expression: max</i> |
|-------|----------------------------------------|

---

## Description

inverse average expression: max

## Usage

```
iae_m(expr, features = NULL, thres = 0)
```

## Arguments

|          |                                                            |
|----------|------------------------------------------------------------|
| expr     | a matrix, features in row and cells in column              |
| features | vector, feature names or indexes to compute                |
| thres    | numeric, cell only counts when expr > threshold, default 0 |

## Details

$$\mathbf{IAE}_{i,j} = \log(1 + \frac{\max_{\{i' \in j\}}(n_{i'})}{\sum_{j=1}^n \max(0, N_{i,j} - \text{threshold}) + 1})$$

where  $i$  is the feature  $i$  and  $i'$  is the feature except  $i$ ,  $N_{i,j}$  is the counts of feature  $i$  in cell  $j$ , and  $n_{i'}$  is  $\sum_{j=1}^n \text{sign}(N_{i,j} > \text{threshold})$ .

## Value

a matrix of inverse average expression score for each feature

**Examples**

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid:::iae_m(data)
```

iae\_prob

*labeled inverse average expression: probability based***Description**

labeled inverse average expression: probability based

**Usage**

```
iae_prob(expr, features = NULL, label, multi = TRUE, thres = 0)
```

**Arguments**

|          |                                                                      |
|----------|----------------------------------------------------------------------|
| expr     | a matrix, features in row and cells in column                        |
| features | vector, feature names or indexes to compute                          |
| label    | vector, group label of each cell                                     |
| multi    | logical, if to compute based on binary (FALSE) or multi-class (TRUE) |
| thres    | numeric, cell only counts when expr > threshold, default 0           |

**Details**

$$\mathbf{IAE}_{i,j} = \log\left(1 + \frac{\text{mean}(N_{i,j \in D})}{\max(\text{mean}(N_{i,j \in \hat{D}})) + e^{-8}} * \text{mean}(N_{i,j \in D})\right)$$

where  $N_{i,j \in D}$  is the counts of feature  $i$  in cell  $j$  within class  $D$ , and  $\hat{D}$  is the class except  $D$ .

**Value**

a matrix of inverse average expression score

**Examples**

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid:::iae_prob(data, label = sample(c("A", "B"), 10, replace = TRUE))
```

---

|        |                                                               |
|--------|---------------------------------------------------------------|
| iae_rf | <i>labeled inverse average expression: relative frequency</i> |
|--------|---------------------------------------------------------------|

---

## Description

labeled inverse average expression: relative frequency

## Usage

```
iae_rf(expr, features = NULL, label, multi = TRUE, thres = 0)
```

## Arguments

|                       |                                                                             |
|-----------------------|-----------------------------------------------------------------------------|
| <code>expr</code>     | a matrix, features in row and cells in column                               |
| <code>features</code> | vector, feature names or indexes to compute                                 |
| <code>label</code>    | vector, group label of each cell                                            |
| <code>multi</code>    | logical, if to compute based on binary (FALSE) or multi-class (TRUE)        |
| <code>thres</code>    | numeric, cell only counts when <code>expr &gt; threshold</code> , default 0 |

## Details

$$\mathbf{IAE} = \log\left(1 + \frac{\text{mean}(N_{i,j \in D})}{\max(\text{mean}(N_{i,j \in \hat{D}})) + e^{-8}}\right)$$

where  $N_{i,j \in D}$  is the counts of feature  $i$  in cell  $j$  within class  $D$ , and  $\hat{D}$  is the class except  $D$ .

## Value

a matrix of inverse average expression score

## Examples

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid:::iae_rf(data, label = sample(c("A", "B"), 10, replace = TRUE))
```

---

|        |                                                                 |
|--------|-----------------------------------------------------------------|
| iae_sd | <i>inverse average expression using standard deviation (SD)</i> |
|--------|-----------------------------------------------------------------|

---

## Description

inverse average expression using standard deviation (SD)

## Usage

```
iae_sd(expr, features = NULL, log = FALSE, thres = 0)
```

## Arguments

|          |                                                            |
|----------|------------------------------------------------------------|
| expr     | a matrix, features in row and cells in column              |
| features | vector, feature names or indexes to compute                |
| log      | logical, if to do log-transformation                       |
| thres    | numeric, cell only counts when expr > threshold, default 0 |

## Details

$$\mathbf{IAE} = \log(1 + sd(tf_i) * \frac{n}{\sum_{j=1}^n \max(0, N_{i,j}) + 1})$$

where  $tf_i$  is the term frequency of feature  $i$ , see details in [tf\(\)](#),  $n$  is the total number of cells and  $N_{i,j}$  is the counts of feature  $i$  in cell  $j$ .

## Value

a vector of inverse average expression score for each feature

## Examples

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::iae_sd(data)
```

---

|     |                                        |
|-----|----------------------------------------|
| idf | <i>standard inverse cell frequency</i> |
|-----|----------------------------------------|

---

**Description**

standard inverse cell frequency

**Usage**

```
idf(expr, features = NULL, thres = 0)
```

**Arguments**

|          |                                                            |
|----------|------------------------------------------------------------|
| expr     | a matrix, features in row and cells in column              |
| features | vector, feature names or indexes to compute                |
| thres    | numeric, cell only counts when expr > threshold, default 0 |

**Details**

$$\mathbf{IDF}_i = \log\left(1 + \frac{n}{n_i + 1}\right)$$

where  $n$  is the total number of cells,  $n_i$  is the number of cells containing feature  $i$ .

**Value**

a vector of inverse cell frequency score for each feature

**Examples**

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::idf(data)
```

---

|         |                                                                  |
|---------|------------------------------------------------------------------|
| idf_hdb | <i>inverse document frequency using hdbscan cluster as label</i> |
|---------|------------------------------------------------------------------|

---

**Description**

inverse document frequency using hdbscan cluster as label

**Usage**

```
idf_hdb(expr, features = NULL, multi = TRUE, thres = 0, minPts = 2, ...)
```

**Arguments**

|                       |                                                                                              |
|-----------------------|----------------------------------------------------------------------------------------------|
| <code>expr</code>     | a matrix, features in row and cells in column                                                |
| <code>features</code> | vector, feature names or indexes to compute                                                  |
| <code>multi</code>    | logical, if to compute based on binary (FALSE) or multi-class (TRUE)                         |
| <code>thres</code>    | numeric, cell only counts when <code>expr &gt; threshold</code> , default 0                  |
| <code>minPts</code>   | integer, minimum size of clusters, default 2. Details in <a href="#">dbscan::hdbscan()</a> . |
| <code>...</code>      | parameters for <a href="#">dbscan::hdbscan()</a>                                             |

**Details**

Details as [idf\\_prob\(\)](#).

**Value**

a matrix of inverse cell frequency score

**Examples**

```
set.seed(123)
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::idf_hdb(data)
```

---

idf\_iae\_methods

*Get names of available IDF and IAE methods*

---

**Description**

Returns a named vector of IDF/IAE methods

**Usage**

```
idf_iae_methods()
```

**Value**

names of methods implemented

**Examples**

```
idf_iae_methods()
```

---

|         |                                            |
|---------|--------------------------------------------|
| idf_igm | <i>labeled inverse cell frequency: IGM</i> |
|---------|--------------------------------------------|

---

## Description

labeled inverse cell frequency: IGM

## Usage

```
idf_igm(expr, features = NULL, label, lambda = 7, thres = 0)
```

## Arguments

|          |                                                                             |
|----------|-----------------------------------------------------------------------------|
| expr     | a matrix, features in row and cells in column                               |
| features | vector, feature names or indexes to compute                                 |
| label    | vector, group label of each cell                                            |
| lambda   | numeric, hyperparameter for IGM                                             |
| thres    | numeric, cell only counts when <code>expr &gt; threshold</code> , default 0 |

## Details

$$\mathbf{IGM}_i = \log\left(1 + \lambda \frac{\max(n_{i,j \in D})_k}{\sum_k^K ((n_{i,j \in D})_k * r_k) + e^{-8}}\right)$$

where  $\lambda$  is the hyper parameter,  $n_{i,j \in D}$  is the number of cells containing feature  $i$  in class  $D$ ,  $r_k$  is the rank of  $n_{i,j \in D}$ .

## Value

a vector of inverse gravity moment score for each feature

## Examples

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::idf_igm(data, label = sample(c("A", "B"), 10, replace = TRUE))
```

---

|       |                                    |
|-------|------------------------------------|
| idf_m | <i>inverse cell frequency: max</i> |
|-------|------------------------------------|

---

**Description**

inverse cell frequency: max

**Usage**

```
idf_m(expr, features = NULL, thres = 0)
```

**Arguments**

|          |                                                            |
|----------|------------------------------------------------------------|
| expr     | a matrix, features in row and cells in column              |
| features | vector, feature names or indexes to compute                |
| thres    | numeric, cell only counts when expr > threshold, default 0 |

**Details**

$$\mathbf{IDF}_{i,j} = \log\left(\frac{\max_{\{i' \in J\}}(n_{i'})}{n_i + 1}\right)$$

where  $i$  is the feature  $i$  and  $i'$  is the feature except  $i$ ,  $n_i$  is the number of cells containing feature  $i$ , and  $n_{i'}$  is the number of cells containing feature  $i'$ .

**Value**

a matrix of inverse cell frequency score for each feature

**Examples**

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::idf_m(data)
```

---

|          |                                                          |
|----------|----------------------------------------------------------|
| idf_prob | <i>labeled inverse cell frequency: probability based</i> |
|----------|----------------------------------------------------------|

---

**Description**

labeled inverse cell frequency: probability based

**Usage**

```
idf_prob(expr, features = NULL, label, multi = TRUE, thres = 0)
```

**Arguments**

|                       |                                                                             |
|-----------------------|-----------------------------------------------------------------------------|
| <code>expr</code>     | a matrix, features in row and cells in column                               |
| <code>features</code> | vector, feature names or indexes to compute                                 |
| <code>label</code>    | vector, group label of each cell                                            |
| <code>multi</code>    | logical, if to compute based on binary (FALSE) or multi-class (TRUE)        |
| <code>thres</code>    | numeric, cell only counts when <code>expr &gt; threshold</code> , default 0 |

**Details**

$$\mathbf{IDF}_{i,j} = \log\left(1 + \frac{\frac{n_{i,j \in D}}{n_{j \in D}}}{\max(\frac{n_{i,j \in \hat{D}}}{n_{j \in \hat{D}}}) + e^{-8}} \frac{n_{i,j \in D}}{n_{j \in D}}\right)$$

where  $n_{i,j \in D}$  is the number of cells containing feature  $i$  in class  $D$ ,  $n_{j \in D}$  is the total number of cells in class  $D$ ,  $\hat{D}$  is the class except  $D$ .

**Value**

a matrix of inverse cell frequency score

**Examples**

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::idf_prob(data, label = sample(c("A", "B"), 10, replace = TRUE))
```

---

|                     |                                                           |
|---------------------|-----------------------------------------------------------|
| <code>idf_rf</code> | <i>labeled inverse cell frequency: relative frequency</i> |
|---------------------|-----------------------------------------------------------|

---

**Description**

labeled inverse cell frequency: relative frequency

**Usage**

```
idf_rf(expr, features = NULL, label, multi = TRUE, thres = 0)
```

**Arguments**

|                       |                                                                             |
|-----------------------|-----------------------------------------------------------------------------|
| <code>expr</code>     | a matrix, features in row and cells in column                               |
| <code>features</code> | vector, feature names or indexes to compute                                 |
| <code>label</code>    | vector, group label of each cell                                            |
| <code>multi</code>    | logical, if to compute based on binary (FALSE) or multi-class (TRUE)        |
| <code>thres</code>    | numeric, cell only counts when <code>expr &gt; threshold</code> , default 0 |

**Details**

$$\mathbf{IDF}_{i,j} = \log\left(1 + \frac{\frac{n_{i,j \in D}}{n_{j \in D}}}{\max(\frac{n_{i,j \in \hat{D}}}{n_{j \in \hat{D}}}) + e^{-8}}\right)$$

where  $n_{i,j \in D}$  is the number of cells containing feature  $i$  in class  $D$ ,  $n_{j \in D}$  is the total number of cells in class  $D$ ,  $\hat{D}$  is the class except  $D$ .

**Value**

a matrix of inverse cell frequency score

**Examples**

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::idf_rf(data, label = sample(c("A", "B"), 10, replace = TRUE))
```

---

|        |                                                             |
|--------|-------------------------------------------------------------|
| idf_sd | <i>inverse cell frequency using standard deviation (SD)</i> |
|--------|-------------------------------------------------------------|

---

**Description**

inverse cell frequency using standard deviation (SD)

**Usage**

```
idf_sd(expr, features = NULL, log = FALSE, thres = 0)
```

**Arguments**

|          |                                                                             |
|----------|-----------------------------------------------------------------------------|
| expr     | a matrix, features in row and cells in column                               |
| features | vector, feature names or indexes to compute                                 |
| log      | logical, if to do log-transformation                                        |
| thres    | numeric, cell only counts when $\text{expr} > \text{threshold}$ , default 0 |

**Details**

$$\mathbf{IDF}_i = \log\left(1 + sd(tf_i) * \frac{n}{n_i + 1}\right)$$

where  $tf_i$  is the term frequency of feature  $i$ , see details in [tf\(\)](#),  $n$  is the total number of cells and  $n_i$  is the number of cells containing feature  $i$ .

**Value**

a vector of inverse cell frequency score for each feature

**Examples**

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid::idf_sd(data)
```

---

|                 |                                            |
|-----------------|--------------------------------------------|
| markers_hdbscan | <i>select markers using HDBSCAN method</i> |
|-----------------|--------------------------------------------|

---

**Description**

select markers using HDBSCAN method

**Usage**

```
markers_hdbscan(
  top_markers,
  column = ".dot",
  s_thres = NULL,
  method = c("max.one", "remove.min"),
  minPts = 5,
  plot = FALSE,
  ...
)
```

**Arguments**

|             |                                                                                                                               |
|-------------|-------------------------------------------------------------------------------------------------------------------------------|
| top_markers | output of <a href="#">top_markers()</a>                                                                                       |
| column      | character, specify which column used as group label                                                                           |
| s_thres     | NULL or numeric, only features with score > threshold will be returned, if NULL will use 2 * average probability as threshold |
| method      | can be "max.one" or "remove.min", if to only keep features in 1st component or return features not in the last component      |
| minPts      | integer, minimum size of clusters for <a href="#">dbscan::hdbscan()</a>                                                       |
| plot        | logical, if to plot mixture density and hist                                                                                  |
| ...         | other params for <a href="#">dbscan::hdbscan()</a>                                                                            |

**Value**

a list of markers for each group

**Examples**

```
data <- matrix(rnorm(100), 10, dimnames = list(1:10))
top_n <- top_markers(data, label = rep(c("A", "B"), 5))
markers_hdbscan(top_n, minPts = 2)
```

---

|                |                                              |
|----------------|----------------------------------------------|
| markers_mclust | <i>select markers using mclust EM method</i> |
|----------------|----------------------------------------------|

---

## Description

select markers using mclust EM method

## Usage

```
markers_mclust(
  top_markers,
  column = ".dot",
  prob = 0.99,
  s_thres = NULL,
  method = c("max.one", "remove.min"),
  plot = FALSE,
  ...
)
```

## Arguments

|             |                                                                                                                               |
|-------------|-------------------------------------------------------------------------------------------------------------------------------|
| top_markers | output of <a href="#">top_markers()</a>                                                                                       |
| column      | character, specify which column used as group label                                                                           |
| prob        | numeric, probability cutoff for 1st component classification                                                                  |
| s_thres     | NULL or numeric, only features with score > threshold will be returned, if NULL will use 2 * average probability as threshold |
| method      | can be "max.one" or "remove.min", if to only keep features in 1st component or return features not in the last component      |
| plot        | logical, if to plot mixture density and hist                                                                                  |
| ...         | other params for <a href="#">mclust::densityMclust()</a>                                                                      |

## Value

a list of markers for each group

## Examples

```
data <- matrix(rnorm(100), 10, dimnames = list(1:10))
top_n <- top_markers(data, label = rep(c("A", "B"), 5))
markers_mclust(top_n)
```

---

|                |                                                |
|----------------|------------------------------------------------|
| markers_mixmdl | <i>select markers using mixtools EM method</i> |
|----------------|------------------------------------------------|

---

## Description

select markers using mixtools EM method

## Usage

```
markers_mixmdl(
  top_markers,
  column = ".dot",
  prob = 0.99,
  k = 3,
  ratio = 2,
  dist = c("norm", "gamma"),
  maxit = 1e+05,
  plot = FALSE,
  ...
)
```

## Arguments

|             |                                                                                                                                       |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------|
| top_markers | output of <a href="#">top_markers()</a>                                                                                               |
| column      | character, specify which column used as group label                                                                                   |
| prob        | numeric, probability cutoff for 1st component classification                                                                          |
| k           | integer, number of components of mixtures                                                                                             |
| ratio       | numeric, ratio cutoff of 1st component mu to 2nd component mu, only when ratio > cutoff will return markers for the group             |
| dist        | can be one of "norm" and "gamma", specify if to use <a href="#">mixtools::normalmixEM()</a> or <a href="#">mixtools::gammamixEM()</a> |
| maxit       | integer, maximum number of iterations for EM                                                                                          |
| plot        | logical, if to plot mixture density and hist                                                                                          |
| ...         | other params for <a href="#">mixtools::normalmixEM()</a> or <a href="#">mixtools::gammamixEM()</a>                                    |

## Value

a list of markers for each group

## Examples

```
set.seed(1000)
data <- matrix(rnorm(100), 10, dimnames = list(1:10))
top_n <- top_markers(data, label = rep(c("A", "B"), 5))
markers_mixmdl(top_n, k = 3)
```

---

|                   |                                          |
|-------------------|------------------------------------------|
| ova_score_boxplot | <i>boxplot of features overall score</i> |
|-------------------|------------------------------------------|

---

**Description**

boxplot of features overall score

**Usage**

```
ova_score_boxplot(data, features, ref.group, label, method = "t.test")
```

**Arguments**

|           |                                                                                             |
|-----------|---------------------------------------------------------------------------------------------|
| data      | matrix, features in row and samples in column                                               |
| features  | vector, feature names to plot                                                               |
| ref.group | character, reference group name                                                             |
| label     | vector, group labels                                                                        |
| method    | character, statistical test to use, details in <a href="#">ggpubr::stat_compare_means()</a> |

**Value**

ggplot object

**Examples**

```
data <- matrix(rnorm(100), 10, dimnames = list(1:10))
ova_score_boxplot(data, 1:5, ref.group = "A", label = rep(c("A", "B"), 5))
```

---

|           |                                                        |
|-----------|--------------------------------------------------------|
| scale_mgm | <i>scale by mean of group mean for imbalanced data</i> |
|-----------|--------------------------------------------------------|

---

**Description**

scale by mean of group mean for imbalanced data

**Usage**

```
scale_mgm(expr, label, pooled.sd = FALSE)
```

**Arguments**

|           |                                          |
|-----------|------------------------------------------|
| expr      | matrix                                   |
| label     | a vector of group label                  |
| pooled.sd | logical, if to use pooled SD for scaling |

Details

$$z = \frac{x - \frac{\sum_k^{n_D} (\mu_k)}{n_D}}{s}$$

where  $\mu_k$  is the mean of  $x$  in  $k^{th}$  class, and  $n_D$  is the number of classes,  $s$  is the standard deviation of  $x$ , when pooled. `sd` is set to be `TRUE`,  $s$  will be replaced with  $s_{pooled}$ ,  $s_{pooled} = \sqrt{\frac{\sum_k^{n_D} (n_k - 1) s_k^2}{\sum_k^{n_D} n_k - k}}$

Value

scaled matrix

Examples

```
scale_mgm(matrix(rnorm(100), 10), label = rep(letters[1:2], 5))
```

---

|               |                                   |
|---------------|-----------------------------------|
| score_barplot | <i>barplot of processed score</i> |
|---------------|-----------------------------------|

---

Description

barplot of processed score

Usage

```
score_barplot(top_markers, column = ".dot", f_list, n = 30)
```

Arguments

- `top_markers` output of `top_markers()`
- `column` character, specify which column used as group label
- `f_list` a named list of markers
- `n` numeric, number of returned top genes for each group

Value

ggplot object

Examples

```
data <- matrix(rnorm(100), 10, dimnames = list(1:10))
top_n <- top_markers(data, label = rep(c("A", "B"), 5))
score_barplot(top_n)
```

---

|              |                                                               |
|--------------|---------------------------------------------------------------|
| sim_sce_test | <i>scRNA-seq test data of 4 groups simulated by splatter.</i> |
|--------------|---------------------------------------------------------------|

---

**Description**

A SingleCellExperiment object containing 4 groups with each group up-regulated DEGs saved in metadata.

**Usage**

```
data(sim_sce_test)
```

**Format**

A SingleCellExperiment object of 100genes \* 400 cells.

**Value**

SingleCellExperiment

**Source**

```
splatter::splatSimulate()
```

---

|                   |                                              |
|-------------------|----------------------------------------------|
| sin_score_boxplot | <i>boxplot of split single feature score</i> |
|-------------------|----------------------------------------------|

---

**Description**

boxplot of split single feature score

**Usage**

```
sin_score_boxplot(data, features = NULL, ref.group, label, method = "t.test")
```

**Arguments**

|           |                                                                                             |
|-----------|---------------------------------------------------------------------------------------------|
| data      | matrix, features in row and samples in column                                               |
| features  | vector, feature names to plot                                                               |
| ref.group | character, reference group name                                                             |
| label     | vector, group labels                                                                        |
| method    | character, statistical test to use, details in <a href="#">ggpubr::stat_compare_means()</a> |

**Value**

faceted ggplot object

**Examples**

```
data <- matrix(rnorm(100), 10, dimnames = list(1:10))
sin_score_boxplot(data, 1:2, ref.group = "A", label = rep(c("A", "B"), 5))
```

smartid\_Package

*Scoring and Marker Selection method based on modified TF-IDF***Description**

smartid This package enables automated selection of group specific signature, especially for rare population. The package is developed for generating specific lists of signature genes based on TF-IDF modified methods. It can also be used as a new gene-set scoring method or data transformation method. Multiple visualization functions are implemented in this package.

**Value**

Marker list and scores

**Author(s)**

Jinjin Chen <chen.j@wehi.edu.au>

**See Also**

Useful links:

- <https://davislaboratory.github.io/smartid>
- Report bugs at <https://github.com/DavisLaboratory/smartid/issues>

tf

*compute term/feature frequency within each cell***Description**

compute term/feature frequency within each cell

**Usage**

```
tf(expr, log = FALSE)
```

**Arguments**

|      |                                                     |
|------|-----------------------------------------------------|
| expr | a count matrix, features in row and cells in column |
| log  | logical, if to do log-transformation                |

**Details**

$$\mathbf{TF}_{i,j} = \frac{N_{i,j}}{\sum_j N_{i,j}}$$

where  $N_{i,j}$  is the counts of feature  $i$  in cell  $j$ .

**Value**

a matrix of term/gene frequency

**Examples**

```
data <- matrix(rpois(100, 2), 10, dimnames = list(1:10))
smartid:::tf(data)
```

---

|             |                                           |
|-------------|-------------------------------------------|
| top_markers | <i>scale score and return top markers</i> |
|-------------|-------------------------------------------|

---

**Description**

scale and transform score and output top markers for groups

**Usage**

```
top_markers(
  data,
  label,
  n = 10,
  use.glm = TRUE,
  batch = NULL,
  scale = TRUE,
  use.mgm = TRUE,
  softmax = TRUE,
  slot = "score",
  ...
)

## S4 method for signature 'AnyMatrix'
top_markers(
  data,
  label,
  n = 10,
  use.glm = TRUE,
  batch = NULL,
  scale = TRUE,
  use.mgm = TRUE,
  softmax = TRUE,
```

```

    slot = "score",
    ...
)

## S4 method for signature 'SummarizedExperiment'
top_markers(
  data,
  label,
  n = 10,
  use.glm = TRUE,
  batch = NULL,
  scale = TRUE,
  use.mgm = TRUE,
  softmax = TRUE,
  slot = "score",
  ...
)

```

### Arguments

|         |                                                                                                                                 |
|---------|---------------------------------------------------------------------------------------------------------------------------------|
| data    | an expression object, can be matrix or SummarizedExperiment                                                                     |
| label   | a vector of group label                                                                                                         |
| n       | integer, number of returned top genes for each group                                                                            |
| use.glm | logical, if to use <code>stats::glm()</code> to compute group mean score, if TRUE, also compute mean score difference as output |
| batch   | a vector of batch labels, default NULL                                                                                          |
| scale   | logical, if to scale data by row                                                                                                |
| use.mgm | logical, if to scale data using <code>scale_mgm()</code>                                                                        |
| softmax | logical, if to apply softmax transformation on output                                                                           |
| slot    | a character, specify which slot to use when data is se object, optional, default 'score'                                        |
| ...     | params for <code>top_markers_abs()</code> or <code>top_markers_glm()</code>                                                     |

### Value

A tibble with top n feature names, group labels and ordered scores

### Examples

```

data <- matrix(rgamma(100, 2), 10, dimnames = list(1:10))
top_markers(data, label = rep(c("A", "B"), 5))

```

---

|                 |                                                                                  |
|-----------------|----------------------------------------------------------------------------------|
| top_markers_abs | <i>calculate group median, MAD or mean score and order genes based on scores</i> |
|-----------------|----------------------------------------------------------------------------------|

---

## Description

calculate group median, MAD or mean score and order genes based on scores

## Usage

```
top_markers_abs(
  data,
  label,
  n = 10,
  pooled.sd = FALSE,
  method = c("median", "mad", "mean"),
  scale = TRUE,
  use.mgm = TRUE,
  softmax = TRUE,
  tau = 1
)
```

## Arguments

|           |                                                                             |
|-----------|-----------------------------------------------------------------------------|
| data      | matrix, features in row and samples in column                               |
| label     | a vector of group label                                                     |
| n         | integer, number of returned top genes for each group                        |
| pooled.sd | logical, if to use pooled SD for scaling                                    |
| method    | character, specify metric to compute, can be one of "median", "mad", "mean" |
| scale     | logical, if to scale data by row                                            |
| use.mgm   | logical, if to scale data using <a href="#">scale_mgm()</a>                 |
| softmax   | logical, if to apply softmax transformation on output                       |
| tau       | numeric, hyper parameter for softmax                                        |

## Value

a tibble with feature names, group labels and ordered processed scores

## Examples

```
data <- matrix(rgamma(100, 2), 10, dimnames = list(1:10))
top_markers_abs(data, label = rep(c("A", "B"), 5))
```

---

|                 |                                                                                        |
|-----------------|----------------------------------------------------------------------------------------|
| top_markers_glm | <i>calculate group mean score using glm and order genes based on scores difference</i> |
|-----------------|----------------------------------------------------------------------------------------|

---

### Description

calculate group mean score using glm and order genes based on scores difference

### Usage

```
top_markers_glm(  
  data,  
  label,  
  n = 10,  
  family = gaussian(),  
  batch = NULL,  
  scale = TRUE,  
  use.mgm = TRUE,  
  pooled.sd = FALSE,  
  softmax = TRUE,  
  tau = 1  
)
```

### Arguments

|           |                                                             |
|-----------|-------------------------------------------------------------|
| data      | matrix, features in row and samples in column               |
| label     | a vector of group label                                     |
| n         | integer, number of returned top genes for each group        |
| family    | family for glm, details in <a href="#">stats::glm()</a>     |
| batch     | a vector of batch labels, default NULL                      |
| scale     | logical, if to scale data by row                            |
| use.mgm   | logical, if to scale data using <a href="#">scale_mgm()</a> |
| pooled.sd | logical, if to use pooled SD for scaling                    |
| softmax   | logical, if to apply softmax transformation on output       |
| tau       | numeric, hyper parameter for softmax                        |

### Value

a tibble with feature names, group labels and ordered processed scores

### Examples

```
data <- matrix(rgamma(100, 2), 10, dimnames = list(1:10))  
top_markers_glm(data, label = rep(c("A", "B"), 5))
```

---

|                  |                                                                                 |
|------------------|---------------------------------------------------------------------------------|
| top_markers_init | <i>compute group summarized score and order genes based on processed scores</i> |
|------------------|---------------------------------------------------------------------------------|

---

## Description

compute group summarized score and order genes based on processed scores

## Usage

```
top_markers_init(
  data,
  label,
  n = 10,
  use.glm = TRUE,
  batch = NULL,
  scale = TRUE,
  use.mgm = TRUE,
  softmax = TRUE,
  ...
)
```

## Arguments

|         |                                                                                                                                    |
|---------|------------------------------------------------------------------------------------------------------------------------------------|
| data    | matrix, features in row and samples in column                                                                                      |
| label   | a vector of group label                                                                                                            |
| n       | integer, number of returned top genes for each group                                                                               |
| use.glm | logical, if to use <a href="#">stats::glm()</a> to compute group mean score, if TRUE, also compute mean score difference as output |
| batch   | a vector of batch labels, default NULL                                                                                             |
| scale   | logical, if to scale data by row                                                                                                   |
| use.mgm | logical, if to scale data using <a href="#">scale_mgm()</a>                                                                        |
| softmax | logical, if to apply softmax transformation on output                                                                              |
| ...     | params for <a href="#">top_markers_abs()</a> or <a href="#">top_markers_glm()</a>                                                  |

## Value

a tibble with feature names, group labels and ordered processed scores

## Examples

```
data <- matrix(rgamma(100, 2), 10, dimnames = list(1:10))
top_markers_init(data, label = rep(c("A", "B"), 5))
```

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