

# Package ‘cellity’

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**Type** Package

**Title** Quality Control for Single-Cell RNA-seq Data

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**Description** A support vector machine approach to identifying and filtering low quality cells from single-cell RNA-seq datasets.

**License** GPL (>= 2)

**Depends** R (>= 3.3)

**Imports** AnnotationDbi, e1071, ggplot2, graphics, grDevices, grid,  
mvoutlier, org.Hs.eg.db, org.Mm.eg.db, robustbase, stats,  
topGO, utils

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**VignetteBuilder** knitr

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**biocViews** ImmunoOncology, RNASeq, QualityControl, Preprocessing,  
Normalization, Visualization, DimensionReduction,  
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SupportVectorMachine

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|                 |                                                     |
|-----------------|-----------------------------------------------------|
| cellity-package | <i>Quality Control for Single-Cell RNA-seq Data</i> |
|-----------------|-----------------------------------------------------|

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Description

**cellity** provides a support vector machine and PCA approaches to identifying and filtering low quality cells from single-cell RNA-seq datasets.

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|                         |                                                            |
|-------------------------|------------------------------------------------------------|
| assess_cell_quality_PCA | <i>ASSESS CELL QUALITY USING PCA AND OUTLIER DETECTION</i> |
|-------------------------|------------------------------------------------------------|

---

Description

ASSESS CELL QUALITY USING PCA AND OUTLIER DETECTION

Usage

```
assess_cell_quality_PCA(features, file = "")
```

### Arguments

|          |                                                     |
|----------|-----------------------------------------------------|
| features | Input dataset containing features (cell x features) |
| file     | Output_file where plot is saved                     |

### Details

This function applies PCA on features and uses outlier detection to determine which cells are low and which are high quality

### Value

Returns a dataframe indicating which cell is low or high quality (0 or 1 respectively)

### Examples

```
data(training_mES_features)
training_mES_features_all <- training_mES_features[[1]]
training_quality_PCA_allF <- assess_cell_quality_PCA(training_mES_features_all)
```

---

assess\_cell\_quality\_SVM

*Assess quality of a cell - SVM version*

---

### Description

Assess quality of a cell - SVM version

### Usage

```
assess_cell_quality_SVM(training_set_features, training_set_labels,
  ensemble_param, test_set_features)
```

### Arguments

|                       |                                                                                 |
|-----------------------|---------------------------------------------------------------------------------|
| training_set_features | A training set containing features (cells x features) for prediction            |
| training_set_labels   | Annotation of each individual cell if high or low quality (1 or 0 respectively) |
| ensemble_param        | Dataframe of parameters for SVM                                                 |
| test_set_features     | Dataset to predict containing features (cells x features)                       |

### Details

This function takes a training set + annotation to predict a test set. It requires that hyper-parameters have been optimised.

**Value**

Returns a dataframe indicating which cell is low or high quality (0 or 1 respectively)  
data.frame with decision on quality of cells

**Examples**

```
data(param_mES_all)
data(training_mES_features)
data(training_mES_labels)
data(mES1_features)
data(mES1_labels)
mES1_features_all <- mES1_features[[1]]
training_mES_features_all <- training_mES_features[[1]]
mES1_quality_SVM <- assess_cell_quality_SVM( training_mES_features_all,
training_mES_labels[,2], param_mES_all, mES1_features_all)
```

---

|                  |                                                                     |
|------------------|---------------------------------------------------------------------|
| extract_features | <i>Extracts biological and technical features for given dataset</i> |
|------------------|---------------------------------------------------------------------|

---

**Description**

Extracts biological and technical features for given dataset

**Usage**

```
extract_features(counts_nm, read_metrics, prefix = "", output_dir = "",
  common_features = NULL, GO_terms = NULL, extra_genes = NULL,
  organism = "mouse")
```

**Arguments**

|                 |                                                                                                   |
|-----------------|---------------------------------------------------------------------------------------------------|
| counts_nm       | Gene expression counts dataframe (genes x cells). Either normalised by library size or TPM values |
| read_metrics    | Dataframe with mapping statistics produced by python pipeline                                     |
| prefix          | Prefix of outputfiles                                                                             |
| output_dir      | Output directory of files                                                                         |
| common_features | Subset of features that are applicable within one species, but across cell types                  |
| GO_terms        | DataFrame with gene ontology term IDs, that will be used in feature extraction                    |
| extra_genes     | Additional genes used for feature extraction                                                      |
| organism        | The target organism to generate the features for                                                  |

**Details**

This function takes a combination of gene counts and mapping statistics to extract biological and technical features, which than can be used for quality data analysis

**Value**

a list with two elements, one providing all features, and one providing common features.

**Examples**

```
data(sample_counts)
data(sample_stats)
sample_counts_nm <- normalise_by_factor(sample_counts, colSums(sample_counts))
sample_features <- extract_features(sample_counts_nm, sample_stats)
```

---

|                   |                                                                   |
|-------------------|-------------------------------------------------------------------|
| extra_human_genes | <i>Additional human genes that are used in feature extraction</i> |
|-------------------|-------------------------------------------------------------------|

---

**Description**

This list contains human genes that are used for feature extraction of biological features

**Usage**

```
extra_human_genes
```

**Format**

a list containing vectors of genes. Name indicates which GO category.

**Value**

NULL, but makes available a list with metadata

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

Wellcome Trust Sanger Institute

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|                   |                                                                   |
|-------------------|-------------------------------------------------------------------|
| extra_mouse_genes | <i>Additional mouse genes that are used in feature extraction</i> |
|-------------------|-------------------------------------------------------------------|

---

**Description**

This list contains mouse genes that are used for feature extraction of biological features

**Usage**

```
extra_mouse_genes
```

**Format**

a list containing vectors of genes. Name indicates which GO category.

**Value**

NULL, but makes available a list with metadata

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

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|                    |                                               |
|--------------------|-----------------------------------------------|
| feature_generation | <i>Helper Function to create all features</i> |
|--------------------|-----------------------------------------------|

---

**Description**

Helper Function to create all features

**Usage**

```
feature_generation(counts_nm, read_metrics, GO_terms, extra_genes, organism)
```

**Arguments**

|              |                                                                                                   |
|--------------|---------------------------------------------------------------------------------------------------|
| counts_nm    | Gene expression counts dataframe (genes x cells). Either normalised by library size or TPM values |
| read_metrics | Dataframe with mapping statistics produced by python pipeline                                     |
| GO_terms     | DataFrame with gene ontology term IDs, that will be used in feature extraction                    |
| extra_genes  | Additional genes used for feature extraction                                                      |
| organism     | The target organism to generate the features for                                                  |

**Value**

Returns the entire set of features in a data.frame

---

|              |                                                                                                                                                          |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| feature_info | <i>Information which genes and GO categories should be included as features. Also defines which features are cell-type independent (common features)</i> |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|

---

**Description**

This list contains metadata information that is used to extract features from in the function `extract_features`

**Usage**

```
feature_info
```

**Format**

a list with 2 elements (GO\_terms,common\_features).

**Value**

NULL, but makes available a list with metadata

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

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|               |                                                                                   |
|---------------|-----------------------------------------------------------------------------------|
| mES1_features | <i>Real test dataset containing all and common features from the paper (mES1)</i> |
|---------------|-----------------------------------------------------------------------------------|

---

**Description**

This list contains 2 dataframes where each contains features per cell (cell X features) that can be used for classification.

**Usage**

```
mES1_features
```

**Format**

a list with 2 elements (all\_features, common\_features).

**Value**

NULL, but makes available a list with 2 dataframes

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

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|             |                                                         |
|-------------|---------------------------------------------------------|
| mES1_labels | <i>Real test dataset containing annotation of cells</i> |
|-------------|---------------------------------------------------------|

---

**Description**

This data frame has 2 columns: First showing cell names, the second indicating if cell is of low (0) or high (1) quality

**Usage**

mES1\_labels

**Format**

a dataframe with 2 columns (cell\_names, label).

**Value**

NULL, but makes available a dataframe with cell annotations

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

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|           |                                                                 |
|-----------|-----------------------------------------------------------------|
| multiplot | <i>Internal multiplot function to combine plots onto a grid</i> |
|-----------|-----------------------------------------------------------------|

---

### Description

Internal multiplot function to combine plots onto a grid

### Usage

```
multiplot(..., plotlist = NULL, file, cols = 6, layout = NULL)
```

### Arguments

|          |                                                             |
|----------|-------------------------------------------------------------|
| ...      | individual plots to combine into a single plot              |
| plotlist | a vector with names of plots to use in the plot             |
| file     | string giving filename to which pdf of plots is to be saved |
| cols     | integer giving number of columns for the plot               |
| layout   | matrix defining the layout for the plots                    |

### Value

a plot object

---

|                     |                                                       |
|---------------------|-------------------------------------------------------|
| normalise_by_factor | <i>Internal function to normalize by library size</i> |
|---------------------|-------------------------------------------------------|

---

### Description

Internal function to normalize by library size

### Usage

```
normalise_by_factor(counts, norm_factor)
```

### Arguments

|             |                                 |
|-------------|---------------------------------|
| counts      | matrix of counts                |
| norm_factor | vector of normalisation factors |

### Value

a matrix with normalized gene counts

**Examples**

```
data(sample_counts)
data(sample_stats)
sample_counts_nm <- normalise_by_factor(sample_counts, colSums(sample_counts))
```

---

|               |                                               |
|---------------|-----------------------------------------------|
| param_mES_all | <i>Parameters used for SVM classification</i> |
|---------------|-----------------------------------------------|

---

**Description**

This data frame has 3 columns: gamma, cost, class.weights and is optimised for all features and our training data

**Usage**

```
param_mES_all
```

**Format**

a dataframe with 3 columns (gamma, cost, class.weights).

**Value**

NULL, but makes available a dataframe with parameters

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

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|                  |                                               |
|------------------|-----------------------------------------------|
| param_mES_common | <i>Parameters used for SVM classification</i> |
|------------------|-----------------------------------------------|

---

**Description**

This data frame has 3 columns: gamma, cost, class.weights and is optimised for common features and our training data

**Usage**

```
param_mES_common
```

**Format**

a dataframe with 3 columns (gamma, cost, class.weights).

**Value**

NULL, but makes available a dataframe with parameters

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

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|          |                                                                                                 |
|----------|-------------------------------------------------------------------------------------------------|
| plot_pca | <i>Plots PCA of all features. Colors high and low quality cells based on outlier detection.</i> |
|----------|-------------------------------------------------------------------------------------------------|

---

**Description**

Plots PCA of all features. Colors high and low quality cells based on outlier detection.

**Usage**

```
plot_pca(features, annot, pca, col, output_file)
```

**Arguments**

|             |                                                                  |
|-------------|------------------------------------------------------------------|
| features    | Input dataset containing features (cell x features)              |
| annot       | Matrix annotation of each cell                                   |
| pca         | PCA of features                                                  |
| col         | color code indicating what color high and what low quality cells |
| output_file | where plot is stored                                             |

**Details**

This function plots PCA of all features + most informative features

**Value**

Plots of PCA

---

|               |                                                        |
|---------------|--------------------------------------------------------|
| sample_counts | <i>Sample gene expression data containing 40 cells</i> |
|---------------|--------------------------------------------------------|

---

**Description**

This data frame contains genes (rows) and cells (columns) showing raw read counts

**Usage**

```
sample_counts
```

**Format**

a dataframe with genes x cells

**Value**

NULL, but makes available a dataframe with raw read counts

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

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---

|              |                                                        |
|--------------|--------------------------------------------------------|
| sample_stats | <i>Sample read statistics data containing 40 cells</i> |
|--------------|--------------------------------------------------------|

---

**Description**

This data frame contains read metrics (columns) and cells (rows)

**Usage**

```
sample_stats
```

**Format**

a dataframe with cells x metrics

**Value**

NULL, but makes available a dataframe with read statistics

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

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simple\_cap

*Converts all first letters to capital letters*

---

**Description**

Converts all first letters to capital letters

**Usage**

```
simple_cap(x)
```

**Arguments**

x                      string

**Value**

a character vector in title case

---

sum\_prop

*Sums up normalised values of genes to groups.*

---

**Description**

Supports TPM and proportion of mapped reads.

**Usage**

```
sum_prop(counts, genes_interest)
```

**Arguments**

counts                      Normalised gene expression count matrix  
genes\_interest      dataframe of genes of interest to merge

**Value**

a vector of sums per group

---

|                       |                                                                                                   |
|-----------------------|---------------------------------------------------------------------------------------------------|
| training_mES_features | <i>Original training dataset containing all and common features from the paper (training mES)</i> |
|-----------------------|---------------------------------------------------------------------------------------------------|

---

**Description**

This list contains 2 dataframes where each contains features per cell (cell X features) that can be used for classification.

**Usage**

```
training_mES_features
```

**Format**

a list with 2 elements (all\_features, common\_features).

**Value**

NULL, but makes available a list with 2 dataframes

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

Wellcome Trust Sanger Institute

---

|                     |                                                                 |
|---------------------|-----------------------------------------------------------------|
| training_mES_labels | <i>Original training dataset containing annotation of cells</i> |
|---------------------|-----------------------------------------------------------------|

---

**Description**

This data frame has 2 columns: First showing cell names, the second indicating if cell is of low (0) or high (1) quality

**Usage**

```
training_mES_labels
```

**Format**

a dataframe with 2 columns (cell\_names, label).

**Value**

NULL, but makes available a dataframe with cell annotations

**Author(s)**

Tomislav Ilicic & Davis McCarthy, 2015-03-05

**Source**

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|          |                                                                                                                        |
|----------|------------------------------------------------------------------------------------------------------------------------|
| uni.plot | <i>Internal function to detect outliers from the mvoutlier package Modified slightly so that plots are not printed</i> |
|----------|------------------------------------------------------------------------------------------------------------------------|

---

**Description**

Internal function to detect outliers from the mvoutlier package Modified slightly so that plots are not printed

**Usage**

```
uni.plot(x, symb = FALSE, quan = 1/2, alpha = 0.025)
```

**Arguments**

|       |                            |
|-------|----------------------------|
| x     | A matrix containing counts |
| symb  | Symbols                    |
| quan  | quan                       |
| alpha | alpha                      |

**Value**

a list of outlier indicators

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