

# Package ‘scTreeViz’

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**Type** Package

**Title** R/Bioconductor package to interactively explore and visualize single cell RNA-seq datasets with hierarchical annotations

**Version** 1.15.0

**Description** scTreeViz provides classes to support interactive data aggregation and visualization of single cell RNA-seq datasets with hierarchies for e.g. cell clusters at different resolutions. The `TreeIndex` class provides methods to manage hierarchy and split the tree at a given resolution or across resolutions. The `TreeViz` class extends `SummarizedExperiment` and can perform quick aggregations on the count matrix defined by clusters.

**License** Artistic-2.0

**Depends** R (>= 4.0), methods, epivizr, SummarizedExperiment

**Imports** data.table, S4Vectors, digest, Matrix, Rtsne, httr, igraph, clustree, scran, sys, epivizrData, epivizrServer, ggraph, scater, Seurat, SingleCellExperiment, ggplot2, stats, utils

**Suggests** knitr, BiocStyle, testthat, SC3, scRNAseq, rmarkdown, msd16s, metagenomeSeq, epivizrStandalone, GenomeInfoDb

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'TreeViz-methods.R' 'startTreeViz.R' 'TreeVizApp-class.R'  
'EpivizTreeData-class.R' 'helper-functions.R'  
'ClusterHierarchy-class.R'

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---

`.generate_hierarchy_tree`

*generate hierarchy tree*

---

### Description

generate hierarchy tree

### Usage

```
.generate_hierarchy_tree(hierarchy, feature_order)
```

### Arguments

`hierarchy` hierarchy as a `data.table`  
`feature_order` order of the tree if different from `colnames`

### Value

a data frame object

---

`.generate_leaf_of_table`  
*generate leaf of table*

---

### Description

generate leaf of table

### Usage

```
.generate_leaf_of_table(  
  hierarchy_tree,  
  node_ids_table,  
  nodes_table,  
  feature_order  
)
```

### Arguments

`hierarchy_tree` hierarchy as a data.table  
`node_ids_table` node ids  
`nodes_table` nodes table  
`feature_order` order of the tree if different from colnames

### Value

a data frame object

---

`.generate_nodes_table` *generate nodes table tree*

---

### Description

generate nodes table tree

### Usage

```
.generate_nodes_table(hierarchy_tree, node_ids_table, feature_order)
```

### Arguments

`hierarchy_tree` hierarchy as a data.table  
`node_ids_table` node ids  
`feature_order` order of the tree if different from colnames

### Value

a data frame object

---

`.generate_node_ids`     *generate node ids in the tree*

---

### **Description**

generate node ids in the tree

### **Usage**

```
.generate_node_ids(hierarchy_tree, feature_order)
```

### **Arguments**

`hierarchy_tree`     hierarchy as a data.table

`feature_order`     order of the tree if different from colnames

### **Value**

a data frame object

---

`.replaceNAFeatures`     *replace if there are NA's in the hierarchy*

---

### **Description**

replace if there are NA's in the hierarchy

### **Usage**

```
.replaceNAFeatures(replacing_na_obj_fData, feature_order)
```

### **Arguments**

`replacing_na_obj_fData`  
                             hierarchy data table

`feature_order`     order of the tree if different from colnames

### **Value**

a data frame object

---

|                  |   |
|------------------|---|
| ClusterHierarchy | <i>Creates a new ClusterHierarchy object.</i> |
|------------------|---|

---

**Description**

Works as a validation check for multiple issues user passed dataframe might have. For example, multiple root nodes, incompatible naming, multiple parents of a single node, etc This function performs all this checks and tries to resolve the issues by making changes in cluster assignment User can give either col\_regex or columns option to filter the columns or specify the column order

**Usage**

```
ClusterHierarchy(hierarchy, col_regex = NULL, columns = NULL)
```

**Arguments**

|           |  |
|-----------|--|
| hierarchy | hierarchy as a dataframe                                       |
| col_regex | Regular Expression for choosing columns                        |
| columns   | Vector containing list of columns to choose from with ordering |

**Value**

‘ClusterHierarchy‘ return an object of class ClusterHierarchy containing cluster information that ensures a valid dataframe for treviz input

**Examples**

```
n=64
# create a hierarchy
df<- data.frame(cluster0=rep(1,n))
for(i in seq(1,5)){
  df[[paste0("cluster",i)]]<- rep(seq(1:(2**i)),each=ceiling(n/(2**i)),len=n)
}
clus_hier<-ClusterHierarchy(df, col_regex = "clus")
```

---

ClusterHierarchy-class

*ClusterHierarchy class to manage treviz cluster data*

---

**Description**

ClusterHierarchy class to manage treviz cluster data

---

|               |   |
|---------------|---|
| createFromSCE | <i>Creates a ‘TreeViz‘ object from ‘SingleCellExperiment‘. Generates clusters based on Walktrap algorithm if no default is provided</i> |
|---------------|---|

---

### Description

Creates a ‘TreeViz‘ object from ‘SingleCellExperiment‘. Generates clusters based on Walktrap algorithm if no default is provided

### Usage

```
createFromSCE(
  object,
  check_coldata = FALSE,
  col_regex = NULL,
  columns = NULL,
  reduced_dim = c("TSNE")
)
```

### Arguments

|               |   |
|---------------|---|
| object        | ‘SingleCellExperiment‘ object to be visualized  |
| check_coldata | whether to colData of ‘SingleCellExperiment‘ object for cluster information or not  |
| col_regex     | common regular expression shared across all columns with cluster information  |
| columns       | vector containing columns with cluster information  |
| reduced_dim   | Vector of Dimensionality reduction information provided in ‘SingleCellExperiment‘ object to be added in ‘TreeViz‘ (if exists) |

### Value

‘TreeViz‘ Object

### Examples

```
library(SingleCellExperiment)
library(scater)
sce <- mockSCE()
sce <- logNormCounts(sce)
sce <- runTSNE(sce)
sce <- runUMAP(sce)
set.seed(1000)
for (i in seq_len(5)) {
  clust.kmeans <- kmeans(reducedDim(sce, "TSNE"), centers = i)
  sce[[paste0("clust", i)]] <- factor(clust.kmeans$cluster)
}
treeviz <- createFromSCE(sce, check_coldata = TRUE, col_regex = "clust", reduced_dim = c("TSNE", "UMAP"))
```

---

createFromSeurat      *Creates a 'TreeViz' object from 'Seurat'*

---

### Description

Creates a 'TreeViz' object from 'Seurat'

### Usage

```
createFromSeurat(
  object,
  check_metadata = FALSE,
  col_regex = "*snn*",
  columns = NULL,
  reduced_dim = c("TSNE")
)
```

### Arguments

|                |   |
|----------------|---|
| object         | 'Seurat' class containing cluster information at different resolutions  |
| check_metadata | whether to metaData of 'Seurat' object for cluster information or not   |
| col_regex      | common regular expression shared across all columns with cluster information                                    |
| columns        | vector containing columns with cluster information  |
| reduced_dim    | Vector of Dimensionality reduction information provided in 'Seurat' object to be added in 'TreeViz' (if exists) |

### Value

'TreeViz' Object

### Examples

```
library(Seurat)
data(pbmc_small)
pbmc <- pbmc_small
treeviz<- createFromSeurat(pbmc, check_metadata = TRUE, reduced_dim = c("pca","tsne"))
```

---

createTreeViz      *Creates 'TreeViz' object from hierarchy and count matrix*

---

### Description

Provided with a count matrix and a dataframe or 'ClusterHierarchy' object, this module runs the necessary checks on the dataframe and tries to convert it to a tree by making necessary changes. Returns the 'TreeViz' object if a tree is successfully generated from dataframe, throws error otherwise

### Usage

```
createTreeViz(clusters, counts)
```

**Arguments**

**clusters** 'ClusterHierarchy' object or a dataframe containing cluster information at different resolutions

**counts** matrix Dense or sparse matrix containing the count matrix

**Value**

'TreeViz' Object

**Examples**

```
n=64
# create a hierarchy
df<- data.frame(cluster0=rep(1,n))
for(i in seq_len(5)){
  df[[paste0("cluster",i)]]<- rep(seq(1:(2**i)),each=ceiling(n/(2**i)),len=n)
}
# generate a count matrix
counts <- matrix(rpois(6400, lambda = 10), ncol=n, nrow=100)
colnames(counts)<- seq_len(64)
# create a `TreeViz` object
treeViz <- createTreeViz(df, counts)
```

---

EpivizTreeData-class *Data container for MRExperiment objects*

---

**Description**

Used to serve hierarchical data (used in e.g., icicle plots and heatmaps).

**Methods**

`df_to_tree(root, df)` Helper function to recursively build nested response for `getHierarchy`

**root** Root of subtree

**df** data.frame containing children to process

`get_default_chart_type()` Get name of default chart type for this data type

`get_measurements()` Get description of measurements served by this object

`getCombined(measurements = NULL, seqName, start = 1, end = 1000, order = NULL, nodeSelection = NULL, selectedLevels)`  
Return the counts aggregated to selected nodes for the given samples

**measurements** Samples to get counts for

**seqName** name of datasource

**start** Start of feature range to query

**end** End of feature range to query

**order** Ordering of nodes

**nodeSelection** Node-id and selectionType pairs

**selectedLevels** Current aggregation level

`getHierarchy(nodeId = NULL)` Retrieve feature hierarchy information for subtree with specified root



**nodeId** Feature identifier with level info

getReducedDim(method = NULL, gene = NULL) Compute PCA over all features for given samples

**method** which dimension to access

**gene** send expression of a gene back with the dimensions

getRows( measurements = NULL, start = 1, end = 1000, selectedLevels = 3, selections = NULL )  
Return the sample annotation and features within the specified range and level for a given sample and features

**measurements** Samples to retrieve for

**start** Start of feature range to query

**end** End of feature range to query

**selections** Node-id and selectionType pairs

**selectedLevels** Current aggregation level

propagateHierarchyChanges( selection = NULL, order = NULL, selectedLevels = NULL, request\_with\_labels )  
Update internal state for hierarchy

**selection** Node-id and selectionType pairs

**order** Ordering of features

**selectedLevels** Current aggregation level

**request\_with\_labels** For handling requests using fData entries from MRexperiment

row\_to\_dict(row) Helper function to format each node entry for getHierarchy response

**row** Information for current node.

searchTaxonomy(query = NULL, max\_results = 15) Return list of features matching a text-based query

**query** String of feature for which to search

**max\_results** Maximum results to return

---

|               |   |
|---------------|---|
| set_gene_list | <i>Sets gene list for visualization</i> |
|---------------|---|

---

## Description

Sets gene list for visualization

## Usage

```
set_gene_list(treeviz, genes)
```

## Arguments

|         |                      |
|---------|----------------------|
| treeviz | TreeViz object       |
| genes   | list of genes to use |

## Value

TreeViz object set with gene list

---

show,TreeViz-method    *show object*

---

### Description

show object  
 Method to aggregate a TreeViz object  
 Method to aggregate a TreeViz object  
 Generic method to register data to the epviz data server  
 plot tree from TreeViz

### Usage

```
## S4 method for signature 'TreeViz'
show(object)

aggregateTree(x, ...)

## S4 method for signature 'TreeViz'
aggregateTree(
  x,
  selectedLevel = 3,
  selectedNodes = NULL,
  aggFun = colSums,
  start = 1,
  end = NULL,
  by = "row",
  format = "TreeViz"
)

## S4 method for signature 'TreeViz'
register(object, tree = "row", columns = NULL, ...)

## S4 method for signature 'TreeViz,ANY'
plot(x, y)
```

### Arguments

|               |  |
|---------------|--|
| object        | The object to register to data server  |
| x             | treeviz object   |
| ...           | Additional arguments passed to object constructors                                   |
| selectedLevel | level to select nodes from   |
| selectedNodes | used to set states on individual nodes to define a cut on the tree                   |
| aggFun        | aggregate function to use, by default colSums if by="row", rowSums if by="col"       |
| start, end    | indices to filter nodes  |
| by            | "row" to aggregate the TreeIndex on rowData, "col" to aggregate TreeIndex on colData |

|         |   |
|---------|---|
| format  | return format can be one of "counts" or "TreeViz"           |
| tree    | Is tree over rows or columns of the object (default: "row") |
| columns | Name of columns containing data to register                 |
| y       | none  |

### Value

describe a `TreeIndex` object

a generic

a `Treeviz` object or type specified by format

An `EpivizTreeData-class` object

Dataframe containing cluster information at different resolutions

### Functions

- `show, TreeViz-method`:
- `aggregateTree`:
- `aggregateTree, TreeViz-method`:
- `register, TreeViz-method`:
- `plot, TreeViz, ANY-method`:

### Examples

```
library(metagenomeSeq)
data(mouseData)
counts <- MRcounts(mouseData)
hierarchy <- fData(mouseData)
tree <- TreeIndex(hierarchy)
mbiome <- TreeViz(SimpleList(counts=counts), rowData=tree)
aggregateTree(mbiome)
```

```
library(metagenomeSeq)
data(mouseData)
counts <- MRcounts(mouseData)
hierarchy <- fData(mouseData)
tree <- TreeIndex(hierarchy)
mbiome <- TreeViz(SimpleList(counts=counts), rowData=tree)
aggregateTree(mbiome)
```

```
library(metagenomeSeq)
data(mouseData)
counts <- MRcounts(mouseData)
hierarchy <- fData(mouseData)
tree <- TreeIndex(hierarchy)
mbiome <- TreeViz(SimpleList(counts=counts), rowData=tree)
plot(mbiome)
```

---

|              |  |
|--------------|--|
| startTreeviz | Start treeviz app and create <a href="#">TreeVizApp</a> object to manage connection. |
|--------------|--|

---

### Description

Start treeviz app and create [TreeVizApp](#) object to manage connection.

### Usage

```
startTreeviz(  
  data = NULL,  
  genes = NULL,  
  top_genes = 100,  
  host = "http://epiviz.cbcb.umd.edu/treeviz",  
  register_function = .register_all_treeviz_things,  
  delay = 2L,  
  ...  
)
```

### Arguments

|                   |   |
|-------------------|---|
| data              | TreeViz object to explore   |
| genes             | (character vector) genes (rownames) to include in heatmap                   |
| top_genes         | (integer) number of top variable genes to include in the heatmap            |
| host              | (character) host address to launch.   |
| register_function | (function) function used to register actions and charts on the treeviz app. |
| delay             | (integer) number of seconds to wait for application to load in browser      |
| ...               | additional parameters passed to <a href="#">startEpiviz</a> .               |

### Value

An object of class [TreeVizApp](#)

### See Also

[TreeVizApp](#)

### Examples

```
# see package vignette for example usage  
app <- startTreeviz(non_interactive=TRUE, open_browser=FALSE)  
app$stop_app()
```

---

TreeIndex                    *create a new TreeIndex object*

---

**Description**

create a new TreeIndex object

**Usage**

```
TreeIndex(hierarchy = NULL, feature_order = NULL)
```

**Arguments**

hierarchy            hierarchy as a data.table  
feature\_order        order of the tree if different from colnames

**Value**

a 'TreeIndex' object

**Examples**

```
library(metagenomeSeq)
data(mouseData)
counts <- MRcounts(mouseData)
hierarchy <- fData(mouseData)
tree <- TreeIndex(hierarchy)
```

---

TreeIndex-class            *TreeIndex class to manage and query hierarchical data*

---

**Description**

TreeIndex class to manage and query hierarchical data

---

TreeViz                    *The TreeViz class.*

---

**Description**

SummarizedExperiment-like class for datasets that have hierarchies on either rowData or colData. For microbiome data, rowData is a tree hierarchy For single cell data, colData is a tree hierarchy

**Usage**

```
TreeViz(assays = SimpleList(), rowData = NULL, colData = NULL, ...)
```

**Arguments**

|         |   |
|---------|---|
| assays  | simple list of counts                     |
| rowData | rowData                                   |
| colData | colData                                   |
| ...     | other parameters for SummarizedExperiment |

**Value**

a 'TreeViz' object

**Examples**

```
library(metagenomeSeq)
data(mouseData)
counts <- MRcounts(mouseData)
hierarchy <- fData(mouseData)
tree <- TreeIndex(hierarchy)
mbiome <- TreeViz(SimpleList(counts=counts), rowData=tree)
```

---

TreeViz-class

*TreeViz class wrapper for SummarizedExperiment objects*

---

**Description**

TreeViz class wrapper for SummarizedExperiment objects

---

TreeVizApp-class

*Class managing connection to metaviz application.*

---

**Description**

Class managing connection to metaviz application.

**Methods**

`plotGene(gene = NULL, datasource_name = "SCRNA_1")` Plot a bar plot for a gene across cell types

**gene** gene to extract expression values

**datasource\_name** object to extract from (automatically selected)

---

[,TreeIndex,ANY,ANY,ANY-method  
*Subset TreeIndex*

---

## Description

Subset TreeIndex

Generic method to get nodes at a tree level

Method to get nodes at a tree level

Generic method for possible node states

Method to get possible node states a node state is 0 if removed, 1 if expanded to show children & 2 if counts are aggregated to the node

Generic method to split the tree

splitAt divides the TreeIndex into groups defined by the level, node selections and filters(start, end)

Show the TreeIndex object

## Usage

```
## S4 method for signature 'TreeIndex,ANY,ANY,ANY'
x[i, j, ..., drop = FALSE]
```

```
getNodeNodes(x, ...)
```

```
## S4 method for signature 'TreeIndex'
getNodeNodes(x, selectedLevel = NULL)
```

```
getNodeStates(x)
```

```
## S4 method for signature 'TreeIndex'
getNodeStates(x)
```

```
splitAt(x, ...)
```

```
## S4 method for signature 'TreeIndex'
splitAt(
  x,
  selectedLevel = 3,
  selectedNodes = NULL,
  start = 1,
  end = NULL,
  format = "list"
)
```

```
## S4 method for signature 'TreeIndex'
show(object)
```

**Arguments**

|               |  |
|---------------|--|
| x             | TreeIndex object   |
| i, j          | indices to subset or keep  |
| ...           | other parameters   |
| drop          | drop the dimensions of the object. defaults to FALSE               |
| selectedLevel | tree level to select nodes from                                    |
| selectedNodes | used to set states on individual nodes to define a cut on the tree |
| start, end    | indices to filter nodes by   |
| format        | return format can be one of "list" or "TreeIndex"                  |
| object        | TreeIndex object   |

**Value**

a 'TreeIndex' subset object  
 a generic  
 levels at node cut  
 node state  
 node states  
 a generic  
 a 'TreeIndex' object or type set in format  
 object description of the 'TreeIndex' object

**Examples**

```
library(metagenomeSeq)
data(mouseData)
counts <- MRcounts(mouseData)
hierarchy <- fData(mouseData)
tree <- TreeIndex(hierarchy)
getNodeStates(tree)
library(metagenomeSeq)
data(mouseData)
counts <- MRcounts(mouseData)
hierarchy <- fData(mouseData)
tree <- TreeIndex(hierarchy)
getNodeStates(tree)
```

```
library(metagenomeSeq)
data(mouseData)
counts <- MRcounts(mouseData)
hierarchy <- fData(mouseData)
tree <- TreeIndex(hierarchy)
splitAt(tree)
```

```
library(metagenomeSeq)
data(mouseData)
counts <- MRcounts(mouseData)
hierarchy <- fData(mouseData)
tree <- TreeIndex(hierarchy)
```



splitAt(tree)

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