Package 'Seurat'

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Title Tools for Single Cell Genomics

Description A toolkit for quality control, analysis, and exploration of single cell RNA sequencing data. 'Seurat' aims to enable users to identify and interpret sources of heterogeneity from single cell transcriptomic measurements, and to integrate diverse types of single cell data. See Satija R, Farrell J, Gennert D, et al (2015) <doi:10.1038/nbt.3192>, Macosko E, Basu A, Satija R, et al (2015) <doi:10.1016/j.cell.2015.05.002>, Stuart T, Butler A, et al (2019) <doi:10.1016/j.cell.2019.05.031>, Hao, Hao, et al (2020) <doi:10.1101/2020.10.12.335331>, Jiang, et al (
tails.

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URL https://satijalab.org/seurat, https://github.com/satijalab/seurat

BugReports https://github.com/satijalab/seurat/issues

Additional_repositories https://satijalab.r-universe.dev,
https://bnprks.r-universe.dev

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`Seurat-package` *Seurat: Tools for Single Cell Genomics*

Description

A toolkit for quality control, analysis, and exploration of single cell RNA sequencing data. 'Seurat' aims to enable users to identify and interpret sources of heterogeneity from single cell transcriptomic measurements, and to integrate diverse types of single cell data. See Satija R, Farrell J, Gennert D, et al (2015) doi:10.1038/nbt.3192, Macosko E, Basu A, Satija R, et al (2015) doi:10.1016/j.cell.2015.05.002, Stuart T, Butler A, et al (2019) doi:10.1016/j.cell.2019.05.031, Hao, Hao, et al (2020) doi:10.1101/2020.10.12.335331, Jiang, et al (2026) for more details.

Package options

Seurat uses the following [options()] to configure behaviour:

`Seurat.memsafe` global option to call gc() after many operations. This can be helpful in cleaning up the memory status of the R session and prevent use of swap space. However, it does add to the computational overhead and setting to FALSE can speed things up if you're working in an environment where RAM availability is not a concern.

`Seurat.warn.umap.uwot` Show warning about the default backend for `RunUMAP` changing from Python UMAP via reticulate to UWOT

`Seurat.checkdots` For functions that have ... as a parameter, this controls the behavior when an item isn't used. Can be one of warn, stop, or silent.

`Seurat.limma.wilcox.msg` Show message about more efficient Wilcoxon Rank Sum test available via the limma package

`Seurat.Rfast2.msg` Show message about more efficient Moran's I function available via the Rfast2 package

`Seurat.warn.vlnplot.split` Show message about changes to default behavior of split/multi violin plots

`Seurat.warn.findmarkers.bpcells.colmajor` Show message about improving memory usage when running FindMarkers with a column-major ordered BPCells IterableMatrix.

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See Also

Useful links:

- https://satijalab.org/seurat
- https://github.com/satijalab/seurat
- Report bugs at https://github.com/satijalab/seurat/issues

AddAzimuthResults *Add Azimuth Results*

Description

Add mapping and prediction scores, UMAP embeddings, and imputed assay (if available) from Azimuth to an existing or new Seurat object

Usage

```
AddAzimuthResults(object = NULL, filename)
```

Arguments

object	A Seurat object
filename	Path to Azimuth mapping scores file

Value

object with Azimuth results added

Examples

```
## Not run:
object <- AddAzimuthResults(object, filename = "azimuth_results.Rds")

## End(Not run)
```

AddModuleScore *Calculate module scores for feature expression programs in single cells*

Description

Calculate the average expression levels of each program (cluster) on single cell level, subtracted by the aggregated expression of control feature sets. All analyzed features are binned based on averaged expression, and the control features are randomly selected from each bin.

Calculate the average expression levels of each program (cluster) on single cell level, subtracted by the aggregated expression of control feature sets. All analyzed features are binned based on averaged expression, and the control features are randomly selected from each bin.

Usage

```
AddModuleScore(object, ...)

## S3 method for class 'Seurat'
AddModuleScore(
  object,
  features,
  pool = NULL,
  nbin = 24,
  ctrl = 100,
  k = FALSE,
  assay = NULL,
  name = "Cluster",
  seed = 1,
  search = FALSE,
  slot = "data",
  ...
)

## S3 method for class 'StdAssay'
AddModuleScore(
  object,
  features,
  kmeans.obj,
  pool = NULL,
  nbin = 24,
  ctrl = 100,
  k = FALSE,
  name = "Cluster",
  seed = 1,
  search = FALSE,
  slot = "data",
  ...
)

## S3 method for class 'Assay'
AddModuleScore(
  object,
  features,
  kmeans.obj,
  pool = NULL,
  nbin = 24,
  ctrl = 100,
  k = FALSE,
  name = "Cluster",
  seed = 1,
  search = FALSE,
  slot = "data",
```

```
  ...
)
```

Arguments

object	Seurat object
...	Extra parameters passed to UpdateSymbolList
features	A list of vectors of features for expression programs; each entry should be a vector of feature names
pool	List of features to check expression levels against, defaults to rownames(x = object)
nbin	Number of bins of aggregate expression levels for all analyzed features
ctrl	Number of control features selected from the same bin per analyzed feature
k	Use feature clusters returned from DoKMeans
assay	Name of assay to use
name	Name for the expression programs; will append a number to the end for each entry in features (eg. if features has three programs, the results will be stored as name1, name2, name3, respectively)
seed	Set a random seed. If NULL, seed is not set.
search	Search for symbol synonyms for features in features that don't match features in object? Searches the HGNC's gene names database; see UpdateSymbolList for more details
slot	Slot to calculate score values off of. Defaults to data slot (i.e log-normalized counts)
kmeans.obj	A DoKMeans output used to define feature clusters when k = TRUE; ignored if k = FALSE.

Value

Returns a Seurat object with module scores added to object meta data; each module is stored as name# for each module program present in features

Returns a Seurat object with module scores added to object meta data; each module is stored as name# for each module program present in features

References

Tirosh et al, Science (2016)

Tirosh et al, Science (2016)

Tirosh et al, Science (2016)

Examples

```
## Not run:
data("pbmc_small")
cd_features <- list(c(
  'CD79B',
  'CD79A',
  'CD19',
  'CD180',
  'CD200',
  'CD3D',
  'CD2',
  'CD3E',
  'CD7',
  'CD8A',
  'CD14',
  'CD1C',
  'CD68',
  'CD9',
  'CD247'
))
pbmc_small <- AddModuleScore(
  object = pbmc_small,
  features = cd_features,
  ctrl = 5,
  name = 'CD_Features'
)
head(x = pbmc_small[])

## End(Not run)
```

AggregateExpression *Aggregated feature expression by identity class*

Description

Returns summed counts ("pseudobulk") for each identity class.

Usage

```
AggregateExpression(
  object,
  assays = NULL,
  features = NULL,
  return.seurat = FALSE,
  group.by = "ident",
  add.ident = NULL,
  normalization.method = "LogNormalize",
  scale.factor = 10000,
```

```
  margin = 1,
  verbose = TRUE,
  ...
)
```

Arguments

object	Seurat object
assays	Which assays to use. Default is all assays
features	Features to analyze. Default is all features in the assay
return.seurat	Whether to return the data as a Seurat object. Default is FALSE
group.by	Category (or vector of categories) for grouping (e.g, ident, replicate, celltype); 'ident' by default To use multiple categories, specify a vector, such as c('ident', 'replicate', 'celltype')
add.ident	(Deprecated). Place an additional label on each cell prior to pseudobulking
normalization.method	Method for normalization, see NormalizeData
scale.factor	Scale factor for normalization, see NormalizeData
margin	Margin to perform CLR normalization, see NormalizeData
verbose	Print messages and show progress bar
...	Arguments to be passed to methods such as CreateSeuratObject

Details

If return.seurat = TRUE, aggregated values are placed in the 'counts' layer of the returned object. The data is then normalized by running NormalizeData on the aggregated counts. ScaleData is then run on the default assay before returning the object.

Value

Returns a matrix with genes as rows, identity classes as columns. If return.seurat is TRUE, returns an object of class Seurat.

Examples

```
## Not run:
data("pbmc_small")
head(AggregateExpression(object = pbmc_small)$RNA)
head(AggregateExpression(object = pbmc_small, group.by = c('ident', 'groups'))$RNA)

## End(Not run)
```

AnchorSet-class *The AnchorSet Class*

Description

The AnchorSet class is an intermediate data storage class that stores the anchors and other related information needed for performing downstream analyses - namely data integration (IntegrateData) and data transfer (TransferData).

Slots

`object.list` List of objects used to create anchors

`reference.cells` List of cell names in the reference dataset - needed when performing data transfer.

`reference.objects` Position of reference object/s in object.list

`query.cells` List of cell names in the query dataset - needed when performing data transfer

`anchors` The anchor matrix. This contains the cell indices of both anchor pair cells, the anchor score, and the index of the original dataset in the object.list for cell1 and cell2 of the anchor.

`offsets` The offsets used to enable cell look up in downstream functions

`weight.reduction` The weight dimensional reduction used to calculate weight matrix

`anchor.features` The features used when performing anchor finding.

`neighbors` List containing Neighbor objects for reuse later (e.g. mapping)

`command` Store log of parameters that were used

AnnotateAnchors *Add info to anchor matrix*

Description

Add info to anchor matrix

Usage

```
AnnotateAnchors(anchors, vars, slot, ...)

## Default S3 method:
AnnotateAnchors(
  anchors,
  vars = NULL,
  slot = NULL,
  object.list,
  assay = NULL,
```

```
  ...
)

## S3 method for class 'IntegrationAnchorSet'
AnnotateAnchors(
  anchors,
  vars = NULL,
  slot = NULL,
  object.list = NULL,
  assay = NULL,
  ...
)

## S3 method for class 'TransferAnchorSet'
AnnotateAnchors(
  anchors,
  vars = NULL,
  slot = NULL,
  reference = NULL,
  query = NULL,
  assay = NULL,
  ...
)
```

Arguments

anchors	An AnchorSet object
vars	Variables to pull for each object via FetchData
slot	Slot to pull feature data for
...	Arguments passed to other methods
object.list	List of Seurat objects
assay	Specify the Assay per object if annotating with expression data
reference	Reference object used in FindTransferAnchors
query	Query object used in FindTransferAnchors

Value

Returns the anchor dataframe with additional columns for annotation metadata

---

as.CellDataSet *Convert objects to CellDataSet objects*

Description

Convert objects to CellDataSet objects

Usage

```
as.CellDataSet(x, ...)

## S3 method for class 'Seurat'
as.CellDataSet(x, assay = NULL, reduction = NULL, ...)
```

Arguments

x	An object to convert to class CellDataSet
...	Arguments passed to other methods
assay	Assay to convert
reduction	Name of DimReduc to set to main reducedDim in cds

---

as.Seurat.CellDataSet *Convert objects to* Seurat *objects*

Description

Convert objects to Seurat objects

Usage

```
## S3 method for class 'CellDataSet'
as.Seurat(x, slot = "counts", assay = "RNA", verbose = TRUE, ...)

## S3 method for class 'SingleCellExperiment'
as.Seurat(
  x,
  counts = "counts",
  data = "logcounts",
  assay = NULL,
  project = "SingleCellExperiment",
  ...
)
```

Arguments

x	An object to convert to class Seurat
slot	Slot to store expression data as
assay	Name of assays to convert; set to NULL for all assays to be converted
verbose	Show progress updates
...	Arguments passed to other methods
counts	name of the SingleCellExperiment assay to store as counts; set to NULL if only normalized data are present
data	name of the SingleCellExperiment assay to slot as data. Set to NULL if only counts are present
project	Project name for new Seurat object

Value

A Seurat object generated from x

See Also

SeuratObject::as.Seurat

---

as.SingleCellExperiment *Convert objects to SingleCellExperiment objects*

Description

Convert objects to SingleCellExperiment objects

Usage

```
as.SingleCellExperiment(x, ...)

## S3 method for class 'Seurat'
as.SingleCellExperiment(x, assay = NULL, ...)
```

Arguments

x	An object to convert to class SingleCellExperiment
...	Arguments passed to other methods
assay	Assays to convert

---

as.sparse.H5Group *Cast to Sparse*

Description

Cast to Sparse

Usage

```
## S3 method for class 'H5Group'
as.sparse(x, ...)

## S3 method for class 'Matrix'
as.data.frame(
  x,
  row.names = NULL,
  optional = FALSE,
  ...,
  stringsAsFactors = getOption(x = "stringsAsFactors", default = FALSE)
)
```

Arguments

x	An object
...	Arguments passed to other methods
row.names	NULL or a character vector giving the row names for the data; missing values are not allowed
optional	logical. If TRUE, setting row names and converting column names (to syntactic names: see make.names) is optional. Note that all of R's **base** package as.data.frame() methods use optional only for column names treatment, basically with the meaning of data.frame(*, check.names = !optional). See also the make.names argument of the matrix method.
stringsAsFactors	logical: should the character vector be converted to a factor?

Value

as.data.frame.Matrix: A data frame representation of the S4 Matrix

See Also

SeuratObject::as.sparse

Assay-class *The Assay Class*

Description

The Assay object is the basic unit of Seurat; for more details, please see the documentation in SeuratObject

See Also

SeuratObject::Assay-class

AugmentPlot *Augments ggplot2-based plot with a PNG image.*

Description

Creates "vector-friendly" plots. Does this by saving a copy of the plot as a PNG file, then adding the PNG image with annotation_raster to a blank plot of the same dimensions as plot. Please note: original legends and axes will be lost during augmentation.

Usage

```
AugmentPlot(plot, width = 10, height = 10, dpi = 100)
```

Arguments

plot	A ggplot object
width, height	Width and height of PNG version of plot
dpi	Plot resolution

Value

A ggplot object

Examples

```
## Not run:
data("pbmc_small")
plot <- DimPlot(object = pbmc_small)
AugmentPlot(plot = plot)

## End(Not run)
```

AutoPointSize *Automagically calculate a point size for ggplot2-based scatter plots*

Description

It happens to look good

Usage

```
AutoPointSize(data, raster = NULL)
```

Arguments

data	A data frame being passed to ggplot2
raster	If TRUE, point size is set to 1

Value

The "optimal" point size for visualizing these data

Examples

```
df <- data.frame(x = rnorm(n = 10000), y = runif(n = 10000))
AutoPointSize(data = df)
```

`AverageExpression` *Averaged feature expression by identity class*

Description

Returns averaged expression values for each identity class.

Usage

```
AverageExpression(
  object,
  assays = NULL,
  features = NULL,
  return.seurat = FALSE,
  group.by = "ident",
  add.ident = NULL,
  layer = "data",
  slot = deprecated(),
  verbose = TRUE,
  ...
)
```

Arguments

`object`	Seurat object
`assays`	Which assays to use. Default is all assays
`features`	Features to analyze. Default is all features in the assay
`return.seurat`	Whether to return the data as a Seurat object. Default is FALSE
`group.by`	Category (or vector of categories) for grouping (e.g, ident, replicate, celltype); 'ident' by default To use multiple categories, specify a vector, such as c('ident', 'replicate', 'celltype')
`add.ident`	(Deprecated). Place an additional label on each cell prior to pseudobulking
`layer`	Layer(s) to use; if multiple layers are given, assumed to follow the order of 'assays' (if specified) or object's assays
`slot`	(Deprecated). Slots(s) to use
`verbose`	Print messages and show progress bar
`...`	Arguments to be passed to methods such as `CreateSeuratObject`

Details

If layer is set to 'data', this function assumes that the data has been log normalized and therefore feature values are exponentiated prior to averaging so that averaging is done in non-log space. Otherwise, if layer is set to either 'counts' or 'scale.data', no exponentiation is performed prior to averaging. If `return.seurat = TRUE` and layer is not 'scale.data', averaged values are placed

in the 'counts' layer of the returned object and 'log1p' is run on the averaged counts and placed in the 'data' layer ScaleData is then run on the default assay before returning the object. If return.seurat = TRUE and layer is 'scale.data', the 'counts' layer contains average counts and 'scale.data' is set to the averaged values of 'scale.data'.

Value

Returns a matrix with genes as rows, identity classes as columns. If return.seurat is TRUE, returns an object of class Seurat.

Examples

```
data("pbmc_small")
head(AverageExpression(object = pbmc_small)$RNA)
head(AverageExpression(object = pbmc_small, group.by = c('ident', 'groups'))$RNA)
```

BarcodeInflectionsPlot

Plot the Barcode Distribution and Calculated Inflection Points

---

Description

This function plots the calculated inflection points derived from the barcode-rank distribution.

Usage

```
BarcodeInflectionsPlot(object)
```

Arguments

object	Seurat object

Details

See [CalculateBarcodeInflections()] to calculate inflection points and [SubsetByBarcodeInflections()] to subsequently subset the Seurat object.

Value

Returns a 'ggplot2' object showing the by-group inflection points and provided (or default) rank threshold values in grey.

Author(s)

Robert A. Amezquita, <robert.amezquita@fredhutch.org>

See Also

CalculateBarcodeInflections SubsetByBarcodeInflections

Examples

```
data("pbmc_small")
pbmc_small <- CalculateBarcodeInflections(pbmc_small, group.column = 'groups')
BarcodeInflectionsPlot(pbmc_small)
```

BGTextColor *Determine text color based on background color*

Description

Determine text color based on background color

Usage

```
BGTextColor(
  background,
  threshold = 186,
  w3c = FALSE,
  dark = "black",
  light = "white"
)
```

Arguments

background	A vector of background colors; supports R color names and hexadecimal codes
threshold	Intensity threshold for light/dark cutoff; intensities greater than theshold yield dark, others yield light
w3c	Use W3C formula for calculating background text color; ignores threshold
dark	Color for dark text
light	Color for light text

Value

A named vector of either dark or light, depending on background; names of vector are background

Source

https://stackoverflow.com/questions/3942878/how-to-decide-font-color-in-white-or-black-depending-o

Examples

```
BGTextColor(background = c('black', 'white', '#E76BF3'))
```

`BlackAndWhite` *Create a custom color palette*

Description

Creates a custom color palette based on low, middle, and high color values

Usage

```
BlackAndWhite(mid = NULL, k = 50)

BlueAndRed(k = 50)

CustomPalette(low = "white", high = "red", mid = NULL, k = 50)

PurpleAndYellow(k = 50)
```

Arguments

`mid`	middle color. Optional.
`k`	number of steps (colors levels) to include between low and high values
`low`	low color
`high`	high color

Value

A color palette for plotting

Examples

```
df <- data.frame(x = rnorm(n = 100, mean = 20, sd = 2), y = rbinom(n = 100, size = 100, prob = 0.2))
plot(df, col = BlackAndWhite())

df <- data.frame(x = rnorm(n = 100, mean = 20, sd = 2), y = rbinom(n = 100, size = 100, prob = 0.2))
plot(df, col = BlueAndRed())

myPalette <- CustomPalette()
myPalette

df <- data.frame(x = rnorm(n = 100, mean = 20, sd = 2), y = rbinom(n = 100, size = 100, prob = 0.2))
plot(df, col = PurpleAndYellow())
```

`BridgeCellsRepresentation` *Construct a dictionary representation for each unimodal dataset*

Description

Construct a dictionary representation for each unimodal dataset

Usage

```
BridgeCellsRepresentation(
  object.list,
  bridge.object,
  object.reduction,
  bridge.reduction,
  laplacian.reduction = "lap",
  laplacian.dims = 1:50,
  bridge.assay.name = "Bridge",
  return.all.assays = FALSE,
  l2.norm = TRUE,
  verbose = TRUE
)
```

Arguments

`object.list`	A list of Seurat objects
`bridge.object`	A multi-omic bridge Seurat which is used as the basis to represent unimodal datasets
`object.reduction`	A list of dimensional reductions from object.list used to be reconstructed by bridge.object
`bridge.reduction`	A list of dimensional reductions from bridge.object used to reconstruct object.reduction
`laplacian.reduction`	Name of bridge graph laplacian dimensional reduction
`laplacian.dims`	Dimensions used for bridge graph laplacian dimensional reduction
`bridge.assay.name`	Assay name used for bridge object reconstruction value (default is 'Bridge')
`return.all.assays`	Whether to return all assays in the object.list. Only bridge assay is returned by default.
`l2.norm`	Whether to l2 normalize the dictionary representation
`verbose`	Print messages and progress

Value

Returns a object list in which each object has a bridge cell derived assay

---

`BridgeReferenceSet-class` *The BridgeReferenceSet Class The BridgeReferenceSet is an output from PrepareBridgeReference*

Description

The BridgeReferenceSet Class The BridgeReferenceSet is an output from PrepareBridgeReference

Slots

`bridge` The multi-omic object

`reference` The Reference object only containing bridge representation assay

`params` A list of parameters used in the PrepareBridgeReference

`command` Store log of parameters that were used

`BuildClusterTree` *Phylogenetic Analysis of Identity Classes*

Description

Constructs a phylogenetic tree relating the 'aggregate' cell from each identity class. Tree is estimated based on a distance matrix constructed in either gene expression space or PCA space.

Usage

```
BuildClusterTree(
  object,
  assay = NULL,
  features = NULL,
  dims = NULL,
  reduction = "pca",
  graph = NULL,
  slot = "data",
  reorder = FALSE,
  reorder.numeric = FALSE,
  verbose = TRUE
)
```

Arguments

object	Seurat object
assay	Assay to use for the analysis.
features	Genes to use for the analysis. Default is the set of variable genes (VariableFeatures(object = object))
dims	If set, tree is calculated in dimension reduction space; overrides features
reduction	Name of dimension reduction to use. Only used if dims is not NULL.
graph	If graph is passed, build tree based on graph connectivity between clusters; overrides dims and features
slot	slot/layer to use.
reorder	Re-order identity classes (factor ordering), according to position on the tree. This groups similar classes together which can be helpful, for example, when drawing violin plots.
reorder.numeric	Re-order identity classes according to position on the tree, assigning a numeric value ('1' is the leftmost node)
verbose	Show progress updates

Details

Note that the tree is calculated for an 'aggregate' cell, so gene expression or PC scores are summed across all cells in an identity class before the tree is constructed.

Value

A Seurat object where the cluster tree can be accessed with Tool

Examples

```
## Not run:
if (requireNamespace("ape", quietly = TRUE)) {
  data("pbmc_small")
  pbmc_small
  pbmc_small <- BuildClusterTree(object = pbmc_small)
  Tool(object = pbmc_small, slot = 'BuildClusterTree')
}

## End(Not run)
```

`BuildNicheAssay` *Construct an assay for spatial niche analysis*

Description

This function will construct a new assay where each feature is a cell label. The values represent the sum of a particular cell label neighboring a given cell.

Usage

```
BuildNicheAssay(
  object,
  fov,
  group.by,
  assay = "niche",
  cluster.name = "niches",
  neighbors.k = 20,
  niches.k = 4,
  ...
)
```

Arguments

`object`	A Seurat object
`fov`	FOV object to gather cell positions from
`group.by`	Cell classifications to count in spatial neighborhood
`assay`	Name for spatial neighborhoods assay
`cluster.name`	Name of output clusters
`neighbors.k`	Number of neighbors to consider for each cell
`niches.k`	Number of niche clusters to construct
`...`	Extra parameters passed to `kmeans`

Value

Seurat object containing a new assay

CalcPerturbSig *Calculate a perturbation Signature*

Description

Function to calculate perturbation signature for pooled CRISPR screen datasets. For each target cell (expressing one target gRNA), we identified 20 cells from the control pool (non-targeting cells) with the most similar mRNA expression profiles. The perturbation signature is calculated by subtracting the averaged mRNA expression profile of the non-targeting neighbors from the mRNA expression profile of the target cell.

Usage

```
CalcPerturbSig(
  object,
  assay = NULL,
  features = NULL,
  slot = "data",
  gd.class = "guide_ID",
  nt.cell.class = "NT",
  split.by = NULL,
  num.neighbors = NULL,
  reduction = "pca",
  ndims = 15,
  new.assay.name = "PRTB",
  verbose = TRUE
)
```

Arguments

object	An object of class Seurat.
assay	Name of Assay PRTB signature is being calculated on.
features	Features to compute PRTB signature for. Defaults to the variable features set in the assay specified.
slot	Data slot to use for PRTB signature calculation.
gd.class	Metadata column containing target gene classification.
nt.cell.class	Non-targeting gRNA cell classification identity.
split.by	Provide metadata column if multiple biological replicates exist to calculate PRTB signature for every replicate separately.
num.neighbors	Number of nearest neighbors to consider.
reduction	Reduction method used to calculate nearest neighbors.
ndims	Number of dimensions to use from dimensionality reduction method.
new.assay.name	Name for the new assay.
verbose	Display progress + messages

Value

Returns a Seurat object with a new assay added containing the perturbation signature for all cells in the data slot.

`CalculateBarcodeInflections` *Calculate the Barcode Distribution Inflection*

Description

This function calculates an adaptive inflection point ("knee") of the barcode distribution for each sample group. This is useful for determining a threshold for removing low-quality samples.

Usage

```
CalculateBarcodeInflections(
  object,
  barcode.column = "nCount_RNA",
  group.column = "orig.ident",
  threshold.low = NULL,
  threshold.high = NULL
)
```

Arguments

`object`	Seurat object
`barcode.column`	Column to use as proxy for barcodes ("nCount_RNA" by default)
`group.column`	Column to group by ("orig.ident" by default)
`threshold.low`	Ignore barcodes of rank below this threshold in inflection calculation
`threshold.high`	Ignore barcodes of rank above this threshold in inflection calculation

Details

The function operates by calculating the slope of the barcode number vs. rank distribution, and then finding the point at which the distribution changes most steeply (the "knee"). Of note, this calculation often must be restricted as to the range at which it performs, so ‘threshold‘ parameters are provided to restrict the range of the calculation based on the rank of the barcodes. [BarcodeInflectionsPlot()] is provided as a convenience function to visualize and test different thresholds and thus provide more sensical end results.

See [BarcodeInflectionsPlot()] to visualize the calculated inflection points and [SubsetByBarcodeInflections()] to subsequently subset the Seurat object.

Value

Returns Seurat object with a new list in the ‘tools‘ slot, ‘CalculateBarcodeInflections‘ with values:

* ‘barcode_distribution‘ - contains the full barcode distribution across the entire dataset * ‘inflection_points‘ - the calculated inflection points within the thresholds * ‘threshold_values‘ - the provided (or default) threshold values to search within for inflections * ‘cells_pass‘ - the cells that pass the inflection point calculation

Author(s)

Robert A. Amezquita, <robert.amezquita@fredhutch.org>

See Also

BarcodeInflectionsPlot SubsetByBarcodeInflections

Examples

```
data("pbmc_small")
CalculateBarcodeInflections(pbmc_small, group.column = 'groups')
```

CaseMatch *Match the case of character vectors*

Description

Match the case of character vectors

Usage

```
CaseMatch(search, match)
```

Arguments

search	A vector of search terms
match	A vector of characters whose case should be matched

Value

Values from search present in match with the case of match

Examples

```
data("pbmc_small")
cd_genes <- c('Cd79b', 'Cd19', 'Cd200')
CaseMatch(search = cd_genes, match = rownames(x = pbmc_small))
```

cc.genes *Cell cycle genes*

Description

A list of genes used in cell-cycle regression

Usage

```
cc.genes
```

Format

A list of two vectors

s.genes Genes associated with S-phase

g2m.genes Genes associated with G2M-phase

Source

'https://doi.org/10.1126/science.aad0501'

cc.genes.updated.2019 *Cell cycle genes: 2019 update*

Description

A list of genes used in cell-cycle regression, updated with 2019 symbols

Usage

```
cc.genes.updated.2019
```

Format

A list of two vectors

s.genes Genes associated with S-phase

g2m.genes Genes associated with G2M-phase

Updated symbols

The following symbols were updated from cc.genes

s.genes
- *MCM2*: *MCM7*
- *MLF1IP*: *CENPU*
- *RPA2*: *POLR1B*
- *BRIP1*: *MRPL36*

g2m.genes
- *FAM64A*: *PIMREG*
- *HN1*: *JPT1*

Source

'https://doi.org/10.1126/science.aad0501'

See Also

cc.genes

Examples

```
## Not run:
cc.genes.updated.2019 <- cc.genes
cc.genes.updated.2019$s.genes <- UpdateSymbolList(symbols = cc.genes.updated.2019$s.genes)
cc.genes.updated.2019$g2m.genes <- UpdateSymbolList(symbols = cc.genes.updated.2019$g2m.genes)

## End(Not run)
```

CCAIntegration *Seurat-CCA Integration*

Description

Seurat-CCA Integration

Usage

```
CCAIntegration(
  object = NULL,
  assay = NULL,
  layers = NULL,
  orig = NULL,
  new.reduction = "integrated.dr",
  reference = NULL,
  features = NULL,
  normalization.method = c("LogNormalize", "SCT"),
  dims = 1:30,
```

```
  k.filter = NA,
  scale.layer = "scale.data",
  dims.to.integrate = NULL,
  k.weight = 100,
  weight.reduction = NULL,
  sd.weight = 1,
  sample.tree = NULL,
  preserve.order = FALSE,
  svd.method = NULL,
  verbose = TRUE,
  ...
)
```

Arguments

object	A Seurat object
assay	Name of Assay in the Seurat object
layers	Names of layers in assay
orig	A DimReduc to correct
new.reduction	Name of new integrated dimensional reduction
reference	A reference Seurat object
features	A vector of features to use for integration
normalization.method	Name of normalization method used: LogNormalize or SCT
dims	Dimensions of dimensional reduction to use for integration
k.filter	Number of anchors to filter
scale.layer	Name of scaled layer in Assay
dims.to.integrate	Number of dimensions to return integrated values for
k.weight	Number of neighbors to consider when weighting anchors
weight.reduction	Dimension reduction to use when calculating anchor weights. This can be one of: • A string, specifying the name of a dimension reduction present in all objects to be integrated • A vector of strings, specifying the name of a dimension reduction to use for each object to be integrated • A vector of DimReduc objects, specifying the object to use for each object in the integration • NULL, in which case the full corrected space is used for computing anchor weights.
sd.weight	Controls the bandwidth of the Gaussian kernel for weighting

`sample.tree` Specify the order of integration. Order of integration should be encoded in a matrix, where each row represents one of the pairwise integration steps. Negative numbers specify a dataset, positive numbers specify the integration results from a given row (the format of the merge matrix included in the `hclust` function output). For example: `matrix(c(-2, 1, -3, -1), ncol = 2)` gives:

```
     [,1]  [,2]
[1,]   -2   -3
[2,]    1   -1
```

Which would cause dataset 2 and 3 to be integrated first, then the resulting object integrated with dataset 1.

If NULL, the sample tree will be computed automatically.

`preserve.order` Do not reorder objects based on size for each pairwise integration.

`svd.method` SVD backend to use when `reduction = "cca"`. If `NULL`, defaults to `"irlba"` except for pairs of dense CCA input matrices whose cell-by-cell cross-product matrix has at least 1,000,000 entries, in which case it defaults to `"rspectra"`. `"irlba"` uses an explicit cross-product CCA path; `"rspectra"` uses an implicit operator to avoid forming the cross-product matrix.

`verbose` Print progress

`...` Arguments passed on to `FindIntegrationAnchors`

Examples

```
## Not run:
# Preprocessing
obj <- SeuratData::LoadData("pbmcsca")
obj[["RNA"]] <- split(obj[["RNA"]], f = obj$Method)
obj <- NormalizeData(obj)
obj <- FindVariableFeatures(obj)
obj <- ScaleData(obj)
obj <- RunPCA(obj)

# After preprocessing, we integrate layers.
obj <- IntegrateLayers(object = obj, method = CCAIntegration,
  orig.reduction = "pca", new.reduction = "integrated.cca",
  verbose = FALSE)

# Modifying parameters
# We can also specify parameters such as `k.anchor` to increase the strength of integration
obj <- IntegrateLayers(object = obj, method = CCAIntegration,
  orig.reduction = "pca", new.reduction = "integrated.cca",
  k.anchor = 20, verbose = FALSE)

# Integrating SCTransformed data
obj <- SCTransform(object = obj)
obj <- IntegrateLayers(object = obj, method = CCAIntegration,
  orig.reduction = "pca", new.reduction = "integrated.cca",
  assay = "SCT", verbose = FALSE)
```

```
## End(Not run)
```

`CellCycleScoring` *Score cell cycle phases*

Description

Score cell cycle phases

Usage

```
CellCycleScoring(
  object,
  s.features,
  g2m.features,
  ctrl = NULL,
  set.ident = FALSE,
  ...
)
```

Arguments

`object`	A Seurat object
`s.features`	A vector of features associated with S phase
`g2m.features`	A vector of features associated with G2M phase
`ctrl`	Number of control features selected from the same bin per analyzed feature supplied to `AddModuleScore`. Defaults to value equivalent to minimum number of features present in 's.features' and 'g2m.features'.
`set.ident`	If true, sets identity to phase assignments Stashes old identities in 'old.ident'
`...`	Arguments to be passed to `AddModuleScore`

Value

A Seurat object with the following columns added to object meta data: S.Score, G2M.Score, and Phase

See Also

`AddModuleScore`

Examples

```
## Not run:
data("pbmc_small")
# pbmc_small doesn't have any cell-cycle genes
# To run CellCycleScoring, please use a dataset with cell-cycle genes
# An example is available at http://satijalab.org/seurat/cell_cycle_vignette.html
pbmc_small <- CellCycleScoring(
  object = pbmc_small,
  g2m.features = cc.genes$g2m.genes,
  s.features = cc.genes$s.genes
)
head(x = pbmc_small@meta.data)

## End(Not run)
```

Cells.SCTModel *Get Cell Names*

Description

Get Cell Names

Usage

```
## S3 method for class 'SCTModel'
Cells(x, ...)

## S3 method for class 'SlideSeq'
Cells(x, ...)

## S3 method for class 'STARmap'
Cells(x, ...)

## S3 method for class 'VisiumV1'
Cells(x, ...)
```

Arguments

x	An object
...	Arguments passed to other methods

See Also

SeuratObject::Cells

`CellScatter` *Cell-cell scatter plot*

Description

Creates a plot of scatter plot of features across two single cells. Pearson correlation between the two cells is displayed above the plot.

Usage

```
CellScatter(
  object,
  cell1,
  cell2,
  features = NULL,
  highlight = NULL,
  cols = NULL,
  pt.size = 1,
  smooth = FALSE,
  raster = NULL,
  raster.dpi = c(512, 512)
)
```

Arguments

`object`	Seurat object
`cell1`	Cell 1 name
`cell2`	Cell 2 name
`features`	Features to plot (default, all features)
`highlight`	Features to highlight
`cols`	Colors to use for identity class plotting.
`pt.size`	Size of the points on the plot
`smooth`	Smooth the graph (similar to smoothScatter)
`raster`	Convert points to raster format, default is `NULL` which will automatically use raster if the number of points plotted is greater than 100,000
`raster.dpi`	Pixel resolution for rasterized plots, passed to geom_scattermore(). Default is c(512, 512).

Value

A ggplot object

Examples

```
data("pbmc_small")
CellScatter(object = pbmc_small, cell1 = 'ATAGGAGAAACAGA', cell2 = 'CATCAGGATGCACA')
```

`CellSelector` *Cell Selector*

Description

Select points on a scatterplot and get information about them

Usage

```
CellSelector(plot, object = NULL, ident = "SelectedCells", ...)

FeatureLocator(plot, ...)
```

Arguments

`plot`	A ggplot2 plot
`object`	An optional Seurat object; if passes, will return an object with the identities of selected cells set to `ident`
`ident`	An optional new identity class to assign the selected cells
`...`	Ignored

Value

If `object` is `NULL`, the names of the points selected; otherwise, a Seurat object with the selected cells identity classes set to `ident`

See Also

`DimPlot` `FeaturePlot`

Examples

```
## Not run:
data("pbmc_small")
plot <- DimPlot(object = pbmc_small)
# Follow instructions in the terminal to select points
cells.located <- CellSelector(plot = plot)
cells.located
# Automatically set the identity class of selected cells and return a new Seurat object
pbmc_small <- CellSelector(plot = plot, object = pbmc_small, ident = 'SelectedCells')

## End(Not run)
```

`CollapseEmbeddingOutliers` *Move outliers towards center on dimension reduction plot*

Description

Move outliers towards center on dimension reduction plot

Usage

```
CollapseEmbeddingOutliers(
  object,
  reduction = "umap",
  dims = 1:2,
  group.by = "ident",
  outlier.sd = 2,
  reduction.key = "UMAP_"
)
```

Arguments

`object`	Seurat object
`reduction`	Name of DimReduc to adjust
`dims`	Dimensions to visualize
`group.by`	Group (color) cells in different ways (for example, orig.ident)
`outlier.sd`	Controls the outlier distance
`reduction.key`	Key for DimReduc that is returned

Value

Returns a DimReduc object with the modified embeddings

Examples

```
## Not run:
data("pbmc_small")
pbmc_small <- FindClusters(pbmc_small, resolution = 1.1)
pbmc_small <- RunUMAP(pbmc_small, dims = 1:5)
DimPlot(pbmc_small, reduction = "umap")
pbmc_small[["umap_new"]] <- CollapseEmbeddingOutliers(pbmc_small,
    reduction = "umap", reduction.key = 'umap_', outlier.sd = 0.5)
DimPlot(pbmc_small, reduction = "umap_new")

## End(Not run)
```

CollapseSpeciesExpressionMatrix *Slim down a multi-species expression matrix, when only one species is primarily of interenst.*

Description

Valuable for CITE-seq analyses, where we typically spike in rare populations of 'negative control' cells from a different species.

Usage

```
CollapseSpeciesExpressionMatrix(
  object,
  prefix = "HUMAN_",
  controls = "MOUSE_",
  ncontrols = 100
)
```

Arguments

object	A UMI count matrix. Should contain rownames that start with the ensuing arguments prefix.1 or prefix.2
prefix	The prefix denoting rownames for the species of interest. Default is "HUMAN_". These rownames will have this prefix removed in the returned matrix.
controls	The prefix denoting rownames for the species of 'negative control' cells. Default is "MOUSE_".
ncontrols	How many of the most highly expressed (average) negative control features (by default, 100 mouse genes), should be kept? All other rownames starting with prefix.2 are discarded.

Value

A UMI count matrix. Rownames that started with `prefix` have this prefix discarded. For rownames starting with `controls`, only the `ncontrols` most highly expressed features are kept, and the prefix is kept. All other rows are retained.

Examples

```
## Not run:
cbmc.rna.collapsed <- CollapseSpeciesExpressionMatrix(cbmc.rna)

## End(Not run)
```

ColorDimSplit *Color dimensional reduction plot by tree split*

Description

Returns a DimPlot colored based on whether the cells fall in clusters to the left or to the right of a node split in the cluster tree.

Usage

```
ColorDimSplit(
  object,
  node,
  left.color = "red",
  right.color = "blue",
  other.color = "grey50",
  ...
)
```

Arguments

object	Seurat object
node	Node in cluster tree on which to base the split
left.color	Color for the left side of the split
right.color	Color for the right side of the split
other.color	Color for all other cells
...	Arguments passed on to DimPlot

dims Dimensions to plot, must be a two-length numeric vector specifying x- and y-dimensions

cells Vector of cells to plot (default is all cells)

cols Vector of colors, each color corresponds to an identity class. This may also be a single character or numeric value corresponding to a palette as specified by brewer.pal.info. By default, ggplot2 assigns colors. We also include a number of palettes from the pals package. See DiscretePalette for details.

pt.size Adjust point size for plotting

reduction Which dimensionality reduction to use. If not specified, first searches for umap, then tsne, then pca

group.by Name of one or more metadata columns to group (color) cells by (for example, orig.ident); pass 'ident' to group by identity class

split.by A factor in object metadata to split the plot by, pass 'ident' to split by cell identity

shape.by If NULL, all points are circles (default). You can specify any cell attribute (that can be pulled with FetchData) allowing for both different colors and different shapes on cells. Only applicable if raster = FALSE.

`order` Specify the order of plotting for the idents. This can be useful for crowded plots if points of interest are being buried. Provide either a full list of valid idents or a subset to be plotted last (on top)

`shuffle` Whether to randomly shuffle the order of points. This can be useful for crowded plots if points of interest are being buried. (default is FALSE)

`seed` Sets the seed if randomly shuffling the order of points.

`label` Whether to label the clusters

`label.size` Sets size of labels

`label.color` Sets the color of the label text

`label.box` Whether to put a box around the label text (geom_text vs geom_label)

`alpha` Alpha value for plotting (default is 1)

`repel` Repel labels

`stroke.size` Adjust stroke (outline) size of points

`cells.highlight` A list of character or numeric vectors of cells to highlight. If only one group of cells desired, can simply pass a vector instead of a list. If set, colors selected cells to the color(s) in `cols.highlight` and other cells black (white if dark.theme = TRUE); will also resize to the size(s) passed to `sizes.highlight`

`cols.highlight` A vector of colors to highlight the cells as; will repeat to the length groups in cells.highlight

`sizes.highlight` Size of highlighted cells; will repeat to the length groups in cells.highlight. If `sizes.highlight` = `TRUE` size of all points will be this value.

`na.value` Color value for NA points when using custom scale

`ncol` Number of columns for display when combining plots

`combine` Combine plots into a single `patchwork`ed ggplot object. If `FALSE`, return a list of ggplot objects

`raster` Convert points to raster format, default is `NULL` which automatically rasterizes if plotting more than 100,000 cells

`raster.dpi` Pixel resolution for rasterized plots, passed to geom_scattermore(). Default is c(512, 512).

`label.size.cutoff` Clusters with fewer cells than the cutoff are not labeled (replaced with ' ' label)

Value

Returns a DimPlot

See Also

`DimPlot`

Examples

```
## Not run:
if (requireNamespace("ape", quietly = TRUE)) {
  data("pbmc_small")
```

```
  pbmc_small <- BuildClusterTree(object = pbmc_small, verbose = FALSE)
  PlotClusterTree(pbmc_small)
  ColorDimSplit(pbmc_small, node = 5)
}

## End(Not run)
```

`CombinePlots` *Combine ggplot2-based plots into a single plot*

Description

Combine ggplot2-based plots into a single plot

Usage

```
CombinePlots(plots, ncol = NULL, legend = NULL, ...)
```

Arguments

`plots`	A list of gg objects
`ncol`	Number of columns
`legend`	Combine legends into a single legend choose from 'right' or 'bottom'; pass 'none' to remove legends, or `NULL` to leave legends as they are
`...`	Extra parameters passed to plot_grid

Value

A combined plot

Examples

```
## Not run:
data("pbmc_small")
pbmc_small[['group']] <- sample(
  x = c('g1', 'g2'),
  size = ncol(x = pbmc_small),
  replace = TRUE
)
plot1 <- FeaturePlot(
  object = pbmc_small,
  features = 'MS4A1',
  split.by = 'group'
)
plot2 <- FeaturePlot(
  object = pbmc_small,
  features = 'FCN1',
```

```
  split.by = 'group'
)
CombinePlots(
  plots = list(plot1, plot2),
  legend = 'none',
  nrow = length(x = unique(x = pbmc_small[['group', drop = TRUE]]))
)

## End(Not run)
```

`contrast-theory` *Get the intensity and/or luminance of a color*

Description

Get the intensity and/or luminance of a color

Usage

```
Intensity(color)

Luminance(color)
```

Arguments

`color`	A vector of colors

Value

A vector of intensities/luminances for each color

Source

https://stackoverflow.com/questions/3942878/how-to-decide-font-color-in-white-or-black-depending-o

Examples

```
Intensity(color = c('black', 'white', '#E76BF3'))

Luminance(color = c('black', 'white', '#E76BF3'))
```

CreateCategoryMatrix *Create one hot matrix for a given label*

Description

Create one hot matrix for a given label

Usage

```
CreateCategoryMatrix(
  labels,
  method = c("aggregate", "average"),
  cells.name = NULL
)
```

Arguments

labels	A vector of labels
method	Method to aggregate cells with the same label. Either 'aggregate' or 'average'
cells.name	A vector of cell names

CreateSCTAssayObject *Create a SCT Assay object*

Description

Create a SCT object from a feature (e.g. gene) expression matrix and a list of SCTModels. The expected format of the input matrix is features x cells.

Usage

```
CreateSCTAssayObject(
  counts,
  data,
  scale.data = NULL,
  umi.assay = "RNA",
  min.cells = 0,
  min.features = 0,
  SCTModel.list = NULL
)
```

Arguments

counts	Unnormalized data such as raw counts or TPMs
data	Prenormalized data; if provided, do not pass counts
scale.data	a residual matrix
umi.assay	The UMI assay name. Default is RNA
min.cells	Include features detected in at least this many cells. Will subset the counts matrix as well. To reintroduce excluded features, create a new object with a lower cutoff
min.features	Include cells where at least this many features are detected
SCTModel.list	list of SCTModels

Details

Non-unique cell or feature names are not allowed. Please make unique before calling this function.

CustomDistance *Run a custom distance function on an input data matrix*

Description

Run a custom distance function on an input data matrix

Usage

```
CustomDistance(my.mat, my.function, ...)
```

Arguments

my.mat	A matrix to calculate distance on
my.function	A function to calculate distance
...	Extra parameters to my.function

Value

A distance matrix

Author(s)

Jean Fan

Examples

```
data("pbmc_small")
# Define custom distance matrix
manhattan.distance <- function(x, y) return(sum(abs(x-y)))

input.data <- GetAssayData(pbmc_small, assay.type = "RNA", layer = "scale.data")
cell.manhattan.dist <- CustomDistance(input.data, manhattan.distance)
```

DEenrichRPlot *DE and EnrichR pathway visualization barplot*

Description

DE and EnrichR pathway visualization barplot

Usage

```
DEenrichRPlot(
  object,
  ident.1 = NULL,
  ident.2 = NULL,
  balanced = TRUE,
  logfc.threshold = 0.25,
  assay = NULL,
  max.genes,
  test.use = "wilcox",
  p.val.cutoff = 0.05,
  cols = NULL,
  enrich.database = NULL,
  num.pathway = 10,
  return.gene.list = FALSE,
  ...
)
```

Arguments

object	Name of object class Seurat.
ident.1	Cell class identity 1.
ident.2	Cell class identity 2.
balanced	Option to display pathway enrichments for both negative and positive DE genes.If false, only positive DE gene will be displayed.
logfc.threshold	Limit testing to genes which show, on average, at least X-fold difference (log-scale) between the two groups of cells. Default is 0.25. Increasing logfc.threshold speeds up the function, but can miss weaker signals.

`assay` Assay to use in differential expression testing

`max.genes` Maximum number of genes to use as input to enrichR.

`test.use` Denotes which test to use. Available options are:

- "wilcox" : Identifies differentially expressed genes between two groups of cells using a Wilcoxon Rank Sum test (default); will use a fast implementation by Presto if installed
- "wilcox_limma" : Identifies differentially expressed genes between two groups of cells using the limma implementation of the Wilcoxon Rank Sum test; set this option to reproduce results from Seurat v4
- "bimod" : Likelihood-ratio test for single cell gene expression, (McDavid et al., Bioinformatics, 2013)
- "roc" : Identifies 'markers' of gene expression using ROC analysis. For each gene, evaluates (using AUC) a classifier built on that gene alone, to classify between two groups of cells. An AUC value of 1 means that expression values for this gene alone can perfectly classify the two groupings (i.e. Each of the cells in cells.1 exhibit a higher level than each of the cells in cells.2). An AUC value of 0 also means there is perfect classification, but in the other direction. A value of 0.5 implies that the gene has no predictive power to classify the two groups. Returns a 'predictive power' (abs(AUC-0.5) * 2) ranked matrix of putative differentially expressed genes.
- "t" : Identify differentially expressed genes between two groups of cells using the Student's t-test.
- "negbinom" : Identifies differentially expressed genes between two groups of cells using a negative binomial generalized linear model. Use only for UMI-based datasets
- "poisson" : Identifies differentially expressed genes between two groups of cells using a poisson generalized linear model. Use only for UMI-based datasets
- "LR" : Uses a logistic regression framework to determine differentially expressed genes. Constructs a logistic regression model predicting group membership based on each feature individually and compares this to a null model with a likelihood ratio test.
- "MAST" : Identifies differentially expressed genes between two groups of cells using a hurdle model tailored to scRNA-seq data. Utilizes the MAST package to run the DE testing.
- "DESeq2" : Identifies differentially expressed genes between two groups of cells based on a model using DESeq2 which uses a negative binomial distribution (Love et al, Genome Biology, 2014).This test does not support pre-filtering of genes based on average difference (or percent detection rate) between cell groups. However, genes may be pre-filtered based on their minimum detection rate (min.pct) across both cell groups. To use this method, please install DESeq2, using the instructions at https://bioconductor.org/packages/release/bioc/html/D

`p.val.cutoff` Cutoff to select DE genes.

`cols` A list of colors to use for barplots.

`enrich.database` Database to use from enrichR.

num.pathway	Number of pathways to display in barplot.
return.gene.list	Return list of DE genes
...	Arguments passed to other methods and to specific DE methods

Value

Returns one (only enriched) or two (both enriched and depleted) barplots with the top enriched/depleted GO terms from EnrichR.

DietSeurat *Slim down a Seurat object*

Description

Keep only certain aspects of the Seurat object. Can be useful in functions that utilize merge as it reduces the amount of data in the merge

Usage

```
DietSeurat(
  object,
  layers = NULL,
  features = NULL,
  assays = NULL,
  dimreducs = NULL,
  graphs = NULL,
  misc = TRUE,
  counts = deprecated(),
  data = deprecated(),
  scale.data = deprecated(),
  ...
)
```

Arguments

object	A Seurat object
layers	A vector or named list of layers to keep
features	Only keep a subset of features, defaults to all features
assays	Only keep a subset of assays specified here
dimreducs	Only keep a subset of DimReducs specified here (if NULL, remove all DimReducs)
graphs	Only keep a subset of Graphs specified here (if NULL, remove all Graphs)
misc	Preserve the misc slot; default is TRUE
counts	Preserve the count matrices for the assays specified

data	Preserve the data matrices for the assays specified
scale.data	Preserve the scale data matrices for the assays specified
...	Ignored

Value

object with only the sub-object specified retained

DimHeatmap *Dimensional reduction heatmap*

Description

Draws a heatmap focusing on a principal component. Both cells and genes are sorted by their principal component scores. Allows for nice visualization of sources of heterogeneity in the dataset.

Usage

```
DimHeatmap(
  object,
  dims = 1,
  nfeatures = 30,
  cells = NULL,
  reduction = "pca",
  disp.min = -2.5,
  disp.max = NULL,
  balanced = TRUE,
  projected = FALSE,
  ncol = NULL,
  fast = TRUE,
  raster = TRUE,
  slot = "scale.data",
  assays = NULL,
  combine = TRUE,
  legend.position = "right"
)

PCHeatmap(object, ...)
```

Arguments

object	Seurat object
dims	Dimensions to plot
nfeatures	Number of genes to plot
cells	A list of cells to plot. If numeric, just plots the top cells.

reduction	Which dimensional reduction to use
disp.min	Minimum display value (all values below are clipped)
disp.max	Maximum display value (all values above are clipped); defaults to 2.5 if slot is 'scale.data', 6 otherwise
balanced	Plot an equal number of genes with both + and - scores.
projected	Use the full projected dimensional reduction
ncol	Number of columns to plot
fast	If true, use image to generate plots; faster than using ggplot2, but not customizable and excludes figure legend in output
raster	If true, plot with geom_raster, else use geom_tile. geom_raster may look blurry on some viewing applications such as Preview due to how the raster is interpolated. Set this to FALSE if you are encountering that issue (note that plots may take longer to produce/render).
slot	Data slot to use, choose from 'raw.data', 'data', or 'scale.data'
assays	A vector of assays to pull data from
combine	Combine plots into a single patchworked ggplot object with single shared figure legend when fast=FALSE. If FALSE, return a list of ggplot objects
legend.position	When combine=TRUE, allows legend position to be adjusted for patchworked output (default "right"). See theme
...	Extra parameters passed to DimHeatmap

Value

No return value by default. If using fast = FALSE, will return a patchworked ggplot object if combine = TRUE, otherwise returns a list of ggplot objects

See Also

image geom_raster

Examples

```
data("pbmc_small")
DimHeatmap(object = pbmc_small)
```

DimPlot *Dimensional reduction plot*

Description

Graphs the output of a dimensional reduction technique on a 2D scatter plot where each point is a cell and it's positioned based on the cell embeddings determined by the reduction technique. By default, cells are colored by their identity class (can be changed with the group.by parameter).

Usage

```
DimPlot(
  object,
  dims = c(1, 2),
  cells = NULL,
  cols = NULL,
  pt.size = NULL,
  reduction = NULL,
  group.by = NULL,
  split.by = NULL,
  shape.by = NULL,
  order = NULL,
  shuffle = FALSE,
  seed = 1,
  label = FALSE,
  label.size = 4,
  label.color = "black",
  label.box = FALSE,
  repel = FALSE,
  alpha = 1,
  stroke.size = NULL,
  cells.highlight = NULL,
  cols.highlight = "#DE2D26",
  sizes.highlight = 1,
  na.value = "grey50",
  ncol = NULL,
  combine = TRUE,
  raster = NULL,
  raster.dpi = c(512, 512),
  label.size.cutoff = 0
)

PCAPlot(object, ...)

TSNEPlot(object, ...)

UMAPPlot(object, ...)
```

Arguments

object	Seurat object
dims	Dimensions to plot, must be a two-length numeric vector specifying x- and y-dimensions
cells	Vector of cells to plot (default is all cells)
cols	Vector of colors, each color corresponds to an identity class. This may also be a single character or numeric value corresponding to a palette as specified by brewer.pal.info. By default, ggplot2 assigns colors. We also include a number of palettes from the pals package. See DiscretePalette for details.
pt.size	Adjust point size for plotting
reduction	Which dimensionality reduction to use. If not specified, first searches for umap, then tsne, then pca
group.by	Name of one or more metadata columns to group (color) cells by (for example, orig.ident); pass 'ident' to group by identity class
split.by	A factor in object metadata to split the plot by, pass 'ident' to split by cell identity
shape.by	If NULL, all points are circles (default). You can specify any cell attribute (that can be pulled with FetchData) allowing for both different colors and different shapes on cells. Only applicable if raster = FALSE.
order	Specify the order of plotting for the idents. This can be useful for crowded plots if points of interest are being buried. Provide either a full list of valid idents or a subset to be plotted last (on top)
shuffle	Whether to randomly shuffle the order of points. This can be useful for crowded plots if points of interest are being buried. (default is FALSE)
seed	Sets the seed if randomly shuffling the order of points.
label	Whether to label the clusters
label.size	Sets size of labels
label.color	Sets the color of the label text
label.box	Whether to put a box around the label text (geom_text vs geom_label)
repel	Repel labels
alpha	Alpha value for plotting (default is 1)
stroke.size	Adjust stroke (outline) size of points
cells.highlight	A list of character or numeric vectors of cells to highlight. If only one group of cells desired, can simply pass a vector instead of a list. If set, colors selected cells to the color(s) in cols.highlight and other cells black (white if dark.theme = TRUE); will also resize to the size(s) passed to sizes.highlight
cols.highlight	A vector of colors to highlight the cells as; will repeat to the length groups in cells.highlight
sizes.highlight	Size of highlighted cells; will repeat to the length groups in cells.highlight. If sizes.highlight = TRUE size of all points will be this value.

na.value	Color value for NA points when using custom scale
ncol	Number of columns for display when combining plots
combine	Combine plots into a single patchworked ggplot object. If FALSE, return a list of ggplot objects
raster	Convert points to raster format, default is NULL which automatically rasterizes if plotting more than 100,000 cells
raster.dpi	Pixel resolution for rasterized plots, passed to geom_scattermore(). Default is c(512, 512).
label.size.cutoff	Clusters with fewer cells than the cutoff are not labeled (replaced with ' ' label)
...	Extra parameters passed to DimPlot

Value

A patchworked ggplot object if combine = TRUE; otherwise, a list of ggplot objects

Note

For the old do.hover and do.identify functionality, please see HoverLocator and CellSelector, respectively.

See Also

FeaturePlot HoverLocator CellSelector FetchData

Examples

```
data("pbmc_small")
DimPlot(object = pbmc_small)
DimPlot(object = pbmc_small, split.by = 'letter.idents')
```

DimReduc-class *The DimReduc Class*

Description

The DimReduc object stores a dimensionality reduction taken out in Seurat; for more details, please see the documentation in SeuratObject

See Also

SeuratObject::DimReduc-class

DiscretePalette *Discrete colour palettes from pals*

Description

These are included here because pals depends on a number of compiled packages, and this can lead to increases in run time for Travis, and generally should be avoided when possible.

Usage

```
DiscretePalette(n, palette = NULL, shuffle = FALSE)
```

Arguments

n	Number of colours to be generated.
palette	Options are "alphabet", "alphabet2", "glasbey", "polychrome", "stepped", and "parade". Can be omitted and the function will use the one based on the requested n.
shuffle	Shuffle the colors in the selected palette.

Details

These palettes are a much better default for data with many classes than the default ggplot2 palette.

Many thanks to Kevin Wright for writing the pals package.

Taken from the pals package (Licence: GPL-3). https://cran.r-project.org/package=pals
Credit: Kevin Wright

Value

A vector of colors

DoHeatmap *Feature expression heatmap*

Description

Draws a heatmap of single cell feature expression.

Usage

```
DoHeatmap(
  object,
  features = NULL,
  cells = NULL,
  group.by = "ident",
  group.bar = TRUE,
  group.colors = NULL,
  disp.min = -2.5,
  disp.max = NULL,
  slot = "scale.data",
  assay = NULL,
  label = TRUE,
  size = 5.5,
  hjust = 0,
  vjust = 0,
  angle = 45,
  raster = TRUE,
  draw.lines = TRUE,
  lines.width = NULL,
  group.bar.height = 0.02,
  combine = TRUE
)
```

Arguments

object	Seurat object
features	A vector of features to plot, defaults to VariableFeatures(object = object)
cells	A vector of cells to plot
group.by	A vector of variables to group cells by; pass 'ident' to group by cell identity classes
group.bar	Add a color bar showing group status for cells
group.colors	Colors to use for the color bar
disp.min	Minimum display value (all values below are clipped)
disp.max	Maximum display value (all values above are clipped); defaults to 2.5 if slot is 'scale.data', 6 otherwise
slot	Data slot to use, choose from 'raw.data', 'data', or 'scale.data'
assay	Assay to pull from
label	Label the cell identies above the color bar
size	Size of text above color bar
hjust	Horizontal justification of text above color bar
vjust	Vertical justification of text above color bar
angle	Angle of text above color bar

raster	If true, plot with geom_raster, else use geom_tile. geom_raster may look blurry on some viewing applications such as Preview due to how the raster is interpolated. Set this to FALSE if you are encountering that issue (note that plots may take longer to produce/render).
draw.lines	Include white lines to separate the groups
lines.width	Integer number to adjust the width of the separating white lines. Corresponds to the number of "cells" between each group.
group.bar.height	Scale the height of the color bar
combine	Combine plots into a single patchworked ggplot object. If FALSE, return a list of ggplot objects

Value

A patchworked ggplot object if combine = TRUE; otherwise, a list of ggplot objects

Examples

```
data("pbmc_small")
DoHeatmap(object = pbmc_small)
```

DotPlot *Dot plot visualization*

Description

Intuitive way of visualizing how feature expression changes across different identity classes (clusters). The size of the dot encodes the percentage of cells within a class, while the color encodes the AverageExpression level across all cells within a class (blue is high).

Usage

```
DotPlot(
  object,
  features,
  assay = NULL,
  cols = c("lightgrey", "blue"),
  col.min = -2.5,
  col.max = 2.5,
  dot.min = 0,
  dot.scale = 6,
  idents = NULL,
  group.by = NULL,
  split.by = NULL,
  cluster.idents = FALSE,
```

```
  scale = TRUE,
  scale.by = "radius",
  scale.min = NA,
  scale.max = NA
)
```

Arguments

object	Seurat object
features	Input vector of features, or named list of feature vectors if feature-grouped panels are desired (replicates the functionality of the old SplitDotPlotGG)
assay	Name of assay to use, defaults to the active assay
cols	Colors to plot: the name of a palette from RColorBrewer::brewer.pal.info, a pair of colors defining a gradient, or 3+ colors defining multiple gradients (if split.by is set)
col.min	Minimum scaled average expression threshold (everything smaller will be set to this)
col.max	Maximum scaled average expression threshold (everything larger will be set to this)
dot.min	The fraction of cells at which to draw the smallest dot (default is 0). All cell groups with less than this expressing the given gene will have no dot drawn.
dot.scale	Scale the size of the points, similar to cex
idents	Identity classes to include in plot (default is all)
group.by	Factor to group the cells by
split.by	A factor in object metadata to split the plot by, pass 'ident' to split by cell identity see FetchData for more details
cluster.idents	Whether to order identities by hierarchical clusters based on given features, default is FALSE
scale	Determine whether the data is scaled, TRUE for default
scale.by	Scale the size of the points by 'size' or by 'radius'
scale.min	Set lower limit for scaling, use NA for default
scale.max	Set upper limit for scaling, use NA for default

Value

A ggplot object

See Also

RColorBrewer::brewer.pal.info

Examples

```
data("pbmc_small")
cd_genes <- c("CD247", "CD3E", "CD9")
DotPlot(object = pbmc_small, features = cd_genes)
pbmc_small[['groups']] <- sample(x = c('g1', 'g2'), size = ncol(x = pbmc_small), replace = TRUE)
DotPlot(object = pbmc_small, features = cd_genes, split.by = 'groups')
```

ElbowPlot *Quickly Pick Relevant Dimensions*

Description

Plots per-component standard deviations (or approximate singular values if running PCAFast), percent variance explained per principal component, or cumulative percent variance explained, to help pick an elbow in the graph. This elbow often corresponds well with significant dimensions and is much faster to run than Jackstraw.

Usage

```
ElbowPlot(
  object,
  ndims = 20,
  reduction = "pca",
  plot_type = c("stdev", "variance", "cumulative_variance")
)
```

Arguments

object	Seurat object
ndims	Number of dimensions to plot (positive integer; capped by stored components)
reduction	Reduction technique to plot (default is 'pca')
plot_type	One of "stdev" (default), "variance" (per-PC % variance), or "cumulative_variance" (running sum of those percentages; equals 100% at the last stored PC when ndims spans all of them)

Value

A ggplot object

Examples

```
data("pbmc_small")
ElbowPlot(object = pbmc_small)
ElbowPlot(object = pbmc_small, plot_type = "variance")
ElbowPlot(object = pbmc_small, plot_type = "cumulative_variance")
```

ExpMean *Calculate the mean of logged values*

Description

Calculate mean of logged values in non-log space (return answer in log-space)

Usage

```
ExpMean(x, ...)
```

Arguments

x	A vector of values
...	Other arguments (not used)

Value

Returns the mean in log-space

Examples

```
ExpMean(x = c(1, 2, 3))
```

ExpSD *Calculate the standard deviation of logged values*

Description

Calculate SD of logged values in non-log space (return answer in log-space)

Usage

```
ExpSD(x)
```

Arguments

x	A vector of values

Value

Returns the standard deviation in log-space

Examples

```
ExpSD(x = c(1, 2, 3))
```

ExpVar *Calculate the variance of logged values*

Description

Calculate variance of logged values in non-log space (return answer in log-space)

Usage

```
ExpVar(x)
```

Arguments

x	A vector of values

Value

Returns the variance in log-space

Examples

```
ExpVar(x = c(1, 2, 3))
```

FastRowScale *Scale and/or center matrix rowwise*

Description

Performs row scaling and/or centering. Equivalent to using t(scale(t(mat))) in R except in the case of NA values.

Usage

```
FastRowScale(mat, center = TRUE, scale = TRUE, scale_max = 10)
```

Arguments

mat	A matrix
center	a logical value indicating whether to center the rows
scale	a logical value indicating whether to scale the rows
scale_max	clip all values greater than scale_max to scale_max. Don't clip if Inf.

Value

Returns the center/scaled matrix

FastRPCAIntegration *Perform integration on the joint PCA cell embeddings.*

Description

This is a convenience wrapper function around the following three functions that are often run together when perform integration. FindIntegrationAnchors, RunPCA, IntegrateEmbeddings.

Usage

```
FastRPCAIntegration(
  object.list,
  reference = NULL,
  anchor.features = 2000,
  k.anchor = 20,
  dims = 1:30,
  scale = TRUE,
  normalization.method = c("LogNormalize", "SCT"),
  new.reduction.name = "integrated_dr",
  npcs = 50,
  findintegrationanchors.args = list(),
  verbose = TRUE
)
```

Arguments

object.list	A list of Seurat objects between which to find anchors for downstream integration.
reference	A vector specifying the object/s to be used as a reference during integration. If NULL (default), all pairwise anchors are found (no reference/s). If not NULL, the corresponding objects in object.list will be used as references. When using a set of specified references, anchors are first found between each query and each reference. The references are then integrated through pairwise integration. Each query is then mapped to the integrated reference.
anchor.features	Can be either: • A numeric value. This will call SelectIntegrationFeatures to select the provided number of features to be used in anchor finding • A vector of features to be used as input to the anchor finding process
k.anchor	How many neighbors (k) to use when picking anchors
dims	Which dimensions to use from the CCA to specify the neighbor search space
scale	Whether or not to scale the features provided. Only set to FALSE if you have previously scaled the features you want to use for each object in the object.list
normalization.method	Name of normalization method used: LogNormalize or SCT

new.reduction.name
: Name of integrated dimensional reduction

npcs
: Total Number of PCs to compute and store (50 by default)

findintegrationanchors.args
: A named list of additional arguments to FindIntegrationAnchors

verbose
: Print messages and progress

Value

Returns a Seurat object with integrated dimensional reduction

---

FeaturePlot *Visualize 'features' on a dimensional reduction plot*

Description

Colors single cells on a dimensional reduction plot according to a 'feature' (i.e. gene expression, PC scores, number of genes detected, etc.)

Usage

```
FeaturePlot(
  object,
  features,
  dims = c(1, 2),
  cells = NULL,
  cols = if (blend) {
     c("lightgrey", "#ff0000", "#00ff00")
 } else {

    c("lightgrey", "blue")
 },
  pt.size = NULL,
  alpha = 1,
  stroke.size = NULL,
  order = FALSE,
  min.cutoff = NA,
  max.cutoff = NA,
  reduction = NULL,
  split.by = NULL,
  keep.scale = "feature",
  shape.by = NULL,
  slot = "data",
  assay = NULL,
  blend = FALSE,
  blend.threshold = 0.5,
```

```
  label = FALSE,
  label.size = 4,
  label.color = "black",
  repel = FALSE,
  ncol = NULL,
  coord.fixed = FALSE,
  by.col = TRUE,
  sort.cell = deprecated(),
  interactive = FALSE,
  combine = TRUE,
  raster = NULL,
  raster.dpi = c(512, 512)
)
```

Arguments

object	Seurat object
features	Vector of features to plot. Features can come from: • An Assay feature (e.g. a gene name - "MS4A1") • A column name from meta.data (e.g. mitochondrial percentage - "percent.mito") • A column name from a DimReduc object corresponding to the cell embedding values (e.g. the PC 1 scores - "PC_1")
dims	Dimensions to plot, must be a two-length numeric vector specifying x- and y-dimensions
cells	Vector of cells to plot (default is all cells)
cols	The two colors to form the gradient over. Provide as string vector with the first color corresponding to low values, the second to high. Also accepts a Brewer color scale or vector of colors. Note: this will bin the data into number of colors provided. When blend is TRUE, takes anywhere from 1-3 colors: **1 color:** Treated as color for double-negatives, will use default colors 2 and 3 for per-feature expression **2 colors:** Treated as colors for per-feature expression, will use default color 1 for double-negatives **3+ colors:** First color used for double-negatives, colors 2 and 3 used for per-feature expression, all others ignored
pt.size	Adjust point size for plotting
alpha	Alpha value for plotting (default is 1)
stroke.size	Adjust stroke (outline) size of points
order	Boolean determining whether to plot cells in order of expression. Can be useful if cells expressing given feature are getting buried.
min.cutoff, max.cutoff	Vector of minimum and maximum cutoff values for each feature, may specify quantile in the form of 'q##' where '##' is the quantile (eg, 'q1', 'q10')

reduction	Which dimensionality reduction to use. If not specified, first searches for umap, then tsne, then pca
split.by	A factor in object metadata to split the plot by, pass 'ident' to split by cell identity
keep.scale	How to handle the color scale across multiple plots. Options are: • "feature" (default; by row/feature scaling): The plots for each individual feature are scaled to the maximum expression of the feature across the conditions provided to split.by • "all" (universal scaling): The plots for all features and conditions are scaled to the maximum expression value for the feature with the highest overall expression • NULL (no scaling): Each individual plot is scaled to the maximum expression value of the feature in the condition provided to split.by. Be aware setting NULL will result in color scales that are not comparable between plots
shape.by	If NULL, all points are circles (default). You can specify any cell attribute (that can be pulled with FetchData) allowing for both different colors and different shapes on cells. Only applicable if raster = FALSE.
slot	Which slot to pull expression data from?
assay	Primary assay to pull feature data from
blend	Scale and blend expression values to visualize coexpression of two features
blend.threshold	The color cutoff from weak signal to strong signal; ranges from 0 to 1.
label	Whether to label the clusters
label.size	Sets size of labels
label.color	Sets the color of the label text
repel	Repel labels
ncol	Number of columns to combine multiple feature plots to, ignored if split.by is not NULL
coord.fixed	Plot cartesian coordinates with fixed aspect ratio
by.col	If splitting by a factor, plot the splits per column with the features as rows; ignored if blend = TRUE
sort.cell	Redundant with order. This argument is being deprecated. Please use order instead.
interactive	Launch an interactive FeaturePlot
combine	Combine plots into a single patchworked ggplot object. If FALSE, return a list of ggplot objects
raster	Convert points to raster format, default is NULL which automatically rasterizes if plotting more than 100,000 cells
raster.dpi	Pixel resolution for rasterized plots, passed to geom_scattermore(). Default is c(512, 512).

Value

A patchworked ggplot object if combine = TRUE; otherwise, a list of ggplot objects

Note

For the old do.hover and do.identify functionality, please see HoverLocator and CellSelector, respectively.

See Also

DimPlot HoverLocator CellSelector

Examples

```
data("pbmc_small")
FeaturePlot(object = pbmc_small, features = 'PC_1')
```

FeatureScatter *Scatter plot of single cell data*

Description

Creates a scatter plot of two features (typically feature expression), across a set of single cells. Cells are colored by their identity class. Pearson correlation between the two features is displayed above the plot.

Usage

```
FeatureScatter(
  object,
  feature1,
  feature2,
  cells = NULL,
  shuffle = FALSE,
  seed = 1,
  group.by = NULL,
  split.by = NULL,
  cols = NULL,
  pt.size = 1,
  shape.by = NULL,
  span = NULL,
  smooth = FALSE,
  combine = TRUE,
  slot = "data",
  plot.cor = TRUE,
  ncol = NULL,
  raster = NULL,
  raster.dpi = c(512, 512),
  jitter = FALSE,
  log = FALSE
)
```

Arguments

object	Seurat object
feature1	First feature to plot. Typically feature expression but can also be metrics, PC scores, etc. - anything that can be retreived with FetchData
feature2	Second feature to plot.
cells	Cells to include on the scatter plot.
shuffle	Whether to randomly shuffle the order of points. This can be useful for crowded plots if points of interest are being buried. (default is FALSE)
seed	Sets the seed if randomly shuffling the order of points.
group.by	Name of one or more metadata columns to group (color) cells by (for example, orig.ident); pass 'ident' to group by identity class
split.by	A factor in object metadata to split the feature plot by, pass 'ident' to split by cell identity
cols	Colors to use for identity class plotting.
pt.size	Size of the points on the plot
shape.by	Ignored for now
span	Spline span in loess function call, if NULL, no spline added
smooth	Smooth the graph (similar to smoothScatter)
combine	Combine plots into a single patchworked
slot	Slot to pull data from, should be one of 'counts', 'data', or 'scale.data'
plot.cor	Display correlation in plot title
ncol	Number of columns if plotting multiple plots
raster	Convert points to raster format, default is NULL which will automatically use raster if the number of points plotted is greater than 100,000
raster.dpi	Pixel resolution for rasterized plots, passed to geom_scattermore(). Default is c(512, 512).
jitter	Jitter for easier visualization of crowded points (default is FALSE)
log	Plot features on the log scale (default is FALSE)

Value

A ggplot object

Examples

```
data("pbmc_small")
FeatureScatter(object = pbmc_small, feature1 = 'CD9', feature2 = 'CD3E')
```

FetchResiduals *Get the Pearson residuals from an sctransform-normalized dataset.*

Description

This function calls sctransform::get_residuals.

Usage

```
FetchResiduals(object, ...)

## S3 method for class 'Seurat'
FetchResiduals(
  object,
  features,
  assay = NULL,
  umi.assay = "RNA",
  layer = "counts",
  clip.range = NULL,
  reference.SCT.model = NULL,
  replace.value = FALSE,
  na.rm = TRUE,
  verbose = TRUE,
  ...
)

## S3 method for class 'SCTAssay'
FetchResiduals(
  object,
  umi.object,
  features,
  layer = "counts",
  clip.range = NULL,
  reference.SCT.model = NULL,
  replace.value = FALSE,
  na.rm = TRUE,
  verbose = TRUE,
  ...
)
```

Arguments

object	An SCTAssay object.
...	Arguments passed to other methods (not used)
features	Name of features to fetch residuals for.
assay	Name of the assay to fetch residuals for.

umi.assay	Name of the assay of the seurat object containing counts matrix to use when recalculating any missing residuals.
layer	The name of the layer(s) in 'umi.assay' to use when recalculating any missing residuals.
clip.range	Numeric of length two specifying the min and max values the Pearson residual will be clipped to.
reference.SCT.model	If provided, the reference model will be used to recalculate missing residuals instead of the
replace.value	Recalculate residuals for all features, even if they are already present. Useful if you want to change the clip.range.
na.rm	For features where there is no feature model stored, return NA for residual value in scale.data when na.rm = FALSE. When na.rm is TRUE, only return residuals for features with a model stored for all cells.
verbose	Whether to print messages and progress bars
umi.object	TK.

Value

A matrix containing the requested pearson residuals.

See Also

get_residuals

FilterSlideSeq *Filter stray beads from Slide-seq puck*

Description

This function is useful for removing stray beads that fall outside the main Slide-seq puck area. Essentially, it's a circular filter where you set a center and radius defining a circle of beads to keep. If the center is not set, it will be estimated from the bead coordinates (removing the 1st and 99th quantile to avoid skewing the center by the stray beads). By default, this function will display a SpatialDimPlot showing which cells were removed for easy adjustment of the center and/or radius.

Usage

```
FilterSlideSeq(
  object,
  image = "image",
  center = NULL,
  radius = NULL,
  do.plot = TRUE
)
```

Arguments

object	Seurat object with slide-seq data
image	Name of the image where the coordinates are stored
center	Vector specifying the x and y coordinates for the center of the inclusion circle
radius	Radius of the circle of inclusion
do.plot	Display a SpatialDimPlot with the cells being removed labeled.

Value

Returns a Seurat object with only the subset of cells that pass the circular filter

Examples

```
## Not run:
# This example uses the ssHippo dataset which you can download
# using the SeuratData package.
library(SeuratData)
data('ssHippo')
# perform filtering of beads
ssHippo.filtered <- FilterSlideSeq(ssHippo, radius = 2300)
# This radius looks to small so increase and repeat until satisfied

## End(Not run)
```

FindAllMarkers *Gene expression markers for all identity classes*

Description

Finds markers (differentially expressed genes) for each of the identity classes in a dataset

Usage

```
FindAllMarkers(
  object,
  assay = NULL,
  features = NULL,
  group.by = NULL,
  logfc.threshold = 0.1,
  test.use = "wilcox",
  slot = "data",
  min.pct = 0.01,
  min.diff.pct = -Inf,
  node = NULL,
  verbose = TRUE,
  only.pos = FALSE,
```

```
  max.cells.per.ident = Inf,
  random.seed = 1,
  latent.vars = NULL,
  min.cells.feature = 3,
  min.cells.group = 3,
  mean.fxn = NULL,
  fc.name = NULL,
  base = 2,
  return.thresh = 0.01,
  densify = FALSE,
  ...
)
```

Arguments

object	An object
assay	Assay to use in differential expression testing
features	Genes to test. Default is to use all genes
group.by	Regroup cells into a different identity class prior to performing differential expression (see example); "ident" to use Idents
logfc.threshold	Limit testing to genes which show, on average, at least X-fold difference (log-scale) between the two groups of cells. Default is 0.1 Increasing logfc.threshold speeds up the function, but can miss weaker signals. If the slot parameter is "scale.data" no filtering is performed.
test.use	Denotes which test to use. Available options are: • "wilcox" : Identifies differentially expressed genes between two groups of cells using a Wilcoxon Rank Sum test (default); will use a fast implementation by Presto if installed • "wilcox_limma" : Identifies differentially expressed genes between two groups of cells using the limma implementation of the Wilcoxon Rank Sum test; set this option to reproduce results from Seurat v4 • "bimod" : Likelihood-ratio test for single cell gene expression, (McDavid et al., Bioinformatics, 2013) • "roc" : Identifies 'markers' of gene expression using ROC analysis. For each gene, evaluates (using AUC) a classifier built on that gene alone, to classify between two groups of cells. An AUC value of 1 means that expression values for this gene alone can perfectly classify the two groupings (i.e. Each of the cells in cells.1 exhibit a higher level than each of the cells in cells.2). An AUC value of 0 also means there is perfect classification, but in the other direction. A value of 0.5 implies that the gene has no predictive power to classify the two groups. Returns a 'predictive power' (abs(AUC-0.5) * 2) ranked matrix of putative differentially expressed genes. • "t" : Identify differentially expressed genes between two groups of cells using the Student's t-test.

- "negbinom" : Identifies differentially expressed genes between two groups of cells using a negative binomial generalized linear model. Use only for UMI-based datasets
- "poisson" : Identifies differentially expressed genes between two groups of cells using a poisson generalized linear model. Use only for UMI-based datasets
- "LR" : Uses a logistic regression framework to determine differentially expressed genes. Constructs a logistic regression model predicting group membership based on each feature individually and compares this to a null model with a likelihood ratio test.
- "MAST" : Identifies differentially expressed genes between two groups of cells using a hurdle model tailored to scRNA-seq data. Utilizes the MAST package to run the DE testing.
- "DESeq2" : Identifies differentially expressed genes between two groups of cells based on a model using DESeq2 which uses a negative binomial distribution (Love et al, Genome Biology, 2014).This test does not support pre-filtering of genes based on average difference (or percent detection rate) between cell groups. However, genes may be pre-filtered based on their minimum detection rate (min.pct) across both cell groups. To use this method, please install DESeq2, using the instructions at https://bioconductor.org/packages/release/bioc/html/D

`slot` Slot to pull data from; note that if `test.use` is "negbinom", "poisson", or "DESeq2", `slot` will be set to "counts"

`min.pct` only test genes that are detected in a minimum fraction of min.pct cells in either of the two populations. Meant to speed up the function by not testing genes that are very infrequently expressed. Default is 0.01

`min.diff.pct` only test genes that show a minimum difference in the fraction of detection between the two groups. Set to -Inf by default

`node` A node to find markers for and all its children; requires `BuildClusterTree` to have been run previously; replaces `FindAllMarkersNode`

`verbose` Print a progress bar once expression testing begins

`only.pos` Only return positive markers (FALSE by default)

`max.cells.per.ident` Down sample each identity class to a max number. Default is no downsampling. Not activated by default (set to Inf)

`random.seed` Random seed for downsampling

`latent.vars` Variables to test, used only when `test.use` is one of 'LR', 'negbinom', 'poisson', or 'MAST'

`min.cells.feature` Minimum number of cells expressing the feature in at least one of the two groups, currently only used for poisson and negative binomial tests

`min.cells.group` Minimum number of cells in one of the groups

`mean.fxn` Function to use for fold change or average difference calculation. The default depends on the the value of `fc.slot`:

- "counts" : difference in the log of the mean counts, with pseudocount.
- "data" : difference in the log of the average exponentiated data, with pseudocount. This adjusts for differences in sequencing depth between cells, and assumes that "data" has been log-normalized.
- "scale.data" : difference in the means of scale.data.

`fc.name`	Name of the fold change, average difference, or custom function column in the output data.frame. If NULL, the fold change column will be named according to the logarithm base (eg, "avg_log2FC"), or if using the scale.data slot "avg_diff".
`base`	The base with respect to which logarithms are computed.
`return.thresh`	Only return markers that have a p-value < return.thresh, or a power > return.thresh (if the test is ROC)
`densify`	Convert the sparse matrix to a dense form before running the DE test. This can provide speedups but might require higher memory; default is FALSE
`...`	Arguments passed to other methods and to specific DE methods

Value

Matrix containing a ranked list of putative markers, and associated statistics (p-values, ROC score, etc.)

Examples

```
data("pbmc_small")
# Find markers for all clusters
all.markers <- FindAllMarkers(object = pbmc_small)
head(x = all.markers)
## Not run:
# Pass a value to node as a replacement for FindAllMarkersNode
pbmc_small <- BuildClusterTree(object = pbmc_small)
all.markers <- FindAllMarkers(object = pbmc_small, node = 4)
head(x = all.markers)

## End(Not run)
```

FindBridgeIntegrationAnchors

Find integration bridge anchors between query and extended bridge-reference

---

Description

Find a set of anchors between unimodal query and the other unimodal reference using a pre-computed `BridgeReferenceSet`. These integration anchors can later be used to integrate query and reference using the `IntegrateEmbeddings` object.

Usage

```
FindBridgeIntegrationAnchors(
  extended.reference,
  query,
  query.assay = NULL,
  dims = 1:30,
  scale = FALSE,
  reduction = c("lsiproject", "pcaproject"),
  integration.reduction = c("direct", "cca"),
  verbose = TRUE
)
```

Arguments

extended.reference	BridgeReferenceSet object generated from PrepareBridgeReference
query	A query Seurat object
query.assay	Assay name for query-bridge integration
dims	Number of dimensions for query-bridge integration
scale	Determine if scale the query data for projection
reduction	Dimensional reduction to perform when finding anchors. Options are: • pcaproject: Project the PCA from the bridge onto the query. We recommend using PCA when bridge and query datasets are from scRNA-seq • lsiproject: Project the LSI from the bridge onto the query. We recommend using LSI when bridge and query datasets are from scATAC-seq or scCUT&TAG data. This requires that LSI or supervised LSI has been computed for the bridge dataset, and the same features (eg, peaks or genome bins) are present in both the bridge and query.
integration.reduction	Dimensional reduction to perform when finding anchors between query and reference. Options are: • direct: find anchors directly on the bridge representation space • cca: perform cca on the on the bridge representation space and then find anchors
verbose	Print messages and progress

Value

Returns an AnchorSet object that can be used as input to IntegrateEmbeddings.

FindBridgeTransferAnchors *Find bridge anchors between query and extended bridge-reference*

Description

Find a set of anchors between unimodal query and the other unimodal reference using a pre-computed BridgeReferenceSet. This function performs three steps: 1. Harmonize the bridge and query cells in the bridge query reduction space 2. Construct the bridge dictionary representations for query cells 3. Find a set of anchors between query and reference in the bridge graph laplacian eigenspace These anchors can later be used to integrate embeddings or transfer data from the reference to query object using the MapQuery object.

Usage

```
FindBridgeTransferAnchors(
  extended.reference,
  query,
  query.assay = NULL,
  dims = 1:30,
  scale = FALSE,
  reduction = c("lsiproject", "pcaproject"),
  bridge.reduction = c("direct", "cca"),
  verbose = TRUE
)
```

Arguments

extended.reference	BridgeReferenceSet object generated from PrepareBridgeReference
query	A query Seurat object
query.assay	Assay name for query-bridge integration
dims	Number of dimensions for query-bridge integration
scale	Determine if scale the query data for projection
reduction	Dimensional reduction to perform when finding anchors. Options are: • pcaproject: Project the PCA from the bridge onto the query. We recommend using PCA when bridge and query datasets are from scRNA-seq • lsiproject: Project the LSI from the bridge onto the query. We recommend using LSI when bridge and query datasets are from scATAC-seq or scCUT&TAG data. This requires that LSI or supervised LSI has been computed for the bridge dataset, and the same features (eg, peaks or genome bins) are present in both the bridge and query.
bridge.reduction	Dimensional reduction to perform when finding anchors. Can be one of:

- cca: Canonical correlation analysis
- direct: Use assay data as a dimensional reduction

verbose Print messages and progress

Value

Returns an AnchorSet object that can be used as input to TransferData, IntegrateEmbeddings and MapQuery.

FindClusters *Cluster Determination*

Description

Identify clusters of cells by a shared nearest neighbor (SNN) modularity optimization based clustering algorithm. First calculate k-nearest neighbors and construct the SNN graph. Then optimize the modularity function to determine clusters. For a full description of the algorithms, see Waltman and van Eck (2013) *The European Physical Journal B*. Thanks to Nigel Delaney (evolvedmicrobe@github) for the initial rewrite (v2.3.4) of the Java modularity optimizer code in Rcpp!

Usage

```
FindClusters(object, ...)

## Default S3 method:
FindClusters(
  object,
  modularity.fxn = 1,
  initial.membership = NULL,
  node.sizes = NULL,
  resolution = 0.8,
  method = deprecated(),
  algorithm = 1,
  leiden_method = c("leidenbase", "igraph"),
  leiden_objective_function = c("modularity", "CPM"),
  n.start = 10,
  n.iter = 10,
  random.seed = 0,
  group.singletons = TRUE,
  temp.file.location = NULL,
  edge.file.name = NULL,
  verbose = TRUE,
  ...
)

## S3 method for class 'Seurat'
FindClusters(
```

```
  object,
  graph.name = NULL,
  cluster.name = NULL,
  modularity.fxn = 1,
  initial.membership = NULL,
  node.sizes = NULL,
  resolution = 0.8,
  method = NULL,
  algorithm = 1,
  leiden_method = c("leidenbase", "igraph"),
  leiden_objective_function = c("modularity", "CPM"),
  n.start = 10,
  n.iter = 10,
  random.seed = 0,
  group.singletons = TRUE,
  temp.file.location = NULL,
  edge.file.name = NULL,
  verbose = TRUE,
  ...
)
```

Arguments

`object`	An object
`...`	Arguments passed to other methods
`modularity.fxn`	Modularity function (1 = standard; 2 = alternative).
`initial.membership`	Passed to the ‘initial_membership‘ parameter of ‘leidenbase::leiden_find_partition‘.
`node.sizes`	Passed to the ‘node_sizes‘ parameter of ‘leidenbase::leiden_find_partition‘.
`resolution`	Value of the resolution parameter, use a value above (below) 1.0 if you want to obtain a larger (smaller) number of communities.
`method`	DEPRECATED.
`algorithm`	Algorithm for modularity optimization (1 = original Louvain algorithm; 2 = Louvain algorithm with multilevel refinement; 3 = SLM algorithm; 4 = Leiden algorithm).
`leiden_method`	Choose from the leidenbase ("leidenbase") or igraph ("igraph") packages for running leiden. Default is "leidenbase"
`leiden_objective_function`	objective function to use if ‘leiden_method = "igraph"‘. See `cluster_leiden` for more information. Default is "modularity".
`n.start`	Number of random starts.
`n.iter`	Maximal number of iterations per random start.
`random.seed`	Seed of the random number generator.
`group.singletons`	Group singletons into nearest cluster. If FALSE, assign all singletons to a "singleton" group

temp.file.location	Directory where intermediate files will be written. Specify the ABSOLUTE path.
edge.file.name	Edge file to use as input for modularity optimizer jar.
verbose	Print output
graph.name	Name of graph to use for the clustering algorithm
cluster.name	Name of output clusters

Details

Leiden clustering can be run with either the `leidenbase` or `igraph` backend; see Traag et al (2018).

Value

Returns a Seurat object where the idents have been updated with new cluster info; latest clustering results will be stored in object metadata under 'seurat_clusters'. Note that 'seurat_clusters' will be overwritten everytime FindClusters is run

Note

When running Louvain clustering with multiple threads, results may differ from single-threaded runs only when `n.start > 1`, because each random start uses an independent random number stream based on `random.seed` plus the restart index. Single-threaded runs use one random number stream across all starts. With `n.start = 1`, all thread settings use the same serial path. For a fixed `random.seed`, multi-threaded Louvain results are expected to be reproducible across thread counts.

FindConservedMarkers *Finds markers that are conserved between the groups*

Description

Finds markers that are conserved between the groups

Usage

```
FindConservedMarkers(
  object,
  ident.1,
  ident.2 = NULL,
  grouping.var,
  assay = "RNA",
  slot = "data",
  min.cells.group = 3,
  meta.method = metap::minimump,
  verbose = TRUE,
  ...
)
```

Arguments

object	An object
ident.1	Identity class to define markers for
ident.2	A second identity class for comparison. If NULL (default) - use all other cells for comparison.
grouping.var	grouping variable
assay	of assay to fetch data for (default is RNA)
slot	Slot to pull data from; note that if test.use is "negbinom", "poisson", or "DESeq2", slot will be set to "counts"
min.cells.group	Minimum number of cells in one of the groups
meta.method	method for combining p-values. Should be a function from the metap package (NOTE: pass the function, not a string)
verbose	Print a progress bar once expression testing begins
...	parameters to pass to FindMarkers

Value

data.frame containing a ranked list of putative conserved markers, and associated statistics (p-values within each group and a combined p-value (such as Fishers combined p-value or others from the metap package), percentage of cells expressing the marker, average differences). Name of group is appended to each associated output column (e.g. CTRL_p_val). If only one group is tested in the grouping.var, max and combined p-values are not returned.

Examples

```
## Not run:
data("pbmc_small")
pbmc_small
# Create a simulated grouping variable
pbmc_small[['groups']] <- sample(x = c('g1', 'g2'), size = ncol(x = pbmc_small), replace = TRUE)
FindConservedMarkers(pbmc_small, ident.1 = 0, ident.2 = 1, grouping.var = "groups")

## End(Not run)
```

FindIntegrationAnchors

Find integration anchors

Description

Find a set of anchors between a list of Seurat objects. These anchors can later be used to integrate the objects using the IntegrateData function.

Usage

```
FindIntegrationAnchors(
  object.list = NULL,
  assay = NULL,
  reference = NULL,
  anchor.features = 2000,
  scale = TRUE,
  normalization.method = c("LogNormalize", "SCT"),
  sct.clip.range = NULL,
  reduction = c("cca", "rpca", "jpca", "rlsi"),
  l2.norm = TRUE,
  dims = 1:30,
  k.anchor = 5,
  k.filter = 200,
  k.score = 30,
  max.features = 200,
  nn.method = "annoy",
  n.trees = 50,
  eps = 0,
  svd.method = NULL,
  verbose = TRUE
)
```

Arguments

`object.list`	A list of Seurat objects between which to find anchors for downstream integration.
`assay`	A vector of assay names specifying which assay to use when constructing anchors. If NULL, the current default assay for each object is used.
`reference`	A vector specifying the object/s to be used as a reference during integration. If NULL (default), all pairwise anchors are found (no reference/s). If not NULL, the corresponding objects in `object.list` will be used as references. When using a set of specified references, anchors are first found between each query and each reference. The references are then integrated through pairwise integration. Each query is then mapped to the integrated reference.
`anchor.features`	Can be either: • A numeric value. This will call SelectIntegrationFeatures to select the provided number of features to be used in anchor finding • A vector of features to be used as input to the anchor finding process
`scale`	Whether or not to scale the features provided. Only set to FALSE if you have previously scaled the features you want to use for each object in the object.list
`normalization.method`	Name of normalization method used: LogNormalize or SCT
`sct.clip.range`	Numeric of length two specifying the min and max values the Pearson residual will be clipped to

reduction	Dimensional reduction to perform when finding anchors. Can be one of: • cca: Canonical correlation analysis • rpca: Reciprocal PCA • jpca: Joint PCA • rlsi: Reciprocal LSI
l2.norm	Perform L2 normalization on the CCA cell embeddings after dimensional reduction
dims	Which dimensions to use from the CCA to specify the neighbor search space
k.anchor	How many neighbors (k) to use when picking anchors
k.filter	How many neighbors (k) to use when filtering anchors
k.score	How many neighbors (k) to use when scoring anchors
max.features	The maximum number of features to use when specifying the neighborhood search space in the anchor filtering
nn.method	Method for nearest neighbor finding. Options include: rann, annoy
n.trees	More trees gives higher precision when using annoy approximate nearest neighbor search
eps	Error bound on the neighbor finding algorithm (from RANN/Annoy)
svd.method	SVD backend to use when reduction = "cca". If NULL, defaults to "irlba" except for pairs of dense CCA input matrices whose cell-by-cell cross-product matrix has at least 1,000,000 entries, in which case it defaults to "rspectra". "irlba" uses an explicit cross-product CCA path; "rspectra" uses an implicit operator to avoid forming the cross-product matrix.
verbose	Print progress bars and output

Details

The main steps of this procedure are outlined below. For a more detailed description of the methodology, please see Stuart, Butler, et al Cell 2019: doi:10.1016/j.cell.2019.05.031; doi:10.1101/460147

First, determine anchor.features if not explicitly specified using SelectIntegrationFeatures. Then for all pairwise combinations of reference and query datasets:

- Perform dimensional reduction on the dataset pair as specified via the reduction parameter. If l2.norm is set to TRUE, perform L2 normalization of the embedding vectors.
- Identify anchors - pairs of cells from each dataset that are contained within each other's neighborhoods (also known as mutual nearest neighbors).
- Filter low confidence anchors to ensure anchors in the low dimension space are in broad agreement with the high dimensional measurements. This is done by looking at the neighbors of each query cell in the reference dataset using max.features to define this space. If the reference cell isn't found within the first k.filter neighbors, remove the anchor.
- Assign each remaining anchor a score. For each anchor cell, determine the nearest k.score anchors within its own dataset and within its pair's dataset. Based on these neighborhoods, construct an overall neighbor graph and then compute the shared neighbor overlap between anchor and query cells (analogous to an SNN graph). We use the 0.01 and 0.90 quantiles on these scores to dampen outlier effects and rescale to range between 0-1.

Value

Returns an AnchorSet object that can be used as input to IntegrateData.

References

Stuart T, Butler A, et al. Comprehensive Integration of Single-Cell Data. Cell. 2019;177:1888-1902 doi:10.1016/j.cell.2019.05.031

Examples

```
## Not run:
# to install the SeuratData package see https://github.com/satijalab/seurat-data
library(SeuratData)
data("panc8")

# panc8 is a merged Seurat object containing 8 separate pancreas datasets
# split the object by dataset
pancreas.list <- SplitObject(panc8, split.by = "tech")

# perform standard preprocessing on each object
for (i in 1:length(pancreas.list)) {
  pancreas.list[[i]] <- NormalizeData(pancreas.list[[i]], verbose = FALSE)
  pancreas.list[[i]] <- FindVariableFeatures(
    pancreas.list[[i]], selection.method = "vst",
    nfeatures = 2000, verbose = FALSE
  )
}

# find anchors
anchors <- FindIntegrationAnchors(object.list = pancreas.list)

# integrate data
integrated <- IntegrateData(anchorset = anchors)

## End(Not run)
```

FindMarkers *Gene expression markers of identity classes*

Description

Finds markers (differentially expressed genes) for each of the identity classes in a dataset. Note that differential expression between groups (e.g. treatment conditions) should account for biological variation across samples, e.g. by using pseudobulk expression profiles.

Usage

```
FindMarkers(object, ...)

## Default S3 method:
FindMarkers(
  object,
  slot = "data",
  cells.1 = NULL,
  cells.2 = NULL,
  features = NULL,
  logfc.threshold = 0.1,
  test.use = "wilcox",
  min.pct = 0.01,
  min.diff.pct = -Inf,
  verbose = TRUE,
  only.pos = FALSE,
  max.cells.per.ident = Inf,
  random.seed = 1,
  latent.vars = NULL,
  min.cells.feature = 3,
  min.cells.group = 3,
  fc.results = NULL,
  densify = FALSE,
  ...
)

## S3 method for class 'Assay'
FindMarkers(
  object,
  slot = "data",
  cells.1 = NULL,
  cells.2 = NULL,
  features = NULL,
  test.use = "wilcox",
  fc.slot = "data",
  pseudocount.use = 1,
  norm.method = NULL,
  mean.fxn = NULL,
  fc.name = NULL,
  base = 2,
  ...
)

## S3 method for class 'SCTAssay'
FindMarkers(
  object,
  cells.1 = NULL,
  cells.2 = NULL,
```

```
  features = NULL,
  test.use = "wilcox",
  pseudocount.use = 1,
  slot = "data",
  fc.slot = "data",
  mean.fxn = NULL,
  fc.name = NULL,
  base = 2,
  recorrect_umi = TRUE,
  ...
)

## S3 method for class 'DimReduc'
FindMarkers(
  object,
  cells.1 = NULL,
  cells.2 = NULL,
  features = NULL,
  logfc.threshold = 0.1,
  test.use = "wilcox",
  min.pct = 0.01,
  min.diff.pct = -Inf,
  verbose = TRUE,
  only.pos = FALSE,
  max.cells.per.ident = Inf,
  random.seed = 1,
  latent.vars = NULL,
  min.cells.feature = 3,
  min.cells.group = 3,
  densify = FALSE,
  mean.fxn = rowMeans,
  fc.name = NULL,
  ...
)

## S3 method for class 'Seurat'
FindMarkers(
  object,
  ident.1 = NULL,
  ident.2 = NULL,
  latent.vars = NULL,
  group.by = NULL,
  subset.ident = NULL,
  assay = NULL,
  reduction = NULL,
  ...
)
```

Arguments

`object`	An object
`...`	Arguments passed to other methods and to specific DE methods
`slot`	Slot to pull data from; note that if `test.use` is "negbinom", "poisson", or "DESeq2", `slot` will be set to "counts"
`cells.1`	Vector of cell names belonging to group 1
`cells.2`	Vector of cell names belonging to group 2
`features`	Genes to test. Default is to use all genes
`logfc.threshold`	Limit testing to genes which show, on average, at least X-fold difference (log-scale) between the two groups of cells. Default is 0.1 Increasing logfc.threshold speeds up the function, but can miss weaker signals. If the `slot` parameter is "scale.data" no filtering is performed.
`test.use`	Denotes which test to use. Available options are:

- "wilcox" : Identifies differentially expressed genes between two groups of cells using a Wilcoxon Rank Sum test (default); will use a fast implementation by Presto if installed
- "wilcox_limma" : Identifies differentially expressed genes between two groups of cells using the limma implementation of the Wilcoxon Rank Sum test; set this option to reproduce results from Seurat v4
- "bimod" : Likelihood-ratio test for single cell gene expression, (McDavid et al., Bioinformatics, 2013)
- "roc" : Identifies 'markers' of gene expression using ROC analysis. For each gene, evaluates (using AUC) a classifier built on that gene alone, to classify between two groups of cells. An AUC value of 1 means that expression values for this gene alone can perfectly classify the two groupings (i.e. Each of the cells in cells.1 exhibit a higher level than each of the cells in cells.2). An AUC value of 0 also means there is perfect classification, but in the other direction. A value of 0.5 implies that the gene has no predictive power to classify the two groups. Returns a 'predictive power' (abs(AUC-0.5) * 2) ranked matrix of putative differentially expressed genes.
- "t" : Identify differentially expressed genes between two groups of cells using the Student's t-test.
- "negbinom" : Identifies differentially expressed genes between two groups of cells using a negative binomial generalized linear model. Use only for UMI-based datasets
- "poisson" : Identifies differentially expressed genes between two groups of cells using a poisson generalized linear model. Use only for UMI-based datasets
- "LR" : Uses a logistic regression framework to determine differentially expressed genes. Constructs a logistic regression model predicting group membership based on each feature individually and compares this to a null model with a likelihood ratio test.

- "MAST" : Identifies differentially expressed genes between two groups of cells using a hurdle model tailored to scRNA-seq data. Utilizes the MAST package to run the DE testing.
- "DESeq2" : Identifies differentially expressed genes between two groups of cells based on a model using DESeq2 which uses a negative binomial distribution (Love et al, Genome Biology, 2014).This test does not support pre-filtering of genes based on average difference (or percent detection rate) between cell groups. However, genes may be pre-filtered based on their minimum detection rate (min.pct) across both cell groups. To use this method, please install DESeq2, using the instructions at https://bioconductor.org/packages/release/bioc/html/D

`min.pct` only test genes that are detected in a minimum fraction of min.pct cells in either of the two populations. Meant to speed up the function by not testing genes that are very infrequently expressed. Default is 0.01

`min.diff.pct` only test genes that show a minimum difference in the fraction of detection between the two groups. Set to -Inf by default

`verbose` Print a progress bar once expression testing begins

`only.pos` Only return positive markers (FALSE by default)

`max.cells.per.ident`
Down sample each identity class to a max number. Default is no downsampling. Not activated by default (set to Inf)

`random.seed` Random seed for downsampling

`latent.vars` Variables to test, used only when `test.use` is one of 'LR', 'negbinom', 'poisson', or 'MAST'

`min.cells.feature`
Minimum number of cells expressing the feature in at least one of the two groups, currently only used for poisson and negative binomial tests

`min.cells.group`
Minimum number of cells in one of the groups

`fc.results` data.frame from FoldChange

`densify` Convert the sparse matrix to a dense form before running the DE test. This can provide speedups but might require higher memory; default is FALSE

`fc.slot` Slot used to calculate fold-change - will also affect the default for `mean.fxn`, see below for more details.

`pseudocount.use`
Pseudocount to add to averaged expression values when calculating logFC. 1 by default.

`norm.method` Normalization method for fold change calculation when `slot` is "`data`"

`mean.fxn` Function to use for fold change or average difference calculation. The default depends on the the value of `fc.slot`:

- "counts" : difference in the log of the mean counts, with pseudocount.
- "data" : difference in the log of the average exponentiated data, with pseudocount. This adjusts for differences in sequencing depth between cells, and assumes that "data" has been log-normalized.
- "scale.data" : difference in the means of scale.data.

fc.name	Name of the fold change, average difference, or custom function column in the output data.frame. If NULL, the fold change column will be named according to the logarithm base (eg, "avg_log2FC"), or if using the scale.data slot "avg_diff".
base	The base with respect to which logarithms are computed.
recorrect_umi	Recalculate corrected UMI counts using minimum of the median UMIs when performing DE using multiple SCT objects; default is TRUE
ident.1	Identity class to define markers for; pass an object of class phylo or 'clustertree' to find markers for a node in a cluster tree; passing 'clustertree' requires BuildClusterTree to have been run
ident.2	A second identity class for comparison; if NULL, use all other cells for comparison; if an object of class phylo or 'clustertree' is passed to ident.1, must pass a node to find markers for
group.by	Regroup cells into a different identity class prior to performing differential expression (see example); "ident" to use Idents
subset.ident	Subset a particular identity class prior to regrouping. Only relevant if group.by is set (see example)
assay	Assay to use in differential expression testing
reduction	Reduction to use in differential expression testing - will test for DE on cell embeddings

Details

p-value adjustment is performed using bonferroni correction based on the total number of genes in the dataset. Other correction methods are not recommended, as Seurat pre-filters genes using the arguments above, reducing the number of tests performed. Lastly, as Aaron Lun has pointed out, p-values should be interpreted cautiously, as the genes used for clustering are the same genes tested for differential expression.

Value

data.frame with a ranked list of putative markers as rows, and associated statistics as columns (p-values, ROC score, etc., depending on the test used (test.use)). The following columns are always present:

- avg_logFC: log fold-chage of the average expression between the two groups. Positive values indicate that the gene is more highly expressed in the first group
- pct.1: The percentage of cells where the gene is detected in the first group
- pct.2: The percentage of cells where the gene is detected in the second group
- p_val_adj: Adjusted p-value, based on bonferroni correction using all genes in the dataset

Note

See the DE vignette for more details and examples

References

McDavid A, Finak G, Chattopadyay PK, et al. Data exploration, quality control and testing in single-cell qPCR-based gene expression experiments. Bioinformatics. 2013;29(4):461-467. doi:10.1093/bioinformatics/bts7

Trapnell C, et al. The dynamics and regulators of cell fate decisions are revealed by pseudotemporal ordering of single cells. Nature Biotechnology volume 32, pages 381-386 (2014)

Andrew McDavid, Greg Finak and Masanao Yajima (2017). MAST: Model-based Analysis of Single Cell Transcriptomics. R package version 1.2.1. https://github.com/RGLab/MAST/

Love MI, Huber W and Anders S (2014). "Moderated estimation of fold change and dispersion for RNA-seq data with DESeq2." Genome Biology. https://bioconductor.org/packages/release/bioc/html/DESeq2.html

Examples

```
## Not run:
data("pbmc_small")
# Find markers for cluster 2
markers <- FindMarkers(object = pbmc_small, ident.1 = 2)
head(x = markers)

# Within cluster 2, find markers for cells in the 'g1' group compared with
# other cells, using the 'groups' metadata variable.
markers <- FindMarkers(pbmc_small, ident.1 = "g1", group.by = 'groups', subset.ident = "2")
head(x = markers)

# Pass 'clustertree' or an object of class phylo to ident.1 and
# a node to ident.2 as a replacement for FindMarkersNode
if (requireNamespace("ape", quietly = TRUE)) {
  pbmc_small <- BuildClusterTree(object = pbmc_small)
  markers <- FindMarkers(object = pbmc_small, ident.1 = 'clustertree', ident.2 = 5)
  head(x = markers)
}

## End(Not run)
```

FindmmNN *Find Multi-Modal Nearest Neighbors*

Description

A wrapper function that finds Multi-Modal weights and generate a Multi-Modal NN object.

Usage

```
FindmmNN(
  object,
  sketch.assay = NULL,
  reduction.list,
```

```
  dims.list,
  k.nn = 20,
  knn.range = 200,
  l2.norm = TRUE,
  fix.wnn.weights = NULL,
  nn.name = "weighted.nn",
  weighted.nn.name = NULL,
  verbose = TRUE,
  ...
)
```

Arguments

object	A Seurat object
sketch.assay	The name of the sketched assay of the landmark cells.
reduction.list	A list of dimensional reductions, one for each modality
dims.list	A list containing the dimensions for each reduction to use
k.nn	The number of nearest neighbors to compute for each modality. Internally clamped to a minimum of 20 (i.e. values below 20 are silently raised to 20).
knn.range	Range parameter for nearest neighbor search
l2.norm	Perform L2 normalization on the cell embeddings
fix.wnn.weights	Pre-specified modality weights. If provided, skips the calculation and uses these weights directly. Should be a list with the same length as reduction.list.
nn.name	Name under which the resulting Neighbor object is stored.
weighted.nn.name	Deprecated. Use nn.name instead.
verbose	Print progress bars and output
...	Additional arguments for Seurat:::FindModalityWeights (for example sigma.idx, sd.scale or prune.SNN) or Seurat:::MultiModalNN (for example kernel.power). Each is routed to whichever of the two declares it; arguments matching neither are reported.

Details

This function is essentially a wrapper function that perform the following 2 procedures:

- Seurat:::FindModalityWeights
- Seurat:::MultiModalNN

Value

return a Seurat object that contains a weighted.nn Neighbor object between the landmark cells and all the other cells.

FindMultiModalNeighbors *Construct weighted nearest neighbor graph*

Description

This function will construct a weighted nearest neighbor (WNN) graph. For each cell, we identify the nearest neighbors based on a weighted combination of two modalities. Takes as input two dimensional reductions, one computed for each modality.Other parameters are listed for debugging, but can be left as default values.

Usage

```
FindMultiModalNeighbors(
  object,
  reduction.list,
  dims.list,
  k.nn = 20,
  l2.norm = TRUE,
  knn.graph.name = "wknn",
  snn.graph.name = "wsnn",
  weighted.nn.name = "weighted.nn",
  modality.weight.name = NULL,
  knn.range = 200,
  prune.SNN = 1/15,
  sd.scale = 1,
  cross.contant.list = NULL,
  smooth = FALSE,
  return.intermediate = FALSE,
  modality.weight = NULL,
  verbose = TRUE
)
```

Arguments

object	A Seurat object
reduction.list	A list of two dimensional reductions, one for each of the modalities to be integrated
dims.list	A list containing the dimensions for each reduction to use
k.nn	the number of multimodal neighbors to compute. 20 by default
l2.norm	Perform L2 normalization on the cell embeddings after dimensional reduction. TRUE by default.
knn.graph.name	Multimodal knn graph name
snn.graph.name	Multimodal snn graph name

weighted.nn.name
: Multimodal neighbor object name

modality.weight.name
: Variable name to store modality weight in object meta data

knn.range
: The number of approximate neighbors to compute

prune.SNN
: Cutoff not to discard edge in SNN graph

sd.scale
: The scaling factor for kernel width. 1 by default

cross.contant.list
: Constant used to avoid divide-by-zero errors. 1e-4 by default

smooth
: Smoothing modality score across each individual modality neighbors. FALSE by default

return.intermediate
: Store intermediate results in misc

modality.weight
: A ModalityWeights object generated by FindModalityWeights

verbose
: Print progress bars and output

Value

Seurat object containing a nearest-neighbor object, KNN graph, and SNN graph - each based on a weighted combination of modalities.

FindNeighbors *(Shared) Nearest-neighbor graph construction*

Description

Computes the k.param nearest neighbors for a given dataset. Can also optionally (via compute.SNN), construct a shared nearest neighbor graph by calculating the neighborhood overlap (Jaccard index) between every cell and its k.param nearest neighbors.

Usage

```
FindNeighbors(object, ...)

## Default S3 method:
FindNeighbors(
  object,
  query = NULL,
  distance.matrix = FALSE,
  k.param = 20,
  return.neighbor = FALSE,
  compute.SNN = !return.neighbor,
  prune.SNN = 1/15,
  nn.method = "annoy",
```

```
  n.trees = 50,
  annoy.metric = "euclidean",
  nn.eps = 0,
  verbose = TRUE,
  l2.norm = FALSE,
  cache.index = FALSE,
  index = NULL,
  ...
)

## S3 method for class 'Assay'
FindNeighbors(
  object,
  features = NULL,
  k.param = 20,
  return.neighbor = FALSE,
  compute.SNN = !return.neighbor,
  prune.SNN = 1/15,
  nn.method = "annoy",
  n.trees = 50,
  annoy.metric = "euclidean",
  nn.eps = 0,
  verbose = TRUE,
  l2.norm = FALSE,
  cache.index = FALSE,
  ...
)

## S3 method for class 'dist'
FindNeighbors(
  object,
  k.param = 20,
  return.neighbor = FALSE,
  compute.SNN = !return.neighbor,
  prune.SNN = 1/15,
  nn.method = "annoy",
  n.trees = 50,
  annoy.metric = "euclidean",
  nn.eps = 0,
  verbose = TRUE,
  l2.norm = FALSE,
  cache.index = FALSE,
  ...
)

## S3 method for class 'Seurat'
FindNeighbors(
  object,
```

```
  reduction = "pca",
  dims = 1:10,
  assay = NULL,
  features = NULL,
  k.param = 20,
  return.neighbor = FALSE,
  compute.SNN = !return.neighbor,
  prune.SNN = 1/15,
  nn.method = "annoy",
  n.trees = 50,
  annoy.metric = "euclidean",
  nn.eps = 0,
  verbose = TRUE,
  do.plot = FALSE,
  graph.name = NULL,
  l2.norm = FALSE,
  cache.index = FALSE,
  ...
)
```

Arguments

object	An object
...	Arguments passed to other methods
query	Matrix of data to query against object. If missing, defaults to object.
distance.matrix	Boolean value of whether the provided matrix is a distance matrix; note, for objects of class dist, this parameter will be set automatically
k.param	Defines k for the k-nearest neighbor algorithm
return.neighbor	Return result as Neighbor object. Not used with distance matrix input.
compute.SNN	also compute the shared nearest neighbor graph
prune.SNN	Sets the cutoff for acceptable Jaccard index when computing the neighborhood overlap for the SNN construction. Any edges with values less than or equal to this will be set to 0 and removed from the SNN graph. Essentially sets the stringency of pruning (0 — no pruning, 1 — prune everything).
nn.method	Method for nearest neighbor finding. Options include: rann, annoy
n.trees	More trees gives higher precision when using annoy approximate nearest neighbor search
annoy.metric	Distance metric for annoy. Options include: euclidean, cosine, manhattan, and hamming
nn.eps	Error bound when performing nearest neighbor search using RANN; default of 0.0 implies exact nearest neighbor search
verbose	Whether or not to print output to the console
l2.norm	Take L2Norm of the data

cache.index	Include cached index in returned Neighbor object (only relevant if return.neighbor = TRUE)
index	Precomputed index. Useful if querying new data against existing index to avoid recomputing.
features	Features to use as input for building the (S)NN; used only when dims is NULL
reduction	Reduction to use as input for building the (S)NN
dims	Dimensions of reduction to use as input
assay	Assay to use in construction of (S)NN; used only when dims is NULL
do.plot	Plot SNN graph on tSNE coordinates
graph.name	Optional naming parameter for stored (S)NN graph (or Neighbor object, if return.neighbor = TRUE). Default is assay.name_(s)nn. To store both the neighbor graph and the shared nearest neighbor (SNN) graph, you must supply a vector containing two names to the graph.name parameter. The first element in the vector will be used to store the nearest neighbor (NN) graph, and the second element used to store the SNN graph. If only one name is supplied, only the NN graph is stored.

Value

This function can either return a Neighbor object with the KNN information or a list of Graph objects with the KNN and SNN depending on the settings of return.neighbor and compute.SNN. When running on a Seurat object, this returns the Seurat object with the Graphs or Neighbor objects stored in their respective slots. Names of the Graph or Neighbor object can be found with Graphs or Neighbors.

Examples

```
data("pbmc_small")
pbmc_small
## Not run:
# Compute an SNN on the gene expression level
pbmc_small <- FindNeighbors(pbmc_small, features = VariableFeatures(object = pbmc_small))

## End(Not run)

# More commonly, we build the SNN on a dimensionally reduced form of the data
# such as the first 10 principle components.

pbmc_small <- FindNeighbors(pbmc_small, reduction = "pca", dims = 1:10)
```

FindsmNN *Find Single-Modality Nearest Neighbors*

Description

A wrapper function that builds a Neighbor object from a single reduction (e.g. the PLS embedding), mapping every cell to its nearest landmark cells.

Usage

```
FindsmNN(
  object,
  sketch.assay = NULL,
  reduction,
  dims = NULL,
  k.nn = 20,
  l2.norm = TRUE,
  nn.name = "single.nn",
  verbose = TRUE,
  ...
)
```

Arguments

object	A Seurat object
sketch.assay	The name of the sketched assay of the landmark cells.
reduction	The name of a single dimensional reduction to use (e.g. "proj.pls").
dims	The dimensions of the reduction to use. If NULL (default), all dimensions are used.
k.nn	The number of nearest neighbors to compute for each cell. Honored as given (unlike FindmmNN, which clamps to a minimum of 20).
l2.norm	Perform L2 normalization on the cell embeddings
nn.name	Name under which the resulting Neighbor object is stored.
verbose	Print progress bars and output
...	Arguments passed to Seurat::FindNeighbors

Details

This is the single-modality counterpart of FindmmNN: instead of combining several reductions with WNN weights, it runs a single Seurat::FindNeighbors call on one reduction, with the landmark (sketched) cells as the reference and all cells as the query. The resulting Neighbor object is a drop-in replacement for the weighted.nn produced by FindmmNN and is consumed by GenerateSampleObject in the same way.

Value

return a Seurat object that contains a Neighbor object between the landmark cells and all the other cells.

`FindSpatiallyVariableFeatures` *Find spatially variable features*

Description

Identify features whose variability in expression can be explained to some degree by spatial location.

Usage

```
FindSpatiallyVariableFeatures(object, ...)

## Default S3 method:
FindSpatiallyVariableFeatures(
  object,
  spatial.location,
  selection.method = c("markvariogram", "moransi"),
  r.metric = 5,
  x.cuts = NULL,
  y.cuts = NULL,
  verbose = TRUE,
  ...
)

## S3 method for class 'Assay'
FindSpatiallyVariableFeatures(
  object,
  layer = "scale.data",
  slot = deprecated(),
  spatial.location,
  selection.method = c("markvariogram", "moransi"),
  features = NULL,
  r.metric = 5,
  x.cuts = NULL,
  y.cuts = NULL,
  nfeatures = 2000,
  verbose = TRUE,
  ...
)

## S3 method for class 'Seurat'
FindSpatiallyVariableFeatures(
  object,
  assay = NULL,
  layer = "scale.data",
  slot = NULL,
  features = NULL,
```

```
  image = NULL,
  selection.method = c("markvariogram", "moransi"),
  r.metric = 5,
  x.cuts = NULL,
  y.cuts = NULL,
  nfeatures = 2000,
  verbose = TRUE,
  ...
)

## S3 method for class 'StdAssay'
FindSpatiallyVariableFeatures(
  object,
  layer = "scale.data",
  slot = deprecated(),
  spatial.location,
  selection.method = c("markvariogram", "moransi"),
  features = NULL,
  r.metric = 5,
  x.cuts = NULL,
  y.cuts = NULL,
  nfeatures = 2000,
  verbose = TRUE,
  ...
)
```

Arguments

`object`	A Seurat object, assay, or expression matrix
`...`	Arguments passed to other methods
`spatial.location`	Coordinates for each cell/spot/bead
`selection.method`	Method for selecting spatially variable features. • `markvariogram`: See `RunMarkVario` for details • `moransi`: See `RunMoransI` for details.
`r.metric`	r value at which to report the "trans" value of the mark variogram
`x.cuts`	Number of divisions to make in the x direction, helps define the grid over which binning is performed
`y.cuts`	Number of divisions to make in the y direction, helps define the grid over which binning is performed
`verbose`	Print messages and progress
`layer`	The layer in the specified assay to pull data from.
`slot`	Deprecated, use ‘layer‘.
`features`	If provided, only compute on given features. Otherwise, compute for all features.

nfeatures	Number of features to mark as the top spatially variable.
assay	Assay to pull the features (marks) from
image	Name of image to pull the coordinates from

`FindSubCluster` *Find subclusters under one cluster*

Description

Find subclusters under one cluster

Usage

```
FindSubCluster(
  object,
  cluster,
  graph.name,
  subcluster.name = "sub.cluster",
  resolution = 0.5,
  algorithm = 1
)
```

Arguments

object	An object
cluster	the cluster to be sub-clustered
graph.name	Name of graph to use for the clustering algorithm
subcluster.name	the name of sub cluster added in the meta.data
resolution	Value of the resolution parameter, use a value above (below) 1.0 if you want to obtain a larger (smaller) number of communities.
algorithm	Algorithm for modularity optimization (1 = original Louvain algorithm; 2 = Louvain algorithm with multilevel refinement; 3 = SLM algorithm; 4 = Leiden algorithm).

Value

return a object with sub cluster labels in the sub-cluster.name variable

`FindTransferAnchors` *Find transfer anchors*

Description

Find a set of anchors between a reference and query object. These anchors can later be used to transfer data from the reference to query object using the `TransferData` object.

Usage

```
FindTransferAnchors(
  reference,
  query,
  normalization.method = "LogNormalize",
  recompute.residuals = TRUE,
  reference.assay = NULL,
  reference.neighbors = NULL,
  query.assay = NULL,
  reduction = "pcaproject",
  reference.reduction = NULL,
  project.query = FALSE,
  features = NULL,
  scale = TRUE,
  npcs = 30,
  l2.norm = TRUE,
  dims = 1:30,
  k.anchor = 5,
  k.filter = NA,
  k.score = 30,
  max.features = 200,
  nn.method = "annoy",
  n.trees = 50,
  eps = 0,
  approx.pca = TRUE,
  mapping.score.k = NULL,
  verbose = TRUE
)
```

Arguments

`reference`	`Seurat` object to use as the reference
`query`	`Seurat` object to use as the query
`normalization.method`	Name of normalization method used: LogNormalize or SCT.
`recompute.residuals`	If using SCT as a normalization method, compute query Pearson residuals using the reference SCT model parameters.

`reference.assay`
: Name of the Assay to use from reference

`reference.neighbors`
: Name of the Neighbor to use from the reference. Optionally enables reuse of precomputed neighbors.

`query.assay`
: Name of the Assay to use from query

`reduction`
: Dimensional reduction to perform when finding anchors. Options are:
  - pcaproject: Project the PCA from the reference onto the query. We recommend using PCA when reference and query datasets are from scRNA-seq
  - lsiproject: Project the LSI from the reference onto the query. We recommend using LSI when reference and query datasets are from scATAC-seq. This requires that LSI has been computed for the reference dataset, and the same features (eg, peaks or genome bins) are present in both the reference and query. See `RunTFIDF` and `RunSVD`
  - rpca: Project the PCA from the reference onto the query, and the PCA from the query onto the reference (reciprocal PCA projection).
  - cca: Run a CCA on the reference and query

`reference.reduction`
: Name of dimensional reduction to use from the reference if running the pcaproject workflow. Optionally enables reuse of precomputed reference dimensional reduction. If NULL (default), use a PCA computed on the reference object.

`project.query`
: Project the PCA from the query dataset onto the reference. Use only in rare cases where the query dataset has a much larger cell number, but the reference dataset has a unique assay for transfer. In this case, the default features will be set to the variable features of the query object that are alos present in the reference.

`features`
: Features to use for dimensional reduction. If not specified, set as variable features of the reference object which are also present in the query.

`scale`
: Scale query data.

`npcs`
: Number of PCs to compute on reference if reference.reduction is not provided.

`l2.norm`
: Perform L2 normalization on the cell embeddings after dimensional reduction

`dims`
: Which dimensions to use from the reduction to specify the neighbor search space

`k.anchor`
: How many neighbors (k) to use when finding anchors

`k.filter`
: How many neighbors (k) to use when filtering anchors. Set to NA to turn off filtering.

`k.score`
: How many neighbors (k) to use when scoring anchors

`max.features`
: The maximum number of features to use when specifying the neighborhood search space in the anchor filtering

`nn.method`
: Method for nearest neighbor finding. Options include: rann, annoy

`n.trees`
: More trees gives higher precision when using annoy approximate nearest neighbor search

`eps`
: Error bound on the neighbor finding algorithm (from `RANN` or `RcppAnnoy`)

`approx.pca`
: Use truncated singular value decomposition to approximate PCA

`mapping.score.k`
: Compute and store nearest k query neighbors in the AnchorSet object that is returned. You can optionally set this if you plan on computing the mapping score and want to enable reuse of some downstream neighbor calculations to make the mapping score function more efficient.

`verbose`
: Print progress bars and output

Details

The main steps of this procedure are outlined below. For a more detailed description of the methodology, please see Stuart, Butler, et al Cell 2019. doi:10.1016/j.cell.2019.05.031; doi:10.1101/460147

- Perform dimensional reduction. Exactly what is done here depends on the values set for the `reduction` and `project.query` parameters. If `reduction = "pcaproject"`, a PCA is performed on either the reference (if `project.query = FALSE`) or the query (if `project.query = TRUE`), using the `features` specified. The data from the other dataset is then projected onto this learned PCA structure. If `reduction = "cca"`, then CCA is performed on the reference and query for this dimensional reduction step. If `reduction = "lsiproject"`, the stored LSI dimension reduction in the reference object is used to project the query dataset onto the reference. If `l2.norm` is set to `TRUE`, perform L2 normalization of the embedding vectors.
- Identify anchors between the reference and query - pairs of cells from each dataset that are contained within each other's neighborhoods (also known as mutual nearest neighbors).
- Filter low confidence anchors to ensure anchors in the low dimension space are in broad agreement with the high dimensional measurements. This is done by looking at the neighbors of each query cell in the reference dataset using `max.features` to define this space. If the reference cell isn't found within the first `k.filter` neighbors, remove the anchor.
- Assign each remaining anchor a score. For each anchor cell, determine the nearest `k.score` anchors within its own dataset and within its pair's dataset. Based on these neighborhoods, construct an overall neighbor graph and then compute the shared neighbor overlap between anchor and query cells (analogous to an SNN graph). We use the 0.01 and 0.90 quantiles on these scores to dampen outlier effects and rescale to range between 0-1.

Value

Returns an `AnchorSet` object that can be used as input to `TransferData`, `IntegrateEmbeddings` and `MapQuery`. The dimension reduction used for finding anchors is stored in the `AnchorSet` object and can be used for computing anchor weights in downstream functions. Note that only the requested dimensions are stored in the dimension reduction object in the `AnchorSet`. This means that if `dims=2:20` is used, for example, the dimension of the stored reduction is `1:19`.

References

Stuart T, Butler A, et al. Comprehensive Integration of Single-Cell Data. Cell. 2019;177:1888-1902 doi:10.1016/j.cell.2019.05.031;

Examples

```
## Not run:
# to install the SeuratData package see https://github.com/satijalab/seurat-data
library(SeuratData)
data("pbmc3k")

# for demonstration, split the object into reference and query
pbmc.reference <- pbmc3k[, 1:1350]
pbmc.query <- pbmc3k[, 1351:2700]

# perform standard preprocessing on each object
pbmc.reference <- NormalizeData(pbmc.reference)
pbmc.reference <- FindVariableFeatures(pbmc.reference)
pbmc.reference <- ScaleData(pbmc.reference)

pbmc.query <- NormalizeData(pbmc.query)
pbmc.query <- FindVariableFeatures(pbmc.query)
pbmc.query <- ScaleData(pbmc.query)

# find anchors
anchors <- FindTransferAnchors(reference = pbmc.reference, query = pbmc.query)

# transfer labels
predictions <- TransferData(
  anchorset = anchors,
  refdata = pbmc.reference$seurat_annotations
)
pbmc.query <- AddMetaData(object = pbmc.query, metadata = predictions)

## End(Not run)
```

FindVariableFeatures *Find variable features*

Description

Identifies features that are outliers on a 'mean variability plot'.

Usage

```
FindVariableFeatures(object, ...)

## S3 method for class 'V3Matrix'
FindVariableFeatures(
  object,
  selection.method = "vst",
  loess.span = 0.3,
  clip.max = "auto",
```

```
  mean.function = FastExpMean,
  dispersion.function = FastLogVMR,
  num.bin = 20,
  binning.method = "equal_width",
  nfeatures = 2000,
  verbose = TRUE,
  ...
)

## S3 method for class 'Assay'
FindVariableFeatures(
  object,
  selection.method = "vst",
  loess.span = 0.3,
  clip.max = "auto",
  mean.function = FastExpMean,
  dispersion.function = FastLogVMR,
  num.bin = 20,
  binning.method = "equal_width",
  nfeatures = 2000,
  mean.cutoff = c(0.1, 8),
  dispersion.cutoff = c(1, Inf),
  verbose = TRUE,
  ...
)

## S3 method for class 'SCTAssay'
FindVariableFeatures(object, nfeatures = 2000, ...)

## S3 method for class 'Seurat'
FindVariableFeatures(
  object,
  assay = NULL,
  selection.method = "vst",
  loess.span = 0.3,
  clip.max = "auto",
  mean.function = FastExpMean,
  dispersion.function = FastLogVMR,
  num.bin = 20,
  binning.method = "equal_width",
  nfeatures = 2000,
  mean.cutoff = c(0.1, 8),
  dispersion.cutoff = c(1, Inf),
  verbose = TRUE,
  ...
)
```

Arguments

object	An object
...	Arguments passed to other methods
selection.method	How to choose top variable features. Choose one of : • "vst": First, fits a line to the relationship of log(variance) and log(mean) using local polynomial regression (loess). Then standardizes the feature values using the observed mean and expected variance (given by the fitted line). Feature variance is then calculated on the standardized values after clipping to a maximum (see clip.max parameter). • "mean.var.plot" (mvp): First, uses a function to calculate average expression (mean.function) and dispersion (dispersion.function) for each feature. Next, divides features into num.bin (default 20) bins based on their average expression, and calculates z-scores for dispersion within each bin. The purpose of this is to identify variable features while controlling for the strong relationship between variability and average expression • "dispersion" (disp): selects the genes with the highest dispersion values
loess.span	(vst method) Loess span parameter used when fitting the variance-mean relationship
clip.max	(vst method) After standardization values larger than clip.max will be set to clip.max; default is 'auto' which sets this value to the square root of the number of cells
mean.function	Function to compute x-axis value (average expression). Default is to take the mean of the detected (i.e. non-zero) values
dispersion.function	Function to compute y-axis value (dispersion). Default is to take the standard deviation of all values
num.bin	Total number of bins to use in the scaled analysis (default is 20)
binning.method	Specifies how the bins should be computed. Available methods are: • "equal_width": each bin is of equal width along the x-axis (default) • "equal_frequency": each bin contains an equal number of features (can increase statistical power to detect overdispersed features at high expression values, at the cost of reduced resolution along the x-axis)
nfeatures	Number of features to select as top variable features; only used when selection.method is set to 'dispersion' or 'vst'
verbose	show progress bar for calculations
mean.cutoff	A two-length numeric vector with low- and high-cutoffs for feature means
dispersion.cutoff	A two-length numeric vector with low- and high-cutoffs for feature dispersions
assay	Assay to use

Details

For the mean.var.plot method: Exact parameter settings may vary empirically from dataset to dataset, and based on visual inspection of the plot. Setting the y.cutoff parameter to 2 identifies features that are more than two standard deviations away from the average dispersion within a bin. The default X-axis function is the mean expression level, and for Y-axis it is the log(Variance/mean). All mean/variance calculations are not performed in log-space, but the results are reported in log-space - see relevant functions for exact details.

FoldChange *Fold Change*

Description

Calculate log fold change and percentage of cells expressing each feature for different identity classes.

Usage

```
FoldChange(object, ...)

## Default S3 method:
FoldChange(object, cells.1, cells.2, mean.fxn, fc.name, features = NULL, ...)

## S3 method for class 'Assay'
FoldChange(
  object,
  cells.1,
  cells.2,
  features = NULL,
  slot = "data",
  pseudocount.use = 1,
  fc.name = NULL,
  mean.fxn = NULL,
  base = 2,
  norm.method = NULL,
  ...
)

## S3 method for class 'SCTAssay'
FoldChange(
  object,
  cells.1,
  cells.2,
  features = NULL,
  slot = "data",
  pseudocount.use = 1,
```

```
  fc.name = NULL,
  mean.fxn = NULL,
  base = 2,
  ...
)

## S3 method for class 'DimReduc'
FoldChange(
  object,
  cells.1,
  cells.2,
  features = NULL,
  slot = NULL,
  pseudocount.use = 1,
  fc.name = NULL,
  mean.fxn = NULL,
  ...
)

## S3 method for class 'Seurat'
FoldChange(
  object,
  ident.1 = NULL,
  ident.2 = NULL,
  group.by = NULL,
  subset.ident = NULL,
  assay = NULL,
  slot = "data",
  reduction = NULL,
  features = NULL,
  pseudocount.use = 1,
  mean.fxn = NULL,
  base = 2,
  fc.name = NULL,
  ...
)
```

Arguments

object	A Seurat object
...	Arguments passed to other methods
cells.1	Vector of cell names belonging to group 1
cells.2	Vector of cell names belonging to group 2
mean.fxn	Function to use for fold change or average difference calculation
fc.name	Name of the fold change, average difference, or custom function column in the output data.frame
features	Features to calculate fold change for. If NULL, use all features

slot	Slot to pull data from
pseudocount.use	Pseudocount to add to averaged expression values when calculating logFC.
base	The base with respect to which logarithms are computed.
norm.method	Normalization method for mean function selection when slot is "data"
ident.1	Identity class to calculate fold change for; pass an object of class phylo or 'clustertree' to calculate fold change for a node in a cluster tree; passing 'clustertree' requires BuildClusterTree to have been run
ident.2	A second identity class for comparison; if NULL, use all other cells for comparison; if an object of class phylo or 'clustertree' is passed to ident.1, must pass a node to calculate fold change for
group.by	Regroup cells into a different identity class prior to calculating fold change (see example in FindMarkers)
subset.ident	Subset a particular identity class prior to regrouping. Only relevant if group.by is set (see example in FindMarkers)
assay	Assay to use in fold change calculation
reduction	Reduction to use - will calculate average difference on cell embeddings

Details

If the slot is scale.data or a reduction is specified, average difference is returned instead of log fold change and the column is named "avg_diff". Otherwise, log2 fold change is returned with column named "avg_log2_FC".

Value

Returns a data.frame

See Also

FindMarkers

Examples

```
## Not run:
data("pbmc_small")
FoldChange(pbmc_small, ident.1 = 1)

## End(Not run)
```

GenerateSampleObject *Generate a sample-level count matrix based on landmark assay and its weighted.nn object*

Description

Returns summed counts of weighted.nn for each landmark cell within each sample.

Usage

```
GenerateSampleObject(
  object,
  nn.name = NULL,
  k.nn = 5,
  sketch.assay = "LANDMARK",
  return.seurat = TRUE,
  new_assay_name = "LMC",
  group.by = "ident",
  normalization.method = "ChiSquared",
  scale.factor = 10000,
  rename.group.by = NULL,
  add.meta.data = TRUE,
  cells.use = NULL,
  verbose = TRUE,
  ...
)
```

Arguments

object	Seurat object
nn.name	Name of the Neighbor object to use for the calculation (e.g. "weighted.nn" as produced by FindmmNN / PrepareSampleObject, or "single.nn" as produced by FindsmNN). If NULL (default), the function auto-detects a Neighbor object named "weighted.nn" or "single.nn"; if both are present it errors and asks you to specify this parameter.
k.nn	the number of nearest neighbors to perform the summing
sketch.assay	the name of the sketch.assay you used to perform the FindmmNN()
return.seurat	Whether to return the data as a Seurat object. Default is TRUE
new_assay_name	Name for the new assay containing landmark counts
group.by	A single meta-data column to group cells by (e.g. Donor ID); 'ident' by default. To group on a combination of columns, add a merged column to the object beforehand and pass that, e.g. object$batch_rep <- paste(object$batch, object$replicate, sep = "_").
normalization.method	Method for normalization. Supports LogNormalize and ChiSquared. see details at NormalizeData and NormalizeChiSquared

scale.factor	Scale factor for Log-Normalization, see NormalizeData
rename.group.by	if rename.group.by is NULL, the rownames of the landmark matrix will used the original cell IDs. But, user can indicate which meta-data column to use to rename the rows. A suffix of "_LM" + order number will be added automatically.
add.meta.data	if TRUE, the function will automatically detect sample-level meta-data (based on 'group.by') and append it to the sample-level object; if FALSE, it will not do so.
cells.use	An optional character vector of cell names to subset before building the sample-level matrix. When non-NULL, only cells in this vector (that are also present in the NN object) are retained. Default is NULL (use all cells).
verbose	Print progress and diagnostic messages
...	Arguments to be passed to methods such as CreateSeuratObject

Value

return a Seurat object that contains a count matrix with number of landmark as rows, sample as columns

---

GetAssay *Get an Assay object from a given Seurat object.*

Description

Get an Assay object from a given Seurat object.

Usage

```
GetAssay(object, ...)

## S3 method for class 'Seurat'
GetAssay(object, assay = NULL, ...)
```

Arguments

object	An object
...	Arguments passed to other methods
assay	Assay to get

Value

Returns an Assay object

Examples

```
data("pbmc_small")
GetAssay(object = pbmc_small, assay = "RNA")
```

GetImage.SlideSeq *Get Image Data*

Description

Get Image Data

Usage

```
## S3 method for class 'SlideSeq'
GetImage(object, mode = c("grob", "raster", "plotly", "raw"), ...)

## S3 method for class 'STARmap'
GetImage(object, mode = c("grob", "raster", "plotly", "raw"), ...)

## S3 method for class 'VisiumV1'
GetImage(object, mode = c("grob", "raster", "plotly", "raw"), ...)

## S3 method for class 'VisiumV2'
GetImage(object, mode = c("grob", "raster", "plotly", "raw"), ...)
```

Arguments

object	An object
mode	How to return the image; should accept one of “grob”, “raster”, “plotly”, or “raw”
...	Arguments passed to other methods

See Also

SeuratObject::GetImage

GetIntegrationData *Get integration data*

Description

Get integration data

Usage

```
GetIntegrationData(object, integration.name, slot)
```

Arguments

object	Seurat object
integration.name	Name of integration object
slot	Which slot in integration object to get

Value

Returns data from the requested slot within the integrated object

---

GetResidual *Calculate pearson residuals of features not in the scale.data*

Description

This function calls sctransform::get_residuals.

Usage

```
GetResidual(
  object,
  features,
  assay = NULL,
  umi.assay = "RNA",
  clip.range = NULL,
  replace.value = FALSE,
  na.rm = TRUE,
  verbose = TRUE
)
```

Arguments

object	A seurat object
features	Name of features to add into the scale.data
assay	Name of the assay of the seurat object generated by SCTransform
umi.assay	Name of the assay of the seurat object containing UMI matrix and the default is RNA
clip.range	Numeric of length two specifying the min and max values the Pearson residual will be clipped to
replace.value	Recalculate residuals for all features, even if they are already present. Useful if you want to change the clip.range.
na.rm	For features where there is no feature model stored, return NA for residual value in scale.data when na.rm = FALSE. When na.rm is TRUE, only return residuals for features with a model stored for all cells.
verbose	Whether to print messages and progress bars

Value

Returns a Seurat object containing Pearson residuals of added features in its scale.data

See Also

get_residuals

Examples

```
## Not run:
data("pbmc_small")
pbmc_small <- SCTransform(object = pbmc_small, variable.features.n = 20)
pbmc_small <- GetResidual(object = pbmc_small, features = c('MS4A1', 'TCL1A'))

## End(Not run)
```

---

getThreads *Get the number of threads being used for parallel processing in Seurat*

Description

Get the number of threads being used for parallel processing in Seurat

Usage

```
getThreads(verbose = TRUE)
```

Arguments

verbose	Whether to print the number of threads set and available cores to the console

Value

The number of threads currently set for processing

`GetTissueCoordinates.SlideSeq` *Get Tissue Coordinates*

Description

Get Tissue Coordinates

Usage

```
## S3 method for class 'SlideSeq'
GetTissueCoordinates(object, ...)

## S3 method for class 'STARmap'
GetTissueCoordinates(object, qhulls = FALSE, ...)

## S3 method for class 'VisiumV1'
GetTissueCoordinates(
  object,
  scale = "lowres",
  cols = c("imagecol", "imagerow"),
  ...
)

## S3 method for class 'VisiumV2'
GetTissueCoordinates(object, scale = NULL, ...)
```

Arguments

`object`	An object
`...`	Arguments passed to other methods
`qhulls`	return qhulls instead of centroids
`scale`	A factor to scale the coordinates by; choose from: 'tissue', 'fiducial', 'hires', 'lowres', or `NULL` for no scaling
`cols`	Columns of tissue coordinates data.frame to pull

See Also

`SeuratObject::GetTissueCoordinates`

GetTransferPredictions *Get the predicted identity*

Description

Utility function to easily pull out the name of the class with the maximum prediction. This is useful if you've set `prediction.assay = TRUE` in `TransferData` and want to have a vector with the predicted class.

Usage

```
GetTransferPredictions(
  object,
  assay = "predictions",
  slot = "data",
  score.filter = 0.75
)
```

Arguments

`object`	Seurat object
`assay`	Name of the assay holding the predictions
`slot`	Slot of the assay in which the prediction scores are stored
`score.filter`	Return "Unassigned" for any cell with a score less than this value

Value

Returns a vector of predicted class names

Examples

```
## Not run:
  prediction.assay <- TransferData(anchorset = anchors, refdata = reference$class)
  query[["predictions"]] <- prediction.assay
  query$predicted.id <- GetTransferPredictions(query)

## End(Not run)
```

Graph-class *The Graph Class*

Description

For more details, please see the documentation in SeuratObject

See Also

SeuratObject::Graph-class

GroupCorrelation *Compute the correlation of features broken down by groups with another covariate*

Description

Compute the correlation of features broken down by groups with another covariate

Usage

```
GroupCorrelation(
  object,
  assay = NULL,
  slot = "scale.data",
  var = NULL,
  group.assay = NULL,
  min.cells = 5,
  ngroups = 6,
  do.plot = TRUE
)
```

Arguments

object	Seurat object
assay	Assay to pull the data from
slot	Slot in the assay to pull feature expression data from (counts, data, or scale.data)
var	Variable with which to correlate the features
group.assay	Compute the gene groups based off the data in this assay.
min.cells	Only compute for genes in at least this many cells
ngroups	Number of groups to split into
do.plot	Display the group correlation boxplot (via GroupCorrelationPlot)

Value

A Seurat object with the correlation stored in metafeatures

GroupCorrelationPlot *Boxplot of correlation of a variable (e.g. number of UMIs) with expression data*

Description

Boxplot of correlation of a variable (e.g. number of UMIs) with expression data

Usage

```
GroupCorrelationPlot(
  object,
  assay = NULL,
  feature.group = "feature.grp",
  cor = "nCount_RNA_cor"
)
```

Arguments

object	Seurat object
assay	Assay where the feature grouping info and correlations are stored
feature.group	Name of the column in meta.features where the feature grouping info is stored
cor	Name of the column in meta.features where correlation info is stored

Value

Returns a ggplot boxplot of correlations split by group

HarmonyIntegration *Harmony Integration*

Description

Harmony Integration

Usage

```
HarmonyIntegration(
  object,
  orig,
  features = NULL,
  scale.layer = "scale.data",
  new.reduction = "harmony",
  layers = NULL,
  npcs = NULL,
```

```
  key = "harmony_",
  theta = NULL,
  lambda = NULL,
  sigma = 0.1,
  nclust = NULL,
  tau = 0,
  block.size = 0.05,
  max.iter.harmony = 10L,
  max.iter.cluster = 20L,
  epsilon.cluster = 1e-05,
  epsilon.harmony = 0.01,
  verbose = TRUE,
  ...
)
```

Arguments

object	An Assay5 object
orig	A dimensional reduction to correct
features	Ignored
scale.layer	Ignored
new.reduction	Name of new integrated dimensional reduction
layers	Ignored
npcs	If doing PCA on input matrix, number of PCs to compute
key	Key for Harmony dimensional reduction
theta	Diversity clustering penalty parameter
lambda	Ridge regression penalty parameter
sigma	Width of soft kmeans clusters
nclust	Number of clusters in model
tau	Protection against overclustering small datasets with large ones
block.size	What proportion of cells to update during clustering
max.iter.harmony	Maximum number of rounds to run Harmony
max.iter.cluster	Maximum number of rounds to run clustering at each round of Harmony
epsilon.cluster	Convergence tolerance for clustering round of Harmony
epsilon.harmony	Convergence tolerance for Harmony
verbose	Whether to print progress messages. TRUE to print, FALSE to suppress
...	Ignored

Value

...

Note

This function requires the **harmony** package to be installed

See Also

RunHarmony

Examples

```
## Not run:
# Preprocessing
obj <- SeuratData::LoadData("pbmcsca")
obj[["RNA"]] <- split(obj[["RNA"]], f = obj$Method)
obj <- NormalizeData(obj)
obj <- FindVariableFeatures(obj)
obj <- ScaleData(obj)
obj <- RunPCA(obj)

# After preprocessing, we integrate layers with added parameters specific to Harmony:
obj <- IntegrateLayers(object = obj, method = HarmonyIntegration, orig.reduction = "pca",
  new.reduction = 'harmony', verbose = FALSE)

# Modifying Parameters
# We can also add arguments specific to Harmony such as theta, to give more diverse clusters
obj <- IntegrateLayers(object = obj, method = HarmonyIntegration, orig.reduction = "pca",
  new.reduction = 'harmony', verbose = FALSE, theta = 3)
# Integrating SCTransformed data
obj <- SCTransform(object = obj)
obj <- IntegrateLayers(object = obj, method = HarmonyIntegration,
  orig.reduction = "pca", new.reduction = 'harmony',
  assay = "SCT", verbose = FALSE)

## End(Not run)
```

HoverLocator *Hover Locator*

Description

Get quick information from a scatterplot by hovering over points

Usage

```
HoverLocator(plot, information = NULL, axes = TRUE, dark.theme = FALSE, ...)
```

Arguments

plot	A ggplot2 plot
information	An optional dataframe or matrix of extra information to be displayed on hover
axes	Display or hide x- and y-axes
dark.theme	Plot using a dark theme?
...	Extra parameters to be passed to layout

See Also

layout ggplot_build DimPlot FeaturePlot

Examples

```
## Not run:
data("pbmc_small")
plot <- DimPlot(object = pbmc_small)
HoverLocator(plot = plot, information = FetchData(object = pbmc_small, vars = 'percent.mito'))

## End(Not run)
```

HTODemux *Demultiplex samples based on data from cell 'hashing'*

Description

Assign sample-of-origin for each cell, annotate doublets.

Usage

```
HTODemux(
  object,
  assay = "HTO",
  positive.quantile = 0.99,
  init = NULL,
  nstarts = 100,
  kfunc = "clara",
  nsamples = 100,
  seed = 42,
  verbose = TRUE
)
```

Arguments

object	Seurat object. Assumes that the hash tag oligo (HTO) data has been added and normalized.
assay	Name of the Hashtag assay (HTO by default)
positive.quantile	The quantile of inferred 'negative' distribution for each hashtag - over which the cell is considered 'positive'. Default is 0.99
init	Initial number of clusters for hashtags. Default is the # of hashtag oligo names + 1 (to account for negatives)
nstarts	nstarts value for k-means clustering (for kfunc = "kmeans"). 100 by default
kfunc	Clustering function for initial hashtag grouping. Default is "clara" for fast k-medoids clustering on large applications, also support "kmeans" for kmeans clustering
nsamples	Number of samples to be drawn from the dataset used for clustering, for kfunc = "clara"
seed	Sets the random seed. If NULL, seed is not set
verbose	Prints the output

Value

The Seurat object with the following demultiplexed information stored in the meta data:

hash.maxID Name of hashtag with the highest signal

hash.secondID Name of hashtag with the second highest signal

hash.margin The difference between signals for hash.maxID and hash.secondID

classification Classification result, with doublets/multiplets named by the top two highest hashtags

classification.global Global classification result (singlet, doublet or negative)

hash.ID Classification result where doublet IDs are collapsed

See Also

HTOHeatmap

Examples

```
## Not run:
object <- HTODemux(object)

## End(Not run)
```

HTOHeatmap *Hashtag oligo heatmap*

Description

Draws a heatmap of hashtag oligo signals across singlets/doublets/negative cells. Allows for the visualization of HTO demultiplexing results.

Usage

```
HTOHeatmap(
  object,
  assay = "HTO",
  classification = paste0(assay, "_classification"),
  global.classification = paste0(assay, "_classification.global"),
  ncells = 5000,
  singlet.names = NULL,
  raster = TRUE
)
```

Arguments

object	Seurat object. Assumes that the hash tag oligo (HTO) data has been added and normalized, and demultiplexing has been run with HTODemux().
assay	Hashtag assay name.
classification	The naming for metadata column with classification result from HTODemux().
global.classification	The slot for metadata column specifying a cell as singlet/doublet/negative.
ncells	Number of cells to plot. Default is to choose 5000 cells by random subsampling, to avoid having to draw exceptionally large heatmaps.
singlet.names	Namings for the singlets. Default is to use the same names as HTOs.
raster	If true, plot with geom_raster, else use geom_tile. geom_raster may look blurry on some viewing applications such as Preview due to how the raster is interpolated. Set this to FALSE if you are encountering that issue (note that plots may take longer to produce/render).

Value

Returns a ggplot2 plot object.

See Also

HTODemux

Examples

```
## Not run:
object <- HTODemux(object)
HTOHeatmap(object)

## End(Not run)
```

`HVFInfo.SCTAssay` *Get Variable Feature Information*

Description

Get variable feature information from `SCTAssay` objects

Usage

```
## S3 method for class 'SCTAssay'
HVFInfo(object, method, status = FALSE, ...)
```

Arguments

`object`	An object
`method`	method to determine variable features
`status`	Add variable status to the resulting data frame
`...`	Arguments passed to other methods

See Also

`HVFInfo`

Examples

```
## Not run:
# Get the HVF info directly from an SCTAssay object
pbmc_small <- SCTransform(pbmc_small)
HVFInfo(pbmc_small[["SCT"]], method = 'sct')[1:5, ]

## End(Not run)
```

IFeaturePlot *Visualize features in dimensional reduction space interactively*

Description

Visualize features in dimensional reduction space interactively

Usage

```
IFeaturePlot(object, feature, dims = c(1, 2), reduction = NULL, slot = "data")
```

Arguments

object	Seurat object
feature	Feature to plot
dims	Dimensions to plot, must be a two-length numeric vector specifying x- and y-dimensions
reduction	Which dimensionality reduction to use. If not specified, first searches for umap, then tsne, then pca
slot	Which slot to pull expression data from?

Value

Returns the final plot as a ggplot object

ImageDimPlot *Spatial Cluster Plots*

Description

Visualize clusters or other categorical groupings in a spatial context

Usage

```
ImageDimPlot(
  object,
  fov = NULL,
  boundaries = NULL,
  group.by = NULL,
  split.by = NULL,
  cols = NULL,
  shuffle.cols = FALSE,
  size = 0.5,
  molecules = NULL,
```

```
  mols.size = 0.1,
  mols.cols = NULL,
  mols.alpha = 1,
  nmols = 1000,
  alpha = 1,
  border.color = "white",
  border.size = NULL,
  na.value = "grey50",
  dark.background = TRUE,
  crop = FALSE,
  cells = NULL,
  overlap = FALSE,
  axes = FALSE,
  combine = TRUE,
  coord.fixed = TRUE,
  flip_xy = NULL
)
```

Arguments

object	A Seurat object
fov	Name of FOV to plot
boundaries	A vector of segmentation boundaries per image to plot; can be a character vector, a named character vector, or a named list. Names should be the names of FOVs and values should be the names of segmentation boundaries
group.by	Name of one or more metadata columns to group (color) cells by (for example, orig.ident); pass 'ident' to group by identity class
split.by	A factor in object metadata to split the plot by, pass 'ident' to split by cell identity
cols	Vector of colors, each color corresponds to an identity class. This may also be a single character or numeric value corresponding to a palette as specified by brewer.pal.info. By default, ggplot2 assigns colors. We also include a number of palettes from the pals package. See DiscretePalette for details.
shuffle.cols	Randomly shuffle colors when a palette or vector of colors is provided to cols
size	Point size for cells when plotting centroids
molecules	A vector of molecules to plot
mols.size	Point size for molecules
mols.cols	A vector of color for molecules. The "Set1" palette from RColorBrewer is used by default.
mols.alpha	Alpha value for molecules, should be between 0 and 1
nmols	Max number of each molecule specified in 'molecules' to plot
alpha	Alpha value for plotting (default is 1)
border.color	Color of cell segmentation border; pass NA to suppress borders for segmentation-based plots
border.size	Thickness of cell segmentation borders; pass NA to suppress borders for centroid-based plots

na.value	Color value for NA points when using custom scale
dark.background	Set plot background to black
crop	Crop the plots to area with cells only
cells	Vector of cells to plot (default is all cells)
overlap	Overlay boundaries from a single image to create a single plot; if TRUE, then boundaries are stacked in the order they're given (first is lowest)
axes	Keep axes and panel background
combine	Combine plots into a single patchwork ggplot object.If FALSE, return a list of ggplot objects
coord.fixed	Plot cartesian coordinates with fixed aspect ratio
flip_xy	Swap x and y in the plot. FALSE shows x horizontally and y increasing downward. TRUE swaps the axes and restores the old (< v6) layout, with vertical values increasing upward. NULL (the default) uses FALSE, except for objects loaded with the deprecated LoadXenium(flip.xy = TRUE), which retain their previous plot layout. Stored coordinates do not change. To crop using the original x/y ranges, use Crop(..., coords = "tissue"). The default Crop() still expects swapped x/y ranges.

Value

If combine = TRUE, a patchwork ggplot object; otherwise, a list of ggplot objects

---

ImageFeaturePlot *Spatial Feature Plots*

Description

Visualize expression in a spatial context

Usage

```
ImageFeaturePlot(
  object,
  features,
  fov = NULL,
  boundaries = NULL,
  cols = if (isTRUE(x = blend)) {
     c("lightgrey", "#ff0000", "#00ff00")
 } else {

     c("lightgrey", "firebrick1")
 },
  size = 0.5,
  min.cutoff = NA,
```

```
  max.cutoff = NA,
  split.by = NULL,
  molecules = NULL,
  mols.size = 0.1,
  mols.cols = NULL,
  nmols = 1000,
  alpha = 1,
  border.color = "white",
  border.size = NULL,
  dark.background = TRUE,
  blend = FALSE,
  blend.threshold = 0.5,
  crop = FALSE,
  cells = NULL,
  scale = c("feature", "all", "none"),
  overlap = FALSE,
  axes = FALSE,
  combine = TRUE,
  coord.fixed = TRUE,
  flip_xy = NULL
)
```

Arguments

object	Seurat object
features	Vector of features to plot. Features can come from: • An Assay feature (e.g. a gene name - "MS4A1") • A column name from meta.data (e.g. mitochondrial percentage - "percent.mito") • A column name from a DimReduc object corresponding to the cell embedding values (e.g. the PC 1 scores - "PC_1")
fov	Name of FOV to plot
boundaries	A vector of segmentation boundaries per image to plot; can be a character vector, a named character vector, or a named list. Names should be the names of FOVs and values should be the names of segmentation boundaries
cols	The two colors to form the gradient over. Provide as string vector with the first color corresponding to low values, the second to high. Also accepts a Brewer color scale or vector of colors. Note: this will bin the data into number of colors provided. When blend is TRUE, takes anywhere from 1-3 colors: **1 color:** Treated as color for double-negatives, will use default colors 2 and 3 for per-feature expression **2 colors:** Treated as colors for per-feature expression, will use default color 1 for double-negatives **3+ colors:** First color used for double-negatives, colors 2 and 3 used for per-feature expression, all others ignored
size	Point size for cells when plotting centroids

`min.cutoff, max.cutoff`
: Vector of minimum and maximum cutoff values for each feature, may specify quantile in the form of 'q##' where '##' is the quantile (eg, 'q1', 'q10')

`split.by`
: A factor in object metadata to split the plot by, pass 'ident' to split by cell identity

`molecules`
: A vector of molecules to plot

`mols.size`
: Point size for molecules

`mols.cols`
: A vector of color for molecules. The "Set1" palette from RColorBrewer is used by default.

`nmols`
: Max number of each molecule specified in 'molecules' to plot

`alpha`
: Alpha value for plotting (default is 1)

`border.color`
: Color of cell segmentation border; pass `NA` to suppress borders for segmentation-based plots

`border.size`
: Thickness of cell segmentation borders; pass `NA` to suppress borders for centroid-based plots

`dark.background`
: Set plot background to black

`blend`
: Scale and blend expression values to visualize coexpression of two features

`blend.threshold`
: The color cutoff from weak signal to strong signal; ranges from 0 to 1.

`crop`
: Crop the plots to area with cells only

`cells`
: Vector of cells to plot (default is all cells)

`scale`
: Set color scaling across multiple plots; choose from:
  - "`feature`": Plots per-feature are scaled across splits
  - "`all`": Plots per-feature are scaled across all features
  - "`none`": Plots are not scaled; **note**: setting `scale` to "`none`" will result in color scales that are *not* comparable between plots

  Ignored if `blend = TRUE`

`overlap`
: Overlay boundaries from a single image to create a single plot; if `TRUE`, then boundaries are stacked in the order they're given (first is lowest)

`axes`
: Keep axes and panel background

`combine`
: Combine plots into a single `patchwork`ed ggplot object. If `FALSE`, return a list of ggplot objects

`coord.fixed`
: Plot cartesian coordinates with fixed aspect ratio

`flip_xy`
: Swap x and y in the plot. `FALSE` shows x horizontally and y increasing downward. `TRUE` swaps the axes and restores the old (< v6) layout, with vertical values increasing upward. `NULL` (the default) uses `FALSE`, except for objects loaded with the deprecated `LoadXenium(flip.xy = TRUE)`, which retain their previous plot layout. Stored coordinates do not change. To crop using the original x/y ranges, use `Crop(..., coords = "tissue")`. The default `Crop()` still expects swapped x/y ranges.

Value

If `combine = TRUE`, a `patchwork` ggplot object; otherwise, a list of ggplot objects

IntegrateData *Integrate data*

Description

Perform dataset integration using a pre-computed AnchorSet.

Usage

```
IntegrateData(
  anchorset,
  new.assay.name = "integrated",
  normalization.method = c("LogNormalize", "SCT"),
  features = NULL,
  features.to.integrate = NULL,
  dims = 1:30,
  k.weight = 100,
  weight.reduction = NULL,
  sd.weight = 1,
  sample.tree = NULL,
  preserve.order = FALSE,
  eps = 0,
  verbose = TRUE
)
```

Arguments

anchorset	An AnchorSet object generated by FindIntegrationAnchors
new.assay.name	Name for the new assay containing the integrated data
normalization.method	Name of normalization method used: LogNormalize or SCT
features	Vector of features to use when computing the PCA to determine the weights. Only set if you want a different set from those used in the anchor finding process
features.to.integrate	Vector of features to integrate. By default, will use the features used in anchor finding.
dims	Number of dimensions to use in the anchor weighting procedure
k.weight	Number of neighbors to consider when weighting anchors
weight.reduction	Dimension reduction to use when calculating anchor weights. This can be one of: • A string, specifying the name of a dimension reduction present in all objects to be integrated • A vector of strings, specifying the name of a dimension reduction to use for each object to be integrated

- A vector of DimReduc objects, specifying the object to use for each object in the integration
- NULL, in which case a new PCA will be calculated and used to calculate anchor weights

Note that, if specified, the requested dimension reduction will only be used for calculating anchor weights in the first merge between reference and query, as the merged object will subsequently contain more cells than was in query, and weights will need to be calculated for all cells in the object.

`sd.weight` Controls the bandwidth of the Gaussian kernel for weighting

`sample.tree` Specify the order of integration. Order of integration should be encoded in a matrix, where each row represents one of the pairwise integration steps. Negative numbers specify a dataset, positive numbers specify the integration results from a given row (the format of the merge matrix included in the hclust function output). For example: `matrix(c(-2, 1, -3, -1), ncol = 2)` gives:

```
     [,1] [,2]
[1,]   -2   -3
[2,]    1   -1
```

Which would cause dataset 2 and 3 to be integrated first, then the resulting object integrated with dataset 1.

If NULL, the sample tree will be computed automatically.

`preserve.order` Do not reorder objects based on size for each pairwise integration.

`eps` Error bound on the neighbor finding algorithm (from RANN)

`verbose` Print progress bars and output

Details

The main steps of this procedure are outlined below. For a more detailed description of the methodology, please see Stuart, Butler, et al Cell 2019. doi:10.1016/j.cell.2019.05.031; doi:10.1101/460147

For pairwise integration:

- Construct a weights matrix that defines the association between each query cell and each anchor. These weights are computed as 1 - the distance between the query cell and the anchor divided by the distance of the query cell to the `k.weight`th anchor multiplied by the anchor score computed in FindIntegrationAnchors. We then apply a Gaussian kernel width a bandwidth defined by `sd.weight` and normalize across all `k.weight` anchors.
- Compute the anchor integration matrix as the difference between the two expression matrices for every pair of anchor cells
- Compute the transformation matrix as the product of the integration matrix and the weights matrix.
- Subtract the transformation matrix from the original expression matrix.

For multiple dataset integration, we perform iterative pairwise integration. To determine the order of integration (if not specified via `sample.tree`), we

- Define a distance between datasets as the total number of cells in the smaller dataset divided by the total number of anchors between the two datasets.
- Compute all pairwise distances between datasets
- Cluster this distance matrix to determine a guide tree

Value

Returns a Seurat object with a new integrated Assay. If normalization.method = "LogNormalize", the integrated data is returned to the data slot and can be treated as log-normalized, corrected data. If normalization.method = "SCT", the integrated data is returned to the scale.data slot and can be treated as centered, corrected Pearson residuals.

References

Stuart T, Butler A, et al. Comprehensive Integration of Single-Cell Data. Cell. 2019;177:1888-1902 doi:10.1016/j.cell.2019.05.031

Examples

```
## Not run:
# to install the SeuratData package see https://github.com/satijalab/seurat-data
library(SeuratData)
data("panc8")

# panc8 is a merged Seurat object containing 8 separate pancreas datasets
# split the object by dataset
pancreas.list <- SplitObject(panc8, split.by = "tech")

# perform standard preprocessing on each object
for (i in 1:length(pancreas.list)) {
  pancreas.list[[i]] <- NormalizeData(pancreas.list[[i]], verbose = FALSE)
  pancreas.list[[i]] <- FindVariableFeatures(
    pancreas.list[[i]], selection.method = "vst",
    nfeatures = 2000, verbose = FALSE
  )
}

# find anchors
anchors <- FindIntegrationAnchors(object.list = pancreas.list)

# integrate data
integrated <- IntegrateData(anchorset = anchors)

## End(Not run)
```

IntegrateEmbeddings *Integrate low dimensional embeddings*

Description

Perform dataset integration using a pre-computed Anchorset of specified low dimensional representations.

Usage

```
IntegrateEmbeddings(anchorset, ...)

## S3 method for class 'IntegrationAnchorSet'
IntegrateEmbeddings(
  anchorset,
  new.reduction.name = "integrated_dr",
  reductions = NULL,
  dims.to.integrate = NULL,
  k.weight = 100,
  weight.reduction = NULL,
  sd.weight = 1,
  sample.tree = NULL,
  preserve.order = FALSE,
  verbose = TRUE,
  ...
)

## S3 method for class 'TransferAnchorSet'
IntegrateEmbeddings(
  anchorset,
  reference,
  query,
  query.assay = NULL,
  new.reduction.name = "integrated_dr",
  reductions = "pcaproject",
  dims.to.integrate = NULL,
  k.weight = 100,
  weight.reduction = NULL,
  reuse.weights.matrix = TRUE,
  sd.weight = 1,
  preserve.order = FALSE,
  verbose = TRUE,
  ...
)
```

Arguments

anchorset	An AnchorSet object

`...` Reserved for internal use

`new.reduction.name`
Name for new integrated dimensional reduction.

`reductions` Name of reductions to be integrated. For a TransferAnchorSet, this should be the name of a reduction present in the anchorset object (for example, "pcaproject"). For an IntegrationAnchorSet, this should be a `DimReduc` object containing all cells present in the anchorset object.

`dims.to.integrate`
Number of dimensions to return integrated values for

`k.weight` Number of neighbors to consider when weighting anchors

`weight.reduction`
Dimension reduction to use when calculating anchor weights. This can be one of:

- A string, specifying the name of a dimension reduction present in all objects to be integrated
- A vector of strings, specifying the name of a dimension reduction to use for each object to be integrated
- A vector of `DimReduc` objects, specifying the object to use for each object in the integration
- NULL, in which case the full corrected space is used for computing anchor weights.

`sd.weight` Controls the bandwidth of the Gaussian kernel for weighting

`sample.tree` Specify the order of integration. Order of integration should be encoded in a matrix, where each row represents one of the pairwise integration steps. Negative numbers specify a dataset, positive numbers specify the integration results from a given row (the format of the merge matrix included in the `hclust` function output). For example: `matrix(c(-2, 1, -3, -1), ncol = 2)` gives:

```
     [,1] [,2]
[1,]   -2   -3
[2,]    1   -1
```

Which would cause dataset 2 and 3 to be integrated first, then the resulting object integrated with dataset 1.

If NULL, the sample tree will be computed automatically.

`preserve.order` Do not reorder objects based on size for each pairwise integration.

`verbose` Print progress bars and output

`reference` Reference object used in anchorset construction

`query` Query object used in anchorset construction

`query.assay` Name of the Assay to use from query

`reuse.weights.matrix`
Can be used in conjunction with the store.weights parameter in TransferData to reuse a precomputed weights matrix.

Details

The main steps of this procedure are identical to IntegrateData with one key distinction. When computing the weights matrix, the distance calculations are performed in the full space of integrated embeddings when integrating more than two datasets, as opposed to a reduced PCA space which is the default behavior in IntegrateData.

Value

When called on a TransferAnchorSet (from FindTransferAnchors), this will return the query object with the integrated embeddings stored in a new reduction. When called on an IntegrationAnchorSet (from IntegrateData), this will return a merged object with the integrated reduction stored.

IntegrateLayers *Integrate Layers*

Description

Integrate Layers

Usage

```
IntegrateLayers(
  object,
  method,
  orig.reduction = "pca",
  assay = NULL,
  features = NULL,
  layers = NULL,
  scale.layer = "scale.data",
  ...
)
```

Arguments

object	A Seurat object
method	Integration method function
orig.reduction	Name of dimensional reduction for correction
assay	Name of assay for integration
features	A vector of features to use for integration
layers	Names of normalized layers in assay
scale.layer	Name(s) of scaled layer(s) in assay
...	Arguments passed on to method

Value

object with integration data added to it

Integration Method Functions

The following integration method functions are available:

- CCAIntegration
- HarmonyIntegration
- JointPCAIntegration
- RPCAIntegration

See Also

Writing integration method functions

IntegrationAnchorSet-class *The IntegrationAnchorSet Class*

Description

Inherits from the Anchorset class. Implemented mainly for method dispatch purposes. See AnchorSet for slot details.

IntegrationData-class *The IntegrationData Class*

Description

The IntegrationData object is an intermediate storage container used internally throughout the integration procedure to hold bits of data that are useful downstream.

Slots

`neighbors` List of neighborhood information for cells (outputs of `RANN::nn2`)

`weights` Anchor weight matrix

`integration.matrix` Integration matrix

`anchors` Anchor matrix

`offsets` The offsets used to enable cell look up in downstream functions

`objects.ncell` Number of cells in each object in the object.list

`sample.tree` Sample tree used for ordering multi-dataset integration

`InteractiveSpatialPlot` *Interactive Spatial Cell Selection Tool*

Description

Launch an interactive gadget for lasso-based cell selection from a spatial Seurat object. Supports Visium, SlideSeq, and Vizgen data. Returns the cell names of the selected subset, suitable for downstream subsetting or analysis.

Usage

```
InteractiveSpatialPlot(
  object,
  image = NULL,
  image.scale = "lowres",
  group.by = NULL,
  alpha = 1,
  pt.size.factor = 1,
  overlay_image = TRUE
)
```

Arguments

`object`	A `Seurat` object with spatial data.
`image`	Name of the spatial image stored in the object. If `NULL`, uses the default image for the object.
`image.scale`	Character. Which image scaling factor to use for spatial coordinate transformation (`"lowres"` by default).
`group.by`	Metadata variable (column name) to use for coloring cell points (e.g., cluster assignment). If `NULL`, uses `"seurat_clusters"` if available, otherwise all cells are grouped together.
`alpha`	Numeric transparency value for cell points (default `1.0`).
`pt.size.factor`	Numeric scaling factor for point size (default `1.0`).
`overlay_image`	Logical; if `TRUE`, overlays the tissue image in the background of the plot (default `TRUE`).

Value

A character vector of cell names selected via lasso, which can be used to subset the object.

Note

This function requires the **plotly**, and **base64enc** packages to be installed. It also requires **shiny** and **miniUI** for the interactive UI.

Examples

```
## Not run:
selected_cells <- InteractiveSpatialPlot(object = brain)
selected_cells <- InteractiveSpatialPlot(object = brain, overlay_image = FALSE)

## End(Not run)
```

`ISpatialDimPlot` *Visualize clusters spatially and interactively*

Description

Visualize clusters spatially and interactively

Usage

```
ISpatialDimPlot(
  object,
  image = NULL,
  image.scale = "lowres",
  group.by = NULL,
  alpha = c(0.3, 1)
)
```

Arguments

`object`	A Seurat object
`image`	Name of the image to use in the plot
`image.scale`	Choose the scale factor ("lowres"/"hires") to apply in order to matchthe plot with the specified ‘image‘ - defaults to "lowres"
`group.by`	Name of meta.data column to group the data by
`alpha`	Controls opacity of spots. Provide as a vector specifying the min and max for SpatialFeaturePlot. For SpatialDimPlot, provide a single alpha value for each plot.

Value

Returns final plot as a ggplot object

ISpatialFeaturePlot *Visualize features spatially and interactively*

Description

Visualize features spatially and interactively

Usage

```
ISpatialFeaturePlot(
  object,
  feature,
  image = NULL,
  image.scale = "lowres",
  slot = "data",
  alpha = c(0.1, 1)
)
```

Arguments

object	A Seurat object
feature	Feature to visualize
image	Name of the image to use in the plot
image.scale	Choose the scale factor ("lowres"/"hires") to apply in order to matchthe plot with the specified ‘image‘ - defaults to "lowres"
slot	If plotting a feature, which data slot to pull from (counts, data, or scale.data)
alpha	Controls opacity of spots. Provide as a vector specifying the min and max for SpatialFeaturePlot. For SpatialDimPlot, provide a single alpha value for each plot.

Value

Returns final plot as a ggplot object

JackStraw *Determine statistical significance of PCA scores.*

Description

Randomly permutes a subset of data, and calculates projected PCA scores for these 'random' genes. Then compares the PCA scores for the 'random' genes with the observed PCA scores to determine statistical significance. End result is a p-value for each gene's association with each principal component.

Usage

```
JackStraw(
  object,
  reduction = "pca",
  assay = NULL,
  dims = 20,
  num.replicate = 100,
  prop.freq = 0.01,
  verbose = TRUE,
  maxit = 1000
)
```

Arguments

object	Seurat object
reduction	DimReduc to use. ONLY PCA CURRENTLY SUPPORTED.
assay	Assay used to calculate reduction.
dims	Number of PCs to compute significance for
num.replicate	Number of replicate samplings to perform
prop.freq	Proportion of the data to randomly permute for each replicate
verbose	Print progress bar showing the number of replicates that have been processed.
maxit	maximum number of iterations for RunPCA (w/ irlba backend)

Value

Returns a Seurat object where JS(object = object[['pca']], slot = 'empirical') represents p-values for each gene in the PCA analysis. If ProjectPCA is subsequently run, JS(object = object[['pca']], slot = 'full') then represents p-values for all genes.

References

Inspired by Chung et al, Bioinformatics (2014)

Examples

```
## Not run:
data("pbmc_small")
pbmc_small = suppressWarnings(JackStraw(pbmc_small))
head(JS(object = pbmc_small[['pca']], slot = 'empirical'))

## End(Not run)
```

JackStrawData-class *The JackStrawData Class*

Description

For more details, please see the documentation in SeuratObject

See Also

SeuratObject::JackStrawData-class

JackStrawPlot *JackStraw Plot*

Description

Plots the results of the JackStraw analysis for PCA significance. For each PC, plots a QQ-plot comparing the distribution of p-values for all genes across each PC, compared with a uniform distribution. Also determines a p-value for the overall significance of each PC (see Details).

Usage

```
JackStrawPlot(
  object,
  dims = 1:5,
  cols = NULL,
  reduction = "pca",
  xmax = 0.1,
  ymax = 0.3
)
```

Arguments

object	Seurat object
dims	Dims to plot
cols	Vector of colors, each color corresponds to an individual PC. This may also be a single character or numeric value corresponding to a palette as specified by brewer.pal.info. By default, ggplot2 assigns colors. We also include a number of palettes from the pals package. See DiscretePalette for details.
reduction	reduction to pull jackstraw info from
xmax	X-axis maximum on each QQ plot.
ymax	Y-axis maximum on each QQ plot.

Details

Significant PCs should show a p-value distribution (black curve) that is strongly skewed to the left compared to the null distribution (dashed line) The p-value for each PC is based on a proportion test comparing the number of genes with a p-value below a particular threshold (score.thresh), compared with the proportion of genes expected under a uniform distribution of p-values.

Value

A ggplot object

Author(s)

Omri Wurtzel

See Also

ScoreJackStraw

Examples

```
data("pbmc_small")
JackStrawPlot(object = pbmc_small)
```

JointPCAIntegration *Seurat-Joint PCA Integration*

Description

Seurat-Joint PCA Integration

Usage

```
JointPCAIntegration(
  object = NULL,
  assay = NULL,
  layers = NULL,
  orig = NULL,
  new.reduction = "integrated.dr",
  reference = NULL,
  features = NULL,
  normalization.method = c("LogNormalize", "SCT"),
  dims = 1:30,
  k.anchor = 20,
  scale.layer = "scale.data",
  dims.to.integrate = NULL,
  k.weight = 100,
```

```
  weight.reduction = NULL,
  sd.weight = 1,
  sample.tree = NULL,
  preserve.order = FALSE,
  verbose = TRUE,
  ...
)
```

Arguments

object	A Seurat object
assay	Name of Assay in the Seurat object
layers	Names of layers in assay
orig	A DimReduc to correct
new.reduction	Name of new integrated dimensional reduction
reference	A reference Seurat object
features	A vector of features to use for integration
normalization.method	Name of normalization method used: LogNormalize or SCT
dims	Dimensions of dimensional reduction to use for integration
k.anchor	How many neighbors (k) to use when picking anchors
scale.layer	Name of scaled layer in Assay
dims.to.integrate	Number of dimensions to return integrated values for
k.weight	Number of neighbors to consider when weighting anchors
weight.reduction	Dimension reduction to use when calculating anchor weights. This can be one of: • A string, specifying the name of a dimension reduction present in all objects to be integrated • A vector of strings, specifying the name of a dimension reduction to use for each object to be integrated • A vector of DimReduc objects, specifying the object to use for each object in the integration • NULL, in which case the full corrected space is used for computing anchor weights.
sd.weight	Controls the bandwidth of the Gaussian kernel for weighting
sample.tree	Specify the order of integration. Order of integration should be encoded in a matrix, where each row represents one of the pairwise integration steps. Negative numbers specify a dataset, positive numbers specify the integration results from a given row (the format of the merge matrix included in the hclust function output). For example: matrix(c(-2, 1, -3, -1), ncol = 2) gives:

```
     [,1]  [,2]
[1,]   -2   -3
[2,]    1   -1
```

Which would cause dataset 2 and 3 to be integrated first, then the resulting object integrated with dataset 1.

If NULL, the sample tree will be computed automatically.

`preserve.order`	Do not reorder objects based on size for each pairwise integration.
`verbose`	Print progress
`...`	Arguments passed on to `FindIntegrationAnchors`

`L2CCA` *L2-Normalize CCA*

Description

Perform l2 normalization on CCs

Usage

```
L2CCA(object, ...)
```

Arguments

`object`	Seurat object
`...`	Additional parameters to L2Dim.

`L2Dim` *L2-normalization*

Description

Perform l2 normalization on given dimensional reduction

Usage

```
L2Dim(object, reduction, new.dr = NULL, new.key = NULL)
```

Arguments

`object`	Seurat object
`reduction`	Dimensional reduction to normalize
`new.dr`	name of new dimensional reduction to store (default is olddr.l2)
`new.key`	name of key for new dimensional reduction

Value

Returns a `Seurat` object

`LabelClusters` *Label clusters on a ggplot2-based scatter plot*

Description

Label clusters on a ggplot2-based scatter plot

Usage

```
LabelClusters(
  plot,
  id,
  clusters = NULL,
  labels = NULL,
  split.by = NULL,
  repel = TRUE,
  box = FALSE,
  geom = "GeomPoint",
  position = "median",
  ...
)
```

Arguments

`plot`	A ggplot2-based scatter plot
`id`	Name of variable used for coloring scatter plot
`clusters`	Vector of cluster ids to label
`labels`	Custom labels for the clusters
`split.by`	Split labels by some grouping label, useful when using `facet_wrap` or `facet_grid`
`repel`	Use `geom_text_repel` to create nicely-repelled labels
`box`	Use geom_label/geom_label_repel (includes a box around the text labels)
`geom`	Name of geom to get X/Y aesthetic names for
`position`	How to place the label if repel = FALSE. If "median", place the label at the median position. If "nearest" place the label at the position of the nearest data point to the median.
`...`	Extra parameters to `geom_text_repel`, such as `size`

Value

A ggplot2-based scatter plot with cluster labels

See Also

`geom_text_repel` `geom_text`

Examples

```
data("pbmc_small")
plot <- DimPlot(object = pbmc_small)
LabelClusters(plot = plot, id = 'ident')
```

`LabelPoints` *Add text labels to a ggplot2 plot*

Description

Add text labels to a ggplot2 plot

Usage

```
LabelPoints(
  plot,
  points,
  labels = NULL,
  repel = FALSE,
  xnudge = 0.3,
  ynudge = 0.05,
  ...
)
```

Arguments

`plot`	A ggplot2 plot with a GeomPoint layer
`points`	A vector of points to label; if `NULL`, will use all points in the plot
`labels`	A vector of labels for the points; if `NULL`, will use rownames of the data provided to the plot at the points selected
`repel`	Use `geom_text_repel` to create a nicely-repelled labels; this is slow when a lot of points are being plotted. If using `repel`, set `xnudge` and `ynudge` to 0
`xnudge, ynudge`	Amount to nudge X and Y coordinates of labels by
`...`	Extra parameters passed to `geom_text`

Value

A ggplot object

See Also

`geom_text`

Examples

```
data("pbmc_small")
ff <- TopFeatures(object = pbmc_small[['pca']])
cc <- TopCells(object = pbmc_small[['pca']])
plot <- FeatureScatter(object = pbmc_small, feature1 = ff[1], feature2 = ff[2])
LabelPoints(plot = plot, points = cc)
```

LeverageScore *Leverage Score Calculation*

Description

This function computes the leverage scores for a given object It uses the concept of sketching and random projections. The function provides an approximation to the leverage scores using a scalable method suitable for large matrices.

Usage

```
LeverageScore(object, ...)

## Default S3 method:
LeverageScore(
  object,
  nsketch = 5000L,
  ndims = NULL,
  method = CountSketch,
  eps = 0.5,
  seed = 123L,
  verbose = TRUE,
  ...
)

## S3 method for class 'StdAssay'
LeverageScore(
  object,
  nsketch = 5000L,
  ndims = NULL,
  method = CountSketch,
  vf.method = NULL,
  layer = "data",
  eps = 0.5,
  seed = 123L,
  verbose = TRUE,
  features = NULL,
  ...
)
```

```
## S3 method for class 'Assay'
LeverageScore(
  object,
  nsketch = 5000L,
  ndims = NULL,
  method = CountSketch,
  vf.method = NULL,
  layer = "data",
  eps = 0.5,
  seed = 123L,
  verbose = TRUE,
  features = NULL,
  ...
)

## S3 method for class 'Seurat'
LeverageScore(
  object,
  assay = NULL,
  nsketch = 5000L,
  ndims = NULL,
  var.name = "leverage.score",
  over.write = FALSE,
  method = CountSketch,
  vf.method = NULL,
  layer = "data",
  eps = 0.5,
  seed = 123L,
  verbose = TRUE,
  features = NULL,
  ...
)
```

Arguments

object	A matrix-like object
...	Arguments passed to other methods
nsketch	A positive integer. The number of sketches to be used in the approximation. Default is 5000.
ndims	A positive integer or NULL. The number of dimensions to use. If NULL, the number of dimensions will default to the number of columns in the object.
method	The sketching method to use, defaults to CountSketch.
eps	A numeric. The error tolerance for the approximation in Johnson–Lindenstrauss embeddings, defaults to 0.5.
seed	A positive integer. The seed for the random number generator, defaults to 123.
verbose	Print progress and diagnostic messages

vf.method	VariableFeatures method
layer	layer to use
features	A vector of feature names to use for calculating leverage score.
assay	assay to use
var.name	name of slot to store leverage scores
over.write	whether to overwrite slot that currently stores leverage scores. Defaults to FALSE, in which case the 'var.name' is modified if it already exists in the object

References

Clarkson, K. L. & Woodruff, D. P. Low-rank approximation and regression in input sparsity time. JACM 63, 1–45 (2017). doi:10.1145/3019134;

`LinkedPlots` *Visualize spatial and clustering (dimensional reduction) data in a linked, interactive framework*

Description

Visualize spatial and clustering (dimensional reduction) data in a linked, interactive framework

Usage

```
LinkedDimPlot(
  object,
  dims = 1:2,
  reduction = NULL,
  image = NULL,
  image.scale = "lowres",
  group.by = NULL,
  alpha = c(0.1, 1),
  combine = TRUE
)

LinkedFeaturePlot(
  object,
  feature,
  dims = 1:2,
  reduction = NULL,
  image = NULL,
  image.scale = "lowres",
  slot = "data",
  alpha = c(0.1, 1),
  combine = TRUE
)
```

Arguments

object	A Seurat object
dims	Dimensions to plot, must be a two-length numeric vector specifying x- and y-dimensions
reduction	Which dimensionality reduction to use. If not specified, first searches for umap, then tsne, then pca
image	Name of the image to use in the plot
image.scale	Choose the scale factor ("lowres"/"hires") to apply in order to matchthe plot with the specified ‘image‘ - defaults to "lowres"
group.by	Name of meta.data column to group the data by
alpha	Controls opacity of spots. Provide as a vector specifying the min and max for SpatialFeaturePlot. For SpatialDimPlot, provide a single alpha value for each plot.
combine	Combine plots into a single gg object; note that if TRUE; themeing will not work when plotting multiple features/groupings
feature	Feature to visualize
slot	If plotting a feature, which data slot to pull from (counts, data, or scale.data)

Value

Returns final plots. If combine, plots are stiched together using CombinePlots; otherwise, returns a list of ggplot objects

Examples

```
## Not run:
LinkedDimPlot(seurat.object)
LinkedFeaturePlot(seurat.object, feature = 'Hpca')

## End(Not run)
```

Load10X_Spatial *Load a 10x Genomics Visium Spatial Experiment into a* Seurat *object*

Description

Load a 10x Genomics Visium Spatial Experiment into a Seurat object

Usage

```
Load10X_Spatial(
  data.dir,
  filename = "filtered_feature_bc_matrix.h5",
  assay = "Spatial",
  slice = "slice1",
  bin.size = NULL,
  filter.matrix = TRUE,
  to.upper = FALSE,
  image = NULL,
  image.name = "tissue_lowres_image.png",
  segmentation.type = NULL,
  compact = TRUE,
  ...
)
```

Arguments

data.dir	Directory containing the H5 file specified by filename and the image data in a subdirectory called spatial
filename	Name of H5 file containing the feature barcode matrix
assay	Name of the initial assay
slice	Name for the stored image of the tissue slice
bin.size	Specifies the bin sizes to read in, can include "polygons" to load segmentations. Defaults to c(16, 8)
filter.matrix	Only keep spots that have been determined to be over tissue
to.upper	Converts all feature names to upper case. Can be useful when analyses require comparisons between human and mouse gene names for example.
image	VisiumV1/VisiumV2 instance(s) - if a vector is passed in it should be co-indexed with `bin.size`
image.name	Name of the tissue image to be plotted. Defaults to tissue_lowres_image.png
segmentation.type	Which segmentations to load (cell or nucleus) when bin.size includes "polygons". Defaults to "cell".
compact	Whether to store segmentations in *only* the sf.data slot in the corresponding Segmentation object (default TRUE) to save memory and processing time. If FALSE, segmentations are also stored in sp format in addition to the sf.data slot.
...	Arguments passed to Read10X_h5

Value

A Seurat object

Examples

```
## Not run:
data_dir <- 'path/to/data/directory'
list.files(data_dir) # Should show filtered_feature_bc_matrix.h5
Load10X_Spatial(data.dir = data_dir)

## End(Not run)
```

`LoadAnnoyIndex` *Load the Annoy index file*

Description

Load the Annoy index file

Usage

```
LoadAnnoyIndex(object, file)
```

Arguments

`object`	Neighbor object
`file`	Path to file with annoy index

Value

Returns the Neighbor object with the index stored

`LoadAteraCodewords` *Load per-codeword transcript breakdowns for specific genes*

Description

Atera's per-transcript `codeword_identity` (which specific barcode/ codeword called each detection) is collapsed away by `LoadAteraMolecules`, which reports one combined position per gene. A gene can map to more than one distinct codeword (more than one probe/barcode design targeting the same gene); this instead returns one `"<gene>_codeword_<id>"` pseudo-feature per codeword, which is useful for a common QC question: whether different codewords for the same gene cluster differently in space (which would suggest a probe-specific artifact rather than true expression).

Usage

```
LoadAteraCodewords(object, data.dir, genes, fov = NULL)
```

Arguments

object	A Seurat object created by LoadAtera
data.dir	The same data.dir passed to the original LoadAtera call (the Atera output bundle directory)
genes	Character vector of one or more gene names to break down by codeword
fov	Name of the FOV to attach the resulting molecules to; defaults to the object's default FOV

Value

object, with one "<gene>_codeword_<id>" molecule entry per codeword mapping to each requested gene, merged into object[[fov]]'s existing molecule layer (regular genes loaded via LoadAteraMolecules are preserved, not overwritten; genes already broken down by a previous call are not re-fetched)

LoadAteraMolecules *Fetch additional Atera transcript molecules for genes not yet loaded*

Description

Fetches transcript molecule coordinates for genes and adds them to the molecule layer of a Seurat object created by LoadAtera(..., molecule.coordinates = TRUE), without re-reading genes that have already been fetched (by this call or by genes at load time). This is meant for interactive exploration, where different genes are plotted one at a time and reloading the full transcript table for each one would be wasteful.

Usage

```
LoadAteraMolecules(object, genes)
```

Arguments

object	A Seurat object created by LoadAtera(..., molecule.coordinates = TRUE)
genes	Character vector of gene names to fetch

Value

object, with genes' transcript coordinates added to its molecule layer (in addition to any genes fetched by a previous call)

LoadAteraSegmentations

Add segmentation polygons to an Atera field of view, for only the cells currently present in it

Description

`LoadAtera(..., segmentations = "cell")` builds a `Polygons` object (via `sp::SpatialPolygons()`) for every cell up front, which doesn't scale to bundles with many hundreds of thousands of cells – that machinery gets impractically slow, and can overflow R's protection stack, well before reaching cell counts typical of a whole-tissue Atera run. This function instead builds segmentation polygons only for the cells already present in `object[[fov]]`, so a bundle too large to load segmentations for up front (`LoadAtera(..., segmentations = NULL)`) can still get polygons for a `Crop`ped region-of-interest FOV, which typically has orders of magnitude fewer cells.

Usage

```
LoadAteraSegmentations(object, data.dir, fov, segmentations = "cell")
```

Arguments

`object`	A Seurat object created by `LoadAtera`
`data.dir`	The same `data.dir` passed to the original `LoadAtera` call (the Atera output bundle directory)
`fov`	Name of the FOV (typically already cropped via `Crop`) to add segmentation polygons to
`segmentations`	One of `"cell"` or `"nucleus"`

Value

`object`, with a `"segmentations"` boundary added to `object[[fov]]`, built only for the cells currently in that FOV

LoadCurioSeeker

Load Curio Seeker data

Description

Load Curio Seeker data

Usage

```
LoadCurioSeeker(data.dir, assay = "Spatial")
```

Arguments

data.dir	location of data directory that contains the counts matrix, gene names, barcodes/beads, and barcodes/bead location files.
assay	Name of assay to associate spatial data to

Value

A Seurat object

LoadSTARmap *Load STARmap data*

Description

Load STARmap data

Usage

```
LoadSTARmap(
  data.dir,
  counts.file = "cell_barcode_count.csv",
  gene.file = "genes.csv",
  qhull.file = "qhulls.tsv",
  centroid.file = "centroids.tsv",
  assay = "Spatial",
  image = "image"
)
```

Arguments

data.dir	location of data directory that contains the counts matrix, gene name, qhull, and centroid files.
counts.file	name of file containing the counts matrix (csv)
gene.file	name of file containing the gene names (csv)
qhull.file	name of file containing the hull coordinates (tsv)
centroid.file	name of file containing the centroid positions (tsv)
assay	Name of assay to associate spatial data to
image	Name of "image" object storing spatial coordinates

Value

A Seurat object

See Also

STARmap

LoadXenium *Read and Load 10x Genomics Xenium in-situ data*

Description

Read and Load 10x Genomics Xenium in-situ data

Usage

```
LoadXenium(
  data.dir,
  fov = "fov",
  assay = "Xenium",
  mols.qv.threshold = 20,
  cell.centroids = TRUE,
  molecule.coordinates = TRUE,
  segmentations = NULL,
  flip.xy = FALSE,
  genes = NULL,
  region = NULL
)

ReadXenium(
  data.dir,
  outs = c("segmentation_method", "matrix", "microns"),
  type = "centroids",
  mols.qv.threshold = 20,
  flip.xy = F,
  genes = NULL,
  region = NULL,
  cells = NULL
)
```

Arguments

data.dir	Directory containing all Xenium output files with default filenames
fov	FOV name
assay	Assay name
mols.qv.threshold	Remove transcript molecules with a QV less than this threshold. QV >= 20 is the standard threshold used to construct the cell x gene count matrix.
cell.centroids	Whether or not to load cell centroids
molecule.coordinates	Whether or not to load molecule coordinates immediately. For Xenium, FALSE skips transcript reads.

segmentations — One of "cell", "nucleus" or NULL (to load either cell segmentations, nucleus segmentations or neither)

flip.xy — Swap x and y in the loaded coordinates. Deprecated for LoadXenium, where flip.xy = TRUE requires SeuratObject >= 5.3.0. To change only the plot, use flip_xy = TRUE in ImageDimPlot or ImageFeaturePlot.

genes — Optional gene names to restrict molecule coordinates to. Counts are unaffected. NULL loads all genes when molecules are requested. LoadXenium accepts source or assay feature names; ReadXenium requires source names.

region — Optional list with x and y elements, each an increasing length-two micron range. Restricts molecule coordinates using the returned coordinate system, including any flip.xy transformation. Counts, centroids, and boundaries are unaffected.

outs — Types of molecular outputs to read; choose one or more of:

- "matrix": the counts matrix
- "microns": molecule coordinates
- "segmentation_method": cell segmentation method (for runs which use multi-modal segmentation)

type — Type of cell spatial coordinate matrices to read; choose one or more of:

- "centroids": cell centroids in micron coordinate space
- "segmentations": cell segmentations in micron coordinate space
- "nucleus_segmentations": nucleus segmentations in micron coordinate space

cells — Optional cell IDs to restrict segmentation boundaries to. Counts and centroids are unaffected.

Details

By default, LoadXenium keeps the original coordinates. ImageDimPlot and ImageFeaturePlot display x horizontally and y increasing downward, including for older objects. Use flip_xy = TRUE in either plotting function to reproduce the old plot layout without changing stored coordinates.

The deprecated LoadXenium(flip.xy = TRUE) requires SeuratObject >= 5.3.0 to record the axis orientation. With that version or later, it swaps stored coordinates and retains its previous plotting behavior. To crop using stored x/y ranges, use Crop(..., coords = "tissue").

Molecule tables are read into memory before gene, region, and QV filters are applied. Parquet files use Arrow, falling back to CSV on failure. CSV files use data.table when available. Legacy transcript tables without a qv column retain their molecules without QV filtering. The selected molecule coordinates are stored in memory.

Use molecule.coordinates = FALSE to load counts and centroids without reading transcript coordinates. LoadXenium retains its default of immediately loading molecules. Cell metadata is read once per call for segmentation methods and centroids.

LoadXenium labels molecules with assay feature names, e.g. Under_score becomes Under-score. ReadXenium keeps source names.

Value

LoadXenium: A Seurat object

ReadXenium: A list with some combination of the following values:

- "matrix": a named list of expression matrices, one per feature type. Matrices are sparse in memory; cells are columns and features are rows
- "centroids": a data frame with cell centroid coordinates in three columns: "x", "y", and "cell"
- "microns": a data frame with molecule coordinates in three columns: "x", "y", and "gene"

Examples

```
## Not run:
xenium <- LoadXenium("xenium_outs", molecule.coordinates = FALSE)
# Select molecules immediately, using micron ranges in the returned axes.
selected <- LoadXenium("xenium_outs", genes = "EPCAM",
  region = list(x = c(100, 500), y = c(200, 600)))

## End(Not run)
```

LocalStruct *Calculate the local structure preservation metric*

Description

Calculates a metric that describes how well the local structure of each group prior to integration is preserved after integration. This procedure works as follows: For each group, compute a PCA, compute the top num.neighbors in pca space, compute the top num.neighbors in corrected pca space, compute the size of the intersection of those two sets of neighbors. Return the average over all groups.

Usage

```
LocalStruct(
  object,
  grouping.var,
  idents = NULL,
  neighbors = 100,
  reduction = "pca",
  reduced.dims = 1:10,
  orig.dims = 1:10,
  verbose = TRUE
)
```

Arguments

object	Seurat object
grouping.var	Grouping variable
idents	Optionally specify a set of idents to compute metric for
neighbors	Number of neighbors to compute in pca/corrected pca space

reduction	Dimensional reduction to use for corrected space
reduced.dims	Number of reduced dimensions to use
orig.dims	Number of PCs to use in original space
verbose	Display progress bar

Value

Returns the average preservation metric

LogNormalize *Normalize Raw Data*

Description

Normalize Raw Data

Usage

```
LogNormalize(data, scale.factor = 10000, margin = 2L, verbose = TRUE, ...)

## S3 method for class 'data.frame'
LogNormalize(data, scale.factor = 10000, margin = 2L, verbose = TRUE, ...)

## S3 method for class 'V3Matrix'
LogNormalize(data, scale.factor = 10000, margin = 2L, verbose = TRUE, ...)

## Default S3 method:
LogNormalize(data, scale.factor = 10000, margin = 2L, verbose = TRUE, ...)
```

Arguments

data	Matrix with the raw count data
scale.factor	Scale the data; default is 1e4
margin	Margin to normalize over
verbose	Print progress
...	Arguments passed to other methods

Value

A matrix with the normalized and log-transformed data

Examples

```
mat <- matrix(data = rbinom(n = 25, size = 5, prob = 0.2), nrow = 5)
mat
mat_norm <- LogNormalize(data = mat)
mat_norm
```

LogVMR *Calculate the variance to mean ratio of logged values*

Description

Calculate the variance to mean ratio (VMR) in non-logspace (return answer in log-space)

Usage

```
LogVMR(x, ...)
```

Arguments

x	A vector of values
...	Other arguments (not used)

Value

Returns the VMR in log-space

Examples

```
LogVMR(x = c(1, 2, 3))
```

MappingScore *Metric for evaluating mapping success*

Description

This metric was designed to help identify query cells that aren't well represented in the reference dataset. The intuition for the score is that we are going to project the query cells into a reference-defined space and then project them back onto the query. By comparing the neighborhoods before and after projection, we identify cells who's local neighborhoods are the most affected by this transformation. This could be because there is a population of query cells that aren't present in the reference or the state of the cells in the query is significantly different from the equivalent cell type in the reference.

Usage

```
MappingScore(anchors, ...)

## Default S3 method:
MappingScore(
  anchors,
  combined.object,
  query.neighbors,
  ref.embeddings,
  query.embeddings,
  kanchors = 50,
  ndim = 50,
  ksmooth = 100,
  ksnn = 20,
  snn.prune = 0,
  subtract.first.nn = TRUE,
  nn.method = "annoy",
  n.trees = 50,
  query.weights = NULL,
  verbose = TRUE,
  ...
)

## S3 method for class 'AnchorSet'
MappingScore(
  anchors,
  kanchors = 50,
  ndim = 50,
  ksmooth = 100,
  ksnn = 20,
  snn.prune = 0,
  subtract.first.nn = TRUE,
  nn.method = "annoy",
  n.trees = 50,
  query.weights = NULL,
  verbose = TRUE,
  ...
)
```

Arguments

anchors	AnchorSet object or just anchor matrix from the Anchorset object returned from FindTransferAnchors
...	Reserved for internal use
combined.object	Combined object (ref + query) from the Anchorset object returned
query.neighbors	Neighbors object computed on query cells

ref.embeddings	Reference embeddings matrix
query.embeddings	Query embeddings matrix
kanchors	Number of anchors to use in projection steps when computing weights
ndim	Number of dimensions to use when working with low dimensional projections of the data
ksmooth	Number of cells to average over when computing transition probabilities
ksnn	Number of cells to average over when determining the kernel bandwidth from the SNN graph
snn.prune	Amount of pruning to apply to edges in SNN graph
subtract.first.nn	Option to the scoring function when computing distances to subtract the distance to the first nearest neighbor
nn.method	Nearest neighbor method to use (annoy or RANN)
n.trees	More trees gives higher precision when using annoy approximate nearest neighbor search
query.weights	Query weights matrix for reuse
verbose	Display messages/progress

Value

Returns a vector of cell scores

MapQuery *Map query cells to a reference*

Description

This is a convenience wrapper function around the following three functions that are often run together when mapping query data to a reference: TransferData, IntegrateEmbeddings, ProjectUMAP. Note that by default, the weight.reduction parameter for all functions will be set to the dimension reduction method used in the FindTransferAnchors function call used to construct the anchor object, and the dims parameter will be the same dimensions used to find anchors.

Usage

```
MapQuery(
  anchorset,
  query,
  reference,
  refdata = NULL,
  new.reduction.name = NULL,
  reference.reduction = NULL,
  reference.dims = NULL,
```

```
  query.dims = NULL,
  store.weights = FALSE,
  reduction.model = NULL,
  transferdata.args = list(),
  integrateembeddings.args = list(),
  projectumap.args = list(),
  verbose = TRUE
)
```

Arguments

anchorset	An AnchorSet object
query	Query object used in anchorset construction
reference	Reference object used in anchorset construction
refdata	Data to transfer. This can be specified in one of two ways: • The reference data itself as either a vector where the names correspond to the reference cells, or a matrix, where the column names correspond to the reference cells. • The name of the metadata field or assay from the reference object provided. This requires the reference parameter to be specified. If pulling assay data in this manner, it will pull the data from the data slot. To transfer data from other slots, please pull the data explicitly with GetAssayData and provide that matrix here.
new.reduction.name	Name for new integrated dimensional reduction.
reference.reduction	Name of reduction to use from the reference for neighbor finding
reference.dims	Dimensions (columns) to use from reference
query.dims	Dimensions (columns) to use from query
store.weights	Determine if the weight and anchor matrices are stored.
reduction.model	DimReduc object that contains the umap model
transferdata.args	A named list of additional arguments to TransferData
integrateembeddings.args	A named list of additional arguments to IntegrateEmbeddings
projectumap.args	A named list of additional arguments to ProjectUMAP
verbose	Print progress bars and output

Value

Returns a modified query Seurat object containing:#'

- New Assays corresponding to the features transferred and/or their corresponding prediction scores from TransferData

- An integrated reduction from IntegrateEmbeddings
- A projected UMAP reduction of the query cells projected into the reference UMAP using ProjectUMAP

---

merge.SCTAssay *Merge SCTAssay objects*

Description

Merge SCTAssay objects

Usage

```
## S3 method for class 'SCTAssay'
merge(
  x = NULL,
  y = NULL,
  add.cell.ids = NULL,
  merge.data = TRUE,
  na.rm = TRUE,
  ...
)
```

Arguments

x	A Seurat object
y	A single Seurat object or a list of Seurat objects
add.cell.ids	A character vector of length(x = c(x, y)); appends the corresponding values to the start of each objects' cell names
merge.data	Merge the data slots instead of just merging the counts (which requires renormalization); this is recommended if the same normalization approach was applied to all objects
na.rm	If na.rm = TRUE, this will only preserve residuals that are present in all SCTAssays being merged. Otherwise, missing residuals will be populated with NAs.
...	Arguments passed to other methods

`MetaFeature` *Aggregate expression of multiple features into a single feature*

Description

Calculates relative contribution of each feature to each cell for given set of features.

Usage

```
MetaFeature(
  object,
  features,
  meta.name = "metafeature",
  cells = NULL,
  assay = NULL,
  slot = "data"
)
```

Arguments

`object`	A Seurat object
`features`	List of features to aggregate
`meta.name`	Name of column in metadata to store metafeature
`cells`	List of cells to use (default all cells)
`assay`	Which assay to use
`slot`	Which slot to take data from (default data)

Value

Returns a `Seurat` object with metafeature stored in objct metadata

Examples

```
data("pbmc_small")
pbmc_small <- MetaFeature(
  object = pbmc_small,
  features = c("LTB", "EAF2"),
  meta.name = 'var.aggregate'
)
head(pbmc_small[[]])
```

MinMax *Apply a ceiling and floor to all values in a matrix*

Description

Apply a ceiling and floor to all values in a matrix

Usage

```
MinMax(data, min, max)
```

Arguments

data	Matrix or data frame
min	all values below this min value will be replaced with min
max	all values above this max value will be replaced with max

Value

Returns matrix after performing these floor and ceil operations

Examples

```
mat <- matrix(data = rbinom(n = 25, size = 20, prob = 0.2 ), nrow = 5)
mat
MinMax(data = mat, min = 4, max = 5)
```

MixingMetric *Calculates a mixing metric*

Description

Here we compute a measure of how well mixed a composite dataset is. To compute, we first examine the local neighborhood for each cell (looking at max.k neighbors) and determine for each group (could be the dataset after integration) the k nearest neighbor and what rank that neighbor was in the overall neighborhood. We then take the median across all groups as the mixing metric per cell.

Usage

```
MixingMetric(
  object,
  grouping.var,
  reduction = "pca",
  dims = 1:2,
  k = 5,
  max.k = 300,
  eps = 0,
  verbose = TRUE
)
```

Arguments

object	Seurat object
grouping.var	Grouping variable for dataset
reduction	Which dimensionally reduced space to use
dims	Dimensions to use
k	Neighbor number to examine per group
max.k	Maximum size of local neighborhood to compute
eps	Error bound on the neighbor finding algorithm (from RANN)
verbose	Displays progress bar

Value

Returns a vector of values of the mixing metric for each cell

---

MixscapeHeatmap *Differential expression heatmap for mixscape*

Description

Draws a heatmap of single cell feature expression with cells ordered by their mixscape ko probabilities.

Usage

```
MixscapeHeatmap(
  object,
  ident.1 = NULL,
  ident.2 = NULL,
  balanced = TRUE,
  logfc.threshold = 0.25,
  assay = "RNA",
  max.genes = 100,
```

```
  test.use = "wilcox",
  max.cells.group = NULL,
  order.by.prob = TRUE,
  group.by = NULL,
  mixscape.class = "mixscape_class",
  prtb.type = "KO",
  fc.name = "avg_log2FC",
  pval.cutoff = 0.05,
  ...
)
```

Arguments

`object`	An object
`ident.1`	Identity class to define markers for; pass an object of class `phylo` or 'clustertree' to find markers for a node in a cluster tree; passing 'clustertree' requires `BuildClusterTree` to have been run
`ident.2`	A second identity class for comparison; if `NULL`, use all other cells for comparison; if an object of class `phylo` or 'clustertree' is passed to `ident.1`, must pass a node to find markers for
`balanced`	Plot an equal number of genes with both groups of cells.
`logfc.threshold`	Limit testing to genes which show, on average, at least X-fold difference (log-scale) between the two groups of cells. Default is 0.25. Increasing logfc.threshold speeds up the function, but can miss weaker signals.
`assay`	Assay to use in differential expression testing
`max.genes`	Total number of DE genes to plot.
`test.use`	Denotes which test to use. Available options are: • "wilcox" : Identifies differentially expressed genes between two groups of cells using a Wilcoxon Rank Sum test (default); will use a fast implementation by Presto if installed • "wilcox_limma" : Identifies differentially expressed genes between two groups of cells using the limma implementation of the Wilcoxon Rank Sum test; set this option to reproduce results from Seurat v4 • "bimod" : Likelihood-ratio test for single cell gene expression, (McDavid et al., Bioinformatics, 2013) • "roc" : Identifies 'markers' of gene expression using ROC analysis. For each gene, evaluates (using AUC) a classifier built on that gene alone, to classify between two groups of cells. An AUC value of 1 means that expression values for this gene alone can perfectly classify the two groupings (i.e. Each of the cells in cells.1 exhibit a higher level than each of the cells in cells.2). An AUC value of 0 also means there is perfect classification, but in the other direction. A value of 0.5 implies that the gene has no predictive power to classify the two groups. Returns a 'predictive power' (abs(AUC-0.5) * 2) ranked matrix of putative differentially expressed genes.

- "t" : Identify differentially expressed genes between two groups of cells using the Student's t-test.
- "negbinom" : Identifies differentially expressed genes between two groups of cells using a negative binomial generalized linear model. Use only for UMI-based datasets
- "poisson" : Identifies differentially expressed genes between two groups of cells using a poisson generalized linear model. Use only for UMI-based datasets
- "LR" : Uses a logistic regression framework to determine differentially expressed genes. Constructs a logistic regression model predicting group membership based on each feature individually and compares this to a null model with a likelihood ratio test.
- "MAST" : Identifies differentially expressed genes between two groups of cells using a hurdle model tailored to scRNA-seq data. Utilizes the MAST package to run the DE testing.
- "DESeq2" : Identifies differentially expressed genes between two groups of cells based on a model using DESeq2 which uses a negative binomial distribution (Love et al, Genome Biology, 2014).This test does not support pre-filtering of genes based on average difference (or percent detection rate) between cell groups. However, genes may be pre-filtered based on their minimum detection rate (min.pct) across both cell groups. To use this method, please install DESeq2, using the instructions at https://bioconductor.org/packages/release/bioc/html/D

`max.cells.group` Number of cells per identity to plot.

`order.by.prob` Order cells on heatmap based on their mixscape knockout probability from highest to lowest score.

`group.by` (Deprecated) Option to split densities based on mixscape classification. Please use mixscape.class instead

`mixscape.class` metadata column with mixscape classifications.

`prtb.type` specify type of CRISPR perturbation expected for labeling mixscape classifications. Default is KO.

`fc.name` Name of the fold change, average difference, or custom function column in the output data.frame. Default is avg_log2FC

`pval.cutoff` P-value cut-off for selection of significantly DE genes.

`...` Arguments passed to other methods and to specific DE methods

Value

A ggplot object.

`MixscapeLDA` *Linear discriminant analysis on pooled CRISPR screen data.*

Description

This function performs unsupervised PCA on each mixscape class separately and projects each subspace onto all cells in the data. Finally, it uses the first 10 principle components from each projection as input to lda in MASS package together with mixscape class labels.

Usage

```
MixscapeLDA(
  object,
  assay = NULL,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.key = "LDA_",
  seed = 42,
  pc.assay = "PRTB",
  labels = "gene",
  nt.label = "NT",
  npcs = 10,
  verbose = TRUE,
  logfc.threshold = 0.25
)
```

Arguments

`object`	An object of class Seurat.
`assay`	Assay to use for performing Linear Discriminant Analysis (LDA).
`ndims.print`	Number of LDA dimensions to print.
`nfeatures.print`	Number of features to print for each LDA component.
`reduction.key`	Reduction key name.
`seed`	Value for random seed
`pc.assay`	Assay to use for running Principle components analysis.
`labels`	Meta data column with target gene class labels.
`nt.label`	Name of non-targeting cell class.
`npcs`	Number of principle components to use.
`verbose`	Print progress bar.
`logfc.threshold`	Limit testing to genes which show, on average, at least X-fold difference (log-scale) between the two groups of cells. Default is 0.25. Increasing logfc.threshold speeds up the function, but can miss weaker signals.

Value

Returns a Seurat object with LDA added in the reduction slot.

`ModalityWeights-class` *The ModalityWeights Class*

Description

The ModalityWeights class is an intermediate data storage class that stores the modality weight and other related information needed for performing downstream analyses - namely data integration (`FindModalityWeights`) and data transfer (`FindMultiModalNeighbors`).

Slots

`modality.weight.list` A list of modality weights value from all modalities

`modality.assay` Names of assays for the list of dimensional reductions

`params` A list of parameters used in the FindModalityWeights

`score.matrix` a list of score matrices representing cross and within-modality prediction score, and kernel value

`command` Store log of parameters that were used

`MULTIseqDemux` *Demultiplex samples based on classification method from MULTI-seq (McGinnis et al., bioRxiv 2018)*

Description

Identify singlets, doublets and negative cells from multiplexing experiments. Annotate singlets by tags.

Usage

```
MULTIseqDemux(
  object,
  assay = "HTO",
  quantile = 0.7,
  autoThresh = FALSE,
  maxiter = 5,
  qrange = seq(from = 0.1, to = 0.9, by = 0.05),
  verbose = TRUE
)
```

Arguments

object	Seurat object. Assumes that the specified assay data has been added
assay	Name of the multiplexing assay (HTO by default)
quantile	The quantile to use for classification
autoThresh	Whether to perform automated threshold finding to define the best quantile. Default is FALSE
maxiter	Maximum number of iterations if autoThresh = TRUE. Default is 5
qrange	A range of possible quantile values to try if autoThresh = TRUE
verbose	Prints the output

Value

A Seurat object with demultiplexing results stored at `object$MULTI_ID`

References

doi:10.1038/s4159201904338

Examples

```
## Not run:
object <- MULTIseqDemux(object)

## End(Not run)
```

Neighbor-class *The Neighbor Class*

Description

For more details, please see the documentation in `SeuratObject`

See Also

`SeuratObject::Neighbor-class`

NNPlot *Highlight Neighbors in DimPlot*

Description

It will color the query cells and the neighbors of the query cells in the DimPlot

Usage

```
NNPlot(
  object,
  reduction,
  nn.idx,
  query.cells,
  dims = 1:2,
  label = FALSE,
  label.size = 4,
  repel = FALSE,
  sizes.highlight = 2,
  pt.size = 1,
  cols.highlight = c("#377eb8", "#e41a1c"),
  na.value = "#bdbdbd",
  order = c("self", "neighbors", "other"),
  show.all.cells = TRUE,
  ...
)
```

Arguments

object	Seurat object
reduction	Which dimensionality reduction to use. If not specified, first searches for umap, then tsne, then pca
nn.idx	the neighbor index of all cells
query.cells	cells used to find their neighbors
dims	Dimensions to plot, must be a two-length numeric vector specifying x- and y-dimensions
label	Whether to label the clusters
label.size	Sets size of labels
repel	Repel labels
sizes.highlight	Size of highlighted cells; will repeat to the length groups in cells.highlight. If sizes.highlight = TRUE size of all points will be this value.
pt.size	Adjust point size for plotting

cols.highlight	A vector of colors to highlight the cells as; will repeat to the length groups in cells.highlight
na.value	Color value for NA points when using custom scale
order	Specify the order of plotting for the idents. This can be useful for crowded plots if points of interest are being buried. Provide either a full list of valid idents or a subset to be plotted last (on top)
show.all.cells	Show all cells or only query and neighbor cells
...	Extra parameters passed to DimPlot

Value

A patchworked ggplot object if combine = TRUE; otherwise, a list of ggplot objects

---

NNtoGraph *Convert Neighbor class to an asymmetrical Graph class*

Description

Convert Neighbor class to an asymmetrical Graph class

Usage

```
NNtoGraph(nn.object, col.cells = NULL, weighted = FALSE)
```

Arguments

nn.object	A neighbor class object
col.cells	Cells names of the neighbors, cell names in nn.object is used by default
weighted	Determine if use distance in the Graph

Value

Returns a Graph object

`NormalizeChiSquared` *Apply Chi-squared normalization to a Seurat object*

Description

This function applies Chi-squared normalization to a (sample-level) Seurat object. It calculates the expected density (count of cells) for each landmark-sample pair assuming random distribution, then normalizes observed counts using: (observed - expected) / sqrt(expected). The resulting values show how much each landmark's density deviates from the expected baseline density values. Positive values indicate higher-than-expected density, negative values indicate lower-than-expected density.

Usage

```
NormalizeChiSquared(object, ...)

## Default S3 method:
NormalizeChiSquared(object = NULL, verbose = TRUE, ...)

## S3 method for class 'Assay'
NormalizeChiSquared(object, verbose = TRUE, ...)

## S3 method for class 'StdAssay'
NormalizeChiSquared(
  object,
  layer = "counts",
  save = "data",
  verbose = TRUE,
  ...
)

## S3 method for class 'Seurat'
NormalizeChiSquared(object, assay = NULL, verbose = TRUE, ...)
```

Arguments

`object`	a count matrix (a landmark-sample density matrix), Assay, StdAssay, or Seurat object. Values must be raw counts (non-negative whole numbers)
`...`	Additional arguments
`verbose`	display progress bar for normalization procedure
`layer`	Layer to use (for StdAssay objects, and passed on by the Seurat method). It must resolve to a single layer whose name starts with "counts"; for split layers, run `JoinLayers` first or name one layer
`save`	Layer to save results to (for StdAssay objects, and passed on by the Seurat method). Its name cannot start with "counts"
`assay`	Name of assay to use (for Seurat objects)

Value

Normalized object of the same class as input

Examples

```
## Not run:
# Normalize a sample-level Seurat object
sample_obj <- NormalizeChiSquared(sample_obj)

## End(Not run)
```

NormalizeData *Normalize Data*

Description

Normalize the count data present in a given assay.

Usage

```
NormalizeData(object, ...)

## S3 method for class 'V3Matrix'
NormalizeData(
  object,
  normalization.method = "LogNormalize",
  scale.factor = 10000,
  margin = 1,
  block.size = NULL,
  verbose = TRUE,
  ...
)

## S3 method for class 'Assay'
NormalizeData(
  object,
  normalization.method = "LogNormalize",
  scale.factor = 10000,
  margin = 1,
  verbose = TRUE,
  ...
)

## S3 method for class 'Seurat'
NormalizeData(
  object,
```

```
  assay = NULL,
  normalization.method = "LogNormalize",
  scale.factor = 10000,
  margin = 1,
  verbose = TRUE,
  ...
)
```

Arguments

object	An object
...	Arguments passed to other methods
normalization.method	Method for normalization. • "LogNormalize": Feature counts for each cell are divided by the total counts for that cell and multiplied by the scale.factor. This is then natural-log transformed using log1p • "CLR": Applies a centered log ratio transformation • "RC": Relative counts. Feature counts for each cell are divided by the total counts for that cell and multiplied by the scale.factor. No log-transformation is applied. For counts per million (CPM) set scale.factor = 1e6
scale.factor	Sets the scale factor for cell-level normalization
margin	If performing CLR normalization, normalize across features (1) or cells (2)
block.size	How many cells should be run in each chunk - will be split evenly across threads. If supplied, temporarily sets the thread count to ceiling(ncol(object) / block.size), capped at the number of available cores.
verbose	Whether to display a progress bar
assay	Name of assay to use

Value

Returns object after normalization

Examples

```
## Not run:
data("pbmc_small")
pbmc_small
pmbc_small <- NormalizeData(object = pbmc_small)

## End(Not run)
```

PCASigGenes *Significant genes from a PCA*

Description

Returns a set of genes, based on the JackStraw analysis, that have statistically significant associations with a set of PCs.

Usage

```
PCASigGenes(
  object,
  pcs.use,
  pval.cut = 0.1,
  use.full = FALSE,
  max.per.pc = NULL
)
```

Arguments

object	Seurat object
pcs.use	PCS to use.
pval.cut	P-value cutoff
use.full	Use the full list of genes (from the projected PCA). Assumes that ProjectDim has been run. Currently, must be set to FALSE.
max.per.pc	Maximum number of genes to return per PC. Used to avoid genes from one PC dominating the entire analysis.

Value

A vector of genes whose p-values are statistically significant for at least one of the given PCs.

See Also

ProjectDim JackStraw

Examples

```
data("pbmc_small")
PCASigGenes(pbmc_small, pcs.use = 1:2)
```

PercentAbove *Calculate the percentage of a vector above some threshold*

Description

Calculate the percentage of a vector above some threshold

Usage

```
PercentAbove(x, threshold)
```

Arguments

x	Vector of values
threshold	Threshold to use when calculating percentage

Value

Returns the percentage of x values above the given threshold

Examples

```
set.seed(42)
PercentAbove(sample(1:100, 10), 75)
```

PercentageFeatureSet *Calculate the percentage of all counts that belong to a given set of features*

Description

This function enables you to easily calculate the percentage of all the counts belonging to a subset of the possible features for each cell. This is useful when trying to compute the percentage of transcripts that map to mitochondrial genes for example. The calculation here is simply the column sum of the matrix present in the counts slot for features belonging to the set divided by the column sum for all features times 100.

Usage

```
PercentageFeatureSet(
  object,
  pattern = NULL,
  features = NULL,
  col.name = NULL,
  assay = NULL
)
```

Arguments

object	A Seurat object
pattern	A regex pattern to match features against
features	A defined feature set. If features provided, will ignore the pattern matching
col.name	Name in meta.data column to assign. If this is not null, returns a Seurat object with the proportion of the feature set stored in metadata.
assay	Assay to use

Value

Returns a vector with the proportion of the feature set or if md.name is set, returns a Seurat object with the proportion of the feature set stored in metadata.

Examples

```
data("pbmc_small")
# Calculate the proportion of transcripts mapping to mitochondrial genes
# NOTE: The pattern provided works for human gene names. You may need to adjust depending on your
# system of interest
pbmc_small[["percent.mt"]] <- PercentageFeatureSet(object = pbmc_small, pattern = "^MT-")
```

PlotAnnotatedHeatmap *Plot an annotated expression heatmap of features across cells*

Description

Draws a features-by-cells expression heatmap with one or more metadata annotation bars on top, built on Heatmap. Columns are ordered by a chosen metadata variable (e.g. a trajectory value) independently of the annotation bars, which makes it suited to trajectory / differential-expression heatmaps where cells are ordered along a continuous axis while still displaying a categorical annotation (something the grouped DoHeatmap cannot do).

Usage

```
PlotAnnotatedHeatmap(
  object,
  features,
  sort.by,
  anno.var = NULL,
  anno.colors = NULL,
  assay = NULL,
  layer = "scale.data",
  hm.limit = c(-2, 0, 2),
  hm.colors = c("#4575b4", "white", "#d73027"),
  cluster.rows = FALSE,
```

```
  cluster.columns = FALSE,
  show.column.names = FALSE,
  row.font.size = 12,
  ...
)
```

Arguments

object	A Seurat object.
features	Character vector of features (rows of the heatmap). Features absent from the requested layer are dropped with a warning.
sort.by	One or more metadata column names used to order the cells (columns of the heatmap). Multiple names are applied in order as tie-breakers.
anno.var	Optional character vector of metadata column names, each drawn as a top annotation bar. NULL (default) draws no annotation.
anno.colors	Optional list of colors for anno.var, one element per variable (named by variable, or positionally matched to anno.var). For a categorical variable supply at least one color per level; for a numeric variable supply exactly three colors (min, median, max). NULL entries use defaults.
assay	Assay to pull expression from. Defaults to the object's default assay.
layer	Layer to pull expression from. Default is "scale.data".
hm.limit	Numeric vector of three breakpoints for the heatmap color gradient (low, mid, high). Default is c(-2, 0, 2).
hm.colors	Three colors mapped to hm.limit. Values beyond the range saturate to the endpoint colors. Default is a blue-white-red gradient.
cluster.rows	Whether to cluster rows (features). Default is FALSE.
cluster.columns	Whether to cluster columns (cells). Default is FALSE; clustering overrides the sort.by ordering.
show.column.names	Whether to show cell names. Default is FALSE.
row.font.size	Font size for row (feature) names. Default is 12.
...	Additional arguments passed to Heatmap.

Details

This is an independent implementation whose interface is inspired by Scillus::plot_heatmap; it does not reuse that package's code.

Value

A Heatmap-class object, which draws when printed. For the horizontal, bottom-placed legend layout use ComplexHeatmap::draw(ht, heatmap_legend_side = "bottom").

Examples

```
## Not run:
PlotAnnotatedHeatmap(
  object = sample_obj,
  features = top_genes,
  sort.by = "pseudotime",
  anno.var = "Disease"
)

## End(Not run)
```

`PlotClusterTree` *Plot clusters as a tree*

Description

Plots previously computed tree (from BuildClusterTree)

Usage

```
PlotClusterTree(object, direction = "downwards", ...)
```

Arguments

`object`	Seurat object
`direction`	A character string specifying the direction of the tree (default is downwards) Possible options: "rightwards", "leftwards", "upwards", and "downwards".
`...`	Additional arguments to `ape::plot.phylo`

Value

Plots dendogram (must be precomputed using BuildClusterTree), returns no value

Examples

```
## Not run:
if (requireNamespace("ape", quietly = TRUE)) {
  data("pbmc_small")
  pbmc_small <- BuildClusterTree(object = pbmc_small)
  PlotClusterTree(object = pbmc_small)
}

## End(Not run)
```

PlotPerturbScore *Function to plot perturbation score distributions.*

Description

Density plots to visualize perturbation scores calculated from RunMixscape function.

Usage

```
PlotPerturbScore(
  object,
  target.gene.class = "gene",
  target.gene.ident = NULL,
  mixscape.class = "mixscape_class",
  col = "orange2",
  split.by = NULL,
  before.mixscape = FALSE,
  prtb.type = "KO"
)
```

Arguments

object	An object of class Seurat.
target.gene.class	meta data column specifying all target gene names in the experiment.
target.gene.ident	Target gene name to visualize perturbation scores for.
mixscape.class	meta data column specifying mixscape classifications.
col	Specify color of target gene class or knockout cell class. For control non-targeting and non-perturbed cells, colors are set to different shades of grey.
split.by	For datasets with more than one cell type. Set equal TRUE to visualize perturbation scores for each cell type separately.
before.mixscape	Option to split densities based on mixscape classification (default) or original target gene classification. Default is set to NULL and plots cells by original class ID.
prtb.type	specify type of CRISPR perturbation expected for labeling mixscape classifications. Default is KO.

Value

A ggplot object.

PolyDimPlot *Polygon DimPlot*

Description

Plot cells as polygons, rather than single points. Color cells by identity, or a categorical variable in metadata

Usage

```
PolyDimPlot(
  object,
  group.by = NULL,
  cells = NULL,
  poly.data = "spatial",
  flip.coords = FALSE
)
```

Arguments

object	Seurat object
group.by	A grouping variable present in the metadata. Default is to use the groupings present in the current cell identities (Idents(object = object))
cells	Vector of cells to plot (default is all cells)
poly.data	Name of the polygon dataframe in the misc slot
flip.coords	Flip x and y coordinates

Value

Returns a ggplot object

PolyFeaturePlot *Polygon FeaturePlot*

Description

Plot cells as polygons, rather than single points. Color cells by any value accessible by FetchData.

Usage

```
PolyFeaturePlot(
  object,
  features,
  cells = NULL,
  poly.data = "spatial",
  ncol = ceiling(x = length(x = features)/2),
  min.cutoff = 0,
  max.cutoff = NA,
  common.scale = TRUE,
  flip.coords = FALSE
)
```

Arguments

object	Seurat object
features	Vector of features to plot. Features can come from: • An Assay feature (e.g. a gene name - "MS4A1") • A column name from meta.data (e.g. mitochondrial percentage - "percent.mito") • A column name from a DimReduc object corresponding to the cell embedding values (e.g. the PC 1 scores - "PC_1")
cells	Vector of cells to plot (default is all cells)
poly.data	Name of the polygon dataframe in the misc slot
ncol	Number of columns to split the plot into
min.cutoff, max.cutoff	Vector of minimum and maximum cutoff values for each feature, may specify quantile in the form of 'q##' where '##' is the quantile (eg, 'q1', 'q10')
common.scale	...
flip.coords	Flip x and y coordinates

Value

Returns a ggplot object

PredictAssay *Predict value from nearest neighbors*

Description

This function will predict expression or cell embeddings from its k nearest neighbors index. For each cell, it will average its k neighbors value to get its new imputed value. It can average expression value in assays and cell embeddings from dimensional reductions.

Usage

```
PredictAssay(
  object,
  nn.idx,
  assay,
  reduction = NULL,
  dims = NULL,
  return.assay = TRUE,
  slot = "scale.data",
  features = NULL,
  mean.function = rowMeans,
  seed = 4273,
  verbose = TRUE
)
```

Arguments

object	The object used to calculate knn
nn.idx	k near neighbor indices. A cells x k matrix.
assay	Assay used for prediction
reduction	Cell embedding of the reduction used for prediction
dims	Number of dimensions of cell embedding
return.assay	Return an assay or a predicted matrix
slot	slot used for prediction
features	features used for prediction
mean.function	the function used to calculate row mean
seed	Sets the random seed to check if the nearest neighbor is query cell
verbose	Print progress

Value

return an assay containing predicted expression value in the data slot

---

PrepareBridgeReference

Prepare the bridge and reference datasets

Description

Preprocess the multi-omic bridge and unimodal reference datasets into an extended reference. This function performs the following three steps: 1. Performs within-modality harmonization between bridge and reference 2. Performs dimensional reduction on the SNN graph of bridge datasets via Laplacian Eigendecomposition 3. Constructs a bridge dictionary representation for unimodal reference cells

Usage

```
PrepareBridgeReference(
  reference,
  bridge,
  reference.reduction = "pca",
  reference.dims = 1:50,
  normalization.method = c("SCT", "LogNormalize"),
  reference.assay = NULL,
  bridge.ref.assay = "RNA",
  bridge.query.assay = "ATAC",
  supervised.reduction = c("slsi", "spca", NULL),
  bridge.query.reduction = NULL,
  bridge.query.features = NULL,
  laplacian.reduction.name = "lap",
  laplacian.reduction.key = "lap_",
  laplacian.reduction.dims = 1:50,
  verbose = TRUE
)
```

Arguments

`reference`	A reference Seurat object
`bridge`	A multi-omic bridge Seurat object
`reference.reduction`	Name of dimensional reduction of the reference object (default is 'pca')
`reference.dims`	Number of dimensions used for the reference.reduction (default is 50)
`normalization.method`	Name of normalization method used: LogNormalize or SCT
`reference.assay`	Assay name for reference (default is `DefaultAssay`)
`bridge.ref.assay`	Assay name for bridge used for reference mapping. RNA by default
`bridge.query.assay`	Assay name for bridge used for query mapping. ATAC by default
`supervised.reduction`	Type of supervised dimensional reduction to be performed for integrating the bridge and query. Options are: • slsi: Perform supervised LSI as the dimensional reduction for the bridge-query integration • spca: Perform supervised PCA as the dimensional reduction for the bridge-query integration • NULL: no supervised dimensional reduction will be calculated. bridge.query.reduction is used for the bridge-query integration
`bridge.query.reduction`	Name of dimensions used for the bridge-query harmonization. 'bridge.query.reduction' and 'supervised.reduction' cannot be NULL together.

bridge.query.features
: Features used for bridge query dimensional reduction (default is NULL which uses VariableFeatures from the bridge object)

laplacian.reduction.name
: Name of dimensional reduction name of graph laplacian eigenspace (default is 'lap')

laplacian.reduction.key
: Dimensional reduction key (default is 'lap_')

laplacian.reduction.dims
: Number of dimensions used for graph laplacian eigenspace (default is 50)

verbose
: Print progress and message (default is TRUE)

Value

Returns a BridgeReferenceSet that can be used as input to FindBridgeTransferAnchors. The parameters used are stored in the BridgeReferenceSet as well

---

PrepareSampleObject *Perform preprocessing procedures for a Seurat object to prepare for the sample-level analysis*

Description

This is a wrapper function to apply landmark sketching, training data sketching (optional), PLS learning, and a nearest neighbor workflow to a single-cell Seurat object to get the necessary components for sample-level analyses later. The output object can be directly used by GenerateSampleObject to obtain a sample-level matrix.

Usage

```
PrepareSampleObject(
  object = NULL,
  assay = NULL,
  add.hvg = TRUE,
  group.by.CorTest = NULL,
  Y = NULL,
  sketch.training = TRUE,
  group.by.Sketch = NULL,
  ncells.per.group = 1000,
  training.assay.name = "TRAINING",
  training.sketch.method = "Uniform",
  ncells.landmark = 2000,
  landmark.assay.name = "LANDMARK",
  landmark.sketch.method = "LeverageScore",
  ncomp = 10,
  pls.function = c("plsr", "spls", "cppls"),
```

```
  pls.reduction.name = "pls",
  modality = c("multi", "single"),
  k.nn = 5,
  knn.range = 200,
  l2.norm = TRUE,
  name.reduction.1 = "pca",
  dims.reduction.1 = 1:30,
  nn.name = "weighted.nn",
  weighted.nn.name = NULL,
  fix.wnn.weights = c(0.5, 0.5),
  rm.training.assay = FALSE,
  verbose = TRUE
)
```

Arguments

object	a Seurat object.
assay	the assay to perform the analyses on
add.hvg	a boolen to specify whether the function runs additional correlation test between features and response (Y) to obtain more response-relevant features to be included in VariableFeatures and used for PLS learning. See QuickCorTest for details. Default is TRUE.
group.by.CorTest	A metadata column name to group cells by before QuickCorTest. If NULL, falls back to QuickCorTest without grouping. Default is NULL.
Y	A metadata column name of responses. Will also be used as the responses for PLS learning. No cell in 'assay' can have a missing (NA) response, including cells that would not be sketched into the training subset.
sketch.training	a boolen to specify whether the function performs sketching for the Seurat object to get a training subset for PLS learning (the PLS learned from subset will be projected to the full data). For efficiency, it is recommended to do so when the Seurat object is very large. If the 'assay' being specified for this Seurat object is an on-disk assay, this parameter must be set to TRUE. Default is TRUE.
group.by.Sketch	A metadata column name to group cells by before sketching. If NULL, falls back to standard sketching without grouping. Default is NULL.
ncells.per.group	A positive integer, named vector, or list specifying the number of cells to sample. Default is 1000 per category in 'group.by.Sketch'. See SketchDataByGroup for detailed usage.
training.assay.name	The assay name of the training data.
training.sketch.method	Sketching method to use for the training subset. Can be 'LeverageScore' or 'Uniform'. Default is 'Uniform' because for training we want to obtain an unbiased subset of the original data. See LeverageScore for details.

ncells.landmark
: A positive integer specifying the number of 'landmark cells'. The function will generate a new assay for these 'landmark cells' (please do not confuse it with the training subset). The landmark cells should be a subset that covers the diverse cell types and cell states of the data. Default is 2000.

landmark.assay.name
: The assay name of the landmark cells. Default is "LANDMARK".

landmark.sketch.method
: Sketching method to use for the landmark cells. Can be 'LeverageScore' or 'Uniform'. Default is 'LeverageScore' because we want the landmark cells to be as diverse/representative as possible. See LeverageScore for details.

ncomp
: Number of components to compute

pls.function
: PLS function from pls package to run (options: plsr, spls, cppls)

pls.reduction.name
: PLS dimensional reduction name

modality
: Whether to build the neighbor graph from two modalities or one. "multi" (default) combines name.reduction.1 with the PLS embedding via WNN (FindmmNN); "single" uses the PLS embedding alone (FindsmNN). In "single" mode, name.reduction.1, dims.reduction.1, knn.range, and fix.wnn.weights are ignored.

k.nn
: The number of nearest neighbors to compute for each modality

knn.range
: Range parameter for nearest neighbor search. Passed to FindmmNN, which clamps it to the number of landmark cells if it exceeds that. Default is 200. Ignored when modality = "single".

l2.norm
: Perform L2 normalization on the cell embeddings during the nearest neighbor process. Default is TRUE.

name.reduction.1
: The name of the DimReduc to use as the 1st embedding (the 2nd is the PLS embedding) in the WNN process. Ignored when modality = "single".

dims.reduction.1
: The dimensions for reduction.1 to use during the WNN process. Ignored when modality = "single".

nn.name
: Name of the output neighbor object. Defaults to "weighted.nn" for modality = "multi", and to "single.nn" for modality = "single" (unless set explicitly).

weighted.nn.name
: Deprecated. Use nn.name instead.

fix.wnn.weights
: Pre-specified modality weights. If provided, skips the calculation and uses these weights directly. Should be a list with the same length as reduction.list. Ignored when modality = "single".

rm.training.assay
: Whether to remove the training assay after running PrepareSampleObject(). This is used to reduce the memory usage when the seurat object is large (e.g., a large on-disk object). Default is FALSE.

verbose
: Print progress and diagnostic messages

Details

Two modalities are supported (see the `modality` argument). The default multi-modal path combines an existing reduction (e.g. PCA, via `name.reduction.1`) with the PLS embedding using the weighted nearest neighbor (WNN) workflow (`FindmmNN`). The single-modal path builds the neighbor graph from the PLS embedding alone (`FindsmNN`), which is useful when no complementary reduction is available or desired.

Value

return a Seurat object that contains a weighted.nn Neighbor object between the landmark cells and all the other cells. the Seurat object will also contain a landmark assay (and a training assay if sketch.training == TRUE).

`PrepLDA` *Function to prepare data for Linear Discriminant Analysis.*

Description

This function performs unsupervised PCA on each mixscape class separately and projects each subspace onto all cells in the data.

Usage

```
PrepLDA(
  object,
  de.assay = "RNA",
  pc.assay = "PRTB",
  labels = "gene",
  nt.label = "NT",
  npcs = 10,
  verbose = TRUE,
  logfc.threshold = 0.25
)
```

Arguments

`object`	An object of class Seurat.
`de.assay`	Assay to use for selection of DE genes.
`pc.assay`	Assay to use for running Principle components analysis.
`labels`	Meta data column with target gene class labels.
`nt.label`	Name of non-targeting cell class.
`npcs`	Number of principle components to use.
`verbose`	Print progress bar.
`logfc.threshold`	Limit testing to genes which show, on average, at least X-fold difference (log-scale) between the two groups of cells. Default is 0.25. Increasing logfc.threshold speeds up the function, but can miss weaker signals.

Value

Returns a list of the first 10 PCs from each projection.

`PrepSCTFindMarkers` *Prepare object to run differential expression on SCT assay with multiple models*

Description

Given a merged object with multiple SCT models, this function uses minimum of the median UMI (calculated using the raw UMI counts) of individual objects to reverse the individual SCT regression model using minimum of median UMI as the sequencing depth covariate. The counts slot of the SCT assay is replaced with recorrected counts and the data slot is replaced with log1p of recorrected counts.

Usage

```
PrepSCTFindMarkers(object, assay = "SCT", verbose = TRUE)
```

Arguments

`object`	Seurat object with SCT assays
`assay`	Assay name where for SCT objects are stored; Default is 'SCT'
`verbose`	Print messages and progress

Value

Returns a Seurat object with recorrected counts and data in the SCT assay.

Progress Updates with progressr

This function uses **progressr** to render status updates and progress bars. To enable progress updates, wrap the function call in `with_progress` or run `handlers(global = TRUE)` before running this function. For more details about **progressr**, please read `vignette("progressr-intro")`

Parallelization with future

This function uses **future** to enable parallelization. Parallelization strategies can be set using `plan`. Common plans include "`sequential`" for non-parallelized processing or "`multisession`" for parallel evaluation using multiple R sessions; for other plans, see the "Implemented evaluation strategies" section of `?future::plan`. For a more thorough introduction to **future**, see `vignette("future-1-overview")`

Examples

```
## Not run:
data("pbmc_small")
pbmc_small1 <- SCTransform(object = pbmc_small, variable.features.n = 20, vst.flavor="v1")
pbmc_small2 <- SCTransform(object = pbmc_small, variable.features.n = 20, vst.flavor="v1")
pbmc_merged <- merge(x = pbmc_small1, y = pbmc_small2)
pbmc_merged <- PrepSCTFindMarkers(object = pbmc_merged)
markers <- FindMarkers(
  object = pbmc_merged,
  ident.1 = "0",
  ident.2 = "1",
  assay = "SCT"
)
pbmc_subset <- subset(pbmc_merged, idents = c("0", "1"))
markers_subset <- FindMarkers(
  object = pbmc_subset,
  ident.1 = "0",
  ident.2 = "1",
  assay = "SCT",
  recorrect_umi = FALSE
)


## End(Not run)
```

PrepSCTIntegration *Prepare an object list normalized with sctransform for integration.*

Description

This function takes in a list of objects that have been normalized with the SCTransform method and performs the following steps:

- If anchor.features is a numeric value, calls SelectIntegrationFeatures to determine the features to use in the downstream integration procedure.
- Ensures that the sctransform residuals for the features specified to anchor.features are present in each object in the list. This is necessary because the default behavior of SCTransform is to only store the residuals for the features determined to be variable. Residuals are recomputed for missing features using the stored model parameters via the GetResidual function.
- Subsets the scale.data slot to only contain the residuals for anchor.features for efficiency in downstream processing.

Usage

```
PrepSCTIntegration(
  object.list,
  assay = NULL,
```

```
  anchor.features = 2000,
  sct.clip.range = NULL,
  verbose = TRUE
)
```

Arguments

object.list	A list of Seurat objects to prepare for integration
assay	The name of the Assay to use for integration. This can be a single name if all the assays to be integrated have the same name, or a character vector containing the name of each Assay in each object to be integrated. The specified assays must have been normalized using SCTransform. If NULL (default), the current default assay for each object is used.
anchor.features	Can be either: • A numeric value. This will call SelectIntegrationFeatures to select the provided number of features to be used in anchor finding • A vector of features to be used as input to the anchor finding process
sct.clip.range	Numeric of length two specifying the min and max values the Pearson residual will be clipped to
verbose	Display output/messages

Value

A list of Seurat objects with the appropriate scale.data slots containing only the required anchor.features.

Examples

```
## Not run:
# to install the SeuratData package see https://github.com/satijalab/seurat-data
library(SeuratData)
data("panc8")

# panc8 is a merged Seurat object containing 8 separate pancreas datasets
# split the object by dataset and take the first 2 to integrate
pancreas.list <- SplitObject(panc8, split.by = "tech")[1:2]

# perform SCTransform normalization
pancreas.list <- lapply(X = pancreas.list, FUN = SCTransform)

# select integration features and prep step
features <- SelectIntegrationFeatures(pancreas.list)
pancreas.list <- PrepSCTIntegration(
  pancreas.list,
  anchor.features = features
)

# downstream integration steps
anchors <- FindIntegrationAnchors(
```

```
  pancreas.list,
  normalization.method = "SCT",
  anchor.features = features
)
pancreas.integrated <- IntegrateData(anchors, normalization.method = "SCT")

## End(Not run)
```

`ProjectData` *Project full data to the sketch assay*

Description

This function allows projection of high-dimensional single-cell RNA expression data from a full dataset onto the lower-dimensional embedding of the sketch of the dataset.

Usage

```
ProjectData(
  object,
  assay = "RNA",
  sketched.assay = "sketch",
  sketched.reduction,
  full.reduction,
  dims,
  normalization.method = c("LogNormalize", "SCT"),
  refdata = NULL,
  k.weight = 50,
  umap.model = NULL,
  recompute.neighbors = FALSE,
  recompute.weights = FALSE,
  verbose = TRUE
)
```

Arguments

`object`	A Seurat object.
`assay`	Assay name for the full data. Default is 'RNA'.
`sketched.assay`	Sketched assay name to project onto. Default is 'sketch'.
`sketched.reduction`	Dimensional reduction results of the sketched assay to project onto.
`full.reduction`	Dimensional reduction name for the projected full dataset.
`dims`	Dimensions to include in the projection.
`normalization.method`	Normalization method to use. Can be 'LogNormalize' or 'SCT'. Default is 'LogNormalize'.

refdata	An optional list for label transfer from sketch to full data. Default is NULL. Similar to refdata in 'MapQuery'
k.weight	Number of neighbors to consider when weighting labels for transfer. Default is 50.
umap.model	An optional pre-computed UMAP model. Default is NULL.
recompute.neighbors	Whether to recompute the neighbors for label transfer. Default is FALSE.
recompute.weights	Whether to recompute the weights for label transfer. Default is FALSE.
verbose	Print progress and diagnostic messages.

Value

A Seurat object with the full data projected onto the sketched dimensional reduction results. The projected data are stored in the specified full reduction.

`ProjectDim` *Project Dimensional reduction onto full dataset*

Description

Takes a pre-computed dimensional reduction (typically calculated on a subset of genes) and projects this onto the entire dataset (all genes). Note that the cell loadings will remain unchanged, but now there are gene loadings for all genes.

Usage

```
ProjectDim(
  object,
  reduction = "pca",
  assay = NULL,
  dims.print = 1:5,
  nfeatures.print = 20,
  overwrite = FALSE,
  do.center = FALSE,
  verbose = TRUE
)
```

Arguments

object	Seurat object
reduction	Reduction to use
assay	Assay to use
dims.print	Number of dims to print features for

nfeatures.print	Number of features with highest/lowest loadings to print for each dimension
overwrite	Replace the existing data in feature.loadings
do.center	Center the dataset prior to projection (should be set to TRUE)
verbose	Print top genes associated with the projected dimensions

Value

Returns Seurat object with the projected values

Examples

```
data("pbmc_small")
pbmc_small
pbmc_small <- ProjectDim(object = pbmc_small, reduction = "pca")
# Visualize top projected genes in heatmap
DimHeatmap(object = pbmc_small, reduction = "pca", dims = 1, balanced = TRUE)
```

ProjectDimReduc *Project query data to reference dimensional reduction*

Description

Project query data to reference dimensional reduction

Usage

```
ProjectDimReduc(
  query,
  reference,
  mode = c("pcaproject", "lsiproject"),
  reference.reduction,
  combine = FALSE,
  query.assay = NULL,
  reference.assay = NULL,
  features = NULL,
  do.scale = TRUE,
  reduction.name = NULL,
  reduction.key = NULL,
  verbose = TRUE
)
```

Arguments

query	Query object
reference	Reference object
mode	Projection mode name for projection • pcaproject: PCA projection • lsiproject: LSI projection
reference.reduction	Name of dimensional reduction in the reference object
combine	Determine if query and reference objects are combined
query.assay	Assay used for query object
reference.assay	Assay used for reference object
features	Features used for projection
do.scale	Determine if scale expression matrix in the pcaproject mode
reduction.name	dimensional reduction name, reference.reduction is used by default
reduction.key	dimensional reduction key, the key in reference.reduction is used by default
verbose	Print progress and message

Value

Returns a query-only or query-reference combined seurat object

---

ProjectIntegration *Integrate embeddings from the integrated sketched.assay*

Description

The main steps of this procedure are outlined below. For a more detailed description of the methodology, please see Hao, et al Biorxiv 2022: doi:10.1101/2022.02.24.481684

Usage

```
ProjectIntegration(
  object,
  sketched.assay = "sketch",
  assay = "RNA",
  reduction = "integrated_dr",
  features = NULL,
  layers = "data",
  reduction.name = NULL,
  reduction.key = NULL,
  method = c("sketch", "data"),
  ratio = 0.8,
```

```
  sketched.layers = NULL,
  seed = 123,
  verbose = TRUE
)
```

Arguments

object	A Seurat object with all cells for one dataset
sketched.assay	Assay name for sketched-cell expression (default is 'sketch')
assay	Assay name for original expression (default is 'RNA')
reduction	Dimensional reduction name for batch-corrected embeddings in the sketched object (default is 'integrated_dr')
features	Features used for atomic sketch integration
layers	Names of layers for correction.
reduction.name	Name to save new reduction as; defaults to `paste0(reduction, '.orig')`
reduction.key	Key for new dimensional reduction; defaults to creating one from `reduction.name`
method	Methods to construct sketch-cell representation for all cells (default is 'sketch'). Can be one of: • "`sketch`": Use random sketched data slot • "`data`": Use data slot
ratio	Sketch ratio of data slot when `dictionary.method` is set to "`sketch`"; defaults to 0.8
sketched.layers	Names of sketched layers, defaults to all layers of "`object[[assay]]`"
seed	A positive integer. The seed for the random number generator, defaults to 123.
verbose	Print progress and message

Details

First learn a atom dictionary representation to reconstruct each cell. Then, using this dictionary representation, reconstruct the embeddings of each cell from the integrated atoms.

Value

Returns a Seurat object with an integrated dimensional reduction

ProjectUMAP *Project query into UMAP coordinates of a reference*

Description

This function will take a query dataset and project it into the coordinates of a provided reference UMAP. This is essentially a wrapper around two steps:

- FindNeighbors - Find the nearest reference cell neighbors and their distances for each query cell.
- RunUMAP - Perform umap projection by providing the neighbor set calculated above and the umap model previously computed in the reference.

Usage

```
ProjectUMAP(query, ...)

## Default S3 method:
ProjectUMAP(
  query,
  query.dims = NULL,
  reference,
  reference.dims = NULL,
  k.param = 30,
  nn.method = "annoy",
  n.trees = 50,
  annoy.metric = "cosine",
  l2.norm = FALSE,
  cache.index = TRUE,
  index = NULL,
  neighbor.name = "query_ref.nn",
  reduction.model,
  ...
)

## S3 method for class 'DimReduc'
ProjectUMAP(
  query,
  query.dims = NULL,
  reference,
  reference.dims = NULL,
  k.param = 30,
  nn.method = "annoy",
  n.trees = 50,
  annoy.metric = "cosine",
  l2.norm = FALSE,
  cache.index = TRUE,
```

```
  index = NULL,
  neighbor.name = "query_ref.nn",
  reduction.model,
  ...
)

## S3 method for class 'Seurat'
ProjectUMAP(
  query,
  query.reduction,
  query.dims = NULL,
  reference,
  reference.reduction,
  reference.dims = NULL,
  k.param = 30,
  nn.method = "annoy",
  n.trees = 50,
  annoy.metric = "cosine",
  l2.norm = FALSE,
  cache.index = TRUE,
  index = NULL,
  neighbor.name = "query_ref.nn",
  reduction.model,
  reduction.name = "ref.umap",
  reduction.key = "refUMAP_",
  ...
)
```

Arguments

query	Query dataset
...	Additional parameters to RunUMAP
query.dims	Dimensions (columns) to use from query
reference	Reference dataset
reference.dims	Dimensions (columns) to use from reference
k.param	Defines k for the k-nearest neighbor algorithm
nn.method	Method for nearest neighbor finding. Options include: rann, annoy
n.trees	More trees gives higher precision when using annoy approximate nearest neighbor search
annoy.metric	Distance metric for annoy. Options include: euclidean, cosine, manhattan, and hamming
l2.norm	Take L2Norm of the data
cache.index	Include cached index in returned Neighbor object (only relevant if return.neighbor = TRUE)
index	Precomputed index. Useful if querying new data against existing index to avoid recomputing.

neighbor.name	Name to store neighbor information in the query
reduction.model	DimReduc object that contains the umap model
query.reduction	Name of reduction to use from the query for neighbor finding
reference.reduction	Name of reduction to use from the reference for neighbor finding
reduction.name	Name of projected UMAP to store in the query
reduction.key	Value for the projected UMAP key

PseudobulkExpression *Pseudobulk Expression*

Description

Normalize the count data present in a given assay.

Returns a representative expression value for each identity class

Usage

```
PseudobulkExpression(object, ...)

## S3 method for class 'Assay'
PseudobulkExpression(
  object,
  assay,
  category.matrix,
  features = NULL,
  layer = "data",
  slot = deprecated(),
  verbose = TRUE,
  ...
)

## S3 method for class 'StdAssay'
PseudobulkExpression(
  object,
  assay,
  category.matrix,
  features = NULL,
  layer = "data",
  slot = deprecated(),
  verbose = TRUE,
  ...
)
```

```
## S3 method for class 'Seurat'
PseudobulkExpression(
  object,
  assays = NULL,
  features = NULL,
  return.seurat = FALSE,
  group.by = "ident",
  add.ident = NULL,
  layer = "data",
  slot = deprecated(),
  method = "average",
  normalization.method = "LogNormalize",
  scale.factor = 10000,
  margin = 1,
  verbose = TRUE,
  ...
)
```

Arguments

object	Seurat object
...	Arguments to be passed to methods such as CreateSeuratObject
assay	The name of the passed assay - used primarily for warning/error messages
category.matrix	A matrix defining groupings for pseudobulk expression calculations; each column represents an identity class, and each row a sample
features	Features to analyze. Default is all features in the assay
layer	Layer(s) to user; if multiple are given, assumed to follow the order of 'assays' (if specified) or object's assays
slot	(Deprecated) See layer
verbose	Print messages and show progress bar
assays	Which assays to use. Default is all assays
return.seurat	Whether to return the data as a Seurat object. Default is FALSE
group.by	Categories for grouping (e.g, "ident", "replicate", "celltype"); "ident" by default
add.ident	(Deprecated) See group.by
method	The method used for calculating pseudobulk expression; one of: "average" or "aggregate"
normalization.method	Method for normalization, see NormalizeData
scale.factor	Scale factor for normalization, see NormalizeData
margin	Margin to perform CLR normalization, see NormalizeData

Value

Returns object after normalization

Returns a matrix with genes as rows, identity classes as columns. If return.seurat is TRUE, returns an object of class Seurat.

`QuickCorTest` *Perform cor.test between each gene and a response variable given a Seurat object*

Description

This function take a Seurat object's gene expression matrix and a meta-data column (a response variable), and run cor.test between each gene and the response variable and keep track of the top-correlated genes and return that gene list to user. It is intended to give users a more response-informative gene list for downstream supervised dimension reduction analyses like partial least squares.

Usage

```
QuickCorTest(
  object = NULL,
  assay = NULL,
  layer = "data",
  group.by = NULL,
  Y = NULL,
  cor.cutoff = NULL,
  top.prop = 0.01,
  min.pct = 0.1,
  min.cells = 100,
  verbose = TRUE,
  unlist = TRUE,
  ...
)
```

Arguments

`object`	A Seurat object
`assay`	The name of the assay to retrieve the expression matrix
`layer`	The name of the layer to use for cor.test
`group.by`	A metadata column name to group cells by before cor.test. If NULL, falls back to cor.test without grouping. Default is NULL.
`Y`	A metadata column name of responses. No cell in 'assay' can have a missing (NA) response.
`cor.cutoff`	The correlation coefficient cutoff to select the top genes. Default is NULL.

top.prop	The proportion of genes to be selected as the top genes. Default is 0.01, i.e. the most correlated 1% of genes will be selected. When used together with cor.cutoff, genes must pass both filters; set top.prop to NULL to select every gene that passes cor.cutoff. They cannot be NULL at the same time.
min.pct	only test genes that are detected in a minimum fraction of min.pct cells in each group. Default is 0.1
min.cells	the minimum number of cells per group to perform the cor.test. Default is 100. groups with < 100 will be skipped.
verbose	Print progress bars and output
unlist	whether to return a unlist object (vector) or a named list (each element is a vector of DEGs for a category in group.by)
...	Additional arguments

Value

return a list of gene names for the genes that highly correlated with the responses

Examples

```
## Not run:
# Find genes correlated with pseudotime
cor_genes <- QuickCorTest(seurat_obj, Y = "pseudotime")

## End(Not run)
```

Radius.SlideSeq *Get Spot Radius*

Description

Get Spot Radius

Usage

```
## S3 method for class 'SlideSeq'
Radius(object, ...)

## S3 method for class 'STARmap'
Radius(object, ...)

## S3 method for class 'VisiumV1'
Radius(object, scale = "lowres", ...)

## S3 method for class 'VisiumV2'
Radius(object, scale = "lowres", ...)
```

Arguments

`object`	An image object
`...`	Arguments passed to other methods
`scale`	A factor to scale the radius by; one of: "hires", "lowres", or `NULL` for the unscaled value.

See Also

`SeuratObject::Radius`

`Read10X` *Load in data from 10X*

Description

Enables easy loading of sparse data matrices provided by 10X genomics.

Usage

```
Read10X(
  data.dir,
  gene.column = 2,
  cell.column = 1,
  unique.features = TRUE,
  strip.suffix = FALSE
)
```

Arguments

`data.dir`	Directory containing the matrix.mtx, genes.tsv (or features.tsv), and barcodes.tsv files provided by 10X. A vector or named vector can be given in order to load several data directories. If a named vector is given, the cell barcode names will be prefixed with the name.
`gene.column`	Specify which column of genes.tsv or features.tsv to use for gene names; default is 2
`cell.column`	Specify which column of barcodes.tsv to use for cell names; default is 1
`unique.features`	Make feature names unique (default TRUE)
`strip.suffix`	Remove trailing "-1" if present in all cell barcodes.

Value

If features.csv indicates the data has multiple data types, a list containing a sparse matrix of the data from each type will be returned. Otherwise a sparse matrix containing the expression data will be returned.

Examples

```
## Not run:
# For output from CellRanger < 3.0
data_dir <- 'path/to/data/directory'
list.files(data_dir) # Should show barcodes.tsv, genes.tsv, and matrix.mtx
expression_matrix <- Read10X(data.dir = data_dir)
seurat_object = CreateSeuratObject(counts = expression_matrix)

# For output from CellRanger >= 3.0 with multiple data types
data_dir <- 'path/to/data/directory'
list.files(data_dir) # Should show barcodes.tsv.gz, features.tsv.gz, and matrix.mtx.gz
data <- Read10X(data.dir = data_dir)
seurat_object = CreateSeuratObject(counts = data$`Gene Expression`)
seurat_object[['Protein']] = CreateAssayObject(counts = data$`Antibody Capture`)

## End(Not run)
```

Read10X_Coordinates *Load 10X Genomics Visium Tissue Positions*

Description

Load 10X Genomics Visium Tissue Positions

Usage

```
Read10X_Coordinates(filename, filter.matrix, cells = NULL)
```

Arguments

filename	Path to a tissue_positions_list.csv, tissue_positions.csv, or tissue_positions.parquet file
filter.matrix	Filter spot/feature matrix to only include spots that have been determined to be over tissue
cells	Optional barcode vector to retain. NULL reads all eligible positions. Filters are applied after reading the table.

Value

A data.frame

Read10X_h5 *Read 10X hdf5 file*

Description

Read count matrix from 10X CellRanger hdf5 file. This can be used to read both scATAC-seq and scRNA-seq matrices.

Usage

```
Read10X_h5(filename, use.names = TRUE, unique.features = TRUE)
```

Arguments

filename	Path to h5 file
use.names	Label row names with feature names rather than ID numbers.
unique.features	Make feature names unique (default TRUE)

Value

A sparse matrix with rows and columns labeled. Multiple feature types return a named list of matrices; legacy multi-genome files return one entry per genome.

Read10X_HD_GeoJson *Load 10X Genomics GeoJson*

Description

Load 10X Genomics GeoJson

Usage

```
Read10X_HD_GeoJson(data.dir, segmentation.type = "cell", cells = NULL)
```

Arguments

data.dir	Path to the directory containing matrix data
segmentation.type	Which segmentations to load, cell or nucleus. If using nucleus the full matrix from cells is still used
cells	Optional cell barcodes to retain after reading the GeoJSON.

Value

An sf object containing polygon segmentations from the GeoJSON provided by 10x, formatted for downstream coordinate retrieval

Read10X_Image *Load a 10X Genomics Visium Image*

Description

Load a 10X Genomics Visium Image

Usage

```
Read10X_Image(
  image.dir,
  image.name = "tissue_lowres_image.png",
  assay = "Spatial",
  slice = "slice1",
  filter.matrix = TRUE,
  image.type = "VisiumV2",
  cells = NULL
)
```

Arguments

image.dir	Path to directory with 10X Genomics visium image data; should include files tissue_lowres_image.png, scalefactors_json.json and tissue_positions_list.csv
image.name	PNG file to read in
assay	Name of associated assay
slice	Name for the image, used to populate the instance's key
filter.matrix	Filter spot/feature matrix to only include spots that have been determined to be over tissue
image.type	Image type to return, one of: "VisiumV1" or "VisiumV2"
cells	Optional barcode vector to restrict tissue positions before collection. NULL reads all eligible positions.

Value

A VisiumV2 object

See Also

VisiumV2 Load10X_Spatial

Read10X_probe_metadata *Read10x Probe Metadata*

Description

This function reads the probe metadata from a 10x Genomics probe barcode matrix file in HDF5 format.

Usage

```
Read10X_probe_metadata(data.dir, filename = "raw_probe_bc_matrix.h5")
```

Arguments

data.dir	The directory where the file is located.
filename	The name of the file containing the raw probe barcode matrix in HDF5 format. The default filename is 'raw_probe_bc_matrix.h5'.

Value

Returns a data.frame containing the probe metadata.

Read10X_ScaleFactors *Load 10X Genomics Visium Scale Factors*

Description

Load 10X Genomics Visium Scale Factors

Usage

```
Read10X_ScaleFactors(filename)
```

Arguments

filename	Path to a scalefactors_json.json file

Value

A scalefactors object

`Read10X_Segmentations` *Load 10X Genomics Visium Cell Segmentations*

Description

Load 10X Genomics Visium Cell Segmentations

Usage

```
Read10X_Segmentations(
  image.dir,
  data.dir,
  image.name = "tissue_lowres_image.png",
  assay = "Spatial.Polygons",
  slice = "slice1.polygons",
  segmentation.type = "cell",
  compact = TRUE,
  cells = NULL
)
```

Arguments

`image.dir`	Path to directory with 10X Genomics visium image data;
`data.dir`	Directory of the base spaceranger outs
`image.name`	Name of the tissue image to be plotted. tissue_lowres_image.png or tissue_hires_image.png
`assay`	Name of assay to associate segmentations to
`slice`	Name of the slice to associate the segmentations to
`segmentation.type`	Which segmentations to load, cell or nucleus. If using nucleus the full matrix from cells is still used
`compact`	Whether to store segmentations in *only* the `sf.data` slot in the corresponding Segmentation object (default TRUE) to save memory and processing time. If FALSE, segmentations are also stored in `sp` format in addition to the `sf.data` slot.
`cells`	Optional vector of cell barcodes to retain.

Value

A VisiumV2 object with segmentations

`ReadAkoya` *Read and Load Akoya CODEX data*

Description

Read and Load Akoya CODEX data

Usage

```
ReadAkoya(
  filename,
  type = c("inform", "processor", "qupath"),
  filter = "DAPI|Blank|Empty",
  inform.quant = c("mean", "total", "min", "max", "std")
)

LoadAkoya(
  filename,
  type = c("inform", "processor", "qupath"),
  fov,
  assay = "Akoya",
  ...
)
```

Arguments

`filename`	Path to matrix generated by upstream processing.
`type`	Specify which type matrix is being provided. • "`processor`": matrix generated by CODEX Processor • "`inform`": matrix generated by inForm • "`qupath`": matrix generated by QuPath
`filter`	A pattern to filter features by; pass `NA` to skip feature filtering
`inform.quant`	When `type` is "`inform`", the quantification level to read in
`fov`	Name to store FOV as
`assay`	Name to store expression matrix as
`...`	Ignored

Value

`ReadAkoya`: A list with some combination of the following values

- "`matrix`": a sparse matrix with expression data; cells are columns and features are rows
- "`centroids`": a data frame with cell centroid coordinates in three columns: "x", "y", and "cell"

- "metadata": a data frame with cell-level meta data; includes all columns in filename that aren't in "matrix" or "centroids"

When type is "inform", additional expression matrices are returned and named using their segmentation type (eg. "nucleus", "membrane"). The "Entire Cell" segmentation type is returned in the "matrix" entry of the list

LoadAkoya: A Seurat object

Progress Updates with progressr

This function uses **progressr** to render status updates and progress bars. To enable progress updates, wrap the function call in with_progress or run handlers(global = TRUE) before running this function. For more details about **progressr**, please read vignette("progressr-intro")

Note

This function requires the **data.table** package to be installed

---

ReadAtera *Load Atera spatial data*

Description

Read the output of 10x Genomics Atera, a next-generation in situ sequencing platform. All Atera outputs (aside from images) are stored in AnnData zarr (storage format v2) files, zipped with Stored (uncompressed) zip entries; reading them requires the blosc and jsonlite packages. Zarr chunks are read directly out of the zip archive by byte-range seeks with no disk extraction.

Usage

```
ReadAtera(
  data.dir,
  outs = c("matrix", "centroids"),
  mols.qv.threshold = 20,
  genes = NULL,
  feature.types = NULL,
  bpcells.dir = NULL,
  morphology.channel = "dapi",
  morphology.resolution = NULL,
  morphology.region = NULL
)

LoadAtera(
  data.dir,
  fov = "fov",
  assay = "Atera",
  mols.qv.threshold = 20,
```

```
  cell.centroids = TRUE,
  molecule.coordinates = FALSE,
  segmentations = NULL,
  cell.annotations = TRUE,
  genes = NULL,
  feature.types = NULL,
  bpcells.dir = NULL,
  morphology.image = FALSE,
  morphology.channel = "dapi",
  morphology.resolution = NULL,
  morphology.region = NULL
)
```

Arguments

`data.dir`	Path to folder containing Atera outputs
`outs`	Types of outputs to read; choose one or more of: • "matrix": the counts matrix • "centroids": cell centroids in micron coordinate space • "segmentations": cell segmentation boundary polygons in micron coordinate space • "nucleus_segmentations": nucleus segmentation boundary polygons in micron coordinate space. Cells may have zero, one, or more than one nucleus polygon • "annotations": per-cell Azimuth cell type annotations (the `azimuth_*` columns of `cell_feature_matrix.zarr.zip`), if available • "microns": transcript molecule coordinates. This is optional as transcripts files can be very large. • "morphology": a single channel plane of a "morphology_2d" image (eg the DAPI stain), by default at the lowest-resolution pyramid level, for use as a background/overview image. Requires the `RBioFormats` package, since these images are pyramidal, JPEG2000-compressed OME-TIFFs that the base `tiff` package cannot reliably decode.
`mols.qv.threshold`	Remove transcript molecules with a calibrated Q-score less than this threshold
`genes`	Optional character vector of gene names to restrict the initial `molecule.coordinates` load to. When `molecule.coordinates = TRUE`, a lazy, on-disk handle onto the transcript table is always kept on the returned object (regardless of whether `genes` is set), so additional genes can be fetched later with `LoadAteraMolecules` without re-reading genes already fetched. See `ReadAtera`
`feature.types`	Optional character vector of feature types to restrict the counts matrix to (eg "Gene Expression"); `NULL` (the default) loads all feature types, matching current behavior. "Gene Expression" is always included, since it backs the object's primary assay. See `ReadAtera`
`bpcells.dir`	Path to a directory used to cache the counts matrix on disk via `BPCells`. `NULL` (the default) auto-selects a session-scoped cache directory so the returned object is BPCells-backed and lazy by default (even for small bundles) whenever

BPCells is installed; pass FALSE to always get plain in-memory matrices instead. See ReadAtera

morphology.channel
: Channel to load when morphology.image = TRUE: either a channel name (matched case-insensitively as a substring, eg "dapi") or a 0-based integer channel index. See ReadAtera

morphology.resolution
: Pyramid resolution level to load when morphology.image = TRUE, where 1 is full resolution. Defaults to NULL, which loads the lowest-resolution (smallest, fastest) level available. See ReadAtera

morphology.region
: Optional list with x/y elements (each a length-2 micron range) to crop the loaded morphology image to a rectangular window instead of reading the whole plane; recommended when using morphology.resolution = 1 (full resolution) on real-world datasets, since these whole-slide images can be tens of thousands of pixels per side. Defaults to NULL, which reads the whole plane. See ReadAtera

fov
: FOV name

assay
: Assay name

cell.centroids
: Whether or not to load cell centroids

molecule.coordinates
: Whether or not to load transcript molecule coordinates

segmentations
: Which segmentation boundary polygons to load, one of "cell" or "nucleus", or NULL to load none

cell.annotations
: Whether or not to add Azimuth cell type annotations (azimuth_*) to the object's metadata; silently skipped when the annotations are not available in data.dir

morphology.image
: Whether to load a single channel plane of a "morphology_2d" image (eg the DAPI stain), by default at the lowest-resolution pyramid level, for use as a background/overview image in plots. Requires the RBioFormats package. Defaults to FALSE since it is an optional dependency and not needed for downstream analysis. See ReadAtera

Details

Parallel processing uses the active future::plan(). Molecule and codeword reads parallelize across tiles; numeric array reads parallelize chunk decoding. Array reads inside tile workers stay sequential to avoid nested parallelism. Configure the strategy and worker count with future::plan(future::multisession, workers = 4), or use future::plan(future::sequential) for sequential processing. This setting is independent of setThreads().

Newly loaded Atera FOVs display x horizontally and y increasing downward in ImageDimPlot and ImageFeaturePlot, keeping stored coordinates unchanged.

Value

ReadAtera: A list with some combination of the following values:

- "matrix": a named list of sparse matrices with expression data, one per feature type (eg "Gene Expression"); cells are columns and features are rows
- "centroids": a data frame with cell centroid coordinates in three columns: "x", "y", and "cell"
- "segmentations"/"nucleus_segmentations": a data frame with one row per polygon vertex, in three columns: "cell", "x", and "y"
- "annotations": a data frame of Azimuth annotations with cell ids as row names, or NULL if none are available
- "microns": a data frame with transcript coordinates in three columns: "x", "y", and "gene"
- "morphology": a list with elements image (a numeric matrix, indexed [x, y], in the same top-left-origin pixel convention as "centroids"/"microns"' micron coordinates – no axis flip is needed), channel, resolution, n.resolutions, pixel.size (microns per pixel of image), and origin (the micron coordinates, c(x=, y=), of image's [1, 1] pixel – c(x=0, y=0) unless morphology.region crops out the top-left corner of the full plane); see morphology.channel/morphology.resolu

LoadAtera: A Seurat object

ReadMtx *Load in data from remote or local mtx files*

Description

Enables easy loading of sparse data matrices

Usage

```
ReadMtx(
  mtx,
  cells,
  features,
  cell.column = 1,
  feature.column = 2,
  cell.sep = "\t",
  feature.sep = "\t",
  skip.cell = 0,
  skip.feature = 0,
  mtx.transpose = FALSE,
  unique.features = TRUE,
  strip.suffix = FALSE
)
```

Arguments

mtx	Name or remote URL of the mtx file
cells	Name or remote URL of the cells/barcodes file

features	Name or remote URL of the features/genes file
cell.column	Specify which column of cells file to use for cell names; default is 1
feature.column	Specify which column of features files to use for feature/gene names; default is 2
cell.sep	Specify the delimiter in the cell name file
feature.sep	Specify the delimiter in the feature name file
skip.cell	Number of lines to skip in the cells file before beginning to read cell names
skip.feature	Number of lines to skip in the features file before beginning to gene names
mtx.transpose	Transpose the matrix after reading in
unique.features	Make feature names unique (default TRUE)
strip.suffix	Remove trailing "-1" if present in all cell barcodes.

Value

A sparse matrix containing the expression data.

Examples

```
## Not run:
# For local files:

expression_matrix <- ReadMtx(
  mtx = "count_matrix.mtx.gz", features = "features.tsv.gz",
  cells = "barcodes.tsv.gz"
)
seurat_object <- CreateSeuratObject(counts = expression_matrix)

# For remote files:

expression_matrix <- ReadMtx(mtx = "http://localhost/matrix.mtx",
cells = "http://localhost/barcodes.tsv",
features = "http://localhost/genes.tsv")
seurat_object <- CreateSeuratObject(counts = data)

## End(Not run)
```

ReadNanostring *Read and Load Nanostring SMI data*

Description

Read and Load Nanostring SMI data

Usage

```
ReadNanostring(
  data.dir,
  mtx.file = NULL,
  metadata.file = NULL,
  molecules.file = NULL,
  segmentations.file = NULL,
  type = "centroids",
  mol.type = "pixels",
  metadata = NULL,
  mols.filter = NA_character_,
  genes.filter = NA_character_,
  fov.filter = NULL,
  subset.counts.matrix = NULL,
  cell.mols.only = TRUE
)

LoadNanostring(data.dir, fov, assay = "Nanostring")
```

Arguments

`data.dir`	Path to folder containing Nanostring SMI outputs
`mtx.file`	Path to Nanostring cell x gene matrix CSV
`metadata.file`	Contains metadata including cell center, area, and stain intensities
`molecules.file`	Path to molecules file
`segmentations.file`	Path to segmentations CSV
`type`	Type of cell spatial coordinate matrices to read; choose one or more of: • "centroids": cell centroids in pixel coordinate space • "segmentations": cell segmentations in pixel coordinate space
`mol.type`	Type of molecule spatial coordinate matrices to read; choose one or more of: • "pixels": molecule coordinates in pixel space
`metadata`	Type of available metadata to read; choose zero or more of: • "Area": number of pixels in cell segmentation • "fov": cell's fov • "Mean.MembraneStain": mean membrane stain intensity • "Mean.DAPI": mean DAPI stain intensity • "Mean.G": mean green channel stain intensity • "Mean.Y": mean yellow channel stain intensity • "Mean.R": mean red channel stain intensity • "Max.MembraneStain": max membrane stain intensity • "Max.DAPI": max DAPI stain intensity • "Max.G": max green channel stain intensity • "Max.Y": max yellow stain intensity

- "Max.R": max red stain intensity

`mols.filter` Filter molecules that match provided string

`genes.filter` Filter genes from cell x gene matrix that match provided string

`fov.filter` Only load in select FOVs. Nanostring SMI data contains 30 total FOVs.

`subset.counts.matrix`
If the counts matrix should be built from molecule coordinates for a specific segmentation; One of:

- "Nuclear": nuclear segmentations
- "Cytoplasm": cell cytoplasm segmentations
- "Membrane": cell membrane segmentations

`cell.mols.only` If TRUE, only load molecules within a cell

`fov` Name to store FOV as

`assay` Name to store expression matrix as

Value

`ReadNanostring`: A list with some combination of the following values:

- "`matrix`": a sparse matrix with expression data; cells are columns and features are rows
- "`centroids`": a data frame with cell centroid coordinates in three columns: "x", "y", and "cell"
- "`pixels`": a data frame with molecule pixel coordinates in three columns: "x", "y", and "gene"

`LoadNanostring`: A `Seurat` object

Progress Updates with progressr

This function uses **progressr** to render status updates and progress bars. To enable progress updates, wrap the function call in `with_progress` or run `handlers(global = TRUE)` before running this function. For more details about **progressr**, please read `vignette("progressr-intro")`

Parallelization with future

This function uses **future** to enable parallelization. Parallelization strategies can be set using `plan`. Common plans include "`sequential`" for non-parallelized processing or "`multisession`" for parallel evaluation using multiple R sessions; for other plans, see the "Implemented evaluation strategies" section of `?future::plan`. For a more thorough introduction to **future**, see `vignette("future-1-overview")`

Note

This function requires the **data.table** package to be installed

ReadParseBio *Read output from Parse Biosciences*

Description

Read output from Parse Biosciences

Usage

```
ReadParseBio(data.dir, ...)
```

Arguments

data.dir	Directory containing the data files
...	Extra parameters passed to ReadMtx

ReadSlideSeq *Load Slide-seq spatial data*

Description

Load Slide-seq spatial data

Usage

```
ReadSlideSeq(coord.file, assay = "Spatial")
```

Arguments

coord.file	Path to csv file containing bead coordinate positions
assay	Name of assay to associate image to

Value

A SlideSeq object

See Also

SlideSeq

ReadSTARsolo *Read output from STARsolo*

Description

Read output from STARsolo

Usage

```
ReadSTARsolo(data.dir, ...)
```

Arguments

data.dir	Directory containing the data files
...	Extra parameters passed to ReadMtx

ReadVitessce *Read Data From Vitessce*

Description

Read in data from Vitessce-formatted JSON files

Usage

```
ReadVitessce(
  counts = NULL,
  coords = NULL,
  molecules = NULL,
  type = c("segmentations", "centroids"),
  filter = NA_character_
)

LoadHuBMAPCODEX(data.dir, fov, assay = "CODEX")
```

Arguments

counts	Path or URL to a Vitessce-formatted JSON file with expression data; should end in ".genes.json" or ".clusters.json"; pass NULL to skip
coords	Path or URL to a Vitessce-formatted JSON file with cell/spot spatial coordinates; should end in ".cells.json"; pass NULL to skip
molecules	Path or URL to a Vitessce-formatted JSON file with molecule spatial coordinates; should end in ".molecules.json"; pass NULL to skip
type	Type of cell/spot spatial coordinates to return, choose one or more from:

- "segmentations" cell/spot segmentations
- "centroids" cell/spot centroids

filter	A character to filter molecules by, pass NA to skip molecule filtering
data.dir	Path to a directory containing Vitessce cells and clusters JSONs
fov	Name to store FOV as
assay	Name to store expression matrix as

Value

ReadVitessce: A list with some combination of the following values:

- "counts": if counts is not NULL, an expression matrix with cells as columns and features as rows
- "centroids": if coords is not NULL and type is contains"centroids", a data frame with cell centroids in three columns: "x", "y", and "cell"
- "segmentations": if coords is not NULL and type contains "centroids", a data frame with cell segmentations in three columns: "x", "y" and "cell"
- "molecules": if molecules is not NULL, a data frame with molecule spatial coordinates in three columns: "x", "y", and "gene"

LoadHuBMAPCODEX: A Seurat object

Progress Updates with progressr

This function uses **progressr** to render status updates and progress bars. To enable progress updates, wrap the function call in with_progress or run handlers(global = TRUE) before running this function. For more details about **progressr**, please read vignette("progressr-intro")

Note

This function requires the **jsonlite** package to be installed

Examples

```
## Not run:
coords <- ReadVitessce(
  counts =
    "https://s3.amazonaws.com/vitessce-data/0.0.31/master_release/wang/wang.genes.json",
  coords =
    "https://s3.amazonaws.com/vitessce-data/0.0.31/master_release/wang/wang.cells.json",
  molecules =
    "https://s3.amazonaws.com/vitessce-data/0.0.31/master_release/wang/wang.molecules.json"
)
names(coords)
coords$counts[1:10, 1:10]
head(coords$centroids)
head(coords$segmentations)
head(coords$molecules)
```

```
## End(Not run)
```

`ReadVizgen` *Read and Load MERFISH Input from Vizgen*

Description

Read and load in MERFISH data from Vizgen-formatted files

Usage

```
ReadVizgen(
  data.dir,
  transcripts = NULL,
  spatial = NULL,
  molecules = NULL,
  type = "segmentations",
  mol.type = "microns",
  metadata = NULL,
  filter = NA_character_,
  z = 3L
)

LoadVizgen(data.dir, fov, assay = "Vizgen", z = 3L)
```

Arguments

`data.dir`	Path to the directory with Vizgen MERFISH files; requires at least one of the following files present: • "`cell_by_gene.csv`": used for reading count matrix • "`cell_metadata.csv`": used for reading cell spatial coordinate matrices • "`detected_transcripts.csv`": used for reading molecule spatial coordinate matrices
`transcripts`	Optional file path for counts matrix; pass `NA` to suppress reading counts matrix
`spatial`	Optional file path for spatial metadata; pass `NA` to suppress reading spatial coordinates. If `spatial` is provided and `type` is "segmentations", uses `dirname(spatial)` instead of `data.dir` to find HDF5 files
`molecules`	Optional file path for molecule coordinates file; pass `NA` to suppress reading spatial molecule information
`type`	Type of cell spatial coordinate matrices to read; choose one or more of: • "segmentations": cell segmentation vertices; requires **hdf5r** to be installed and requires a directory "`cell_boundaries`" within `data.dir`. Within "`cell_boundaries`", there must be one or more HDF5 file named "`feature_data_##.hdf5`" • "centroids": cell centroids in micron coordinate space

- "boxes": cell box outlines in micron coordinate space

`mol.type` Type of molecule spatial coordinate matrices to read; choose one or more of:
- "pixels": molecule coordinates in pixel space
- "microns": molecule coordinates in micron space

`metadata` Type of available metadata to read; choose zero or more of:
- "volume": estimated cell volume
- "fov": cell's fov

`filter` A character to filter molecules by, pass `NA` to skip molecule filtering

`z` Z-index to load; must be between 0 and 6, inclusive

`fov` Name to store FOV as

`assay` Name to store expression matrix as

Value

`ReadVizgen`: A list with some combination of the following values:

- "`transcripts`": a sparse matrix with expression data; cells are columns and features are rows
- "`segmentations`": a data frame with cell polygon outlines in three columns: "x", "y", and "cell"
- "`centroids`": a data frame with cell centroid coordinates in three columns: "x", "y", and "cell"
- "`boxes`": a data frame with cell box outlines in three columns: "x", "y", and "cell"
- "`microns`": a data frame with molecule micron coordinates in three columns: "x", "y", and "gene"
- "`pixels`": a data frame with molecule pixel coordinates in three columns: "x", "y", and "gene"
- "`metadata`": a data frame with the cell-level metadata requested by `metadata`

`LoadVizgen`: A `Seurat` object

Progress Updates with progressr

This function uses **progressr** to render status updates and progress bars. To enable progress updates, wrap the function call in `with_progress` or run `handlers(global = TRUE)` before running this function. For more details about **progressr**, please read `vignette("progressr-intro")`

Parallelization with future

This function uses **future** to enable parallelization. Parallelization strategies can be set using `plan`. Common plans include "`sequential`" for non-parallelized processing or "`multisession`" for parallel evaluation using multiple R sessions; for other plans, see the "Implemented evaluation strategies" section of `?future::plan`. For a more thorough introduction to **future**, see `vignette("future-1-overview")`

Note

This function requires the **data.table** package to be installed

RegroupIdents *Regroup idents based on meta.data info*

Description

For cells in each ident, set a new identity based on the most common value of a specified metadata column.

Usage

```
RegroupIdents(object, metadata)
```

Arguments

object	Seurat object
metadata	Name of metadata column

Value

A Seurat object with the active idents regrouped

Examples

```
data("pbmc_small")
pbmc_small <- RegroupIdents(pbmc_small, metadata = "groups")
```

RelativeCounts *Normalize raw data to fractions*

Description

Normalize count data to relative counts per cell by dividing by the total per cell. Optionally use a scale factor, e.g. for counts per million (CPM) use `scale.factor = 1e6`.

Usage

```
RelativeCounts(data, scale.factor = 1, verbose = TRUE)
```

Arguments

data	Matrix with the raw count data
scale.factor	Scale the result. Default is 1
verbose	Print progress

Value

Returns a matrix with the relative counts

Examples

```
mat <- matrix(data = rbinom(n = 25, size = 5, prob = 0.2), nrow = 5)
mat
mat_norm <- RelativeCounts(data = mat)
mat_norm
```

`RenameCells.SCTAssay` *Rename Cells in an Object*

Description

Rename Cells in an Object

Usage

```
## S3 method for class 'SCTAssay'
RenameCells(object, new.names = NULL, ...)

## S3 method for class 'SlideSeq'
RenameCells(object, new.names = NULL, ...)

## S3 method for class 'STARmap'
RenameCells(object, new.names = NULL, ...)

## S3 method for class 'VisiumV1'
RenameCells(object, new.names = NULL, ...)
```

Arguments

`object`	An object
`new.names`	vector of new cell names
`...`	Arguments passed to other methods

See Also

`SeuratObject::RenameCells`

RidgePlot *Single cell ridge plot*

Description

Draws a ridge plot of single cell data (gene expression, metrics, PC scores, etc.)

Usage

```
RidgePlot(
  object,
  features,
  cols = NULL,
  idents = NULL,
  sort = FALSE,
  assay = NULL,
  group.by = NULL,
  y.max = NULL,
  same.y.lims = FALSE,
  log = FALSE,
  ncol = NULL,
  slot = deprecated(),
  layer = "data",
  stack = FALSE,
  combine = TRUE,
  fill.by = NULL
)
```

Arguments

object	Seurat object
features	Features to plot (gene expression, metrics, PC scores, anything that can be retreived by FetchData)
cols	Colors to use for plotting
idents	Which classes to include in the plot (default is all)
sort	Sort identity classes (on the x-axis) by the average expression of the attribute being potted, can also pass 'increasing' or 'decreasing' to change sort direction
assay	Name of assay to use, defaults to the active assay
group.by	Group (color) cells in different ways (for example, orig.ident)
y.max	Maximum y axis value
same.y.lims	Set all the y-axis limits to the same values
log	plot the feature axis on log scale
ncol	Number of columns if multiple plots are displayed
slot	Slot to pull expression data from (e.g. "counts" or "data")

layer	Layer to pull expression data from (e.g. "counts" or "data")
stack	Horizontally stack plots for each feature
combine	Combine plots into a single patchworked ggplot object. If FALSE, return a list of ggplot
fill.by	Color violins/ridges based on either 'feature' or 'ident'

Value

A patchworked ggplot object if combine = TRUE; otherwise, a list of ggplot objects

Examples

```
data("pbmc_small")
RidgePlot(object = pbmc_small, features = 'PC_1')
```

RPCAIntegration *Seurat-RPCA Integration*

Description

Seurat-RPCA Integration

Usage

```
RPCAIntegration(
  object = NULL,
  assay = NULL,
  layers = NULL,
  orig = NULL,
  new.reduction = "integrated.dr",
  reference = NULL,
  features = NULL,
  normalization.method = c("LogNormalize", "SCT"),
  dims = 1:30,
  k.filter = NA,
  scale.layer = "scale.data",
  dims.to.integrate = NULL,
  k.weight = 100,
  weight.reduction = NULL,
  sd.weight = 1,
  sample.tree = NULL,
  preserve.order = FALSE,
  verbose = TRUE,
  ...
)
```

Arguments

object	A Seurat object
assay	Name of Assay in the Seurat object
layers	Names of layers in assay
orig	A DimReduc to correct
new.reduction	Name of new integrated dimensional reduction
reference	A reference Seurat object
features	A vector of features to use for integration
normalization.method	Name of normalization method used: LogNormalize or SCT
dims	Dimensions of dimensional reduction to use for integration
k.filter	Number of anchors to filter
scale.layer	Name of scaled layer in Assay
dims.to.integrate	Number of dimensions to return integrated values for
k.weight	Number of neighbors to consider when weighting anchors
weight.reduction	Dimension reduction to use when calculating anchor weights. This can be one of: • A string, specifying the name of a dimension reduction present in all objects to be integrated • A vector of strings, specifying the name of a dimension reduction to use for each object to be integrated • A vector of DimReduc objects, specifying the object to use for each object in the integration • NULL, in which case the full corrected space is used for computing anchor weights.
sd.weight	Controls the bandwidth of the Gaussian kernel for weighting

sample.tree	Specify the order of integration. Order of integration should be encoded in a matrix, where each row represents one of the pairwise integration steps. Negative numbers specify a dataset, positive numbers specify the integration results from a given row (the format of the merge matrix included in the hclust function output). For example: matrix(c(-2, 1, -3, -1), ncol = 2) gives:
	`[,1] [,2]`
	`[1,] -2 -3`
	`[2,] 1 -1`
	Which would cause dataset 2 and 3 to be integrated first, then the resulting object integrated with dataset 1.
	If NULL, the sample tree will be computed automatically.

preserve.order	Do not reorder objects based on size for each pairwise integration.
verbose	Print progress
...	Arguments passed on to FindIntegrationAnchors

Examples

```
## Not run:
# Preprocessing
obj <- SeuratData::LoadData("pbmcsca")
obj[["RNA"]] <- split(obj[["RNA"]], f = obj$Method)
obj <- NormalizeData(obj)
obj <- FindVariableFeatures(obj)
obj <- ScaleData(obj)
obj <- RunPCA(obj)

# After preprocessing, we run integration
obj <- IntegrateLayers(object = obj, method = RPCAIntegration,
  orig.reduction = "pca", new.reduction = 'integrated.rpca',
  verbose = FALSE)

# Reference-based Integration
# Here, we use the first layer as a reference for integraion
# Thus, we only identify anchors between the reference and the rest of the datasets,
# saving computational resources
obj <- IntegrateLayers(object = obj, method = RPCAIntegration,
  orig.reduction = "pca", new.reduction = 'integrated.rpca',
  reference = 1, verbose = FALSE)

# Modifying parameters
# We can also specify parameters such as `k.anchor` to increase the strength of
# integration
obj <- IntegrateLayers(object = obj, method = RPCAIntegration,
  orig.reduction = "pca", new.reduction = 'integrated.rpca',
  k.anchor = 20, verbose = FALSE)

# Integrating SCTransformed data
obj <- SCTransform(object = obj)
obj <- IntegrateLayers(object = obj, method = RPCAIntegration,
  orig.reduction = "pca", new.reduction = 'integrated.rpca',
  assay = "SCT", verbose = FALSE)

## End(Not run)
```

RunCCA *Perform Canonical Correlation Analysis*

Description

Runs a canonical correlation analysis using a diagonal implementation of CCA.

Usage

```
RunCCA(object1, object2, ...)
```

```
## Default S3 method:
RunCCA(
  object1,
  object2,
  standardize = TRUE,
  num.cc = 20,
  seed.use = 42,
  svd.method = NULL,
  verbose = FALSE,
  ...
)

## S3 method for class 'Seurat'
RunCCA(
  object1,
  object2,
  assay1 = NULL,
  assay2 = NULL,
  num.cc = 20,
  features = NULL,
  renormalize = FALSE,
  rescale = FALSE,
  compute.gene.loadings = TRUE,
  add.cell.id1 = NULL,
  add.cell.id2 = NULL,
  svd.method = NULL,
  verbose = TRUE,
  ...
)
```

Arguments

object1	First Seurat object
object2	Second Seurat object.
...	Extra parameters (passed onto MergeSeurat in case with two objects passed, passed onto ScaleData in case with single object and rescale.groups set to TRUE)
standardize	Standardize matrices - scales columns to have unit variance and mean 0
num.cc	Number of canonical vectors to calculate
seed.use	Random seed to set. If NULL, does not set a seed
svd.method	SVD backend for CCA. If NULL, defaults to "irlba" except for pairs of dense CCA input matrices whose cell-by-cell cross-product matrix has at least 1,000,000 entries, in which case it defaults to "rspectra". "irlba" uses an explicit cross-product CCA path; "rspectra" uses an implicit operator to avoid forming the cross-product matrix.
verbose	Show progress messages

assay1, assay2 Assays to pull from in the first and second objects, respectively

features Set of genes to use in CCA. Default is the union of both the variable features sets present in both objects.

renormalize Renormalize raw data after merging the objects. If FALSE, merge the data matrices also.

rescale Rescale the datasets prior to CCA. If FALSE, uses existing data in the scale data slots.

compute.gene.loadings
Also compute the gene loadings. NOTE - this will scale every gene in the dataset which may impose a high memory cost.

add.cell.id1, add.cell.id2
Add ...

Value

Returns a combined Seurat object with the CCA results stored.

See Also

merge.Seurat

Examples

```
## Not run:
data("pbmc_small")
pbmc_small
# As CCA requires two datasets, we will split our test object into two just for this example
pbmc1 <- subset(pbmc_small, cells = colnames(pbmc_small)[1:40])
pbmc2 <- subset(pbmc_small, cells = colnames(x = pbmc_small)[41:80])
pbmc1[["group"]] <- "group1"
pbmc2[["group"]] <- "group2"
pbmc_cca <- RunCCA(object1 = pbmc1, object2 = pbmc2)
# Print results
print(x = pbmc_cca[["cca"]])

## End(Not run)
```

RunDiffusionMap *Run Diffusion Map*

Description

Run diffusion map dimensionality reduction on single-cell data.

Usage

```
RunDiffusionMap(object, ...)

## Default S3 method:
RunDiffusionMap(
  object,
  assay = NULL,
  metric = "cosine",
  distance.matrix = NULL,
  ncomp = 20,
  reduction.name = "DiffMap",
  reduction.key = "DC_",
  weight.by.var = TRUE,
  verbose = TRUE,
  seed.use = 101,
  ...
)

## S3 method for class 'Assay'
RunDiffusionMap(
  object,
  assay = NULL,
  features = NULL,
  ncomp = 20,
  metric = "cosine",
  distance.matrix = NULL,
  reduction.name = "DiffMap",
  reduction.key = "DC_",
  weight.by.var = TRUE,
  verbose = TRUE,
  seed.use = 101,
  ...
)

## S3 method for class 'StdAssay'
RunDiffusionMap(
  object,
  assay = NULL,
  features = NULL,
  layer = "scale.data",
  ncomp = 20,
  metric = "cosine",
  distance.matrix = NULL,
  reduction.name = "DiffMap",
  reduction.key = "DC_",
  weight.by.var = TRUE,
  verbose = TRUE,
  seed.use = 101,
```

```
  ...
)

## S3 method for class 'Seurat'
RunDiffusionMap(
  object,
  assay = NULL,
  features = NULL,
  layer = "scale.data",
  ncomp = 20,
  metric = "cosine",
  distance.matrix = NULL,
  reduction.name = "DiffMap",
  reduction.key = "DC_",
  weight.by.var = TRUE,
  verbose = TRUE,
  seed.use = 101,
  ...
)
```

Arguments

object	An object to run diffusion map on
...	Additional arguments to be passed to DiffusionMap()
assay	Name of Assay diffusion map is being run on
metric	This determines the choice of metric used to measure distance in the input space. Check DiffusionMap() for details. If a distance.matrix is provided, this will be ignored.
distance.matrix	If set, runs DiffusionMap on the given distance matrix instead of data matrix.
ncomp	Number of components to compute
reduction.name	the name of the DimReduc object
reduction.key	dimensional reduction key, specifies the string before the number for the dimension names.
weight.by.var	Weight the cell embeddings by the eigenvalues of the diffusion map
verbose	To print diagnostic messages. Default is TRUE.
seed.use	Set a random seed. Setting NULL will not set a seed.
features	Features to compute Diffusion Map
layer	The layer in assay to use when running diffusion map analysis.

Value

Returns a DimReduc object with diffusion map results

Examples

```
## Not run:
# Run diffusion map on a Seurat object
seurat_obj <- RunDiffusionMap(seurat_obj, ncomp = 10)

## End(Not run)
```

RunGraphLaplacian *Run Graph Laplacian Eigendecomposition*

Description

Run a graph laplacian dimensionality reduction. It is used as a low dimensional representation for a cell-cell graph. The input graph should be symmetric

Usage

```
RunGraphLaplacian(object, ...)

## S3 method for class 'Seurat'
RunGraphLaplacian(
  object,
  graph,
  reduction.name = "lap",
  reduction.key = "LAP_",
  n = 50,
  verbose = TRUE,
  ...
)

## Default S3 method:
RunGraphLaplacian(object, n = 50, reduction.key = "LAP_", verbose = TRUE, ...)
```

Arguments

object	A Seurat object
...	Arguments passed to eigs_sym
graph	The name of graph
reduction.name	dimensional reduction name, lap by default
reduction.key	dimensional reduction key, specifies the string before the number for the dimension names. LAP by default
n	Total Number of Eigenvectors to compute and store (50 by default)
verbose	Print message and process

Value

Returns Seurat object with the Graph laplacian eigenvector calculation stored in the reductions slot

---

RunICA *Run Independent Component Analysis on gene expression*

Description

Run fastica algorithm from the ica package for ICA dimensionality reduction. For details about stored ICA calculation parameters, see `PrintICAParams`.

Usage

```
RunICA(object, ...)

## Default S3 method:
RunICA(
  object,
  assay = NULL,
  nics = 50,
  rev.ica = FALSE,
  ica.function = "icafast",
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.name = "ica",
  reduction.key = "ica_",
  seed.use = 42,
  ...
)

## S3 method for class 'Assay'
RunICA(
  object,
  assay = NULL,
  features = NULL,
  nics = 50,
  rev.ica = FALSE,
  ica.function = "icafast",
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.name = "ica",
  reduction.key = "ica_",
  seed.use = 42,
  ...
```

```
)

## S3 method for class 'StdAssay'
RunICA(
  object,
  assay = NULL,
  features = NULL,
  layer = "scale.data",
  nics = 50,
  rev.ica = FALSE,
  ica.function = "icafast",
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.name = "ica",
  reduction.key = "ica_",
  seed.use = 42,
  ...
)

## S3 method for class 'Seurat'
RunICA(
  object,
  assay = NULL,
  features = NULL,
  nics = 50,
  rev.ica = FALSE,
  ica.function = "icafast",
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.name = "ica",
  reduction.key = "IC_",
  seed.use = 42,
  ...
)
```

Arguments

object	Seurat object
...	Additional arguments to be passed to fastica
assay	Name of Assay ICA is being run on
nics	Number of ICs to compute
rev.ica	By default, computes the dimensional reduction on the cell x feature matrix. Setting to true will compute it on the transpose (feature x cell matrix).
ica.function	ICA function from ica package to run (options: icafast, icaimax, icajade)
verbose	Print the top genes associated with high/low loadings for the ICs

ndims.print	ICs to print genes for
nfeatures.print	Number of genes to print for each IC
reduction.name	dimensional reduction name
reduction.key	dimensional reduction key, specifies the string before the number for the dimension names.
seed.use	Set a random seed. Setting NULL will not set a seed.
features	Features to compute ICA on
layer	The layer in 'assay' to use when running independant component analysis.

RunLDA *Run Linear Discriminant Analysis*

Description

Run Linear Discriminant Analysis

Function to perform Linear Discriminant Analysis.

Usage

```
RunLDA(object, ...)

## Default S3 method:
RunLDA(
  object,
  labels,
  assay = NULL,
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.key = "LDA_",
  seed = 42,
  ...
)

## S3 method for class 'Assay'
RunLDA(
  object,
  assay = NULL,
  labels,
  features = NULL,
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.key = "LDA_",
```

```
  seed = 42,
  ...
)

## S3 method for class 'Seurat'
RunLDA(
  object,
  assay = NULL,
  labels,
  features = NULL,
  reduction.name = "lda",
  reduction.key = "LDA_",
  seed = 42,
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  ...
)
```

Arguments

object	An object of class Seurat.
...	Arguments passed to other methods
labels	Meta data column with target gene class labels.
assay	Assay to use for performing Linear Discriminant Analysis (LDA).
verbose	Print the top genes associated with high/low loadings for the PCs
ndims.print	Number of LDA dimensions to print.
nfeatures.print	Number of features to print for each LDA component.
reduction.key	Reduction key name.
seed	Value for random seed
features	Features to compute LDA on
reduction.name	dimensional reduction name, lda by default

RunLeiden *Run Leiden clustering algorithm*

Description

Returns a vector of partition indices.

Usage

```
RunLeiden(
  object,
  method = deprecated(),
  leiden_method = c("leidenbase", "igraph"),
 partition.type = c("RBConfigurationVertexPartition", "ModularityVertexPartition",
    "RBERVertexPartition", "CPMVertexPartition", "MutableVertexPartition",
    "SignificanceVertexPartition", "SurpriseVertexPartition"),
  leiden_objective_function = c("modularity", "CPM"),
  initial.membership = NULL,
  node.sizes = NULL,
  resolution.parameter = 1,
  random.seed = 1,
  n.iter = 10
)
```

Arguments

object	An adjacency matrix or adjacency list.
method	DEPRECATED.
leiden_method	Choose from the leidenbase ("leidenbase") or igraph ("igraph") packages for running leiden. Default is "leidenbase"
partition.type	Type of partition to use for Leiden algorithm. Defaults to "RBConfigurationVertexPartition", see https://cran.rstudio.com/web/packages/leidenbase/leidenbase.pdf for more options.
leiden_objective_function	objective function to use if ‘leiden_method = "igraph"‘. See cluster_leiden for more information. Default is "modularity".
initial.membership	Passed to the ‘initial_membership‘ parameter of ‘leidenbase::leiden_find_partition‘.
node.sizes	Passed to the ‘node_sizes‘ parameter of ‘leidenbase::leiden_find_partition‘.
resolution.parameter	A parameter controlling the coarseness of the clusters for Leiden algorithm. Higher values lead to more clusters. (defaults to 1.0 for partition types that accept a resolution parameter)
random.seed	Seed of the random number generator, must be greater than 0.
n.iter	Maximal number of iterations per random start

References

igraph-based leiden clustering is adapted from cluster_graph_leiden (MIT License), author: Benjamin Parks. Reordering of igraph leiden cluster numbers by cluster size adapted from rliger v2.0 ‘.labelClustBySize‘ (GPL-3.0 License) authors: Josh Welch & Yichen Wang

RunMarkVario — *Run the mark variogram computation on a given position matrix and expression matrix.*

Description

Wraps the functionality of markvario from the spatstat package.

Usage

```
RunMarkVario(spatial.location, data, ...)
```

Arguments

spatial.location	A 2 column matrix giving the spatial locations of each of the data points also in data
data	Matrix containing the data used as "marks" (e.g. gene expression)
...	Arguments passed to markvario

RunMixscape — *Run Mixscape*

Description

Function to identify perturbed and non-perturbed gRNA expressing cells that accounts for multiple treatments/conditions/chemical perturbations.

Usage

```
RunMixscape(
  object,
  assay = "PRTB",
  slot = "scale.data",
  labels = "gene",
  nt.class.name = "NT",
  new.class.name = "mixscape_class",
  min.de.genes = 5,
  min.cells = 5,
  de.assay = "RNA",
  logfc.threshold = 0.25,
  iter.num = 10,
  verbose = FALSE,
  split.by = NULL,
  fine.mode = FALSE,
```

```
  fine.mode.labels = "guide_ID",
  prtb.type = "KO"
)
```

Arguments

object	An object of class Seurat.
assay	Assay to use for mixscape classification.
slot	Assay data slot to use.
labels	metadata column with target gene labels.
nt.class.name	Classification name of non-targeting gRNA cells.
new.class.name	Name of mixscape classification to be stored in metadata.
min.de.genes	Required number of genes that are differentially expressed for method to separate perturbed and non-perturbed cells.
min.cells	Minimum number of cells in target gene class. If fewer than this many cells are assigned to a target gene class during classification, all are assigned NP.
de.assay	Assay to use when performing differential expression analysis. Usually RNA.
logfc.threshold	Limit testing to genes which show, on average, at least X-fold difference (log-scale) between the two groups of cells. Default is 0.25 Increasing logfc.threshold speeds up the function, but can miss weaker signals.
iter.num	Number of normalmixEM iterations to run if convergence does not occur.
verbose	Display messages
split.by	metadata column with experimental condition/cell type classification information. This is meant to be used to account for cases a perturbation is condition/cell type -specific.
fine.mode	When this is equal to TRUE, DE genes for each target gene class will be calculated for each gRNA separately and pooled into one DE list for calculating the perturbation score of every cell and their subsequent classification.
fine.mode.labels	metadata column with gRNA ID labels.
prtb.type	specify type of CRISPR perturbation expected for labeling mixscape classifications. Default is KO.

Value

Returns Seurat object with with the following information in the meta data and tools slots:

mixscape_class Classification result with cells being either classified as perturbed (KO, by default) or non-perturbed (NP) based on their target gene class.

mixscape_class.global Global classification result (perturbed, NP or NT)

p_ko Posterior probabilities used to determine if a cell is KO (default). Name of this item will change to match prtb.type parameter setting. (>0.5) or NP

perturbation score Perturbation scores for every cell calculated in the first iteration of the function.

RunMoransI *Compute Moran's I value.*

Description

Wraps the functionality of the Moran.I function from the ape package. Weights are computed as 1/distance.

Usage

```
RunMoransI(data, pos, verbose = TRUE)
```

Arguments

data	Expression matrix
pos	Position matrix
verbose	Display messages/progress

RunPCA *Run Principal Component Analysis*

Description

Run a PCA dimensionality reduction. For details about stored PCA calculation parameters, see PrintPCAParams.

Usage

```
RunPCA(object, ...)

## Default S3 method:
RunPCA(
  object,
  assay = NULL,
  npcs = 50,
  rev.pca = FALSE,
  weight.by.var = TRUE,
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.key = "PC_",
  seed.use = 42,
  approx = TRUE,
  ...
)
```

```
## S3 method for class 'Assay'
RunPCA(
  object,
  assay = NULL,
  features = NULL,
  npcs = 50,
  rev.pca = FALSE,
  weight.by.var = TRUE,
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.key = "PC_",
  seed.use = 42,
  ...
)

## S3 method for class 'Seurat'
RunPCA(
  object,
  assay = NULL,
  features = NULL,
  npcs = 50,
  rev.pca = FALSE,
  weight.by.var = TRUE,
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.name = "pca",
  reduction.key = "PC_",
  seed.use = 42,
  ...
)
```

Arguments

object	An object
...	Arguments passed to other methods and PCA backends
assay	Name of Assay PCA is being run on
npcs	Total Number of PCs to compute and store (50 by default)
rev.pca	By default computes the PCA on the cell x gene matrix. Setting to true will compute it on gene x cell matrix.
weight.by.var	Weight the cell embeddings by the variance of each PC (weights the gene loadings if rev.pca is TRUE)
verbose	Print progress messages and the top genes associated with high/low loadings for the PCs
ndims.print	PCs to print genes for

nfeatures.print
: Number of genes to print for each PC

reduction.key
: dimensional reduction key, specifies the string before the number for the dimension names. PC by default

seed.use
: Set a random seed. By default, sets the seed to 42. Setting NULL will not set a seed.

approx
: Use an approximate PCA backend when available

features
: Features to compute PCA on. If features=NULL, PCA will be run using the variable features for the Assay. Note that the features must be present in the scaled data. Any requested features that are not scaled or have 0 variance will be dropped, and the PCA will be run using the remaining features.

reduction.name
: dimensional reduction name, pca by default

Value

Returns Seurat object with the PCA calculation stored in the reductions slot

PCA backends

With default settings, dense-matrix PCA uses dense Gram + top-k eigendecomposition: it forms the feature-by-feature Gram matrix XX^T and computes its leading eigenpairs using Eigen/Spectra. To use **irlba** instead of the Gram-matrix backend for an in-memory matrix, pass an **irlba** argument to `RunPCA` through `...`, for example, `RunPCA(object, maxit = 1000)`.

`RunPLS` *Run Partial Least Squares (PLS) on Seurat Objects*

Description

Performs Partial Least Squares regression analysis on single-cell data. This function provides methods for plsr, spls, and cppls from the pls and spls packages.

Usage

```
RunPLS(object, ...)

## Default S3 method:
RunPLS(
  object,
  assay = NULL,
  ncomp = 20,
  Y = NULL,
  Y.add = NULL,
  pls.function = c("plsr", "spls", "cppls"),
  verbose = TRUE,
  ndims.print = 1:5,
```

```
  nfeatures.print = 30,
  reduction.name = "pls",
  reduction.key = "PLS_",
  seed.use = 42,
  eta = 0.5,
  threads = NULL,
  ...
)

## S3 method for class 'IterableMatrix'
RunPLS(
  object,
  assay = NULL,
  ncomp = 20,
  Y = NULL,
  Y.add = NULL,
  pls.function = c("plsr", "spls", "cppls"),
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.name = "pls",
  reduction.key = "PLS_",
  seed.use = 42,
  eta = 0.5,
  threads = NULL,
  ...
)

## S3 method for class 'Assay'
RunPLS(
  object,
  assay = NULL,
  features = NULL,
  layer = "scale.data",
  ncomp = 20,
  Y = NULL,
  Y.add = NULL,
  pls.function = c("plsr", "spls", "cppls"),
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.name = "pls",
  reduction.key = "PLS_",
  seed.use = 42,
  eta = 0.5,
  threads = NULL,
  materialize = FALSE,
  materialize.dir = NULL,
```

```
  overwrite = FALSE,
  ...
)

## S3 method for class 'StdAssay'
RunPLS(
  object,
  assay = NULL,
  features = NULL,
  layer = "scale.data",
  ncomp = 20,
  Y = NULL,
  Y.add = NULL,
  pls.function = c("plsr", "spls", "cppls"),
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.name = "pls",
  reduction.key = "PLS_",
  seed.use = 42,
  eta = 0.5,
  threads = NULL,
  materialize = FALSE,
  materialize.dir = NULL,
  overwrite = FALSE,
  ...
)

## S3 method for class 'Seurat'
RunPLS(
  object,
  assay = NULL,
  features = NULL,
  ncomp = 20,
  Y = NULL,
  Y.add = NULL,
  pls.function = c("plsr", "spls", "cppls"),
  verbose = TRUE,
  ndims.print = 1:5,
  nfeatures.print = 30,
  reduction.name = "pls",
  reduction.key = "PLS_",
  seed.use = 42,
  eta = 0.5,
  threads = NULL,
  materialize = FALSE,
  materialize.dir = NULL,
  overwrite = FALSE,
```

```
  ...
)
```

Arguments

object	An object to run PLS on
...	Additional arguments to be passed to the PLS function
assay	Name of Assay PLS is being run on
ncomp	Number of components to compute
Y	The response variable(s) for PLS regression. Accepted formats: • A character vector of column names in the Seurat object metadata (Seurat method only). • A data.frame, which is converted via model.matrix(~. + 0, data = Y). • A numeric matrix (used as-is). • A numeric vector (promoted to a single-column matrix). The number of rows must match the number of cells/samples, and no cell can have a missing (NA) response.
Y.add	Additional response variable(s) containing relevant information about the observations. Only used for cppls. Accepts the same formats as Y.
pls.function	PLS function from pls package to run (options: plsr, spls, cppls)
verbose	Print progress messages, diagnostics (e.g. R2), and the top genes associated with high/low loadings for the components
ndims.print	components to print genes for
nfeatures.print	Number of genes to print for each component
reduction.name	the name of the DimReduc object
reduction.key	dimensional reduction key, specifies the string before the number for the dimension names.
seed.use	Set a random seed. Setting NULL will not set a seed.
eta	Thresholding parameter that controls the sparsity of the spls method (larger –> sparser). eta should be between 0 and 1.
threads	Integer; number of threads for BPCells parallel computation (IterableMatrix path only). NULL (default) uses the package-wide thread count set by setThreads (1 unless changed); 0 = auto-detect via parallel::detectCores(logical = FALSE); values ≥ 1 use that many threads. Ignored for in-memory data.
features	Features to compute PLS on
layer	The layer in assay to use when running PLS analysis. Sparse in-memory layers, such as an in-memory data layer, are not supported and raise an error.
materialize	Logical; for on-disk (BPCells) assays only. If TRUE, the feature-subsetted matrix is written once to a single contiguous BPCells store before PLS, instead of re-streaming a fragmented lazy chain on each of the ~2*ncomp+3 passes. This can substantially speed up PLS on a CellAnova-corrected assay whose on-disk root is a per-sample ColBindMatrices. Ignored for in-memory data. Default FALSE.

materialize.dir
: Directory for the materialized matrix (only used when materialize = TRUE). NULL (default) writes to a temporary directory that is removed after PLS completes; supplying a path keeps the matrix there for reuse by downstream steps.

overwrite
: Logical; only used when materialize = TRUE and a materialize.dir is supplied. Passed to BPCells::write_matrix_dir() to control whether an existing directory may be overwritten. Default FALSE so that a non-empty materialize.dir is never clobbered without explicit consent.

Value

Returns a DimReduc object with PLS results

Examples

```
## Not run:
# Run PLS on a Seurat object using metadata column names
seurat_obj <- RunPLS(seurat_obj, Y = "condition", ncomp = 10)

# Run PLS with a pre-built numeric design matrix
design_mat <- model.matrix(~ age + sex, data = seurat_obj[[]])
seurat_obj <- RunPLS(seurat_obj, Y = design_mat, ncomp = 10)

## End(Not run)
```

RunSLSI *Run Supervised Latent Semantic Indexing*

Description

Run a supervised LSI (SLSI) dimensionality reduction supervised by a cell-cell kernel. SLSI is used to capture a linear transformation of peaks that maximizes its dependency to the given cell-cell kernel.

Usage

```
RunSLSI(object, ...)

## Default S3 method:
RunSLSI(
  object,
  assay = NULL,
  n = 50,
  reduction.key = "SLSI_",
  graph = NULL,
  verbose = TRUE,
  seed.use = 42,
```

```
  ...
)

## S3 method for class 'Assay'
RunSLSI(
  object,
  assay = NULL,
  features = NULL,
  n = 50,
  reduction.key = "SLSI_",
  graph = NULL,
  verbose = TRUE,
  seed.use = 42,
  ...
)

## S3 method for class 'StdAssay'
RunSLSI(
  object,
  assay = NULL,
  features = NULL,
  n = 50,
  reduction.key = "SLSI_",
  graph = NULL,
  layer = "data",
  verbose = TRUE,
  seed.use = 42,
  ...
)

## S3 method for class 'Seurat'
RunSLSI(
  object,
  assay = NULL,
  features = NULL,
  n = 50,
  reduction.name = "slsi",
  reduction.key = "SLSI_",
  graph = NULL,
  verbose = TRUE,
  seed.use = 42,
  ...
)
```

Arguments

object	An object
...	Arguments passed to IRLBA irlba

assay	Name of Assay SLSI is being run on
n	Total Number of SLSI components to compute and store
reduction.key	dimensional reduction key, specifies the string before the number for the dimension names
graph	Graph used supervised by SLSI
verbose	Display messages
seed.use	Set a random seed. Setting NULL will not set a seed.
features	Features to compute SLSI on. If features=NULL, SLSI will be run using the variable features for the Assay5.
layer	Layer to run SLSI on
reduction.name	dimensional reduction name

Value

Returns Seurat object with the SLSI calculation stored in the reductions slot

---

RunSPCA *Run Supervised Principal Component Analysis*

Description

Run a supervised PCA (SPCA) dimensionality reduction supervised by a cell-cell kernel. SPCA is used to capture a linear transformation which maximizes its dependency to the given cell-cell kernel. We use SNN graph as the kernel to supervise the linear matrix factorization.

Usage

```
RunSPCA(object, ...)

## Default S3 method:
RunSPCA(
  object,
  assay = NULL,
  npcs = 50,
  reduction.key = "SPC_",
  graph = NULL,
  verbose = FALSE,
  seed.use = 42,
  ...
)

## S3 method for class 'Assay'
RunSPCA(
  object,
  assay = NULL,
```

```
  features = NULL,
  npcs = 50,
  reduction.key = "SPC_",
  graph = NULL,
  verbose = TRUE,
  seed.use = 42,
  ...
)

## S3 method for class 'Assay5'
RunSPCA(
  object,
  assay = NULL,
  features = NULL,
  npcs = 50,
  reduction.key = "SPC_",
  graph = NULL,
  verbose = TRUE,
  seed.use = 42,
  layer = "scale.data",
  ...
)

## S3 method for class 'Seurat'
RunSPCA(
  object,
  assay = NULL,
  features = NULL,
  npcs = 50,
  reduction.name = "spca",
  reduction.key = "SPC_",
  graph = NULL,
  verbose = TRUE,
  seed.use = 42,
  ...
)
```

Arguments

object	An object
...	Arguments passed to other methods and IRLBA
assay	Name of Assay SPCA is being run on
npcs	Total Number of SPCs to compute and store (50 by default)
reduction.key	dimensional reduction key, specifies the string before the number for the dimension names. SPC by default
graph	Graph used supervised by SPCA
verbose	Print the top genes associated with high/low loadings for the SPCs

seed.use	Set a random seed. By default, sets the seed to 42. Setting NULL will not set a seed.
features	Features to compute SPCA on. If features=NULL, SPCA will be run using the variable features for the Assay.
layer	Layer to run SPCA on
reduction.name	dimensional reduction name, spca by default

Value

Returns Seurat object with the SPCA calculation stored in the reductions slot

References

Barshan E, Ghodsi A, Azimifar Z, Jahromi MZ. Supervised principal component analysis: Visualization, classification and regression on subspaces and submanifolds. Pattern Recognition. 2011 Jul 1;44(7):1357-71. doi:10.1016/j.patcog.2010.12.015;

RunTSNE *Run t-distributed Stochastic Neighbor Embedding*

Description

Run t-SNE dimensionality reduction on selected features. Has the option of running in a reduced dimensional space (i.e. spectral tSNE, recommended), or running based on a set of genes. For details about stored TSNE calculation parameters, see PrintTSNEParams.

Usage

```
RunTSNE(object, ...)

## S3 method for class 'matrix'
RunTSNE(
  object,
  assay = NULL,
  seed.use = 1,
  tsne.method = "Rtsne",
  dim.embed = 2,
  reduction.key = "tSNE_",
  ...
)

## S3 method for class 'DimReduc'
RunTSNE(
  object,
  cells = NULL,
  dims = 1:5,
```

```
  seed.use = 1,
  tsne.method = "Rtsne",
  dim.embed = 2,
  reduction.key = "tSNE_",
  ...
)

## S3 method for class 'dist'
RunTSNE(
  object,
  assay = NULL,
  seed.use = 1,
  tsne.method = "Rtsne",
  dim.embed = 2,
  reduction.key = "tSNE_",
  ...
)

## S3 method for class 'Seurat'
RunTSNE(
  object,
  reduction = "pca",
  cells = NULL,
  dims = 1:5,
  features = NULL,
  seed.use = 1,
  tsne.method = "Rtsne",
  dim.embed = 2,
  distance.matrix = NULL,
  reduction.name = "tsne",
  reduction.key = "tSNE_",
  ...
)
```

Arguments

`object`	Seurat object
`...`	Arguments passed to other methods and to t-SNE call (most commonly used is perplexity)
`assay`	Name of assay that that t-SNE is being run on
`seed.use`	Random seed for the t-SNE. If NULL, does not set the seed
`tsne.method`	Select the method to use to compute the tSNE. Available methods are: • "`Rtsne`": Use the Rtsne package Barnes-Hut implementation of tSNE (default) • "`FIt-SNE`": Use the FFT-accelerated Interpolation-based t-SNE. Based on Kluger Lab code found here: https://github.com/KlugerLab/FIt-SNE

dim.embed	The dimensional space of the resulting tSNE embedding (default is 2). For example, set to 3 for a 3d tSNE
reduction.key	dimensional reduction key, specifies the string before the number for the dimension names. "tSNE_" by default
cells	Which cells to analyze (default, all cells)
dims	Which dimensions to use as input features
reduction	Which dimensional reduction (e.g. PCA, ICA) to use for the tSNE. Default is PCA
features	If set, run the tSNE on this subset of features (instead of running on a set of reduced dimensions). Not set (NULL) by default; dims must be NULL to run on features
distance.matrix	If set, runs tSNE on the given distance matrix instead of data matrix (experimental)
reduction.name	dimensional reduction name, specifies the position in the object$dr list. tsne by default

---

RunUMAP *Run UMAP*

Description

Runs the Uniform Manifold Approximation and Projection (UMAP) dimensional reduction technique. To run using umap.method="umap-learn", you must first install the umap-learn python package (e.g. via pip install umap-learn). Details on this package can be found here: https://github.com/lmcinnes/umap. For a more in depth discussion of the mathematics underlying UMAP, see the ArXiv paper here: https://arxiv.org/abs/1802.03426.

Usage

```
RunUMAP(object, ...)

## Default S3 method:
RunUMAP(
  object,
  reduction.key = "UMAP_",
  assay = NULL,
  reduction.model = NULL,
  return.model = FALSE,
  umap.method = "uwot",
  n.neighbors = 30L,
  n.components = 2L,
  metric = "cosine",
  n.epochs = NULL,
  learning.rate = 1,
```

```
  min.dist = 0.3,
  spread = 1,
  set.op.mix.ratio = 1,
  local.connectivity = 1L,
  repulsion.strength = 1,
  negative.sample.rate = 5,
  a = NULL,
  b = NULL,
  uwot.sgd = FALSE,
  uwot.approx_pow = FALSE,
  uwot.init = "spectral",
  seed.use = 42,
  metric.kwds = NULL,
  angular.rp.forest = FALSE,
  densmap = FALSE,
  dens.lambda = 2,
  dens.frac = 0.3,
  dens.var.shift = 0.1,
  verbose = TRUE,
  ...
)

## S3 method for class 'Graph'
RunUMAP(
  object,
  assay = NULL,
  umap.method = "umap-learn",
  n.components = 2L,
  metric = "correlation",
  n.epochs = 0L,
  learning.rate = 1,
  min.dist = 0.3,
  spread = 1,
  repulsion.strength = 1,
  negative.sample.rate = 5L,
  a = NULL,
  b = NULL,
  uwot.sgd = FALSE,
  uwot.approx_pow = FALSE,
  uwot.init = "spectral",
  seed.use = 42L,
  metric.kwds = NULL,
  densmap = FALSE,
  densmap.kwds = NULL,
  verbose = TRUE,
  reduction.key = "UMAP_",
  ...
)
```

```
## S3 method for class 'Neighbor'
RunUMAP(object, reduction.model, ...)

## S3 method for class 'Seurat'
RunUMAP(
  object,
  dims = NULL,
  reduction = "pca",
  features = NULL,
  graph = NULL,
  assay = DefaultAssay(object = object),
  nn.name = NULL,
  slot = "data",
  umap.method = "uwot",
  reduction.model = NULL,
  return.model = FALSE,
  n.neighbors = 30L,
  n.components = 2L,
  metric = "cosine",
  n.epochs = NULL,
  learning.rate = 1,
  min.dist = 0.3,
  spread = 1,
  set.op.mix.ratio = 1,
  local.connectivity = 1L,
  repulsion.strength = 1,
  negative.sample.rate = 5L,
  a = NULL,
  b = NULL,
  uwot.sgd = FALSE,
  uwot.approx_pow = FALSE,
  uwot.init = "spectral",
  seed.use = 42L,
  metric.kwds = NULL,
  angular.rp.forest = FALSE,
  densmap = FALSE,
  dens.lambda = 2,
  dens.frac = 0.3,
  dens.var.shift = 0.1,
  verbose = TRUE,
  reduction.name = "umap",
  reduction.key = NULL,
  ...
)
```

Arguments

object	An object

`...` Arguments passed to other methods and UMAP

`reduction.key` dimensional reduction key, specifies the string before the number for the dimension names. UMAP by default

`assay` Assay to pull data for when using `features`, or assay used to construct Graph if running UMAP on a Graph

`reduction.model`
`DimReduc` object that contains the umap model

`return.model` whether UMAP will return the uwot model

`umap.method` UMAP implementation to run. Can be

`uwot`**:** Runs umap via the uwot R package `umap`

`uwot2`**:** Runs umap2 via the uwot R package `umap2`

`umap-learn`**:** Run the Seurat wrapper of the python umap-learn package

`n.neighbors` This determines the number of neighboring points used in local approximations of manifold structure. Larger values will result in more global structure being preserved at the loss of detailed local structure. In general this parameter should often be in the range 5 to 50.

`n.components` The dimension of the space to embed into.

`metric` metric: This determines the choice of metric used to measure distance in the input space. A wide variety of metrics are already coded, and a user defined function can be passed as long as it has been JITd by numba.

`n.epochs` he number of training epochs to be used in optimizing the low dimensional embedding. Larger values result in more accurate embeddings. If NULL is specified, a value will be selected based on the size of the input dataset (200 for large datasets, 500 for small).

`learning.rate` The initial learning rate for the embedding optimization.

`min.dist` This controls how tightly the embedding is allowed compress points together. Larger values ensure embedded points are more evenly distributed, while smaller values allow the algorithm to optimize more accurately with regard to local structure. Sensible values are in the range 0.001 to 0.5.

`spread` The effective scale of embedded points. In combination with min.dist this determines how clustered/clumped the embedded points are.

`set.op.mix.ratio`
Interpolate between (fuzzy) union and intersection as the set operation used to combine local fuzzy simplicial sets to obtain a global fuzzy simplicial sets. Both fuzzy set operations use the product t-norm. The value of this parameter should be between 0.0 and 1.0; a value of 1.0 will use a pure fuzzy union, while 0.0 will use a pure fuzzy intersection.

`local.connectivity`
The local connectivity required - i.e. the number of nearest neighbors that should be assumed to be connected at a local level. The higher this value the more connected the manifold becomes locally. In practice this should be not more than the local intrinsic dimension of the manifold.

repulsion.strength
: Weighting applied to negative samples in low dimensional embedding optimization. Values higher than one will result in greater weight being given to negative samples.

negative.sample.rate
: The number of negative samples to select per positive sample in the optimization process. Increasing this value will result in greater repulsive force being applied, greater optimization cost, but slightly more accuracy.

a
: More specific parameters controlling the embedding. If NULL, these values are set automatically as determined by min. dist and spread. Parameter of differentiable approximation of right adjoint functor.

b
: More specific parameters controlling the embedding. If NULL, these values are set automatically as determined by min. dist and spread. Parameter of differentiable approximation of right adjoint functor.

uwot.sgd
: Set `uwot::umap(fast_sgd = TRUE)`; see umap for more details

uwot.approx_pow
: Set `uwot::umap(approx_pow = TRUE)`. Default is `FALSE`. See umap for more details.

uwot.init
: Set the initialization method to use for umap or umap2, which is passed to the `init` parameter of these functions. See these functions for available options. Default is `"spectral"`.

seed.use
: Set a random seed. By default, sets the seed to 42. Setting NULL will not set a seed

metric.kwds
: A dictionary of arguments to pass on to the metric, such as the p value for Minkowski distance. If NULL then no arguments are passed on.

angular.rp.forest
: Whether to use an angular random projection forest to initialize the approximate nearest neighbor search. This can be faster, but is mostly on useful for metric that use an angular style distance such as cosine, correlation etc. In the case of those metrics angular forests will be chosen automatically.

densmap
: Whether to use the density-augmented objective of densMAP. Turning on this option generates an embedding where the local densities are encouraged to be correlated with those in the original space. Parameters below with the prefix 'dens' further control the behavior of this extension. Default is FALSE. Only compatible with 'umap-learn' method and version of umap-learn >= 0.5.0

dens.lambda
: Specific parameter which controls the regularization weight of the density correlation term in densMAP. Higher values prioritize density preservation over the UMAP objective, and vice versa for values closer to zero. Setting this parameter to zero is equivalent to running the original UMAP algorithm. Default value is 2.

dens.frac
: Specific parameter which controls the fraction of epochs (between 0 and 1) where the density-augmented objective is used in densMAP. The first (1 - dens_frac) fraction of epochs optimize the original UMAP objective before introducing the density correlation term. Default is 0.3.

dens.var.shift	Specific parameter which specifies a small constant added to the variance of local radii in the embedding when calculating the density correlation objective to prevent numerical instability from dividing by a small number. Default is 0.1.
verbose	Controls verbosity
densmap.kwds	A dictionary of arguments to pass on to the densMAP optimization.
dims	Which dimensions to use as input features, used only if features is NULL
reduction	Which dimensional reduction (PCA or ICA) to use for the UMAP input. Default is PCA
features	If set, run UMAP on this subset of features (instead of running on a set of reduced dimensions). Not set (NULL) by default; dims must be NULL to run on features
graph	Name of graph on which to run UMAP
nn.name	Name of knn output on which to run UMAP
slot	The slot used to pull data for when using features. data slot is by default.
reduction.name	Name to store dimensional reduction under in the Seurat object

Value

Returns a Seurat object containing a UMAP representation

References

McInnes, L, Healy, J, UMAP: Uniform Manifold Approximation and Projection for Dimension Reduction, ArXiv e-prints 1802.03426, 2018

Examples

```
## Not run:
data("pbmc_small")
pbmc_small
# Run UMAP map on first 5 PCs
pbmc_small <- RunUMAP(object = pbmc_small, dims = 1:5)
# Plot results
DimPlot(object = pbmc_small, reduction = 'umap')

## End(Not run)
```

SampleUMI *Sample UMI*

Description

Downsample each cell to a specified number of UMIs. Includes an option to upsample cells below specified UMI as well.

Usage

```
SampleUMI(data, max.umi = 1000, upsample = FALSE, verbose = FALSE)
```

Arguments

data	Matrix with the raw count data
max.umi	Number of UMIs to sample to
upsample	Upsamples all cells with fewer than max.umi
verbose	Display the progress bar

Value

Matrix with downsampled data

Examples

```
data("pbmc_small")
counts = as.matrix(x = GetAssayData(object = pbmc_small, assay = "RNA", layer = "counts"))
downsampled = SampleUMI(data = counts)
head(x = downsampled)
```

SaveAnnoyIndex *Save the Annoy index*

Description

Save the Annoy index

Usage

```
SaveAnnoyIndex(object, file)
```

Arguments

object	A Neighbor object with the annoy index stored
file	Path to file to write index to

ScaleData *Scale and center the data.*

Description

Scales and centers features in the dataset. If variables are provided in vars.to.regress, they are individually regressed against each feature, and the resulting residuals are then scaled and centered.

Usage

```
ScaleData(object, ...)

## Default S3 method:
ScaleData(
  object,
  features = NULL,
  vars.to.regress = NULL,
  latent.data = NULL,
  split.by = NULL,
  model.use = "linear",
  use.umi = FALSE,
  do.scale = TRUE,
  do.center = TRUE,
  scale.max = 10,
  block.size = 1000,
  min.cells.to.block = 3000,
  verbose = TRUE,
  ...
)

## S3 method for class 'IterableMatrix'
ScaleData(
  object,
  features = NULL,
  vars.to.regress = NULL,
  latent.data = NULL,
  do.scale = TRUE,
  do.center = TRUE,
  scale.max = 10,
  verbose = TRUE,
  ...
)

## S3 method for class 'Assay'
ScaleData(
  object,
  features = NULL,
```

```
  vars.to.regress = NULL,
  latent.data = NULL,
  split.by = NULL,
  model.use = "linear",
  use.umi = FALSE,
  do.scale = TRUE,
  do.center = TRUE,
  scale.max = 10,
  block.size = 1000,
  min.cells.to.block = 3000,
  verbose = TRUE,
  ...
)

## S3 method for class 'Seurat'
ScaleData(
  object,
  features = NULL,
  assay = NULL,
  vars.to.regress = NULL,
  split.by = NULL,
  model.use = "linear",
  use.umi = FALSE,
  do.scale = TRUE,
  do.center = TRUE,
  scale.max = 10,
  block.size = 1000,
  min.cells.to.block = 3000,
  verbose = TRUE,
  ...
)
```

Arguments

object	An object
...	Arguments passed to other methods
features	Vector of features names to scale/center. Default is variable features.
vars.to.regress	Variables to regress out (previously latent.vars in RegressOut). For example, nUMI, or percent.mito.
latent.data	Extra data to regress out, should be cells x latent data
split.by	Name of variable in object metadata or a vector or factor defining grouping of cells. See argument f in split for more details
model.use	Use a linear model or generalized linear model (poisson, negative binomial) for the regression. Options are 'linear' (default), 'poisson', and 'negbinom'
use.umi	Regress on UMI count data. Default is FALSE for linear modeling, but automatically set to TRUE if model.use is 'negbinom' or 'poisson'

do.scale	Whether to scale the data.
do.center	Whether to center the data.
scale.max	Max value to return for scaled data. The default is 10. Setting this can help reduce the effects of features that are only expressed in a very small number of cells. If regressing out latent variables and using a non-linear model, the default is 50.
block.size	Default size for number of features to scale at in a single computation. Increasing block.size may speed up calculations but at an additional memory cost.
min.cells.to.block	If object contains fewer than this number of cells, don't block for scaling calculations.
verbose	Displays a progress bar for scaling procedure
assay	Name of Assay to scale

Details

ScaleData now incorporates the functionality of the function formerly known as RegressOut (which regressed out given the effects of provided variables and then scaled the residuals). To make use of the regression functionality, simply pass the variables you want to remove to the vars.to.regress parameter.

Setting center to TRUE will center the expression for each feature by subtracting the average expression for that feature. Setting scale to TRUE will scale the expression level for each feature by dividing the centered feature expression levels by their standard deviations if center is TRUE and by their root mean square otherwise.

ScaleFactors *Get image scale factors*

Description

Get image scale factors

Usage

```
ScaleFactors(object, ...)

scalefactors(spot = 1, fiducial = 1, hires = 1, lowres = 1)

## S3 method for class 'SlideSeq'
ScaleFactors(object, ...)

## S3 method for class 'STARmap'
ScaleFactors(object, ...)

## S3 method for class 'VisiumV1'
```

```
ScaleFactors(object, ...)

## S3 method for class 'VisiumV2'
ScaleFactors(object, ...)
```

Arguments

object	An object to get scale factors from
...	Arguments passed to other methods
spot	Spot full resolution scale factor
fiducial	Fiducial full resolution scale factor
hires	High resolutoin scale factor
lowres	Low resolution scale factor

Value

An object of class scalefactors

Note

scalefactors objects can be created with scalefactors()

ScoreJackStraw *Compute Jackstraw scores significance.*

Description

Significant PCs should show a p-value distribution that is strongly skewed to the left compared to the null distribution. The p-value for each PC is based on a proportion test comparing the number of features with a p-value below a particular threshold (score.thresh), compared with the proportion of features expected under a uniform distribution of p-values.

Usage

```
ScoreJackStraw(object, ...)

## S3 method for class 'JackStrawData'
ScoreJackStraw(object, dims = 1:5, score.thresh = 1e-05, ...)

## S3 method for class 'DimReduc'
ScoreJackStraw(object, dims = 1:5, score.thresh = 1e-05, ...)

## S3 method for class 'Seurat'
ScoreJackStraw(
  object,
  reduction = "pca",
```

```
  dims = 1:5,
  score.thresh = 1e-05,
  do.plot = FALSE,
  ...
)
```

Arguments

object	An object
...	Arguments passed to other methods
dims	Which dimensions to examine
score.thresh	Threshold to use for the proportion test of PC significance (see Details)
reduction	Reduction associated with JackStraw to score
do.plot	Show plot. To return ggplot object, use JackStrawPlot after running ScoreJackStraw.

Value

Returns a Seurat object

Author(s)

Omri Wurtzel

See Also

JackStrawPlot

JackStrawPlot

SCTAssay-class *The SCTModel Class*

Description

The SCTModel object is a model and parameters storage from SCTransform. It can be used to calculate Pearson residuals for new genes.

The SCTAssay object contains all the information found in an Assay object, with extra information from the results of SCTransform

Usage

```
## S3 method for class 'SCTAssay'
levels(x)

## S3 replacement method for class 'SCTAssay'
levels(x) <- value
```

Arguments

x	An SCTAssay object
value	New levels, must be in the same order as the levels present

Value

levels: SCT model names

levels<-: x with updated SCT model names

Slots

feature.attributes A data.frame with feature attributes in SCTransform

cell.attributes A data.frame with cell attributes in SCTransform

clips A list of two numeric of length two specifying the min and max values the Pearson residual will be clipped to. One for vst and one for SCTransform

umi.assay Name of the assay of the seurat object containing UMI matrix and the default is RNA

model A formula used in SCTransform

arguments other information used in SCTransform

median_umi Median UMI (or scale factor) used to calculate corrected counts

SCTModel.list A list containing SCT models

Get and set SCT model names

SCT results are named by initial run of SCTransform in order to keep SCT parameters straight between runs. When working with merged SCTAssay objects, these model names are important. levels allows querying the models present. levels<- allows the changing of the names of the models present, useful when merging SCTAssay objects. Note: unlike normal levels<-, levels<-.SCTAssay allows complete changing of model names, not reordering.

Creating an SCTAssay from an Assay

Conversion from an Assay object to an SCTAssay object by is done by adding the additional slots to the object. If from has results generated by SCTransform from Seurat v3.0.0 to v3.1.1, the conversion will automagically fill the new slots with the data

See Also

Assay

Assay

Examples

```
## Not run:
# SCTAssay objects are generated from SCTransform
pbmc_small <- SCTransform(pbmc_small)

## End(Not run)

## Not run:
# SCTAssay objects are generated from SCTransform
pbmc_small <- SCTransform(pbmc_small)
pbmc_small[["SCT"]]

## End(Not run)

## Not run:
# Query and change SCT model names
levels(pbmc_small[['SCT']])
levels(pbmc_small[['SCT']]) <- '3'
levels(pbmc_small[['SCT']])

## End(Not run)
```

`SCTransform` *Perform sctransform-based normalization*

Description

Perform a variance-stabilizing transformation on UMI counts using `sctransform::vst` (https://github.com/satijalab/sctransf
This replaces the `NormalizeData` → `FindVariableFeatures` → `ScaleData` workflow by fitting a
regularized negative binomial model per gene and returning:

Usage

```
SCTransform(object, ...)

## Default S3 method:
SCTransform(
  object,
  cell.attr,
  reference.SCT.model = NULL,
  do.correct.umi = TRUE,
  ncells = 5000,
  residual.features = NULL,
  variable.features.n = 3000,
  variable.features.rv.th = 1.3,
  vars.to.regress = NULL,
  latent.data = NULL,
```

```
  do.scale = FALSE,
  do.center = TRUE,
  clip.range = c(-sqrt(x = ncol(x = umi)/30), sqrt(x = ncol(x = umi)/30)),
  vst.flavor = "v2",
  conserve.memory = FALSE,
  return.only.var.genes = TRUE,
  defer.residual.matrix = FALSE,
  seed.use = 1448145,
  verbose = TRUE,
  ...
)

## S3 method for class 'Assay'
SCTransform(
  object,
  cell.attr,
  reference.SCT.model = NULL,
  do.correct.umi = TRUE,
  ncells = 5000,
  residual.features = NULL,
  variable.features.n = 3000,
  variable.features.rv.th = 1.3,
  vars.to.regress = NULL,
  latent.data = NULL,
  do.scale = FALSE,
  do.center = TRUE,
  clip.range = c(-sqrt(x = ncol(x = object)/30), sqrt(x = ncol(x = object)/30)),
  vst.flavor = "v2",
  conserve.memory = FALSE,
  return.only.var.genes = TRUE,
  seed.use = 1448145,
  verbose = TRUE,
  ...
)

## S3 method for class 'Seurat'
SCTransform(
  object,
  assay = "RNA",
  new.assay.name = "SCT",
  reference.SCT.model = NULL,
  do.correct.umi = TRUE,
  ncells = 5000,
  residual.features = NULL,
  variable.features.n = 3000,
  variable.features.rv.th = 1.3,
  vars.to.regress = NULL,
  do.scale = FALSE,
```

```
  do.center = TRUE,
  clip.range = c(-sqrt(x = ncol(x = object[[assay]])/30), sqrt(x = ncol(x =
    object[[assay]])/30)),
  vst.flavor = "v2",
  conserve.memory = FALSE,
  return.only.var.genes = TRUE,
  seed.use = 1448145,
  verbose = TRUE,
  ...
)

## S3 method for class 'IterableMatrix'
SCTransform(
  object,
  cell.attr,
  reference.SCT.model = NULL,
  do.correct.umi = TRUE,
  ncells = 5000,
  residual.features = NULL,
  variable.features.n = 3000,
  variable.features.rv.th = 1.3,
  vars.to.regress = NULL,
  latent.data = NULL,
  do.scale = FALSE,
  do.center = TRUE,
  clip.range = c(-sqrt(x = ncol(x = object)/30), sqrt(x = ncol(x = object)/30)),
  vst.flavor = "v2",
  conserve.memory = FALSE,
  return.only.var.genes = TRUE,
  seed.use = 1448145,
  verbose = TRUE,
  ...
)
```

Arguments

`object`	A Seurat object or UMI count matrix.
`...`	Additional arguments passed to `sctransform::vst`.
`cell.attr`	Optional metadata frame (cells × attributes).
`reference.SCT.model`	Pre-fitted SCT model (supports only `log_umi` as latent variable). If provided, computes residuals via that model. When `residual.features` is NULL, uses the model's top `variable.features.n`; otherwise, sets the assay's variable features to `residual.features`.
`do.correct.umi`	Logical; if TRUE (default), stores corrected UMIs in `counts`.
`ncells`	Integer; number of cells to subsample when fitting NB regression (default: 5000).

`residual.features`
: Character vector of genes to compute residuals for. Default NULL (all genes). If set, these become the assay's variable features.

`variable.features.n`
: Integer; when `residual.features` is NULL, select this many top features by residual variance (default: 3000).

`variable.features.rv.th`
: Numeric; if `variable.features.n` is NULL, select features exceeding this residual-variance threshold (default: 1.3).

`vars.to.regress`
: Character vector of metadata columns (e.g. `percent.mito`) to regress out in a second, non-regularized model.

`latent.data`
: Numeric matrix (cells × latent covariates) to regress out.

`do.scale`
: Logical; if TRUE, scale residuals to unit variance (default: FALSE).

`do.center`
: Logical; if TRUE, center residuals to mean zero (default: TRUE).

`clip.range`
: Numeric vector of length 2; range to clip residuals (default `c(-sqrt(n/30), sqrt(n/30))`, with n = number of cells).

`vst.flavor`
: Character; if `"v2"`, uses `method = "glmGamPoi_offset"`, `n_cells = 2000`, and `exclude_poisson = TRUE` to fit θ and intercept only.

`conserve.memory`
: Logical; if TRUE, never builds the full residual matrix (slower but memory-efficient; forces `return.only.var.genes=TRUE`; default: FALSE).

`return.only.var.genes`
: Logical; if TRUE (default), `scale.data` is subset to variable features only.

`defer.residual.matrix`
: Logical; if TRUE, skip materializing the Pearson residual matrix in this call. (For internal use by the v5 multi-layer `SCTransform` workflow, which computes the final merged `scale.data` matrix after processing all layers. Not used for the standard v3/single-matrix workflow.)

`seed.use`
: Integer; random seed for reproducibility (default: 1448145). Set to NULL to skip setting a seed.

`verbose`
: Logical; whether to print progress messages (default: TRUE).

`assay`
: Name of assay to pull the count data from; default is 'RNA'

`new.assay.name`
: Name for the new assay containing the normalized data; default is 'SCT'

Details

- A new assay (default name "SCT"), in which: - `counts`: depth-corrected UMI counts (as if each cell had uniform sequencing depth; controlled by `do.correct.umi`). - `data`: `log1p` of corrected counts. - `scale.data`: Pearson residuals from the fitted NB model (optionally centered and/or scaled). - `misc`: intermediate outputs from `sctransform::vst`.

When multiple `counts` layers exist (e.g. after `split()`), each layer is modeled independently. A consensus variable-feature set is then defined by ranking features by how often they're called "variable" across different layers (ties broken by median rank).

By default, `sctransform::vst` will drop features expressed in fewer than five cells. In the multi-layer case, this can lead to consenus variable-features being excluded from the output's `scale.data` when a feature is "variable" across many layers but sparsely expressed in at least one.

Value

A Seurat object with a new SCT assay containing: counts (corrected UMIs), data (log1p counts), and scale.data (Pearson residuals), plus misc for intermediate vst outputs.

See Also

vst, get_residuals, correct_counts

SCTResults *Get SCT results from an Assay*

Description

Pull the SCTResults information from an SCTAssay object.

Usage

```
SCTResults(object, ...)

SCTResults(object, ...) <- value

## S3 method for class 'SCTModel'
SCTResults(object, slot, ...)

## S3 replacement method for class 'SCTModel'
SCTResults(object, slot, ...) <- value

## S3 method for class 'SCTAssay'
SCTResults(object, slot, model = NULL, ...)

## S3 replacement method for class 'SCTAssay'
SCTResults(object, slot, model = NULL, ...) <- value

## S3 method for class 'Seurat'
SCTResults(object, assay = "SCT", slot, model = NULL, ...)
```

Arguments

object	An object
...	Arguments passed to other methods (not used)
value	new data to set
slot	Which slot to pull the SCT results from
model	Name of SCModel to pull result from. Available names can be retrieved with levels.
assay	Assay in the Seurat object to pull from

Value

Returns the value present in the requested slot for the requested group. If group is not specified, returns a list of slot results for each group unless there is only one group present (in which case it just returns the slot directly).

`SelectIntegrationFeatures` *Select integration features*

Description

Choose the features to use when integrating multiple datasets. This function ranks features by the number of datasets they are deemed variable in, breaking ties by the median variable feature rank across datasets. It returns the top scoring features by this ranking.

Usage

```
SelectIntegrationFeatures(
  object.list,
  nfeatures = 2000,
  assay = NULL,
  verbose = TRUE,
  fvf.nfeatures = 2000,
  ...
)
```

Arguments

`object.list`	List of seurat objects
`nfeatures`	Number of features to return
`assay`	Name or vector of assay names (one for each object) from which to pull the variable features.
`verbose`	Print messages
`fvf.nfeatures`	nfeatures for `FindVariableFeatures`. Used if `VariableFeatures` have not been set for any object in `object.list`.
`...`	Additional parameters to `FindVariableFeatures`

Details

If for any assay in the list, `FindVariableFeatures` hasn't been run, this method will try to run it using the `fvf.nfeatures` parameter and any additional ones specified through the ....

Value

A vector of selected features

Examples

```
## Not run:
# to install the SeuratData package see https://github.com/satijalab/seurat-data
library(SeuratData)
data("panc8")

# panc8 is a merged Seurat object containing 8 separate pancreas datasets
# split the object by dataset and take the first 2
pancreas.list <- SplitObject(panc8, split.by = "tech")[1:2]

# perform SCTransform normalization
pancreas.list <- lapply(X = pancreas.list, FUN = SCTransform)

# select integration features
features <- SelectIntegrationFeatures(pancreas.list)

## End(Not run)
```

SelectIntegrationFeatures5

Select integration features

Description

Select integration features

Usage

```
SelectIntegrationFeatures5(
  object,
  nfeatures = 2000,
  assay = NULL,
  method = NULL,
  layers = NULL,
  verbose = TRUE,
  ...
)
```

Arguments

object	Seurat object
nfeatures	Number of features to return for integration
assay	Name of assay to use for integration feature selection
method	Which method to pull. For HVFInfo and VariableFeatures, choose one from one of the following: • "vst"

- "sctransform" or "sct"
- "mean.var.plot", "dispersion", "mvp", or "disp"

layers	Name of layers to use for integration feature selection
verbose	Print messages
...	Arguments passed on to method

SelectSCTIntegrationFeatures *Select SCT integration features*

Description

Select SCT integration features

Usage

```
SelectSCTIntegrationFeatures(
  object,
  nfeatures = 3000,
  assay = NULL,
  verbose = TRUE,
  ...
)
```

Arguments

object	Seurat object
nfeatures	Number of features to return for integration
assay	Name of assay to use for integration feature selection
verbose	Print messages
...	Arguments passed on to method

SetIntegrationData *Set integration data*

Description

Set integration data

Usage

```
SetIntegrationData(object, integration.name, slot, new.data)
```

Arguments

object	Seurat object
integration.name	Name of integration object
slot	Which slot in integration object to set
new.data	New data to insert

Value

Returns a Seurat object

SetQuantile *Find the Quantile of Data*

Description

Converts a quantile in character form to a number regarding some data. String form for a quantile is represented as a number prefixed with "q"; for example, 10th quantile is "q10" while 2nd quantile is "q2". Will only take a quantile of non-zero data values

Usage

```
SetQuantile(cutoff, data)
```

Arguments

cutoff	The cutoff to turn into a quantile
data	The data to turn find the quantile of

Value

The numerical representation of the quantile

Examples

```
set.seed(42)
SetQuantile('q10', sample(1:100, 10))
```

setThreads *Set the number of threads to use for parallel processing in Seurat*

Description

Set the number of threads to use for parallel processing in Seurat

Usage

```
setThreads(n = NULL, verbose = TRUE)
```

Arguments

n	Number of threads (>= 1) to use for processing. If NULL, will be set to (available cores / 2).
verbose	Whether to print the number of threads set and available cores to the console

Details

The default is one thread. Calling `setThreads()` without specifying `n` selects half the available cores. This setting applies to supported C++ kernels in `NormalizeData`, `FindVariableFeatures`, `ScaleData`, `SCTransform`, `RunPCA`, `FindNeighbors`, `FindClusters`, and CCA/RPCA integration. `RunUMAP` also passes this setting to the **uwot** backend. Support depends on the input type, backend, and arguments; not every stage of these functions can be run in parallel.

Note that this thread setting is separate from `plan`.

See Also

`getThreads`

Seurat-class *The Seurat Class*

Description

The Seurat object is a representation of single-cell expression data for R; for more details, please see the documentation in `SeuratObject`

See Also

`SeuratObject::Seurat-class`

SeuratCommand-class *The SeuratCommand Class*

Description

For more details, please see the documentation in SeuratObject

See Also

SeuratObject::SeuratCommand-class

SeuratTheme *Seurat Themes*

Description

Various themes to be applied to ggplot2-based plots

SeuratTheme The curated Seurat theme, consists of ...

DarkTheme A dark theme, axes and text turn to white, the background becomes black

NoAxes Removes axis lines, text, and ticks

NoLegend Removes the legend

FontSize Sets axis and title font sizes

NoGrid Removes grid lines

SeuratAxes Set Seurat-style axes

SpatialTheme A theme designed for spatial visualizations (eg PolyFeaturePlot, PolyDimPlot)

RestoreLegend Restore a legend after removal

RotatedAxis Rotate X axis text 45 degrees

BoldTitle Enlarges and emphasizes the title

Usage

```
SeuratTheme()

CenterTitle(...)

DarkTheme(...)

FontSize(
  x.text = NULL,
  y.text = NULL,
  x.title = NULL,
  y.title = NULL,
```

```
  main = NULL,
  ...
)

NoAxes(..., keep.text = FALSE, keep.ticks = FALSE)

NoLegend(...)

NoGrid(...)

SeuratAxes(...)

SpatialTheme(...)

RestoreLegend(..., position = "right")

RotatedAxis(...)

BoldTitle(...)

WhiteBackground(...)
```

Arguments

`...`	Extra parameters to be passed to `theme`
`x.text`, `y.text`	X and Y axis text sizes
`x.title`, `y.title`	X and Y axis title sizes
`main`	Plot title size
`keep.text`	Keep axis text
`keep.ticks`	Keep axis ticks
`position`	A position to restore the legend to

Value

A ggplot2 theme object

See Also

`theme`

Examples

```
# Generate a plot with a dark theme
library(ggplot2)
df <- data.frame(x = rnorm(n = 100, mean = 20, sd = 2), y = rbinom(n = 100, size = 100, prob = 0.2))
p <- ggplot(data = df, mapping = aes(x = x, y = y)) + geom_point(mapping = aes(color = 'red'))
p + DarkTheme(legend.position = 'none')
```

```
# Generate a plot with no axes
library(ggplot2)
df <- data.frame(x = rnorm(n = 100, mean = 20, sd = 2), y = rbinom(n = 100, size = 100, prob = 0.2))
p <- ggplot(data = df, mapping = aes(x = x, y = y)) + geom_point(mapping = aes(color = 'red'))
p + NoAxes()

# Generate a plot with no legend
library(ggplot2)
df <- data.frame(x = rnorm(n = 100, mean = 20, sd = 2), y = rbinom(n = 100, size = 100, prob = 0.2))
p <- ggplot(data = df, mapping = aes(x = x, y = y)) + geom_point(mapping = aes(color = 'red'))
p + NoLegend()

# Generate a plot with no grid lines
library(ggplot2)
df <- data.frame(x = rnorm(n = 100, mean = 20, sd = 2), y = rbinom(n = 100, size = 100, prob = 0.2))
p <- ggplot(data = df, mapping = aes(x = x, y = y)) + geom_point(mapping = aes(color = 'red'))
p + NoGrid()
```

SketchData *Sketch Data*

Description

This function uses sketching methods to downsample high-dimensional single-cell RNA expression data, which can help with scalability for large datasets.

Usage

```
SketchData(
  object,
  assay = NULL,
  ncells = 5000L,
  sketched.assay = "sketch",
  method = c("LeverageScore", "Uniform"),
  var.name = "leverage.score",
  over.write = FALSE,
  seed = 123L,
  cast = "dgCMatrix",
  verbose = TRUE,
  features = NULL,
  ...
)
```

Arguments

object	A Seurat object.

assay	Assay name. Default is NULL, in which case the default assay of the object is used.
ncells	A positive integer or a named vector/list specifying the number of cells to sample per layer. If a single integer is provided, the same number of cells will be sampled from each layer. Default is 5000.
sketched.assay	Sketched assay name. A sketch assay is created or overwrite with the sketch data. Default is 'sketch'.
method	Sketching method to use. Can be 'LeverageScore' or 'Uniform'. Default is 'LeverageScore'.
var.name	A metadata column name to store the leverage scores. Default is 'leverage.score'.
over.write	whether to overwrite existing column in the metadata. Default is FALSE.
seed	A positive integer for the seed of the random number generator. Default is 123.
cast	The type to cast the resulting assay to. Default is 'dgCMatrix'.
verbose	Print progress and diagnostic messages
features	A character vector of feature names to include in the sketched assay.
...	Arguments passed to other methods

Value

A Seurat object with the sketched data added as a new assay.

SketchDataByGroup *Sketch Data by Group*

Description

This function uses sketching methods to downsample high-dimensional single-cell RNA expression data within specified groups/categories, which can help with scalability for large datasets while maintaining representation across different cell types or conditions.

Usage

```
SketchDataByGroup(
  object,
  group.by = NULL,
  assay = NULL,
  ncells = 1000L,
  sketched.assay = "sketch",
  method = c("Uniform", "LeverageScore"),
  var.name = "leverage.score",
  over.write = FALSE,
  seed = 123L,
  cast = NULL,
  verbose = TRUE,
```

```
  features = NULL,
  min.cells.per.group = 10L,
  ...
)
```

Arguments

object	A Seurat object.
group.by	A metadata column name to group cells by before sketching. If NULL, falls back to standard sketching without grouping. Default is NULL.
assay	Assay name. Default is NULL, in which case the default assay of the object is used.
ncells	A positive integer, named vector, or named list specifying the number of cells to sample. • If a single integer: same number of cells sampled from each group and layer • If a named vector with group names: specific number per group • If a named list with group names containing layer vectors: specific number per group per layer Without group.by, this is the number of cells per layer, and names refer to layers. Default is 1000.
sketched.assay	Sketched assay name. A sketch assay is created or overwritten with the sketch data. Default is 'sketch'.
method	Sketching method to use. Can be 'LeverageScore' or 'Uniform'. Default is 'Uniform'.
var.name	A metadata column name to store the leverage scores. Default is 'leverage.score'.
over.write	Whether to overwrite existing column in the metadata. Default is FALSE.
seed	A positive integer for the seed of the random number generator. Default is 123.
cast	The type to cast the resulting assay to. Default is NULL (no casting), which preserves the original matrix format (e.g. on-disk BPCells IterableMatrix objects stay on disk). Set to "dgCMatrix" to force the sketched assay into an in-memory sparse matrix.
verbose	Print progress and diagnostic messages. Default is TRUE.
features	A character vector of feature names to include in the sketched assay.
min.cells.per.group	Minimum number of cells required per group to perform sketching. Groups with fewer cells will be included entirely. Default is 10.
...	Arguments passed to other methods

Details

Normalized or transformed expression must be stored in a layer named data, or split layers such as data.batch1

When group.by is specified, the function performs the following steps:
1. Splits cells into groups based on the metadata column

2. Calculates leverage scores (if method = 'LeverageScore') within each group
3. Samples the specified number of cells from each group
4. Combines all sampled cells into the sketched assay

This approach ensures that rare cell types or conditions are not underrepresented in the final sketched dataset.

Value

A Seurat object with the sketched data added as a new assay. The metadata will contain information about which groups each sketched cell belongs to.

Examples

```
## Not run:
# Basic usage with grouping by cell type
sketched_obj <- SketchDataByGroup(
  object = seurat_obj,
  group.by = "cell_type",
  ncells = 500
)

# Different number of cells per group
sketched_obj <- SketchDataByGroup(
  object = seurat_obj,
  group.by = "condition",
  ncells = c("control" = 1000, "treatment" = 800)
)

# Without grouping (falls back to original behavior)
sketched_obj <- SketchDataByGroup(
  object = seurat_obj,
  ncells = 5000
)

## End(Not run)
```

SlideSeq-class *The SlideSeq class*

Description

The SlideSeq class represents spatial information from the Slide-seq platform

Slots

`coordinates` ...

Slots

`assay` Name of assay to associate image data with; will give this image priority for visualization when the assay is set as the active/default assay in a `Seurat` object

`key` A one-length character vector with the object's key; keys must be one or more alphanumeric characters followed by an underscore "_" (regex pattern "`^[a-zA-Z][a-zA-Z0-9]*_$`")

`misc` A named list of unstructured miscellaneous data

`SpatialImage-class` *The SpatialImage Class*

Description

For more details, please see the documentation in `SeuratObject`

See Also

`SeuratObject::SpatialImage-class`

`SpatialPlot` *Visualize spatial clustering and expression data.*

Description

SpatialPlot plots a feature or discrete grouping (e.g. cluster assignments) as spots over the image that was collected. We also provide SpatialFeaturePlot and SpatialDimPlot as wrapper functions around SpatialPlot for a consistent naming framework.

Usage

```
SpatialPlot(
  object,
  group.by = NULL,
  features = NULL,
  images = NULL,
  cols = NULL,
  image.alpha = 1,
  image.scale = "lowres",
  crop = TRUE,
  slot = "data",
  keep.scale = "feature",
  min.cutoff = NA,
  max.cutoff = NA,
  cells.highlight = NULL,
  cols.highlight = c("#DE2D26", "grey50"),
```

```
  facet.highlight = FALSE,
  label = FALSE,
  label.size = 5,
  label.color = "white",
  label.box = TRUE,
  repel = FALSE,
  ncol = NULL,
  combine = TRUE,
  pt.size.factor = 1.6,
  alpha = c(1, 1),
  shape = 21,
  stroke = NA,
  stroke.alpha = NA,
  interactive = FALSE,
  do.identify = FALSE,
  identify.ident = NULL,
  do.hover = FALSE,
  information = NULL,
  plot_segmentations = FALSE
)

SpatialDimPlot(
  object,
  group.by = NULL,
  images = NULL,
  cols = NULL,
  crop = TRUE,
  cells.highlight = NULL,
  cols.highlight = c("#DE2D26", "grey50"),
  facet.highlight = FALSE,
  label = FALSE,
  label.size = 7,
  label.color = "white",
  repel = FALSE,
  ncol = NULL,
  combine = TRUE,
  pt.size.factor = 1.6,
  alpha = c(1, 1),
  image.alpha = 1,
  image.scale = "lowres",
  shape = 21,
  stroke = NA,
  stroke.alpha = NA,
  label.box = TRUE,
  interactive = FALSE,
  information = NULL,
  plot_segmentations = FALSE
)
```

```
SpatialFeaturePlot(
  object,
  features,
  images = NULL,
  crop = TRUE,
  slot = "data",
  keep.scale = "feature",
  min.cutoff = NA,
  max.cutoff = NA,
  ncol = NULL,
  combine = TRUE,
  pt.size.factor = 1.6,
  alpha = c(1, 1),
  image.alpha = 1,
  image.scale = "lowres",
  shape = 21,
  stroke = NA,
  stroke.alpha = NA,
  interactive = FALSE,
  information = NULL,
  plot_segmentations = FALSE
)
```

Arguments

object	A Seurat object
group.by	Name of meta.data column to group the data by
features	Name of the feature to visualize. Provide either group.by OR features, not both.
images	Name of the images to use in the plot(s)
cols	Vector of colors, each color corresponds to an identity class. This may also be a single character or numeric value corresponding to a palette as specified by brewer.pal.info. By default, ggplot2 assigns colors
image.alpha	Adjust the opacity of the background images. Set to 0 to remove.
image.scale	Choose the scale factor ("lowres"/"hires") to apply in order to matchthe plot with the specified 'image' - defaults to "lowres"
crop	Crop the plot in to focus on points plotted. Set to FALSE to show entire background image.
slot	If plotting a feature, which data slot to pull from (counts, data, or scale.data)
keep.scale	How to handle the color scale across multiple plots. Options are: • "feature" (default; by row/feature scaling): The plots for each individual feature are scaled to the maximum expression of the feature across the conditions provided to split.by • "all" (universal scaling): The plots for all features and conditions are scaled to the maximum expression value for the feature with the highest overall expression

- NULL (no scaling): Each individual plot is scaled to the maximum expression value of the feature in the condition provided to split.by; be aware setting NULL will result in color scales that are not comparable between plots

min.cutoff, max.cutoff
: Vector of minimum and maximum cutoff values for each feature, may specify quantile in the form of 'q##' where '##' is the quantile (eg, 'q1', 'q10')

cells.highlight
: A list of character or numeric vectors of cells to highlight. If only one group of cells desired, can simply pass a vector instead of a list. If set, colors selected cells to the color(s) in cols.highlight

cols.highlight
: A vector of colors to highlight the cells as; ordered the same as the groups in cells.highlight; last color corresponds to unselected cells.

facet.highlight
: When highlighting certain groups of cells, split each group into its own plot

label
: Whether to label the clusters

label.size
: Sets the size of the labels

label.color
: Sets the color of the label text

label.box
: Whether to put a box around the label text (geom_text vs geom_label)

repel
: Repels the labels to prevent overlap

ncol
: Number of columns if plotting multiple plots

combine
: Combine plots into a single gg object; note that if TRUE; themeing will not work when plotting multiple features/groupings

pt.size.factor
: Scale the size of the spots.

alpha
: Controls opacity of spots. Provide as a vector specifying the min and max for SpatialFeaturePlot. For SpatialDimPlot, provide a single alpha value for each plot.

shape
: Control the shape of the spots - same as the ggplot2 parameter. The default is 21, which plots circles - use 22 to plot squares.

stroke
: Control the width of the border around the spots

stroke.alpha
: Control the opacity of spot borders (when stroke is specified). Set to NA to use the same alpha as the fill.

interactive
: Launch an interactive SpatialDimPlot or SpatialFeaturePlot session, see ISpatialDimPlot or ISpatialFeaturePlot for more details

do.identify, do.hover
: DEPRECATED in favor of interactive

identify.ident
: DEPRECATED

information
: An optional dataframe or matrix of extra information to be displayed on hover

plot_segmentations
: Define whether plot should plot centroids or segmentations

Value

If do.identify, either a vector of cells selected or the object with selected cells set to the value of identify.ident (if set). Else, if do.hover, a plotly object with interactive graphics. Else, a ggplot object

Examples

```
## Not run:
# For functionality analagous to FeaturePlot
SpatialPlot(seurat.object, features = "MS4A1")
SpatialFeaturePlot(seurat.object, features = "MS4A1")

# For functionality analagous to DimPlot
SpatialPlot(seurat.object, group.by = "clusters")
SpatialDimPlot(seurat.object, group.by = "clusters")

## End(Not run)
```

SplitObject *Splits object into a list of subsetted objects.*

Description

Splits object based on a single attribute into a list of subsetted objects, one for each level of the attribute. For example, useful for taking an object that contains cells from many patients, and subdividing it into patient-specific objects.

Usage

```
SplitObject(object, split.by = "ident")
```

Arguments

object	Seurat object
split.by	Attribute for splitting. Default is "ident". Currently only supported for class-level (i.e. non-quantitative) attributes.

Value

A named list of Seurat objects, each containing a subset of cells from the original object.

Examples

```
data("pbmc_small")
# Assign the test object a three level attribute
groups <- sample(c("group1", "group2", "group3"), size = 80, replace = TRUE)
names(groups) <- colnames(pbmc_small)
pbmc_small <- AddMetaData(object = pbmc_small, metadata = groups, col.name = "group")
obj.list <- SplitObject(pbmc_small, split.by = "group")
```

STARmap-class *The STARmap class*

Description

The STARmap class

Slots

`assay` Name of assay to associate image data with; will give this image priority for visualization when the assay is set as the active/default assay in a `Seurat` object

`key` A one-length character vector with the object's key; keys must be one or more alphanumeric characters followed by an underscore "_" (regex pattern "`^[a-zA-Z][a-zA-Z0-9]*_$`")

`misc` A named list of unstructured miscellaneous data

---

subset.AnchorSet *Subset an AnchorSet object*

Description

Subset an AnchorSet object

Usage

```
## S3 method for class 'AnchorSet'
subset(
  x,
  score.threshold = NULL,
  disallowed.dataset.pairs = NULL,
  dataset.matrix = NULL,
  group.by = NULL,
  disallowed.ident.pairs = NULL,
  ident.matrix = NULL,
  ...
)
```

Arguments

x	object to be subsetted.
score.threshold	Only anchor pairs with scores greater than this value are retained.
disallowed.dataset.pairs	Remove any anchors formed between the provided pairs. E.g. `list(c(1, 5), c(1, 2))` filters out any anchors between datasets 1 and 5 and datasets 1 and 2.
dataset.matrix	Provide a binary matrix specifying whether a dataset pair is allowable (1) or not (0). Should be a dataset x dataset matrix.
group.by	Grouping variable to determine allowable ident pairs
disallowed.ident.pairs	Remove any anchors formed between provided ident pairs. E.g. `list(c("CD4", "CD8"), c("B-cell", "T-cell"))`
ident.matrix	Provide a binary matrix specifying whether an ident pair is allowable (1) or not (0). Should be an ident x ident symmetric matrix
...	further arguments to be passed to or from other methods.

Value

Returns an AnchorSet object with specified anchors filtered out

---

SubsetByBarcodeInflections

Subset a Seurat Object based on the Barcode Distribution Inflection Points

---

Description

This convenience function subsets a Seurat object based on calculated inflection points.

Usage

```
SubsetByBarcodeInflections(object)
```

Arguments

object	Seurat object

Details

See [CalculateBarcodeInflections()] to calculate inflection points and [BarcodeInflectionsPlot()] to visualize and test inflection point calculations.

Value

Returns a subsetted Seurat object.

Author(s)

Robert A. Amezquita, <robert.amezquita@fredhutch.org>

See Also

CalculateBarcodeInflections BarcodeInflectionsPlot

Examples

```
data("pbmc_small")
pbmc_small <- CalculateBarcodeInflections(
  object = pbmc_small,
  group.column = 'groups',
  threshold.low = 20,
  threshold.high = 30
)
SubsetByBarcodeInflections(object = pbmc_small)
```

TopCells *Find cells with highest scores for a given dimensional reduction technique*

Description

Return a list of genes with the strongest contribution to a set of components

Usage

```
TopCells(object, dim = 1, ncells = 20, balanced = FALSE, ...)
```

Arguments

object	DimReduc object
dim	Dimension to use
ncells	Number of cells to return
balanced	Return an equal number of cells with both + and - scores.
...	Extra parameters passed to Embeddings

Value

Returns a vector of cells

Examples

```
data("pbmc_small")
pbmc_small
head(TopCells(object = pbmc_small[["pca"]]))
# Can specify which dimension and how many cells to return
TopCells(object = pbmc_small[["pca"]], dim = 2, ncells = 5)
```

`TopFeatures` *Find features with highest scores for a given dimensional reduction technique*

Description

Return a list of features with the strongest contribution to a set of components

Usage

```
TopFeatures(
  object,
  dim = 1,
  nfeatures = 20,
  projected = FALSE,
  balanced = FALSE,
  ...
)
```

Arguments

`object`	DimReduc object
`dim`	Dimension to use
`nfeatures`	Number of features to return
`projected`	Use the projected feature loadings
`balanced`	Return an equal number of features with both + and - scores.
`...`	Extra parameters passed to `Loadings`

Value

Returns a vector of features

Examples

```
data("pbmc_small")
pbmc_small
TopFeatures(object = pbmc_small[["pca"]], dim = 1)
# After projection:
TopFeatures(object = pbmc_small[["pca"]], dim = 1,  projected = TRUE)
```

TopNeighbors *Get nearest neighbors for given cell*

Description

Return a vector of cell names of the nearest n cells.

Usage

```
TopNeighbors(object, cell, n = 5)
```

Arguments

object	Neighbor object
cell	Cell of interest
n	Number of neighbors to return

Value

Returns a vector of cell names

TrajDETest *Trajectory Differential Expression Test*

Description

Perform trajectory-based differential expression analysis using negative binomial regression. This function tests for genes that change expression along a continuous trajectory variable.

Usage

```
TrajDETest(object, ...)

## Default S3 method:
TrajDETest(
  object,
  traj.var = NULL,
  latent.vars = NULL,
  features = NULL,
  fc.results = NULL,
  verbose = TRUE,
  ...
)

## S3 method for class 'Assay'
```

```
TrajDETest(
  object,
  layer = "counts",
  traj.var = NULL,
  latent.vars = NULL,
  samples = NULL,
  features = NULL,
  logfc.threshold = 0,
  prob.break.point = c(1/3, 2/3),
  min.pct = 0.1,
  min.count = 10,
  pseudocount.use = 1,
  verbose = TRUE,
  ...
)

## S3 method for class 'StdAssay'
TrajDETest(
  object,
  layer = "counts",
  traj.var = NULL,
  latent.vars = NULL,
  samples = NULL,
  features = NULL,
  logfc.threshold = 0,
  prob.break.point = c(1/3, 2/3),
  min.pct = 0.1,
  min.count = 10,
  pseudocount.use = 1,
  verbose = TRUE,
  ...
)

## S3 method for class 'Seurat'
TrajDETest(
  object,
  assay = NULL,
  layer = "counts",
  traj.var = NULL,
  latent.vars = NULL,
  samples = NULL,
  features = NULL,
  logfc.threshold = 0,
  prob.break.point = c(1/3, 2/3),
  min.pct = 0.1,
  min.count = 10,
  pseudocount.use = 1,
  complete.results = FALSE,
```

```
  verbose = TRUE,
  ...
)
```

Arguments

object	Expression data matrix, Assay, StdAssay, or Seurat object
...	additional parameters to be passed to glmGamPoi::glm_gp or filterByExpr
traj.var	For the Seurat method: a single character string naming a column in the object metadata. For the Assay/default methods: a data frame (one column) containing the trajectory variable of the samples to be tested against.
latent.vars	a data frame containing the latent variables (e.g., covariates that might affect the gene expression) to include in regression.
features	Genes to test. Default is to use all genes (after QC)
fc.results	fc.results calculated by FoldChange(); if not null QC will be performed based on this
verbose	Print a progress bar once expression testing begins
layer	the data layer to be used for trajectory DE test. Currently only 'counts' is supported.
samples	the cells/samples to be included in the DE test
logfc.threshold	Limit testing to genes which show, on average, at least X-fold difference (log-scale) between the top and bottom groups of samples (see prob.break.point for details). Default is 0 (i.e., no filtering).
prob.break.point	a numeric vector of probability break points with values in (0, 1). It will be used to calculate 2 quantiles along the trajectory and to calculate the logfc.
min.pct	only test genes that are detected in a minimum proportion of cells (passed as `min.prop` to the internal `filterByExpr()` filter). Default is 0.1.
min.count	Minimum count threshold for gene filtering
pseudocount.use	Pseudocount to add to averaged expression values when calculating logFC. 1 by default.
assay	the assay to be used (for Seurat objects)
complete.results	Whether to return complete results or summary

Value

A data frame with differential expression results

Examples

```
## Not run:
# Run trajectory DE test on a Seurat object
de_results <- TrajDETest(seurat_obj, traj.var = "pseudotime")

## End(Not run)
```

`TransferAnchorSet-class` *The TransferAnchorSet Class*

Description

Inherits from the Anchorset class. Implemented mainly for method dispatch purposes. See `AnchorSet` for slot details.

`TransferData` *Transfer data*

Description

Transfer categorical or continuous data across single-cell datasets. For transferring categorical information, pass a vector from the reference dataset (e.g. `refdata = reference$celltype`). For transferring continuous information, pass a matrix from the reference dataset (e.g. `refdata = GetAssayData(reference[['RNA']])`).

Usage

```
TransferData(
  anchorset,
  refdata,
  reference = NULL,
  query = NULL,
  query.assay = NULL,
  weight.reduction = "pcaproject",
  l2.norm = FALSE,
  dims = NULL,
  k.weight = 50,
  sd.weight = 1,
  eps = 0,
  n.trees = 50,
  verbose = TRUE,
  slot = "data",
  prediction.assay = FALSE,
  only.weights = FALSE,
  store.weights = TRUE
)
```

Arguments

anchorset	An AnchorSet object generated by FindTransferAnchors
refdata	Data to transfer. This can be specified in one of two ways: • The reference data itself as either a vector where the names correspond to the reference cells, or a matrix, where the column names correspond to the reference cells. • The name of the metadata field or assay from the reference object provided. This requires the reference parameter to be specified. If pulling assay data in this manner, it will pull the data from the data slot. To transfer data from other slots, please pull the data explicitly with GetAssayData and provide that matrix here.
reference	Reference object from which to pull data to transfer
query	Query object into which the data will be transferred.
query.assay	Name of the Assay to use from query
weight.reduction	Dimensional reduction to use for the weighting anchors. Options are: • pcaproject: Use the projected PCA used for anchor building • lsiproject: Use the projected LSI used for anchor building • pca: Use an internal PCA on the query only • cca: Use the CCA used for anchor building • custom DimReduc: User provided \[SeuratObject]{DimReduc} object computed on the query cells
l2.norm	Perform L2 normalization on the cell embeddings after dimensional reduction
dims	Set of dimensions to use in the anchor weighting procedure. If NULL, the same dimensions that were used to find anchors will be used for weighting.
k.weight	Number of neighbors to consider when weighting anchors
sd.weight	Controls the bandwidth of the Gaussian kernel for weighting
eps	Error bound on the neighbor finding algorithm (from RANN)
n.trees	More trees gives higher precision when using annoy approximate nearest neighbor search
verbose	Print progress bars and output
slot	Slot to store the imputed data. Must be either "data" (default) or "counts"
prediction.assay	Return an Assay object with the prediction scores for each class stored in the data slot.
only.weights	Only return weights matrix
store.weights	Optionally store the weights matrix used for predictions in the returned query object.

Details

The main steps of this procedure are outlined below. For a more detailed description of the methodology, please see Stuart, Butler, et al Cell 2019. doi:10.1016/j.cell.2019.05.031; doi:10.1101/460147

For both transferring discrete labels and also feature imputation, we first compute the weights matrix.

- Construct a weights matrix that defines the association between each query cell and each anchor. These weights are computed as 1 - the distance between the query cell and the anchor divided by the distance of the query cell to the `k.weight`th anchor multiplied by the anchor score computed in `FindIntegrationAnchors`. We then apply a Gaussian kernel width a bandwidth defined by `sd.weight` and normalize across all `k.weight` anchors.

The main difference between label transfer (classification) and feature imputation is what gets multiplied by the weights matrix. For label transfer, we perform the following steps:

- Create a binary classification matrix, the rows corresponding to each possible class and the columns corresponding to the anchors. If the reference cell in the anchor pair is a member of a certain class, that matrix entry is filled with a 1, otherwise 0.
- Multiply this classification matrix by the transpose of weights matrix to compute a prediction score for each class for each cell in the query dataset.

For feature imputation, we perform the following step:

- Multiply the expression matrix for the reference anchor cells by the weights matrix. This returns a predicted expression matrix for the specified features for each cell in the query dataset.

Value

If `query` is not provided, for the categorical data in `refdata`, returns a data.frame with label predictions. If `refdata` is a matrix, returns an Assay object where the imputed data has been stored in the provided slot.

If `query` is provided, a modified query object is returned. For the categorical data in refdata, prediction scores are stored as Assays (prediction.score.NAME) and two additional metadata fields: predicted.NAME and predicted.NAME.score which contain the class prediction and the score for that predicted class. For continuous data, an Assay called NAME is returned. NAME here corresponds to the name of the element in the refdata list.

References

Stuart T, Butler A, et al. Comprehensive Integration of Single-Cell Data. Cell. 2019;177:1888-1902 doi:10.1016/j.cell.2019.05.031

Examples

```
## Not run:
# to install the SeuratData package see https://github.com/satijalab/seurat-data
library(SeuratData)
data("pbmc3k")
```

```
# for demonstration, split the object into reference and query
pbmc.reference <- pbmc3k[, 1:1350]
pbmc.query <- pbmc3k[, 1351:2700]

# perform standard preprocessing on each object
pbmc.reference <- NormalizeData(pbmc.reference)
pbmc.reference <- FindVariableFeatures(pbmc.reference)
pbmc.reference <- ScaleData(pbmc.reference)

pbmc.query <- NormalizeData(pbmc.query)
pbmc.query <- FindVariableFeatures(pbmc.query)
pbmc.query <- ScaleData(pbmc.query)

# find anchors
anchors <- FindTransferAnchors(reference = pbmc.reference, query = pbmc.query)

# transfer labels
predictions <- TransferData(anchorset = anchors, refdata = pbmc.reference$seurat_annotations)
pbmc.query <- AddMetaData(object = pbmc.query, metadata = predictions)

## End(Not run)
```

`TransferSketchLabels` *Transfer data from sketch data to full data*

Description

This function transfers cell type labels from a sketched dataset to a full dataset based on the similarities in the lower dimensional space.

Usage

```
TransferSketchLabels(
  object,
  sketched.assay = "sketch",
  reduction,
  dims,
  refdata = NULL,
  k = 50,
  reduction.model = NULL,
  neighbors = NULL,
  recompute.neighbors = FALSE,
  recompute.weights = FALSE,
  verbose = TRUE
)
```

Arguments

object	A Seurat object.
sketched.assay	Sketched assay name. Default is 'sketch'.
reduction	Dimensional reduction name to use for label transfer.
dims	An integer vector indicating which dimensions to use for label transfer.
refdata	A list of character strings indicating the metadata columns containing labels to transfer. Default is NULL. Similar to refdata in 'MapQuery'
k	Number of neighbors to use for label transfer. Default is 50.
reduction.model	Dimensional reduction model to use for label transfer. Default is NULL.
neighbors	An object storing the neighbors found during the sketching process. Default is NULL.
recompute.neighbors	Whether to recompute the neighbors for label transfer. Default is FALSE.
recompute.weights	Whether to recompute the weights for label transfer. Default is FALSE.
verbose	Print progress and diagnostic messages

Value

A Seurat object with transferred labels stored in the metadata. If a UMAP model is provided, the full data are also projected onto the UMAP space, with the results stored in a new reduction, full.'reduction.model'

UnSketchEmbeddings *Transfer embeddings from sketched cells to the full data*

Description

Transfer embeddings from sketched cells to the full data

Usage

```
UnSketchEmbeddings(
  atom.data,
  atom.cells = NULL,
  orig.data,
  embeddings,
  sketch.matrix = NULL
)
```

Arguments

atom.data	Atom data
atom.cells	Atom cells
orig.data	Original data
embeddings	Embeddings of atom cells
sketch.matrix	Sketch matrix

UpdateSCTAssays *Update pre-V4 Assays generated with SCTransform in the Seurat to the new SCTAssay class*

Description

Update pre-V4 Assays generated with SCTransform in the Seurat to the new SCTAssay class

Usage

```
UpdateSCTAssays(object)
```

Arguments

object	A Seurat object

Value

A Seurat object with updated SCTAssays

UpdateSymbolList *Get updated synonyms for gene symbols*

Description

Find current gene symbols based on old or alias symbols using the gene names database from the HUGO Gene Nomenclature Committee (HGNC)

Usage

```
GeneSymbolThesarus(
  symbols,
  timeout = 10,
  several.ok = FALSE,
  search.types = c("alias_symbol", "prev_symbol"),
  verbose = TRUE,
  ...
)

UpdateSymbolList(
  symbols,
  timeout = 10,
  several.ok = FALSE,
  verbose = TRUE,
  ...
)
```

Arguments

symbols	A vector of gene symbols
timeout	Time to wait before canceling query in seconds
several.ok	Allow several current gene symbols for each provided symbol
search.types	Type of query to perform: **"alias_symbol"** Find alternate symbols for the genes described by symbols **"prev_symbol"** Find new new symbols for the genes described by symbols This parameter accepts multiple options and short-hand options (eg. "prev" for "prev_symbol")
verbose	Show a progress bar depicting search progress
...	Extra parameters passed to GET

Details

For each symbol passed, we query the HGNC gene names database for current symbols that have the provided symbol as either an alias (alias_symbol) or old (prev_symbol) symbol. All other queries are **not** supported.

Value

GeneSymbolThesarus:, if several.ok, a named list where each entry is the current symbol found for each symbol provided and the names are the provided symbols. Otherwise, a named vector with the same information.

UpdateSymbolList: symbols with updated symbols from HGNC's gene names database

Note

This function requires internet access

Source

https://www.genenames.org/ https://www.genenames.org/help/rest/

See Also

GET

Examples

```
## Not run:
GeneSybmolThesarus(symbols = c("FAM64A"))

## End(Not run)

## Not run:
UpdateSymbolList(symbols = cc.genes$s.genes)

## End(Not run)
```

VariableFeaturePlot *View variable features*

Description

View variable features

Usage

```
VariableFeaturePlot(
  object,
  cols = c("black", "red"),
  pt.size = 1,
  log = NULL,
  selection.method = NULL,
  assay = NULL,
  raster = NULL,
  raster.dpi = c(512, 512)
)
```

Arguments

object	Seurat object
cols	Colors to specify non-variable/variable status
pt.size	Size of the points on the plot
log	Plot the x-axis in log scale

selection.method
: **[Deprecated]**

assay
: Assay to pull variable features from

raster
: Convert points to raster format, default is NULL which will automatically use raster if the number of points plotted is greater than 100,000

raster.dpi
: Pixel resolution for rasterized plots, passed to geom_scattermore(). Default is c(512, 512).

Value

A ggplot object

See Also

FindVariableFeatures

Examples

```
data("pbmc_small")
VariableFeaturePlot(object = pbmc_small)
```

VisiumV1-class *The VisiumV1 class*

Description

The VisiumV1 class represents spatial information from the 10X Genomics Visium platform

Slots

image A three-dimensional array with PNG image data, see readPNG for more details

scale.factors An object of class scalefactors; see scalefactors for more information

coordinates A data frame with tissue coordinate information

spot.radius Single numeric value giving the radius of the spots

---

VisiumV2-class *The VisiumV2 class*

Description

The VisiumV2 class represents spatial information from the 10X Genomics Visium HD platform - it can also accomodate data from the standard Visium platform

Slots

image A three-dimensional array with PNG image data, see readPNG for more details

scale.factors An object of class scalefactors; see scalefactors for more information

VizDimLoadings *Visualize Dimensional Reduction genes*

Description

Visualize top genes associated with reduction components

Usage

```
VizDimLoadings(
  object,
  dims = 1:5,
  nfeatures = 30,
  col = "blue",
  reduction = "pca",
  projected = FALSE,
  balanced = FALSE,
  ncol = NULL,
  combine = TRUE
)
```

Arguments

object	Seurat object
dims	Number of dimensions to display
nfeatures	Number of genes to display
col	Color of points to use
reduction	Reduction technique to visualize results for
projected	Use reduction values for full dataset (i.e. projected dimensional reduction values)
balanced	Return an equal number of genes with + and - scores. If FALSE (default), returns the top genes ranked by the scores absolute values
ncol	Number of columns to display
combine	Combine plots into a single patchwork ggplot object. If FALSE, return a list of ggplot objects

Value

A patchwork ggplot object if combine = TRUE; otherwise, a list of ggplot objects

Examples

```
data("pbmc_small")
VizDimLoadings(object = pbmc_small, dims = 1)
```

`VlnPlot` *Single cell violin plot*

Description

Draws a violin plot of single cell data (gene expression, metrics, PC scores, etc.)

Usage

```
VlnPlot(
  object,
  features,
  cols = NULL,
  pt.size = NULL,
  alpha = 1,
  idents = NULL,
  sort = FALSE,
  assay = NULL,
  group.by = NULL,
  split.by = NULL,
  adjust = 1,
  y.max = NULL,
  same.y.lims = FALSE,
  log = FALSE,
  ncol = NULL,
  slot = deprecated(),
  layer = NULL,
  split.plot = FALSE,
  stack = FALSE,
  combine = TRUE,
  fill.by = "feature",
  flip = FALSE,
  add.noise = TRUE,
  raster = NULL,
  raster.dpi = 300
)
```

Arguments

`object`	Seurat object
`features`	Features to plot (gene expression, metrics, PC scores, anything that can be retreived by FetchData)
`cols`	Colors to use for plotting
`pt.size`	Point size for points
`alpha`	Alpha value for points

idents	Which classes to include in the plot (default is all)
sort	Sort identity classes (on the x-axis) by the average expression of the attribute being potted, can also pass 'increasing' or 'decreasing' to change sort direction
assay	Name of assay to use, defaults to the active assay
group.by	Group (color) cells in different ways (for example, orig.ident)
split.by	A factor in object metadata to split the plot by, pass 'ident' to split by cell identity
adjust	Adjust parameter for geom_violin
y.max	Maximum y axis value
same.y.lims	Set all the y-axis limits to the same values
log	plot the feature axis on log scale
ncol	Number of columns if multiple plots are displayed
slot	Slot to pull expression data from (e.g. "counts" or "data")
layer	Layer to pull expression data from (e.g. "counts" or "data")
split.plot	plot each group of the split violin plots by multiple or single violin shapes.
stack	Horizontally stack plots for each feature
combine	Combine plots into a single patchworked ggplot object. If FALSE, return a list of ggplot
fill.by	Color violins/ridges based on either 'feature' or 'ident'
flip	flip plot orientation (identities on x-axis)
add.noise	determine if adding a small noise for plotting
raster	Convert points to raster format. Requires 'ggrastr' to be installed.
raster.dpi	the dpi for raster layer, default is 300. See rasterize for more info.

Value

A patchworked ggplot object if combine = TRUE; otherwise, a list of ggplot objects

See Also

FetchData

Examples

```
data("pbmc_small")
VlnPlot(object = pbmc_small, features = 'PC_1')
VlnPlot(object = pbmc_small, features = 'LYZ', split.by = 'groups')
```

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