

# Package ‘mdp’

May 20, 2024

**Title** Molecular Degree of Perturbation calculates scores for transcriptome data samples based on their perturbation from controls

**Version** 1.24.0

**Description** The Molecular Degree of Perturbation webtool quantifies the heterogeneity of samples. It takes a data.frame of omic data that contains at least two classes (control and test) and assigns a score to all samples based on how perturbed they are compared to the controls. It is based on the Molecular Distance to Health (Pankla et al. 2009), and expands on this algorithm by adding the options to calculate the z-score using the modified z-score (using median absolute deviation), change the z-score zeroing threshold, and look at genes that are most perturbed in the test versus control classes.

**URL** <https://mdp.sysbio.tools/>

**biocViews** BiomedicalInformatics, QualityControl, Transcriptomics, SystemsBiology, Microarray, QualityControl

**Depends** R (>= 4.0)

**License** GPL-3

**Encoding** UTF-8

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**RoxygenNote** 7.1.1

**Imports** ggplot2, gridExtra, grid, stats, utils

**Suggests** testthat, knitr, rmarkdown, fgsea, BiocManager

**VignetteBuilder** knitr

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|                    |  |
|--------------------|--|
| compute_gene_score | <i>Compute gene score Computes gene scores for each gene within each class and perturbation freq</i> |
|--------------------|--|

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## Description

Compute gene score Computes gene scores for each gene within each class and perturbation freq

## Usage

```
compute_gene_score(zscore, pdata, control_lab,
  score_type = c("gene_score", "gene_freq"))
```

## Arguments

|             |  |
|-------------|--|
| zscore      | zscore data frame  |
| pdata       | phenotypic data with Class and Sample columns                            |
| control_lab | character specifying control class                                       |
| score_type  | set to 'gene_score' or 'gene_freq' to compute gene scores or frequencies |

## Value

data frame of gene scores or gene frequencies

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`compute_perturbed_genes`

*Compute perturbed genes Find the top fraction of genes that are more perturbed in test versus controls*

---

**Description**

Compute perturbed genes Find the top fraction of genes that are more perturbed in test versus controls

**Usage**

```
compute_perturbed_genes(gmdp_results, control_lab, fraction_genes)
```

**Arguments**

`gmdp_results` results table of gene scores  
`control_lab` label specifying control class  
`fraction_genes` fraction of top perturbed genes that will make the set of perturbed genes

**Value**

vector of perturbed genes

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`compute_sample_scores` *Compute sample scores for each pathway*

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**Description**

Compute sample scores for each pathway

**Usage**

```
compute_sample_scores(zscore, perturbed_genes, control_samples,  
test_samples, pathways, pdata)
```

**Arguments**

`zscore` zscore data frame  
`perturbed_genes` list of pertured genes  
`control_samples` vector of control sample names  
`test_samples` vector of test sample names  
`pathways` list of pathways  
`pdata` phenotypic data with Sample and Class columns

**Value**

data frame of sample scores

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|                |   |
|----------------|---|
| compute_zscore | <i>Computes the thresholded Z score Plots the Z score using control samples to compute the average and standard deviation</i> |
|----------------|---|

---

**Description**

Computes the thresholded Z score Plots the Z score using control samples to compute the average and standard deviation

**Usage**

```
compute_zscore(data, control_samples, measure = c("mean", "median"),
  std = 2)
```

**Arguments**

|                 |   |
|-----------------|---|
| data            | Gene expression data with gene symbols in rows, sample names in columns   |
| control_samples | Character vector specifying the control sample names  |
| measure         | Either 'mean' or 'median'. 'mean' uses mean and standard deviation. 'median' uses the median and the median absolute deviation to estimate the standard deviation (modified z-score). |
| std             | Set as default to 2. This controls the standard deviation threshold for the Z-score calculation. #' Normalised expression values less than 'std' will be set to 0.                    |

**Value**

zscore data frame

**Examples**

```
control_samples <- example_pheno$Sample[example_pheno$Class == 'baseline']
compute_zscore(example_data, control_samples, 'median', 2)
```

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|              |                                |
|--------------|--------------------------------|
| example_data | <i>Expression data example</i> |
|--------------|--------------------------------|

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**Description**

**rownames** HGNC gene names

**colnames** sample expression data ...

**Usage**

example\_data

**Format**

A data frame with 13838 rows and 40 variables:

**Details**

Author expression data for GEO dataset GSE17156 of transcriptome blood samples from patients that were inoculated with the RSV virus that has been altered by collapsing for HGNC gene symbols.

**Source**

<https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE17156>

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|               |                                |
|---------------|--------------------------------|
| example_pheno | <i>Phenotypic data example</i> |
|---------------|--------------------------------|

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**Description**

Subset of the annotation data for GEO dataset GSE17156, using only patients that have been inoculated with the RSV virus

**Usage**

example\_pheno

**Format**

A data frame with 40 rows and 2 variables:

**Sample** GSM identified

**Class** Symptomatic state ...

**Source**

<https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE17156>

mdp

*Molecular Degree of Perturbation***Description**

Based on the Molecular Distance to Health, this function calculates scores to each sample based on their perturbation from healthy

**Usage**

```
mdp(data, pdata, control_lab, directory = "", pathways, print = TRUE,
     measure = c("mean", "median"), std = 2, fraction_genes = 0.25,
     save_tables = TRUE, file_name = "")
```

**Arguments**

|                |   |
|----------------|---|
| data           | data frame of gene expression data with the gene symbols in the row names   |
| pdata          | data frame of phenodata with a column headed Class and the other headed Sample.   |
| control_lab    | character vector specifying the control class   |
| directory      | (optional) character string of output directory   |
| pathways       | (optional) list whose names are pathways and elements are genes in the pathway. see details section for more information  |
| print          | set as default to TRUE for pdfs of the sample scores to be saved  |
| measure        | 'medan' as default, can change to 'median'. mean will select for z-score and median will select for modified z-score. (see details)                             |
| std            | numeric set as default to 2, this governs the thresholding of expression data. z-scored expression values with absolute value less than 'std' will be set to 0. |
| fraction_genes | numeric fraction of genes that will contribute to the top perturbed genes. Set as default to 0.25   |
| save_tables    | Set as default to TRUE. Tables of zscore and gene and sample scores will be saved.  |
| file_name      | (optional) character string that will be added to the saved file names  |

**Value**

A list: zscore, gene\_scores, gene\_freq, sample\_scores, perturbed\_genes

- Z-score - z-score is calculated using the control samples to compute the average and the standard deviation. The absolute value of this matrix is taken and values less than the std are set to zero. This z-score data frame is used to compute the gene and sample scores.
- Gene scores - mean z-score value for each gene in each class
- Gene frequency - frequency with which a gene has a non zero z-score value in each class

- Sample scores - list containing sample scores for different genesets. Sample scores are the sum of the z-scored gene values for each sample, averaged for the number of genes in that geneset.
- Perturbed genes - vector of the top fraction of genes that have higher gene scores in the test classes compared to the control.
- Pathways - if genesets are provided, they are ranked according to the signal-to-noise #' ratio of test sample scores versus control sample scores calculated using that geneset.

### Loading pathways

a list of pathways can be loaded from a .gmt file using the fgsea function using `fgsea::gmtPathways('gmt.file.location')`

### Selecting mean or median

if median is selected, the z-score will be calculated using the median, and the standard deviation will be estimated using the median absolute deviation, utilising the `mad` function.

### Examples

```
# basic run
mdp(example_data, example_pheno, 'baseline')
# run with pathways
pathway_file <- system.file('extdata', 'ReactomePathways.gmt',
package = 'mdp')
mypathway <- fgsea::gmtPathways(pathway_file) # load a gmt file
mdp(data=example_data, pdata=example_pheno, control_lab='baseline',
pathways=mypathway)
```

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|                 |  |
|-----------------|--|
| pathway_summary | <i>print pathways generates a summary plot for pathways and sample score plot of best gene set</i> |
|-----------------|--|

---

### Description

print pathways generates a summary plot for pathways and sample score plot of best gene set

### Usage

```
pathway_summary(sample_results, path, file_name, control_samples,
control_lab)
```

### Arguments

|                 |  |
|-----------------|--|
| sample_results  | list of sample scores for each geneset |
| path            | directory to save images               |
| file_name       | name of saved imaged                   |
| control_samples | list of control sample names           |
| control_lab     | label that specifies control class     |

**Value**

data frame of signal to noise ratio of control vc test sample scores for each pathway

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|             |                             |
|-------------|-----------------------------|
| sample_data | <i>Sample score results</i> |
|-------------|-----------------------------|

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**Description**

Resultant sample scores when the mdp is applied to example\_data and example\_pheno

**Usage**

```
sample_data
```

**Format**

A data frame with 40 rows and 3 variables:

**Sample** GSM identified

**Score** Sample score

**Class** Sympomatic state ...

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|             |  |
|-------------|--|
| sample_plot | <i>Plot sample scores Plots the sample scores data.frame for a given geneset. Data frame must have Score, Sample and Class columns</i> |
|-------------|--|

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**Description**

Plot sample scores Plots the sample scores data.frame for a given geneset. Data frame must have Score, Sample and Class columns

**Usage**

```
sample_plot(sample_data, filename = "", directory = "", title = "",
  print = TRUE, display = TRUE, control_lab)
```

**Arguments**

|             |  |
|-------------|--|
| sample_data | data frame of sample score information for a geneset. Must have columns 'Sample', 'Score' and 'Class'    |
| filename    | (optional) character string that will be added to the saved pdf filename                                 |
| directory   | (optional) character string of directory to save file  |
| title       | (optional) character string of title name for graph  |
| print       | (default TRUE) Save as a pdf file  |
| display     | (default TRUE) Display plot  |
| control_lab | (optional) character string Specifying control_lab will set the control class as light blue as a default |



*sample\_plot*

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**Value**

generates a plot of the sample scores

**Examples**

```
sample_plot(sample_data = sample_data, control_lab = 'baseline')
```

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