Package 'musicatk'

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Type Package

Title Mutational Signature Comprehensive Analysis Toolkit

Version 2.6.0

Description Mutational signatures are carcinogenic exposures or aberrant cellular processes that can cause alterations to the genome. We created musicatk (MUtational SIgnature Comprehensive Analysis ToolKit) to address shortcomings in versatility and ease of use in other pre-existing computational tools. Although many different types of mutational data have been generated, current software packages do not have a flexible framework to allow users to mix and match different types of mutations in the mutational signature inference process. Musicatk enables users to count and combine multiple mutation types, including SBS, DBS, and indels. Musicatk calculates replication strand, transcription strand and combinations of these features along with discovery from unique and proprietary genomic feature associated with any mutation type. Musicatk also implements several methods for discovery of new signatures as well as methods to infer exposure given an existing set of signatures. Musicatk provides functions for visualization and downstream exploratory analysis including the ability to compare signatures between cohorts and find matching signatures in COSMIC V2 or COSMIC V3.

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URL https://www.camplab.net/musicatk/

BugReports https://github.com/campbio/musicatk/issues

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`.jsd` *Calculates 1 - Jensen-Shannon Divergences between all pairs of columns between two matrices*

Description

Calculates 1 - Jensen-Shannon Divergences between all pairs of columns between two matrices

Usage

```
.jsd(p, q, epsilon = 1e-07)
```

Arguments

p	First matrix
q	Second matrix
epsilon	Number to add to all probabilities. Default 0.0000001.

Value

Returns matrix of 1 - Jensen-Shannon Divergences

---

add_flank_to_variants *Uses a genome object to find context and add it to the variant table*

Description

Uses a genome object to find context and add it to the variant table

Usage

```
add_flank_to_variants(
  musica,
  g,
  flank_start,
  flank_end,
  build_table = TRUE,
  overwrite = FALSE
)
```

Arguments

musica	Input samples
g	A BSgenome object indicating which genome reference the variants and their coordinates were derived from.
flank_start	Start of flank area to add, can be positive or negative
flank_end	End of flank area to add, can be positive or negative
build_table	Automatically build a table using the annotation and add
overwrite	Overwrite existing count table

Value

None it to the musica

Examples

```
data(musica_sbs96_tiny)
g <- select_genome("19")
add_flank_to_variants(musica_sbs96_tiny, g, 1, 2)
add_flank_to_variants(musica_sbs96_tiny, g, -2, -1)
```

add_result *Load an external model into a musica object*

Description

This function creates a result_model object from signatures, exposures, and a mutation count table, and stores it in a provided musica object.

Usage

```
add_result(
  signatures,
  exposures,
  musica,
  result_name,
  modality,
  model_id,
  make_copy = FALSE
)
```

Arguments

signatures	A matrix or data.frame of signatures by mutational motifs
exposures	A matrix or data.frame of samples by signature weights
musica	Existing musica object to add the new model to
result_name	Name of result list entry to store the model in
modality	Modality of the model
model_id	Name of model
make_copy	If FALSE, the inputted musica object is updated and nothing is returned. If TRUE, a new musica object is created and returned. Default FALSE.

Value

A musica object

Examples

```
signatures <- signatures(res, "result", "SBS96", "res")
exposures <- exposures(res, "result", "SBS96", "res")
add_result(signatures, exposures, musica = musica_annot,
result_name = "result", modality = "SBS96", model_id = "example_model")
```

add_variant_type *Generates a variant type table*

Description

Generates a variant type table

Usage

```
add_variant_type(tab)
```

Arguments

tab	Input variant table

Value

Returns the inputted variant table with variant type ("SBS", "DBS", "INS", "DEL") added as an appended "Variant_Type" column

Examples

```
data(musica)
variants <- variants(musica)
musicatk:::add_variant_type(variants)
```

annotate_replication_strand *Add replication strand annotation to SBS variants based on bedgraph file*

Description

Add replication strand annotation to SBS variants based on bedgraph file

Usage

```
annotate_replication_strand(musica, rep_range, build_table = TRUE)
```

Arguments

musica	A musica object.
rep_range	A GRanges object with replication timing as metadata
build_table	Automatically build a table from this annotation

Value

None

Examples

```
data(musica)
data(rep_range)
annotate_replication_strand(musica, rep_range)
```

`annotate_transcript_strand` *Add transcript strand annotation to SBS variants (defined in genes only)*

Description

Add transcript strand annotation to SBS variants (defined in genes only)

Usage

```
annotate_transcript_strand(musica, genome_build, build_table = TRUE)
```

Arguments

`musica`	A `musica` object.
`genome_build`	Which genome build to use: hg19, hg38, or a custom TxDb object
`build_table`	Automatically build a table from this annotation

Value

None

Examples

```
data(musica)
annotate_transcript_strand(musica, 19)
```

annotate_variant_length

Adds an annotation to the input musica's variant table with length of each variant

Description

Adds an annotation to the input musica's variant table with length of each variant

Usage

```
annotate_variant_length(musica)
```

Arguments

musica	Input samples

Value

None

Examples

```
data(musica)
annotate_variant_length(musica)
musica
```

annotate_variant_type

Annotate variants with variant type ("SBS", "INS", "DEl", "DBS")

Description

Annotate variants with variant type ("SBS", "INS", "DEl", "DBS")

Usage

```
annotate_variant_type(musica)
```

Arguments

musica	A musica object.

Value

None

Examples

```
data(musica)
annotate_variant_type(musica)
```

`auto_predict_grid` *Automatic filtering of signatures for exposure prediction gridded across specific annotation*

Description

Automatic filtering of signatures for exposure prediction gridded across specific annotation

Usage

```
auto_predict_grid(
  musica,
  modality,
  signature_res,
  algorithm,
  model_id = NULL,
  result_name = "result",
  sample_annotation = NULL,
  min_exists = 0.05,
  proportion_samples = 0.25,
  rare_exposure = 0.4,
  verbose = TRUE,
  combine_res = TRUE,
  make_copy = FALSE,
  table_name = NULL
)
```

Arguments

`musica`	Input samples to predict signature weights
`modality`	Modality used for posterior prediction (e.g. SBS96)
`signature_res`	Signatures to automatically subset from for prediction
`algorithm`	Algorithm to use for prediction. Choose from "lda_posterior", and decompTumor2Sig
`model_id`	Name of model
`result_name`	Name for result_list entry to save the results to. Default `"result"`.
`sample_annotation`	Annotation to grid across, if none given, prediction subsetting on all samples together
`min_exists`	Threshold to consider a signature active in a sample

proportion_samples
: Threshold of samples to consider a signature active in the cohort

rare_exposure
: A sample will be considered active in the cohort if at least one sample has more than this threshold proportion

verbose
: Print current annotation value being predicted on

combine_res
: Automatically combines a list of annotation results into a single result object with zero exposure values for signatures not found in a given annotation's set of samples

make_copy
: If FALSE, the inputted musica object is updated and nothing is returned. If TRUE, a new musica object is created and returned. Default FALSE.

table_name
: Use modality instead

Value

Returns nothing or a new musica object, depending on the make_copy parameter.

Examples

```
data(musica_annot)
data(cosmic_v2_sigs)
auto_predict_grid(
  musica = musica_annot, modality = "SBS96",
  signature_res = cosmic_v2_sigs, algorithm = "lda",
  sample_annotation = "Tumor_Subtypes"
)
auto_predict_grid(musica_annot, "SBS96", cosmic_v2_sigs, "lda")
```

---

auto_subset_sigs *Automatic filtering of inactive signatures*

Description

Automatic filtering of inactive signatures

Usage

```
auto_subset_sigs(
  musica,
  modality,
  signature_res,
  algorithm,
  min_exists = 0.05,
  proportion_samples = 0.25,
  rare_exposure = 0.4,
  result_name = "result",
  model_id = NULL
)
```

Arguments

musica	A musica object.
modality	Modality used for posterior prediction (e.g. SBS96)
signature_res	Signatures to automatically subset from for prediction
algorithm	Algorithm to use for prediction. Choose from "lda_posterior" and decompTumor2Sig
min_exists	Threshold to consider a signature active in a sample
proportion_samples	Threshold of samples to consider a signature active in the cohort
rare_exposure	A sample will be considered active in the cohort if at least one sample has more than this threshold proportion
result_name	Name for result_list entry to save the results to. Default "result".
model_id	Identifier for the result. If NULL, will be automatically set to the algorithm and number of signatures. Default NULL.

Value

Returns new musica object with the results.

---

build_custom_table *Builds a custom table from specified user variants*

Description

Builds a custom table from specified user variants

Usage

```
build_custom_table(
  musica,
  variant_annotation,
  name,
  description = character(),
  data_factor = NA,
  annotation_df = NULL,
  features = NULL,
  type = NULL,
  color_variable = NULL,
  color_mapping = NULL,
  return_instead = FALSE,
  overwrite = FALSE
)
```

Arguments

musica	A musica object.
variant_annotation	User column to use for building table
name	Table name to refer to (must be unique)
description	Optional description of the table content
data_factor	Full set of table values, in case some are missing from the data. If NA, a superset of all available unique data values will be used
annotation_df	A data.frame of annotations to use for plotting
features	A data.frame of the input data from which the count table will be built
type	The type of data/mutation in each feature as an Rle object
color_variable	The name of the column of annotation_df used for the coloring in plots
color_mapping	The mapping from the values in the selected color_variable column to color values for plotting
return_instead	Instead of adding to musica object, return the created table
overwrite	Overwrite existing count table

Value

If return_instead = TRUE then the created table object is returned, otherwise the table object is automatically added to the musica's count_tables list and nothing is returned

Examples

```
data(musica)
annotate_transcript_strand(musica, "19", build_table = FALSE)
build_custom_table(musica, "Transcript_Strand", "Transcript_Strand",
  data_factor = factor(c("T", "U"))
)
```

---

build_standard_table *Builds count tables using various mutation type schemas*

Description

Generates count tables for different mutation type schemas which can be used as input to the mutational signature discovery or prediction functions. "SBS96" generates a table for single base substitutions following the standard 96 mutation types derived from the trinucleotide context. "SBS192" is the 96 mutation type schema with the addition of transcriptional strand or replication strand information added to each base. "DBS" generates a table for the double base substitution schema used in COSMIC V3. "Indel" generates a table for insertions and deletions following the schema used in COSMIC V3.

Usage

```
build_standard_table(
  musica,
  g,
  modality,
  strand_type = NULL,
  overwrite = FALSE,
  verbose = FALSE,
  table_name = NULL
)
```

Arguments

musica	A musica object.
g	A BSgenome object indicating which genome reference the variants and their coordinates were derived from.
modality	Modality of table to build. One of "SBS96", "SBS192", "DBS", or "Indel".
strand_type	Strand type to use in SBS192 schema. One of "Transcript_Strand" or "Replication_Strand". Only used if modality = SBS192.
overwrite	If TRUE, any existing count table with the same name will be overwritten. If FALSE, then an error will be thrown if a table with the same name exists within the musica object.
verbose	Show progress bar for processed samples
table_name	Use modality instead

Value

No object will be returned. The count tables will be automatically added to the musica object.

Examples

```
g <- select_genome("19")

data(musica)
build_standard_table(musica, g, "SBS96", overwrite = TRUE)

data(musica)
annotate_transcript_strand(musica, "19")
build_standard_table(musica, g, "SBS192", "Transcript_Strand")

data(musica)
data(rep_range)
annotate_replication_strand(musica, rep_range)
build_standard_table(musica, g, "SBS192", "Replication_Strand")

data(dbs_musica)
build_standard_table(dbs_musica, g, "DBS", overwrite = TRUE)
```

```
data(indel_musica)
build_standard_table(indel_musica, g, modality = "INDEL")
```

`built_tables` *Retrieve the names of count_tables from a musica object*

Description

The `count_tables` contains standard and/or custom count tables created from variants

Usage

```
built_tables(object)

## S4 method for signature 'musica'
built_tables(object)
```

Arguments

`object`	A `musica` object generated by the create_musica_from_variants or create_musica_from_counts function.

Value

The names of created count_tables

Examples

```
data(res)
built_tables(res)
```

`cluster_exposure` *Perform clustering analysis from a musica result object*

Description

Proportional sample exposures will be used as input to perform clustering.

Usage

```
cluster_exposure(
  musica,
  model_name,
  modality = "SBS96",
  result_name = "result",
  nclust,
  proportional = TRUE,
  method = "kmeans",
  dis.method = "euclidean",
  hc.method = "ward.D",
  clara.samples = 5,
  iter.max = 10,
  tol = 1e-15
)
```

Arguments

musica	A musica object containing a mutational discovery or prediction.
model_name	The name of the desired model.
modality	The modality of the model. Must be "SBS96", "DBS78", or "IND83". Default "SBS96".
result_name	Name of the result list entry containing desired model. Default "result".
nclust	Pre-defined number of clusters.
proportional	Logical, indicating if proportional exposure (default) will be used for clustering.
method	Clustering algorithms. Options are "kmeans" (K-means), "hkmeans" (hybrid of hierarchical K-means), "hclust" (hierarchical clustering), "pam" (PAM), and "clara" (Clara).
dis.method	Methods to calculate dissimilarity matrix. Options are "euclidean" (default), "manhattan", "jaccard", "cosine", and "canberra".
hc.method	Methods to perform hierarchical clustering. Options are "ward.D" (default), "ward.D2", "single", "complete", "average", "mcquitty", "median", and "centroid".
clara.samples	Number of samples to be drawn from dataset. Only used when "clara" is selected. Default is 5.
iter.max	Maximum number of iterations for k-means clustering.
tol	Tolerance level for kmeans clustering level iterations

Value

A one-column data frame with sample IDs as row names and cluster number for each sample.

See Also

kmeans

Examples

```
set.seed(123)
data(res_annot)
clust_out <- cluster_exposure(res_annot, model_name = "res_annot",
nclust = 2)
```

`combine_count_tables` *Combines tables into a single table that can be used for discovery/prediction*

Description

Combines tables into a single table that can be used for discovery/prediction

Usage

```
combine_count_tables(
  musica,
  to_comb,
  name,
  description = character(),
  color_variable = character(),
  color_mapping = character(),
  overwrite = FALSE
)
```

Arguments

`musica`	A `musica` object.
`to_comb`	A vector of table names to combine. Each table must already exist within the input musica object
`name`	Name of table build, must be a new name
`description`	Description of the new table
`color_variable`	Annotation column to use for coloring plotted motifs, provided by counts table from input result's musica object
`color_mapping`	Mapping from color_variable to color names, provided by counts table from input result's musica object
`overwrite`	Overwrite existing count table

Value

None

Examples

```
g <- select_genome("19")

data(musica)
build_standard_table(musica, g, "SBS96", overwrite = TRUE)

annotate_transcript_strand(musica, "19")
build_standard_table(musica, g, "SBS192", "Transcript_Strand")

combine_count_tables(musica, c("SBS96", "SBS192_Trans"), "combo")
```

`combine_predict_grid` *Combine signatures and exposures of different models. Exposure values are zero for samples in an annotation where that signature was not predicted*

Description

Combine signatures and exposures of different models. Exposure values are zero for samples in an annotation where that signature was not predicted

Usage

```
combine_predict_grid(
  musica,
  modality,
  signature_res,
  model_ids = NULL,
  result_name = "result",
  model_rename = NULL,
  make_copy = FALSE,
  table_name = NULL
)
```

Arguments

`musica`	A `musica` object.
`modality`	Modality used for prediction.
`signature_res`	Signatures to automatically subset from for prediction
`model_ids`	Vector of ids for the models to combine. If null, all models in the modality and result_list entry will be combined. Default `NULL`.
`result_name`	Name of the result list entry containing the signatures to plot. Default `"result"`.
`model_rename`	New model identifier. If null, will be combination of the ids for the models being combined. Deafult `NULL`.
`make_copy`	If `FALSE`, the inputted `musica` object is updated and nothing is returned. If `TRUE`, a new `musica` object is created and returned. Default `FALSE`.
`table_name`	Use modality instead

Value

Returns nothing or a new musica object, depending on the make_copy parameter.

Examples

```
data(musica_annot)
data(cosmic_v2_sigs)
grid <- auto_predict_grid(musica_annot, "SBS96", cosmic_v2_sigs, "lda",
  "Tumor_Subtypes",
  combine_res = FALSE, make_copy = TRUE
)
combined <- combine_predict_grid(grid, "SBS96", cosmic_v2_sigs,
make_copy = TRUE)
```

---

compare_cosmic_v2 *Compare a result object to COSMIC V2 SBS Signatures (combination whole-exome and whole-genome)*

Description

Compare a result object to COSMIC V2 SBS Signatures (combination whole-exome and whole-genome)

Usage

```
compare_cosmic_v2(
  musica,
  model_id,
  modality = "SBS96",
  result_name = "result",
  metric = "cosine",
  threshold = 0.9,
  result_rename = deparse(substitute(result)),
  decimals = 2,
  same_scale = FALSE
)
```

Arguments

musica	A musica object.
model_id	The name of the model containing the signatures to compare.
modality	Compare to SBS, DBS, or Indel. Default "SBS96"
result_name	Name of the result list entry. Default "result".
metric	One of "cosine" for cosine similarity or "jsd" for 1 minus the Jensen-Shannon Divergence. Default "cosine".
threshold	threshold for similarity

result_rename	title for plot user result signatures
decimals	Specifies rounding for similarity metric displayed. Default 2.
same_scale	If TRUE, the scale of the probability for each signature will be the same. If FALSE, then the scale of the y-axis will be adjusted for each signature. Default TRUE.

Value

Returns the comparisons

Examples

```
data(res)
compare_cosmic_v2(res, model_id = "res", threshold = 0.7)
```

---

compare_cosmic_v3 *Compare a result object to COSMIC V3 Signatures; Select exome or genome for SBS and only genome for DBS or Indel classes*

Description

Compare a result object to COSMIC V3 Signatures; Select exome or genome for SBS and only genome for DBS or Indel classes

Usage

```
compare_cosmic_v3(
  musica,
  model_id,
  sample_type,
  modality = "SBS96",
  result_name = "result",
  metric = "cosine",
  threshold = 0.9,
  result_rename = deparse(substitute(model_id)),
  decimals = 2,
  same_scale = FALSE
)
```

Arguments

musica	A musica object.
model_id	The name of the model containing the signatures to compare.
sample_type	exome (SBS only) or genome
modality	Compare to SBS, DBS, or Indel. Default "SBS96"
result_name	Name of the result list entry. Default "result".

metric	One of "cosine" for cosine similarity or "jsd" for 1 minus the Jensen-Shannon Divergence. Default "cosine".
threshold	threshold for similarity
result_rename	title for plot user result signatures
decimals	Specifies rounding for similarity metric displayed. Default 2.
same_scale	If TRUE, the scale of the probability for each signature will be the same. If FALSE, then the scale of the y-axis will be adjusted for each signature. Default TRUE.

Value

Returns the comparisons

Examples

```
data(res)
compare_cosmic_v3(res,
  model_id = "res", modality = "SBS96",
  sample_type = "genome", threshold = 0.8
)
```

---

compare_k_vals *Compare k values*

Description

Compare the stability and error of various k values to help determine the correct number of signatures (k).

Usage

```
compare_k_vals(
  musica,
  modality,
  reps = 100,
  min_k = 1,
  max_k = 10,
  error_type = "prop",
  algorithm = "nmf"
)
```

Arguments

musica	A musica object.
modality	The modality to use, either "SBS96", "DBS78", or "IND83".
reps	Number of times prediction is performed. For each replicate, the count table data is perturbed. Multiple replicates allows for stability analysis by calculating silhouette width on the multiple results. Default 100.

min_k	Lower range of number of signatures for discovery. Default 1.
max_k	Upper range of number of signatures for discovery. Default 10.
error_type	Whether to calculate reconstruction error by proportions ("prop") or raw counts ("raw"). Default "prop".
algorithm	Algorithm for signature discovery. Default "nmf".

Value

a data.frame with stats for each k value tested

Examples

```
data(musica)
compare_k_vals(musica, "SBS96", reps = 3, min_k = 1, max_k = 5)
```

---

compare_results *Compare two result files to find similar signatures*

Description

Compare two result files to find similar signatures

Usage

```
compare_results(
  musica,
  model_id,
  other_model_id,
  modality = "SBS96",
  result_name = "result",
  other_musica = NULL,
  other_result_name = "result",
  threshold = 0.9,
  metric = "cosine",
  result_rename = deparse(substitute(model_id)),
  other_result_rename = deparse(substitute(other_model_id)),
  decimals = 2,
  same_scale = FALSE
)
```

Arguments

musica	A musica object.
model_id	The name of the first model to compare.
other_model_id	The name of the second model to compare.
modality	Modality of results being compared. Default "SBS96".

result_name	Name of the result list entry for the first result to compare. Default "result".
other_musica	A second musica object. If null, the provided musica object is used twice. Default NULL.
other_result_name	Name of the result list entry for the second result to compare. Default "result".
threshold	threshold for similarity
metric	One of "cosine" for cosine similarity or "jsd" for 1 minus the Jensen-Shannon Divergence. Default "cosine".
result_rename	title for plot of first result signatures
other_result_rename	title for plot of second result signatures
decimals	Specifies rounding for similarity metric displayed. Default 2.
same_scale	If TRUE, the scale of the probability for each signature will be the same. If FALSE, then the scale of the y-axis will be adjusted for each signature. Default FALSE.

Value

Returns the comparisons

Examples

```
data(res)
compare_results(res,
  model_id = "res", other_model_id = "res",
  modality = "SBS96", threshold = 0.8
)
```

---

cosmic_v2_sigs *COSMIC v2 SBS96 Signatures Result Object*

Description

Data from COSMIC formatted to be used for prediction with individual tumors and cohorts.

Usage

```
data(cosmic_v2_sigs)
```

Format

An object of class result_model See [predict_exposure()].

Source

COSMIC v2, <https://cancer.sanger.ac.uk/cosmic/signatures_v2>

References

Alexandrov, L., Nik-Zainal, S., Wedge, D. et al. (2013) Signatures of mutational processes in human cancer. Nature 500, 415–421 ([Nature](https://www.ncbi.nlm.nih.gov/pubmed/23945592))

`cosmic_v2_subtype_map` *Input a cancer subtype to return a list of related COSMIC signatures*

Description

Input a cancer subtype to return a list of related COSMIC signatures

Usage

```
cosmic_v2_subtype_map(tumor_type)
```

Arguments

`tumor_type`	Cancer subtype to view related signatures

Value

Returns signatures related to a partial string match

Examples

```
cosmic_v2_subtype_map("lung")
```

`cosmic_v3_dbs_sigs` *COSMIC v3 DBS Genome Signatures Result Object*

Description

Data from COSMIC formatted to be used for prediction with individual tumors and cohorts.

Usage

```
data(cosmic_v3_dbs_sigs)
```

Format

An object of class `result_model`. See [predict_exposure()].

Source

COSMIC v3, <https://cancer.sanger.ac.uk/cosmic/signatures>

References

Alexandrov, L.B., Kim, J., Haradhvala, N.J. et al. (2020) The repertoire of mutational signatures in human cancer. Nature 578, 94–101 ([Nature](https://doi.org/10.1038/s41586-020-1943-3))

`cosmic_v3_indel_sigs` *COSMIC v3 Indel Genome Signatures Result Object*

Description

Data from COSMIC formatted to be used for prediction with individual tumors and cohorts.

Usage

```
data(cosmic_v3_indel_sigs)
```

Format

An object of class `result_model`. See [predict_exposure()].

Source

COSMIC v3, <https://cancer.sanger.ac.uk/cosmic/signatures>

References

Alexandrov, L.B., Kim, J., Haradhvala, N.J. et al. (2020) The repertoire of mutational signatures in human cancer. Nature 578, 94–101 ([Nature](https://doi.org/10.1038/s41586-020-1943-3))

`cosmic_v3_sbs_sigs` *COSMIC v3 SBS96 Genome Signatures Result Object*

Description

Data from COSMIC formatted to be used for prediction with individual tumors and cohorts.

Usage

```
data(cosmic_v3_sbs_sigs)
```

Format

An object of class `result_model`. See [predict_exposure()].

Source

COSMIC v3, <https://cancer.sanger.ac.uk/cosmic/signatures>

References

Alexandrov, L.B., Kim, J., Haradhvala, N.J. et al. (2020) The repertoire of mutational signatures in human cancer. Nature 578, 94–101 ([Nature](https://doi.org/10.1038/s41586-020-1943-3))

`cosmic_v3_sbs_sigs_exome` *COSMIC v3 SBS96 Exome Signatures Result Object*

Description

Data from COSMIC formatted to be used for prediction with individual tumors and cohorts.

Usage

```
data(cosmic_v3_sbs_sigs_exome)
```

Format

An object of class `result_model`. See [predict_exposure()].

Source

COSMIC v3, <https://cancer.sanger.ac.uk/cosmic/signatures>

References

Alexandrov, L.B., Kim, J., Haradhvala, N.J. et al. (2020) The repertoire of mutational signatures in human cancer. Nature 578, 94–101 ([Nature](https://doi.org/10.1038/s41586-020-1943-3))

`count_table-class` *Object containing the count table matrices, their names and descriptions that we generated by provided and by user functions. These are used to discover and infer signatures and exposures.*

Description

Object containing the count table matrices, their names and descriptions that we generated by provided and by user functions. These are used to discover and infer signatures and exposures.

Slots

`name` A name that describes the type of table (e.g. "SBS96")

`count_table` An array of counts with samples as the columns and motifs as the rows

`annotation` A data.frame of annotations with three columns used for plotting: motif, mutation, and context

`features` Original features used to generate the count_table

`type` The mutation type of each feature, in case we need to plot or model they differently

`color_variable` The variable used for plotting colors, selected from the annotation slot

`color_mapping` The mapping of the annotations chosen by color_variable to color values for plotting

`description` A summary table of the result objects in result_list a list of lists. The nested lists created combined (rbind) tables, and the tables at the first list level are modelled independantly. Combined tables must be named. list("tableA", comboTable = list("tableC", "tableD"))

`create_dbs78_table` *Creates and adds a table for standard doublet base subsitution (DBS)*

Description

Creates and adds a table for standard doublet base subsitution (DBS)

Usage

```
create_dbs78_table(musica, overwrite = overwrite, verbose)
```

Arguments

`musica`	A `musica` object.
`overwrite`	Overwrite existing count table

Value

Returns the created DBS table object

create_musica_from_counts

Creates a musica object from a mutation count table

Description

This function creates a musica object from a mutation count table or matrix. The musica class stores variants information, variant-level annotations, sample-level annotations, and count tables and is used as input to the mutational signature discovery and prediction algorithms.

Usage

```
create_musica_from_counts(x, variant_class)
```

Arguments

x	A data.table, matrix, or data.frame that contains counts of mutation types for each sample, with samples as columns.
variant_class	Mutations are SBS, DBS, or Indel.

Value

Returns a musica object

Examples

```
data(musica)
count_table <- get_count_table(extract_count_tables(musica)$SBS96)
musica <- create_musica_from_counts(count_table, "SBS96")
```

create_musica_from_variants

Creates a musica object from a variant table

Description

This function creates a musica object from a variant table or matrix. The musica class stores variants information, variant-level annotations, sample-level annotations, and count tables and is used as input to the mutational signature discovery and prediction algorithms. The input variant table or matrix must have columns for chromosome, start position, end position, reference allele, alternate allele, and sample names. The column names in the variant table can be mapped using the chromosome_col, start_col, end_col, ref_col, alt_col, and sample_col parameters.

Usage

```
create_musica_from_variants(
  x,
  genome,
  check_ref_chromosomes = TRUE,
  check_ref_bases = TRUE,
  chromosome_col = "chr",
  start_col = "start",
  end_col = "end",
  ref_col = "ref",
  alt_col = "alt",
  sample_col = "sample",
  extra_fields = NULL,
  standardize_indels = TRUE,
  convert_dbs = TRUE,
  verbose = TRUE
)
```

Arguments

x	A data.table, matrix, or data.frame that contains columns with the variant information.
genome	A BSgenome object indicating which genome reference the variants and their coordinates were derived from.
check_ref_chromosomes	Whether to peform a check to ensure that the chromosomes in the variant object match the reference chromosomes in the genome object. If there are mismatches, this may cause errors in downstream generation of count tables. If mismatches occur, an attept to be automatically fix these with the seqlevelsStyle function will be made. Default TRUE.
check_ref_bases	Whether to check if the reference bases in the variant object match the reference bases in the genome object. Default TRUE.
chromosome_col	The name of the column that contains the chromosome reference for each variant. Default "chr".
start_col	The name of the column that contains the start position for each variant. Default "start".
end_col	The name of the column that contains the end position for each variant. Default "end".
ref_col	The name of the column that contains the reference base(s) for each variant. Default "ref".
alt_col	The name of the column that contains the alternative base(s) for each variant. Default "alt".
sample_col	The name of the column that contains the sample id for each variant. Default "sample".

extra_fields	Which additional fields to extract and include in the musica object. Default NULL.
standardize_indels	Flag to convert indel style (e.g. 'C > CAT' becomes '- > AT' and 'GCACA > G' becomes 'CACA > -')
convert_dbs	Flag to convert adjacent SBS into DBS (original SBS are removed)
verbose	Whether to print status messages during error checking. Default TRUE.

Value

Returns a musica object

Examples

```
maf_file <- system.file("extdata", "public_TCGA.LUSC.maf",
  package = "musicatk"
)
variants <- extract_variants_from_maf_file(maf_file)
g <- select_genome("38")
musica <- create_musica_from_variants(x = variants, genome = g)
```

---

create_sbs192_table *Uses a genome object to find context and generate standard SBS192 table using transcript strand*

Description

Uses a genome object to find context and generate standard SBS192 table using transcript strand

Usage

```
create_sbs192_table(musica, g, strand_type, overwrite = FALSE)
```

Arguments

musica	Input samples
g	A BSgenome object indicating which genome reference the variants and their coordinates were derived from.
strand_type	Transcript_Strand or Replication_Strand
overwrite	Overwrite existing count table

Value

Returns the created SBS192 count table object built using either transcript strand or replication strand

create_sbs96_table *Uses a genome object to find context and generate standard SBS96 tables*

Description

Uses a genome object to find context and generate standard SBS96 tables

Usage

```
create_sbs96_table(musica, g, overwrite = FALSE)
```

Arguments

musica	A musica object.
g	A BSgenome object indicating which genome reference the variants and their coordinates were derived from.
overwrite	Overwrite existing count table

Value

Returns the created SBS96 count table object

create_umap *Create a UMAP from a model result*

Description

Proportional sample exposures will be used as input into the umap function to generate a two dimensional UMAP.

Usage

```
create_umap(
  musica,
  model_name,
  modality = "SBS96",
  result_name = "result",
  n_neighbors = 30,
  min_dist = 0.75,
  spread = 1
)
```

Arguments

musica	A musica object containing a mutational signature discovery or prediction.
model_name	The name of the desired model.
modality	The modality of the model. Must be "SBS96", "DBS78", or "IND83". Default "SBS96".
result_name	Name of the result list entry containing the model. Default "result".
n_neighbors	The size of local neighborhood used for views of manifold approximation. Larger values result in more global the manifold, while smaller values result in more local data being preserved. If n_neighbors is larger than the number of samples, then n_neighbors will automatically be set to the number of samples in the musica. Default 30.
min_dist	The effective minimum distance between embedded points. Smaller values will result in a more clustered/clumped embedding where nearby points on the manifold are drawn closer together, while larger values will result on a more even dispersal of points. Default 0.2.
spread	The effective scale of embedded points. In combination with 'min_dist', this determines how clustered/clumped the embedded points are. Default 1.

Value

A musica object with a new UMAP stored in the UMAP slot of the result_model object for the model.

See Also

See plot_umap to display the UMAP and umap for more information on the individual parameters for generating UMAPs.

Examples

```
data(res_annot)
create_umap(res_annot, model_name = "res_annot")
```

---

credible_intervals *Retrieve credible_intervals from a result_model, result_collection, or musica object*

Description

Credible intervals for the model

Usage

```
credible_intervals(x, ...)

## S4 method for signature 'musica'
credible_intervals(x, result, modality, model_id)

## S4 method for signature 'result_collection'
credible_intervals(x, modality, model_id)

## S4 method for signature 'result_model'
credible_intervals(x)

credible_intervals(x, ...) <- value

## S4 replacement method for signature 'musica,matrix'
credible_intervals(x, result, modality, model_id) <- value

## S4 replacement method for signature 'result_collection,matrix'
credible_intervals(x, modality, model_id) <- value

## S4 replacement method for signature 'result_model,matrix'
credible_intervals(x) <- value
```

Arguments

x	A musica, result_collection, or result_model object generated by a mutational discovery or prediction tool.
...	Other inputs
result	Name of result from result_list to assign the credible_intervals. Used when result is a musica object.
modality	Modality to assign the credible_intervals. Used when result is a musica or result_collection object.
model_id	Model identifier to assign the credible_intervals. Used when result is a musica or result_collection object.
value	List of credible intervals

Value

The credible intervals for the model

Examples

```
data(res)
credible_intervals(res, "result", "SBS96", "res")
```

dbs_musica *dbs_musica*

Description

A musica created for testing that includes DBS variants

Usage

```
data(dbs_musica)
```

Format

An object of class `musica` See [create_musica_from_variants()] and [create_musica_from_counts()].

discover_signatures *Discover mutational signatures*

Description

Mutational signatures and exposures will be discovered using methods such as Latent Dirichlet Allocation (lda) or Non-Negative Matrix Factorization (nmf). These algorithms will deconvolute a matrix of counts for mutation types in each sample to two matrices: 1) a "signature" matrix containing the probability of each mutation type in each sample and 2) an "exposure" matrix containing the estimated counts for each signature in each sample. Before mutational discovery can be performed, samples first need to be stored in a `musica` object using the create_musica_from_variants or create_musica_from_counts function and mutation count tables need to be created using functions such as build_standard_table if create_musica_from_counts was not used.

Usage

```
discover_signatures(
  musica,
  modality,
  num_signatures,
  algorithm = "lda",
  result_name = "result",
  model_id = NULL,
  seed = 1,
  nstart = 10,
  par_cores = 1,
  make_copy = FALSE,
  table_name = NULL
)
```

Arguments

musica	A musica object.
modality	Modality to use for signature discovery. Needs to be the same name supplied to the table building functions such as build_standard_table.
num_signatures	Number of signatures to discover.
algorithm	Method to use for mutational signature discovery. One of "lda" or "nmf". Default "lda".
result_name	Name for result_list entry to save the results to. Default "result".
model_id	Identifier for the result. If NULL, will be automatically set to the algorithm and number of signatures. Default NULL.
seed	Seed to be used for the random number generators in the signature discovery algorithms. Default 1.
nstart	Number of independent random starts used in the mutational signature algorithms. Default 10.
par_cores	Number of parallel cores to use. Only used if method = "nmf". Default 1.
make_copy	If FALSE, the inputted musica object is updated and nothing is returned. If TRUE, a new musica object is created and returned. Default FALSE.
table_name	Use modality instead

Value

Returns nothing or a new musica object, depending on the make_copy parameter.

Examples

```
data(musica)
g <- select_genome("19")
build_standard_table(musica, g, "SBS96", overwrite = TRUE)
discover_signatures(
  musica = musica, modality = "SBS96",
  num_signatures = 3, algorithm = "lda", seed = 12345, nstart = 1
)
```

---

drop_annotation *Drops a column from the variant table that the user no longer needs*

Description

Drops a column from the variant table that the user no longer needs

Usage

```
drop_annotation(musica, column_name)
```

Arguments

musica	A musica object.
column_name	Name of column to drop

Value

None

Examples

```
data(musica)
drop_annotation(musica, "Variant_Type")
```

---

exposures *Retrieve exposures from a result_model, result_collection, or musica object*

Description

The exposure matrix contains estimated amount of each signature for each sample. Rows correspond to each signature and columns correspond to each sample.

Usage

```
exposures(x, ...)

## S4 method for signature 'musica'
exposures(x, result, modality, model_id)

## S4 method for signature 'result_collection'
exposures(x, modality, model_id)

## S4 method for signature 'result_model'
exposures(x)

exposures(x, ...) <- value

## S4 replacement method for signature 'musica,matrix'
exposures(x, result, modality, model_id) <- value

## S4 replacement method for signature 'result_collection,matrix'
exposures(x, modality, model_id) <- value

## S4 replacement method for signature 'result_model,matrix'
exposures(x) <- value
```

Arguments

x	A musica, result_collection, or result_model object generated by a mutational discovery or prediction tool.
...	Other inputs
result	Name of result from result_list to assign the exposures. Used when result is a musica object.
modality	Modality to assign the exposures. Used when result is a musica or result_collection object.
model_id	Model identifier to assign the exposures. Used when result is a musica or result_collection object.
value	A matrix of samples by signature exposures

Value

A matrix of exposures

Examples

```
data(res)
exposures(res, "result", "SBS96", "res")
data(res)
exposures(res, "result", "SBS96", "res") <- matrix()
```

---

exposure_differential_analysis

Compare exposures of annotated samples

Description

exposure_differential_analysis is used to run differential analysis on the signature exposures of annotated samples.

Usage

```
exposure_differential_analysis(
  musica,
  model_name,
  annotation,
  modality = "SBS96",
  result_name = "result",
  method = c("wilcox", "kruskal", "glm.nb"),
  group1 = NULL,
  group2 = NULL,
  ...
)
```

Arguments

musica	A musica object.
model_name	The name of the model.
annotation	Column in the sample_annotations table of the musica object
modality	The modality. Must be "SBS96", "DBS78", or "IND83". Default "SBS96".
result_name	Name of the result list entry. Default "result".
method	Any method in c("wilcox", "kruskal", "glm.nb") used to perform differential analysis on signature exposures
group1	character vector used in the Wilcox test. Elements in group1 are compared to elements in group2. This is required for annotation with more than 2 levels.
group2	character vector used in the Wilcox test. Elements in group2 are compared to elements in group1. This is required for annotation with more than 2 levels.
...	Additional arguments to be passed to the chosen method

Value

A matrix containing statistics summarizing the analysis dependent on the chosen method

Examples

```
data("res_annot")
exposure_differential_analysis(res_annot,
  model_name = "res_annot",
  annotation = "Tumor_Subtypes", method = "wilcox"
)
```

---

extract_count_tables *Extract count tables list from a musica object*

Description

Extract count tables list from a musica object

Usage

```
extract_count_tables(musica)
```

Arguments

musica	A musica object.

Value

List of count tables objects

Examples

```
data(musica)
extract_count_tables(musica)
```

`extract_variants` *Extract variants from mutliple objects*

Description

Chooses the correct function to extract variants from input based on the class of the object or the file extension. Different types of objects can be mixed within the list. For example, the list can include VCF files and maf objects. Certain parameters such as `id` and `rename` only apply to VCF objects or files and need to be individually specified for each VCF. Therefore, these parameters should be suppied as a vector that is the same length as the number of inputs. If other types of objects are in the input list, then the value of `id` and `rename` will be ignored for these items.

Usage

```
extract_variants(
  inputs,
  id = NULL,
  rename = NULL,
  sample_field = NULL,
  filename_as_id = FALSE,
  strip_extension = c(".vcf", ".vcf.gz", ".gz"),
  filter = TRUE,
  multiallele = c("expand", "exclude"),
  fix_vcf_errors = TRUE,
  extra_fields = NULL,
  chromosome_col = "chr",
  start_col = "start",
  end_col = "end",
  ref_col = "ref",
  alt_col = "alt",
  sample_col = "sample",
  verbose = TRUE
)
```

Arguments

`inputs`	A vector or list of objects or file names. Objects can be CollapsedVCF, ExpandedVCF, MAF, an object that inherits from `matrix` or `data.frame`, or character strings that denote the path to a vcf or maf file.
`id`	A character vector the same length as `inputs` denoting the sample to extract from a vcf. See `extract_variants_from_vcf` for more details. Only used if the input is a vcf object or file. Default `NULL`.

rename	A character vector the same length as inputs denoting what the same will be renamed to. See extract_variants_from_vcf for more details. Only used if the input is a vcf object or file. Default NULL.
sample_field	Some algoriths will save the name of the sample in the ##SAMPLE portion of header in the VCF. See extract_variants_from_vcf for more details. Default NULL.
filename_as_id	If set to TRUE, the file name will be used as the sample name. See extract_variants_from_vcf_file for more details. Only used if the input is a vcf file. Default TRUE.
strip_extension	Only used if filename_as_id is set to TRUE. If set to TRUE, the file extention will be stripped from the filename before setting the sample name. See extract_variants_from_vcf_file for more details. Only used if the input is a vcf file. Default c(".vcf",".vcf.gz",".gz")
filter	Exclude variants that do not have a PASS in the FILTER column of VCF inputs.
multiallele	Multialleles are when multiple alternative variants are listed in the same row in the vcf. See extract_variants_from_vcf for more details. Only used if the input is a vcf object or file. Default "expand".
fix_vcf_errors	Attempt to automatically fix VCF file formatting errors. See extract_variants_from_vcf_file for more details. Only used if the input is a vcf file. Default TRUE.
extra_fields	Optionally extract additional fields from all input objects. Default NULL.
chromosome_col	The name of the column that contains the chromosome reference for each variant. Only used if the input is a matrix or data.frame. Default "Chromosome".
start_col	The name of the column that contains the start position for each variant. Only used if the input is a matrix or data.frame. Default "Start_Position".
end_col	The name of the column that contains the end position for each variant. Only used if the input is a matrix or data.frame. Default "End_Position".
ref_col	The name of the column that contains the reference base(s) for each variant. Only used if the input is a matrix or data.frame. Default "Tumor_Seq_Allele1".
alt_col	The name of the column that contains the alternative base(s) for each variant. Only used if the input is a matrix or data.frame. Default "Tumor_Seq_Allele2".
sample_col	The name of the column that contains the sample id for each variant. Only used if the input is a matrix or data.frame. Default "sample".
verbose	Show progress of variant extraction. Default TRUE.

Value

Returns a data.table of variants from a vcf

Examples

```
# Get loations of two vcf files and a maf file
luad_vcf_file <- system.file("extdata", "public_LUAD_TCGA-97-7938.vcf",
  package = "musicatk"
)
lusc_maf_file <- system.file("extdata", "public_TCGA.LUSC.maf",
```

```
  package = "musicatk"
)
melanoma_vcfs <- list.files(system.file("extdata", package = "musicatk"),
  pattern = glob2rx("*SKCM*vcf"), full.names = TRUE
)

# Read all files in at once
inputs <- c(luad_vcf_file, melanoma_vcfs, lusc_maf_file)
variants <- extract_variants(inputs = inputs)
table(variants$sample)

# Run again but renaming samples in first four vcfs
new_name <- c(paste0("Sample", 1:4), NA)
variants <- extract_variants(inputs = inputs, rename = new_name)
table(variants$sample)
```

`extract_variants_from_maf` *Extract variants from a maf object*

Description

Add description

Usage

```
extract_variants_from_maf(maf, extra_fields = NULL)
```

Arguments

`maf`	MAF object loaded by read.maf() from the 'maftools' package
`extra_fields`	Optionally extract additional columns from the maf object. Default `NULL`.

Value

Returns a data.table of variants from a maf which can be used to create a `musica` object.

Examples

```
maf_file <- system.file("extdata", "public_TCGA.LUSC.maf",
  package = "musicatk"
)
library(maftools)
maf <- read.maf(maf_file)
variants <- extract_variants_from_maf(maf = maf)
```

extract_variants_from_maf_file

Extracts variants from a maf file

Description

Add Description - Aaron

Usage

```
extract_variants_from_maf_file(maf_file, extra_fields = NULL)
```

Arguments

maf_file	Location of maf file
extra_fields	Optionally extract additional columns from the object. Default NULL.

Value

Returns a data.table of variants from a maf

Examples

```
maf_file <- system.file("extdata", "public_TCGA.LUSC.maf",
  package = "musicatk"
)
maf <- extract_variants_from_maf_file(maf_file = maf_file)
```

extract_variants_from_matrix

Extract variants from matrix or data.frame like objects

Description

Add Description

Usage

```
extract_variants_from_matrix(
  mat,
  chromosome_col = "Chromosome",
  start_col = "Start_Position",
  end_col = "End_Position",
  ref_col = "Tumor_Seq_Allele1",
  alt_col = "Tumor_Seq_Allele2",
  sample_col = "Tumor_Sample_Barcode",
  extra_fields = NULL
)
```

Arguments

mat	An object that inherits from classes "matrix" or "data.frame" Examples include a matrix, data.frame, or data.table.
chromosome_col	The name of the column that contains the chromosome reference for each variant. Default "Chromosome".
start_col	The name of the column that contains the start position for each variant. Default "Start_Position".
end_col	The name of the column that contains the end position for each variant. Default "End_Position".
ref_col	The name of the column that contains the reference base(s) for each variant. Default "Tumor_Seq_Allele1".
alt_col	The name of the column that contains the alternative base(s) for each variant. Default "Tumor_Seq_Allele2".
sample_col	The name of the column that contains the sample id for each variant. Default "Tumor_Sample_Barcode".
extra_fields	Optionally extract additional columns from the object. Default NULL.

Value

Returns a data.table of variants from a maf which can be used to create a musica object.

Examples

```
maf_file <- system.file("extdata", "public_TCGA.LUSC.maf",
  package = "musicatk"
)
library(maftools)
maf <- read.maf(maf_file)
variants <- extract_variants_from_maf(maf = maf)
variants <- extract_variants_from_matrix(
  mat = variants,
  chromosome_col = "chr", start_col = "start", end_col = "end",
  ref_col = "ref", alt_col = "alt", sample_col = "sample"
)
```

---

extract_variants_from_vcf

Extracts variants from a VariantAnnotation VCF object

Description

Aaron - Need to describe differnce between ID, and name in the header, and rename in terms of naming the sample. Need to describe differences in multiallelic choices. Also need to describe the automatic error fixing

Usage

```
extract_variants_from_vcf(
  vcf,
  id = NULL,
  rename = NULL,
  sample_field = NULL,
  filter = TRUE,
  multiallele = c("expand", "exclude"),
  extra_fields = NULL
)
```

Arguments

vcf	Location of vcf file
id	ID of the sample to select from VCF. If NULL, then the first sample will be selected. Default NULL.
rename	Rename the sample to this value when extracting variants. If NULL, then the sample will be named according to ID.
sample_field	Some algoriths will save the name of the sample in the ##SAMPLE portion of header in the VCF (e.g. ##SAMPLE=<ID=TUMOR,SampleName=TCGA-01-0001>). If the ID is specified via the id parameter ("TUMOR" in this example), then sample_field can be used to specify the name of the tag ("SampleName" in this example). Default NULL.
filter	Exclude variants that do not have a PASS in the FILTER column of the VCF. Default TRUE.
multiallele	Multialleles are when multiple alternative variants are listed in the same row in the vcf. One of "expand" or "exclude". If "expand" is selected, then each alternate allele will be given their own rows. If "exclude" is selected, then these rows will be removed. Default "expand".
extra_fields	Optionally extract additional fields from the INFO section of the VCF. Default NULL.

Value

Returns a data.table of variants from a vcf

Examples

```
vcf_file <- system.file("extdata", "public_LUAD_TCGA-97-7938.vcf",
  package = "musicatk"
)

library(VariantAnnotation)
vcf <- readVcf(vcf_file)
variants <- extract_variants_from_vcf(vcf = vcf)
```

`extract_variants_from_vcf_file` *Extracts variants from a vcf file*

Description

Add Description

Usage

```
extract_variants_from_vcf_file(
  vcf_file,
  id = NULL,
  rename = NULL,
  sample_field = NULL,
  filename_as_id = FALSE,
  strip_extension = c(".vcf", ".vcf.gz", ".gz"),
  filter = TRUE,
  multiallele = c("expand", "exclude"),
  extra_fields = NULL,
  fix_vcf_errors = TRUE
)
```

Arguments

`vcf_file`	Path to the vcf file
`id`	ID of the sample to select from VCF. If `NULL`, then the first sample will be selected. Default `NULL`.
`rename`	Rename the sample to this value when extracting variants. If `NULL`, then the sample will be named according to `ID`.
`sample_field`	Some algoriths will save the name of the sample in the ##SAMPLE portion of header in the VCF (e.g. ##SAMPLE=<ID=TUMOR,SampleName=TCGA-01-0001>). If the ID is specified via the `id` parameter ("TUMOR" in this example), then `sample_field` can be used to specify the name of the tag ("SampleName" in this example). Default `NULL`.
`filename_as_id`	If set to `TRUE`, the file name will be used as the sample name.
`strip_extension`	Only used if `filename_as_id` is set to `TRUE`. If set to `TRUE`, the file extention will be stripped from the filename before setting the sample name. If a character vector is given, then all the strings in the vector will removed from the end of the filename before setting the sample name. Default `c(".vcf",".vcf.gz",".gz")`
`filter`	Exclude variants that do not have a `PASS` in the `FILTER` column of the VCF. Default `TRUE`.

multiallele	Multialleles are when multiple alternative variants are listed in the same row in the vcf. One of "expand" or "exclude". If "expand" is selected, then each alternate allele will be given their own rows. If "exclude" is selected, then these rows will be removed. Default "expand".
extra_fields	Optionally extract additional fields from the INFO section of the VCF. Default NULL.
fix_vcf_errors	Attempt to automatically fix VCF file formatting errors.

Value

Returns a data.table of variants extracted from a vcf

Examples

```
vcf <- system.file("extdata", "public_LUAD_TCGA-97-7938.vcf",
  package = "musicatk"
)
variants <- extract_variants_from_vcf_file(vcf_file = vcf)
```

---

generate_result_grid *Generate result_grid from musica based on annotation and range of k*

Description

Generate result_grid from musica based on annotation and range of k

Usage

```
generate_result_grid(
  musica,
  modality,
  algorithm = "lda",
  annotation = NA,
  k_start,
  k_end,
  result_name = "result_grid",
  n_start = 1,
  seed = NULL,
  par_cores = FALSE,
  verbose = FALSE,
  make_copy = FALSE,
  table_name = NULL
)
```

Arguments

musica	A musica object.
modality	Modality used for signature discovery
algorithm	Algorithm for signature discovery
annotation	Sample annotation to split results into
k_start	Lower range of number of signatures for discovery
k_end	Upper range of number of signatures for discovery
result_name	Name for result_list entry to save the results to. Default "result_grid".
n_start	Number of times to discover signatures and compare based on posterior loglikihood
seed	Seed to use for reproducible results, set to null to disable
par_cores	Number of parallel cores to use (NMF only)
verbose	Whether to output loop iterations
make_copy	If FALSE, the inputted musica object is updated and nothing is returned. If TRUE, a new musica object is created and returned. Default FALSE.
table_name	Use modality instead

Value

Returns nothing or a new musica object, depending on the make_copy parameter.

Examples

```
data(musica_sbs96)
grid <- generate_result_grid(musica_sbs96, "SBS96", "lda",
  k_start = 2,
  k_end = 5
)
```

---

get_count_table *Retrieve count_table matrix from count_table object*

Description

The count table

Usage

```
get_count_table(count_table)
```

Arguments

count_table	A count_table object.

Value

The count table

get_modality *Retrieve a specific modality entry from a musica or result_collection object*

Description

`modality` list contains model results for a modality

Usage

```
get_modality(x, ...)

## S4 method for signature 'musica'
get_modality(x, result, modality)

## S4 method for signature 'result_collection'
get_modality(x, modality)
```

Arguments

`x`	A `result_model` or `result_collection` object
`...`	Other inputs
`result`	The name of the result_list entry.
`modality`	The modality.

Value

A list of modality which contains result_model objects

Examples

```
data(res)
get_modality(res, "result", "SBS96")
```

get_model *Retrieve model from a musica or result collection object*

Description

Extract the `result_model` object from the `musica` or `result_collection` object that contains the model.

Usage

```
get_model(x, ...)

## S4 method for signature 'musica'
get_model(x, result, modality, model)

## S4 method for signature 'result_collection'
get_model(x, modality, model)
```

Arguments

x	A musica or result_collection object.
...	Other inputs
result	The name of the result_list entry.
modality	The modality.
model	The name of the model.

Value

A result_model object

Examples

```
data(res)
get_model(res, "result", "SBS96", "res")
```

---

get_result_list_entry *Retrieve result_list entry from a musica object*

Description

The result_list contains results from various runs

Usage

```
get_result_list_entry(object, result_name)

## S4 method for signature 'musica,character'
get_result_list_entry(object, result_name)
```

Arguments

object	A musica object generated by the create_musica_from_variants or create_musica_from_counts function.
result_name	The name of the result_list entry.

Value

A list of results

Examples

```
data(res)
get_result_list_entry(res, "result")
```

`hyperparameter` *Retrieve hyperparameter from a musica or result_collection object*

Description

The `hyperparameter` contain list of prior and tuning parameters

Usage

```
hyperparameter(x, ...)

## S4 method for signature 'musica'
hyperparameter(x, result)

## S4 method for signature 'result_collection'
hyperparameter(x)

hyperparameter(x, ...) <- value

## S4 replacement method for signature 'musica,list'
hyperparameter(x, result) <- value

## S4 replacement method for signature 'result_collection,list'
hyperparameter(x) <- value
```

Arguments

`x`	A `result_model` or `result_collection` object
`...`	Other inputs
`result`	The name of the result_list entry.
`value`	A `list` of hyperparameters for model

Value

A list of hyperparameters

Examples

```
data(res)
hyperparameter(res, "result")
```

indel_musica *indel_musica*

Description

A musica created for testing that includes INDEL variants

Usage

```
data(indel_musica)
```

Format

An object of class `musica` See [create_musica_from_variants()] and [create_musica_from_counts()].

k_select *Plots for helping decide number of clusters*

Description

To help decide the number of cluster, three different methods are provided: total within cluster sum of squares, average silhouette coefficient, and gap statistics.

Usage

```
k_select(
  musica,
  model_name,
  modality = "SBS96",
  result_name = "result",
  method = "wss",
  clust.method = "kmeans",
  n = 10,
  proportional = TRUE
)
```

Arguments

`musica`	A `musica` object containing a mutational discovery or prediction. A two-dimensional UMAP has to be stored in this object.
`model_name`	The name of the desired model.
`modality`	The modality of the model. Must be "SBS96", "DBS78", or "IND83". Default `"SBS96"`.
`result_name`	Name of the result list entry containing desired model. Default `"result"`.

method	A single character string indicating which statistic to use for plot. Options are "wss" (total within cluster sum of squares), "silhouette" (average silhouette coefficient), and "gap_stat" (gap statistic). Default is "wss".
clust.method	A character string indicating clustering method. Options are "kmeans" (default), "hclust" (hierarchical clustering), "hkmeans", "pam", and "clara".
n	An integer indicating maximum number of clusters to test. Default is 10.
proportional	Logical, indicating if proportional exposure (default) will be used for clustering.

Value

A ggplot object.

See Also

fviz_nbclust

Examples

```
data(res_annot)
set.seed(123)
# Make an elbow plot
k_select(res_annot, model_name = "res_annot", method = "wss", n = 6)
# Plot average silhouette coefficient against number of clusters
k_select(res_annot, model_name = "res_annot", method = "silhouette", n = 6)
# Plot gap statistics against number of clusters
k_select(res_annot, model_name = "res_annot", method = "gap_stat", n = 6)
```

---

metrics *Retrieve metrics from a result_model, result_collection, or musica object*

Description

Metrics for the model

Usage

```
metrics(x, ...)

## S4 method for signature 'musica'
metrics(x, result, modality, model_id)

## S4 method for signature 'result_collection'
metrics(x, modality, model_id)

## S4 method for signature 'result_model'
metrics(x)
```

```
metrics(x, ...) <- value

## S4 replacement method for signature 'musica,SimpleList'
metrics(x, result, modality, model_id) <- value

## S4 replacement method for signature 'result_collection,SimpleList'
metrics(x, modality, model_id) <- value

## S4 replacement method for signature 'result_model,SimpleList'
metrics(x) <- value
```

Arguments

x	A musica, result_collection, or result_model object generated by a mutational discovery or prediction tool.
...	Other inputs
result	Name of result from result_list to assign the metrics. Used when result is a musica object.
modality	Modality to assign the metrics. Used when result is a musica or result_collection object.
model_id	Model identifier to assign the metrics. Used when result is a musica or result_collection object.
value	List of metrics

Value

The metrics for the model

Examples

```
data(res)
metrics(res, "result", "SBS96", "res")
```

---

modality *Retrieve modality from a result_model, result_collection, or musica object*

Description

The modality

Usage

```
modality(x, ...)

## S4 method for signature 'musica'
modality(x, result, modality, model_id)

## S4 method for signature 'result_collection'
modality(x, modality, model_id)

## S4 method for signature 'result_model'
modality(x)

modality(x, ...) <- value

## S4 replacement method for signature 'musica,matrix'
modality(x, result, modality, model_id) <- value

## S4 replacement method for signature 'result_collection,matrix'
modality(x, modality, model_id) <- value

## S4 replacement method for signature 'result_model,matrix'
modality(x) <- value
```

Arguments

x	A musica, result_collection, or result_model object generated by a mutational discovery or prediction tool.
...	Other inputs result_collection object.
result	Name of result from result_list to assign the modality. Used when result is a musica object.
modality	Modality to assign the modality. Used when result is a musica or result_collection object.
model_id	Model identifier to assign the modality. Used when result is a musica or
value	A modality

Value

The modality for the model

Examples

```
data(res)
modality(res, "result", "SBS96", "res")
```

model_id *Retrieve model_id from a result_model, result_collection, or musica object*

Description

Model identifier

Usage

```
model_id(x, ...)

## S4 method for signature 'musica'
model_id(x, result, modality, model_id)

## S4 method for signature 'result_collection'
model_id(x, modality, model_id)

## S4 method for signature 'result_model'
model_id(x)

model_id(x, ...) <- value

## S4 replacement method for signature 'musica,matrix'
model_id(x, result, modality, model_id) <- value

## S4 replacement method for signature 'result_collection,matrix'
model_id(x, modality, model_id) <- value

## S4 replacement method for signature 'result_model,matrix'
model_id(x) <- value
```

Arguments

x	A musica, result_collection, or result_model object generated by a mutational discovery or prediction tool.
...	Other inputs
result	Name of result from result_list to assign the model_id. Used when result is a musica object.
modality	Modality to assign the model_id. Used when result is a musica or result_collection object.
model_id	Model identifier to assign the model_id. Used when result is a musica or result_collection object.
value	Model identifier

Value

The model_id for the model

Examples

```
data(res)
model_id(res, "result", "SBS96", "res")
```

`musica` *musica*

Description

A musica created for testing that includes SBS variants

Usage

```
data(musica)
```

Format

An object of class `musica` See [create_musica_from_variants()] and [create_musica_from_counts()].

`musica-class` *The primary object that contains variants, count_tables, and samples annotations*

Description

The primary object that contains variants, count_tables, and samples annotations

Slots

`variants` `data.table` of variants

`count_tables` Summary table with per-sample unnormalized motif counts

`sample_annotations` Sample-level annotations (e.g. age, sex, primary)

`result_list` Results from various algorithms, modalities, and models

musicatk *Starts the musicatk interactive Shiny app*

Description

The musicatk Shiny app allows users to perform mutational signature analysis using an interative graphical user interface (GUI)

Usage

```
musicatk(include_version = TRUE, theme = "yeti")
```

Arguments

include_version	Include the version number in the header. Default TRUE.
theme	The theme to use for the GUI. Default "yeti".

Value

The shiny app will open. No data will be returned.

Examples

```
## Not run:
# Start the app
musicatk()

## End(Not run)
```

musica_annot *musica_annot*

Description

A musica created for testing that includes SBS variants and sample annotations

Usage

```
data(musica_annot)
```

Format

An object of class musica See [create_musica_from_variants()] and [create_musica_from_counts()].

musica_sbs96 *musica_sbs96*

Description

A musica created for testing that includes SBS variants and a build counts table for them

Usage

```
data(musica_sbs96)
```

Format

An object of class `musica` See [build_standard_table()].

musica_sbs96_tiny *musica_sbs96_tiny*

Description

A very small musica created for testing that includes SBS variants and a build counts table for them

Usage

```
data(musica_sbs96_tiny)
```

Format

An object of class `musica` See [build_standard_table()].

name_signatures *Rename signatures for a model*

Description

Rename signatures for a model

Usage

```
name_signatures(
  musica,
  model_id,
  name_vector,
  modality = "SBS96",
  result_name = "result"
)
```

Arguments

musica	A musica object containing a mutational signature discovery or prediction.
model_id	The name of the model to rename signatures for.
name_vector	Vector of user-defined signature names
modality	The modality of the model. Must be "SBS96", "DBS78", or "IND83". Default "SBS96".
result_name	Name of the result list entry containing the model. Default "result".

Value

Musica object with user-defined signatures names

Examples

```
data(res)
name_signatures(res,
  model_id = "res",
  name_vector = c("smoking", "apobec", "unknown")
)
```

---

num_signatures *Retrieve num_signatures from a result_model, result_collection, or musica object*

Description

The number of signatures in a model

Usage

```
num_signatures(x, ...)

## S4 method for signature 'musica'
num_signatures(x, result, modality, model_id)

## S4 method for signature 'result_collection'
num_signatures(x, modality, model_id)

## S4 method for signature 'result_model'
num_signatures(x)

num_signatures(x, ...) <- value

## S4 replacement method for signature 'musica,matrix'
num_signatures(x, result, modality, model_id) <- value
```

```
## S4 replacement method for signature 'result_collection,matrix'
num_signatures(x, modality, model_id) <- value

## S4 replacement method for signature 'result_model,matrix'
num_signatures(x) <- value
```

Arguments

x	A musica, result_collection, or result_model object generated by a mutational discovery or prediction tool.
...	Other inputs
result	Name of result from result_list to assign the num_signatures. Used when result is a musica object.
modality	Modality to assign the num_signatures. Used when result is a musica or result_collection object.
model_id	Model identifier to assign the num_signatures. Used when result is a musica or result_collection object.
value	Number of signatures in the model

Value

The number of signatures in a model

Examples

```
data(res)
num_signatures(res, "result", "SBS96", "res")
```

---

other_parameters *Retrieve other_parameters from a result_model, result_collection, or musica object*

Description

Parameters for the model

Usage

```
other_parameters(x, ...)

## S4 method for signature 'musica'
other_parameters(x, result, modality, model_id)

## S4 method for signature 'result_collection'
other_parameters(x, modality, model_id)
```

```
## S4 method for signature 'result_model'
other_parameters(x)

other_parameters(x, ...) <- value

## S4 replacement method for signature 'musica,matrix'
other_parameters(x, result, modality, model_id) <- value

## S4 replacement method for signature 'result_collection,matrix'
other_parameters(x, modality, model_id) <- value

## S4 replacement method for signature 'result_model,matrix'
other_parameters(x) <- value
```

Arguments

x	A musica, result_collection, or result_model object generated by a mutational discovery or prediction tool.
...	Other inputs
result	Name of result from result_list to assign the other_parameters. Used when result is a musica object.
modality	Modality to assign the other_parameters. Used when result is a musica or result_collection object.
model_id	Model identifier to assign the other_parameters. Used when result is a musica or result_collection object.
value	List of other parameters

Value

The other parameters for the model

Examples

```
data(res)
other_parameters(res, "result", "SBS96", "res")
```

---

parameter *Retrieve parameter from a musica or result_collection object*

Description

The parameter contains input parameters used in the model

Usage

```
parameter(x, ...)

## S4 method for signature 'musica'
parameter(x, result)

## S4 method for signature 'result_collection'
parameter(x)

parameter(x, ...) <- value

## S4 replacement method for signature 'result_collection,list'
parameter(x) <- value

## S4 replacement method for signature 'musica,list'
parameter(x, result) <- value
```

Arguments

x	A result_model or result_collection object
...	Other inputs
result	The name of the result_list entry.
value	a list of input parameters

Value

a list of parameters

Examples

```
data(res)
parameter(res, "result")
```

---

plot_cluster *Visualize clustering results*

Description

The clustering results can be visualized on a UMAP panel. Three different types of plots can be generated using this function: cluster-by-signature plot, cluster-by-annotation plot, and a single UMAP plot.

Usage

```
plot_cluster(
  musica,
  model_name,
  modality = "SBS96",
  result_name = "result",
  clusters,
  group = "signature",
  annotation = NULL,
  plotly = TRUE
)
```

Arguments

musica	A musica object containing a mutational discovery or prediction. A two-dimensional UMAP has to be stored in this object.
model_name	The name of the desired model.
modality	The modality of the model. Must be "SBS96", "DBS78", or "IND83". Default "SBS96".
result_name	Name of the result list entry containing desired model. Default "result".
clusters	The result generated from cluster_exposure function.
group	A single character string indicating the grouping factor. Possible options are: "signature" (columns are signatures in a grid), "annotation" (columns are sample annotation), and "none" (a single UMAP plot). Default is "signature".
annotation	Column name of annotation.
plotly	If TRUE, the plot will be made interactive using plotly.

Value

Generate a ggplot or plotly object.

See Also

create_umap

Examples

```
set.seed(123)
data(res_annot)
# Get clustering result
clust_out <- cluster_exposure(
  musica = res_annot, model_name = "res_annot",
  nclust = 2, iter.max = 15
)
# UMAP
create_umap(musica = res_annot, model_name = "res_annot")
# generate cluster X signature plot
plot_cluster(
```

```
  musica = res_annot, model_name = "res_annot",
  clusters = clust_out, group = "signature"
)
# generate cluster X annotation plot
plot_cluster(
  musica = res_annot, model_name = "res_annot",
  clusters = clust_out, group = "annotation",
  annotation = "Tumor_Subtypes"
)
# generate a single UMAP plot
plot_cluster(
  musica = res_annot, model_name = "res_annot",
  clusters = clust_out, group = "none"
)
```

`plot_differential_analysis` *Compare exposures of annotated samples*

Description

`plot_differential_analysis` is used to plot differential analysis created by `exposure_differential_analysis`.

Usage

```
plot_differential_analysis(analysis, analysis_type, samp_num)
```

Arguments

`analysis`	Analysis created by `exposure_differential_analysis`
`analysis_type`	Currently only `"glm"` supported
`samp_num`	Number of samples that went into the analysis

Value

Generates a ggplot object

Examples

```
data("res_annot")
analysis <- exposure_differential_analysis(res_annot,
  model_name = "res_annot",
  annotation = "Tumor_Subtypes", method = "wilcox"
)
plot_differential_analysis(analysis, "glm", 2)
```

plot_exposures *Display sample exposures with bar, box, or violin plots*

Description

The distributions of mutational signatures can be viewed with barplots or box/violin plots. Barplots are most useful for viewing the proportion of signatures within and across samples. The box/violin plots are most useful for viewing the distributions of signatures with respect to sample annotations. Samples can be grouped using the `group_by` parameter. For barplots, various methods of sorting samples from left to right can be chosen using the `sort_samples` parameter.

Usage

```
plot_exposures(
  musica,
  model_name,
  modality = "SBS96",
  result_name = "result",
  plot_type = c("bar", "box", "violin"),
  proportional = FALSE,
  group_by = "none",
  color_by = c("signature", "annotation"),
  annotation = NULL,
  num_samples = NULL,
  sort_samples = "total",
  threshold = NULL,
  same_scale = FALSE,
  add_points = FALSE,
  point_size = 2,
  label_x_axis = FALSE,
  legend = TRUE,
  plotly = FALSE
)
```

Arguments

`musica`	A `musica` object containing a mutational discovery or prediction.
`model_name`	The name of the desired model.
`modality`	The modality of the model. Must be "SBS96", "DBS78", or "IND83". Default `"SBS96"`.
`result_name`	Name of the result list entry containing desired model. Default `"result"`.
`plot_type`	One of `"bar"`, `"box"`, or `"violin"`. Default `"bar"`.
`proportional`	If `TRUE`, then the exposures will be normalized to between 0 and 1 by dividing by the total number of counts for each sample. Default `FALSE`.

group_by	Determines how to group samples into the subplots (i.e. facets). One of "none", "signature" or "annotation". If set to "annotation", then a sample annotation must be supplied via the annotation parameter. Default "none".
color_by	Determines how to color the bars or box/violins. One of "signature" or "annotation". If set to "annotation", then a sample annotation must be supplied via the annotation parameter. Default "signature".
annotation	Sample annotation used to group the subplots and/or color the bars, boxes, or violins. Default NULL.
num_samples	The top number of sorted samples to display. If NULL, then all samples will be displayed. If group_by is set, then the top samples will be shown within each group. Default NULL.
sort_samples	This is used to change how samples are sorted in the barplot from left to right. If set to "total", then samples will be sorted from those with the highest number of mutation counts to the lowest (regardless of how the parameter "proportional" is set). If set to "name", then samples are sorted by their name with the mixedsort function. If set to one or more signature names (e.g. "Signature1"), then samples will be sorted from those with the highest level of that signature to the lowest. If multiple signatures are supplied then, samples will be sorted by each signature sequentially. Default "total".
threshold	Exposures less than this threshold will be set to 0. This is most useful when more than one signature is supplied to sort_samples as samples that are set to zero for the first exposure will then be sorted by the levels of the second exposure. Default NULL.
same_scale	If TRUE, then all subplots will have the same scale. Only used when group_by is set. Default FALSE.
add_points	If TRUE, then points for individual sample exposures will be plotted on top of the violin/box plots. Only used when plot_type is set to "violin" or "box". Default TRUE.
point_size	Size of the points to be plotted on top of the violin/box plots. Only used when plot_type is set to "violin" or "box" and add_points is set to TRUE. Default 2.
label_x_axis	If TRUE, x-axis labels will be displayed at the bottom of the plot. Default FALSE.
legend	If TRUE, the legend will be displayed. Default TRUE.
plotly	If TRUE, the the plot will be made interactive using plotly. Default FALSE.

Value

Generates a ggplot or plotly object

Examples

```
data(res_annot)
plot_exposures(res_annot,
  model_name = "res_annot", plot_type = "bar",
  annotation = "Tumor_Subtypes"
)
```

plot_heatmap *Plot heatmaps using the exposures matrix*

Description

The exposures for different signatures can be visualized using a heatmap with this function. Heatmaps make it easier to visualize the data by representing the magnitude of exposure values as color in 2-dimensions. The variation in color intensity can help see if the exposures are clustered or how they vary over space. Exposures can be normalized by providing the `proportional` argument. Column annotations can also be seen by passing the `col_annot` argument.

Usage

```
plot_heatmap(
  musica,
  model_name,
  modality = "SBS96",
  result_name = "result",
  proportional = FALSE,
  show_column_names = FALSE,
  show_row_names = TRUE,
  scale = TRUE,
  subset_tumor = NULL,
  subset_signatures = NULL,
  annotation = NULL,
  ...
)
```

Arguments

`musica`	A `musica` object containing a mutational discovery or prediction.
`model_name`	The name of the desired model.
`modality`	The modality of the model. Must be "SBS96", "DBS78", or "IND83". Default `"SBS96"`.
`result_name`	Name of the result list entry containing desired model. Default `"result"`.
`proportional`	If `TRUE`, then the exposures will be normalized to between 0 and 1 by dividing by the total number of counts for each sample. Default `FALSE`.
`show_column_names`	Boolean check. If `True`, column names are shown. Otherwise, they aren't. Default `FALSE`
`show_row_names`	Boolean check. If `True`, row names are shown. Otherwise, they aren't. Default `FALSE`
`scale`	Boolean check. If `True`, values are scaled by z-score. Otherwise, they aren't. Default `TRUE`

subset_tumor	Users can specify certain tumor types on which they want to subset the exposure matrix for plotting the heatmap.
subset_signatures	Users can specify certain signatures on which they want to subset the exposure matrix plotting the heatmap.
annotation	Users have the option of plotting the exposure matrix based on their given annotation like Tumor_Subtypes or age. Error given if the user given annotation doesn't exist in the res_annot annotation object.
...	Ellipsis used for passing any arguments directly to the ComplexHeatmap's heatmap function.

Value

Generates a heatmap for using the exposure matrix.

Examples

```
data(res_annot)
plot_heatmap(
  musica = res_annot, model_name = "res_annot",
  proportional = TRUE, scale = TRUE, annotation = "Tumor_Subtypes"
)
```

---

plot_k_comparison *Plot k comparison*

Description

Plot the results of comparing k values

Usage

```
plot_k_comparison(k_comparison)
```

Arguments

k_comparison	data.frame with k value comparisons returned from the compare_k_vals function.

Value

a ggplot figure

Examples

```
data(musica)
k_comparison <- compare_k_vals(musica, "SBS96",
  reps = 3, min_k = 1,
  max_k = 5
)
plot_k_comparison(k_comparison)
```

`plot_sample_counts` *Plot distribution of sample counts*

Description

Displays the proportion of counts for each mutation type across one or more samples.

Usage

```
plot_sample_counts(
  musica,
  sample_names,
  modality = "SBS96",
  text_size = 10,
  show_x_labels = TRUE,
  show_y_labels = TRUE,
  same_scale = TRUE,
  annotation = NULL,
  table_name = NULL
)
```

Arguments

`musica`	A `musica` object.
`sample_names`	Names of the samples to plot.
`modality`	Name of table used for plotting counts. Default `"SBS96"`.
`text_size`	Size of axis text. Default `10`.
`show_x_labels`	If `TRUE`, the labels for the mutation types on the x-axis will be shown. Default `TRUE`.
`show_y_labels`	If `TRUE`, the y-axis ticks and labels will be shown. Default `TRUE`.
`same_scale`	If `TRUE`, the scale of the y-axis for each sample will be the same. If `FALSE`, then the scale of the y-axis will be adjusted for each sample. Default `TRUE`.
`annotation`	Vector of annotations to be displayed in the top right corner of each sample. Vector length must be equivalent to the number of samples. Default `NULL`.
`table_name`	Use modality instead

Value

Generates a ggplot object

Examples

```
data(musica_sbs96)
plot_sample_counts(musica_sbs96,
  sample_names =
    sample_names(musica_sbs96)[1]
)
```

`plot_sample_reconstruction_error`
Plot reconstruction error for a sample

Description

Displays the observed distribution of counts for each mutation type, the distribution of reconstructed counts for each mutation type using the inferred mutational signatures, and the difference between the two distributions.

Usage

```
plot_sample_reconstruction_error(
  musica,
  sample,
  model_id,
  modality = "SBS96",
  result_name = "result",
  plotly = FALSE
)
```

Arguments

`musica`	A `musica` object.
`sample`	Name of the sample within the `musica` object.
`model_id`	The name of the desired model.
`modality`	The modality of the model. Must be "SBS96", "DBS78", or "IND83". Default `"SBS96"`.
`result_name`	Name of the result list entry containing desired model. Default `"result"`.
`plotly`	If `TRUE`, the the plot will be made interactive using `plotly`. Default `FALSE`.

Value

Generates a ggplot or plotly object

Examples

```
data(res)
plot_sample_reconstruction_error(res, "TCGA-ER-A197-06A-32D-A197-08",
model_id = "res")
```

`plot_signatures` *Plots the mutational signatures*

Description

After mutational signature discovery has been performed, this function can be used to display the distribution of each mutational signature. The `color_variable` and `color_mapping` parameters can be used to change the default color scheme of the bars.

Usage

```
plot_signatures(
  musica,
  model_id,
  modality = "SBS96",
  result_name = "result",
  color_variable = NULL,
  color_mapping = NULL,
  text_size = 10,
  show_x_labels = TRUE,
  show_y_labels = TRUE,
  same_scale = FALSE,
  y_max = NULL,
  annotation = NULL,
  percent = TRUE,
  plotly = FALSE
)
```

Arguments

`musica`	A `musica` object containing a mutational discovery or prediction.
`model_id`	The name of the model to plot.
`modality`	The modality of the signatures to plot. Must be "SBS96", "DBS78", or "IND83". Default `"SBS96"`.
`result_name`	Name of the result list entry containing the signatures to plot. Default `"result"`.
`color_variable`	Name of the column in the variant annotation data.frame to use for coloring the mutation type bars. The variant annotation data.frame can be found within the count table of the `musica` object. If `NULL`, then the default column specified in the count table will be used. Default `NULL`.

color_mapping	A character vector used to map items in the color_variable to a color. The items in color_mapping correspond to the colors. The names of the items in color_mapping should correspond to the unique items in color_variable. If NULL, then the default color_mapping specified in the count table will be used. Default NULL.
text_size	Size of axis text. Default 10.
show_x_labels	If TRUE, the labels for the mutation types on the x-axis will be shown. Default TRUE.
show_y_labels	If TRUE, the y-axis ticks and labels will be shown. Default TRUE.
same_scale	If TRUE, the scale of the probability for each signature will be the same. If FALSE, then the scale of the y-axis will be adjusted for each signature. Default FALE.
y_max	Vector of maximum y-axis limits for each signature. One value may also be provided to specify a constant y-axis limit for all signatures. Vector length must be 1 or equivalent to the number of signatures. Default NULL.
annotation	Vector of annotations to be displayed in the top right corner of each signature. Vector length must be equivalent to the number of signatures. Default NULL.
percent	If TRUE, the y-axis will be represented in percent format instead of mutation counts. Default TRUE.
plotly	If TRUE, the the plot will be made interactive using plotly. Default FALSE.

Value

Generates a ggplot or plotly object

Examples

```
data(res)
plot_signatures(res, model_id = "res")
```

---

plot_umap *Plot a UMAP from a musica result*

Description

Plots samples on a UMAP scatterplot. Samples can be colored by the levels of mutational signatures or by a annotation variable.

Usage

```
plot_umap(
  musica,
  model_name,
  modality = "SBS96",
  result_name = "result",
  color_by = c("signatures", "annotation", "cluster", "none"),
```

```
  proportional = TRUE,
  annotation = NULL,
  point_size = 0.7,
  same_scale = TRUE,
  add_annotation_labels = FALSE,
  annotation_label_size = 3,
  annotation_text_box = TRUE,
  plotly = FALSE,
  clust = NULL,
  legend = TRUE,
  strip_axes = FALSE
)
```

Arguments

musica	A musica object containing a mutational signature discovery or prediction.
model_name	The name of the desired model.
modality	The modality of the model. Must be "SBS96", "DBS78", or "IND83". Default "SBS96".
result_name	Name of the result list entry containing the model.Default "result".
color_by	One of "signatures", "annotation", or "none". If "signatures", then one UMAP scatterplot will be generated for each signature and points will be colored by the level of that signature in each sample. If annotation, a single UMAP will be generated colored by the annotation selected using the parameter annotation. If "none", a single UMAP scatterplot will be generated with no coloring. Default "signature".
proportional	If TRUE, then the exposures will be normalized to between 0 and 1 by dividing by the total number of counts for each sample. Default TRUE.
annotation	Sample annotation used to color the points. One used when color_by = "annotation". Default NULL.
point_size	Scatter plot point size. Default 0.7.
same_scale	If TRUE, then all points will share the same color scale in each signature subplot. If FALSE, then each signature subplot will be colored by a different scale with different maximum values. Only used when color_by = "signature". Setting to FALSE is most useful when the maximum value of various signatures are vastly different from one another. Default TRUE.
add_annotation_labels	If TRUE, labels for each group in the annotation variable will be displayed. Only used if color_by = "annotation". This not recommended if the annotation is a continuous variable. The label is plotting using the centriod of each group within the annotation variable. Default FALSE.
annotation_label_size	Size of annotation labels. Only used if color_by = "annotation" and add_annotation_labels = TRUE. Default 3.

annotation_text_box
: Place a white box around the annotation labels to improve readability. Only used if color_by = "annotation" and add_annotation_labels = TRUE. Default TRUE.

plotly
: If TRUE, the the plot will be made interactive using plotly. Not used if color_by = "signature" and same_scale = FALSE. Default FALSE.

clust
: Add cluster labels as annotation

legend
: Plot legend

strip_axes
: Remove axes labels for cleaner looking plots

Value

Generates a ggplot or plotly object

See Also

See create_umap to generate a UMAP in a musica result.

Examples

```
data(res_annot)
create_umap(res_annot, "res_annot")
plot_umap(res_annot, "res_annot", color_by = "none")
```

---

predict_exposure *Prediction of exposures in new samples using pre-existing signatures*

Description

Exposures for samples will be predicted using an existing set of signatures stored in a result_model object. Algorithms available for prediction include a modify version of "lda", and "decompTumor2Sig".

Usage

```
predict_exposure(
  musica,
  modality,
  signature_res,
  algorithm = c("lda", "decompTumor2Sig"),
  result_name = "result",
  model_id = NULL,
  signatures_to_use = seq_len(ncol(signatures(signature_res))),
  verbose = FALSE,
  make_copy = FALSE,
  table_name = NULL
)
```

Arguments

musica	A musica object.
modality	Modality for posterior prediction. Must match the table type used to generate the prediction signatures
signature_res	Signatures used to predict exposures for the samples musica object. Existing signatures need to stored in a result_model object.
algorithm	Algorithm to use for prediction of exposures. One of "lda" or "decompTumor2Sig".
result_name	Name for result_list entry to save the results to. Default "result".
model_id	Identifier for the result. If NULL, will be automatically set to the algorithm and number of signatures. Default NULL.
signatures_to_use	Which signatures in the signature_res result object to use. Default is to use all signatures.
verbose	If TRUE, progress will be printing. Only used if algorithm = "lda". Default FALSE.
make_copy	If FALSE, the inputted musica object is updated and nothing is returned. If TRUE, a new musica object is created and returned. Default FALSE.
table_name	Use modality instead

Value

Returns nothing or a new musica object, depending on the make_copy parameter.

Examples

```
data(musica)
data(cosmic_v2_sigs)
g <- select_genome("19")
build_standard_table(musica, g, "SBS96", overwrite = TRUE)
result <- predict_exposure(
  musica = musica, modality = "SBS96",
  signature_res = cosmic_v2_sigs, algorithm = "lda"
)

# Predict using LDA-like algorithm with seed set to 1
set.seed(1)
predict_exposure(
  musica = musica, modality = "SBS96",
  signature_res = cosmic_v2_sigs, algorithm = "lda"
)
```

rc *Reverse complement of a string using biostrings*

Description

Reverse complement of a string using biostrings

Usage

```
rc(dna)
```

Arguments

dna	Input DNA string

Value

Returns the reverse compliment of the input DNA string

Examples

```
rc("ATGC")
```

rep_range *Replication Timing Data as GRanges Object*

Description

Supplementary data converted from bigWig to bedgraph to GRanges, with low RFD indicating the leading strand and high RFD indicating lagging strand and removing uninformative zero RFD intervals. Timing data is 10kb bins from a colon cancer sample.

Usage

```
data(rep_range)
```

Format

An object of class `"GRanges"`; see [annotate_replication_strand()].

Source

GEO, <https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE134225>

References

Sriramachandran, A. M. et al. (2020) Genome-wide Nucleotide-Resolution Mapping of DNA Replication Patterns, Single-Strand Breaks, and Lesions by GLOE-Seq. ([Molecular Cell] (doi:10.1016/j.molcel.2020.03.027

res *res*

Description

A musica created for testing that includes SBS variants with discovered exposures and signatures

Usage

```
data(res)
```

Format

An object of class `musica` See [discover_signatures()].

result_collection-class *The Result Collection object that contains modality, input parameters, prior hyperparameters*

Description

The Result Collection object that contains modality, input parameters, prior hyperparameters

Slots

`modality` a list contains model results for different modality

`parameter` a list contains input parameters

`hyperparameter` a list contains prior and tuning parameters

result_list *Retrieve result_list from a musica object*

Description

The `result_list` contains results from various runs

Usage

```
result_list(object)

## S4 method for signature 'musica'
result_list(object)

result_list(musica) <- value

## S4 replacement method for signature 'musica,SimpleList'
result_list(musica) <- value
```

Arguments

object	A musica object generated by the create_musica_from_variants or create_musica_from_counts function.
musica	A musica object generated by the create_musica_from_variants or create_musica_from_counts function
value	A list of results

Value

A list of results

Examples

```
data(res)
result_list(res)
```

---

result_model-class *Object that contains results for a single model*

Description

Object that contains results for a single model

Slots

`signatures` A matrix of signatures by mutational motifs

`exposures` A matrix of samples by signature weights

`num_signatures` Number of signatures in the model

`other_parameters` Parameters relevant to the model

`credible_intervals` Credible intervals for parameters

`metrics` Performance metrics for the model

`umap` List of umap data.frames for plotting and analysis

`model_id` Model identifier

`modality` Modality of result (SBS96, DBS78, IND83)

res_annot *res_annot*

Description

A musica created for testing that includes SBS variants with annotations and discovered exposures and signatures

Usage

```
data(res_annot)
```

Format

An object of class `musica` See [discover_signatures()].

sample_names *Retrieve sample names from a musica object*

Description

Sample names were included in the `sample` column in the variant object passed to `create_musica_from_variants`, or in the colnames of the count table object passed to `create_musica_from_counts`. This returns a unique list of samples names in the order they are inside the `musica` object.

Usage

```
sample_names(object)

## S4 method for signature 'musica'
sample_names(object)
```

Arguments

`object`	A `musica` object generated by the create_musica_from_variants or create_musica_from_counts function.

Value

A character vector of sample names

Examples

```
data(res)
sample_names(res)
```

samp_annot *Get or set sample annotations from a musica object*

Description

Sample annotations can be used to store information about each sample such as tumor type or treatment status. These are used in downstream plotting functions such as plot_exposures or plot_umap to group or color samples by a particular annotation.

Usage

```
samp_annot(object)

## S4 method for signature 'musica'
samp_annot(object)

samp_annot(object, name) <- value

## S4 replacement method for signature 'musica,character,vector'
samp_annot(object, name) <- value
```

Arguments

object	A musica object generated by the create_musica_from_variants or create_musica_from_counts function.
name	The name of the new annotation to add.
value	A vector containing the new sample annotations. Needs to be the same length as the number of samples in the object.

Value

A new object with the sample annotations added to the table in the sample_annotations slot.

See Also

See sample_names to get a vector of sample names in the musica object.

Examples

```
data(res_annot)
samp_annot(res_annot)

# Add new annotation
samp_annot(res_annot, "New_Annotation") <- rep(c("A", "B"), c(3, 4))
samp_annot(res_annot)
data(musica)
samp_annot(musica, "example") <- rep("ex", 7)
```

select_genome *Helper function to load common human or mouse genomes*

Description

Helper function to load common human or mouse genomes

Usage

```
select_genome(x)
```

Arguments

x	Select the hg19 or hg38 human genome or the mm9 or mm10 mouse genome in UCSC format

Value

Returns BSgenome of given version

Examples

```
g <- select_genome(x = "hg38")
```

signatures *Retrieve signatures from a result_model, result_collection, or musica object*

Description

The `signatures` matrix contains the probability of mutation motif in each sample. Rows correspond to each motif and columns correspond to each signature.

Usage

```
signatures(x, ...)

## S4 method for signature 'musica'
signatures(x, result, modality, model_id)

## S4 method for signature 'result_collection'
signatures(x, modality, model_id)

## S4 method for signature 'result_model'
signatures(x)
```

```
signatures(x, ...) <- value

## S4 replacement method for signature 'musica,matrix'
signatures(x, result, modality, model_id) <- value

## S4 replacement method for signature 'result_collection,matrix'
signatures(x, modality, model_id) <- value

## S4 replacement method for signature 'result_model,matrix'
signatures(x) <- value
```

Arguments

x	A musica, result_collection, or result_model object generated by a mutational discovery or prediction tool.
...	Other inputs
result	Name of result from result_list to assign the signatures. Used when result is a musica object.
modality	Modality to assign the signatures. Used when result is a musica or result_collection object.
model_id	Model identifier to assign the signatures. Used when result is a musica or result_collection object.
value	A matrix of motifs counts by samples

Value

A matrix of mutational signatures

Examples

```
data(res)
signatures(res, "result", "SBS96", "res")
data(res)
signatures(res, "result", "SBS96", "res") <- matrix()
```

---

subset_musica_by_annotation

Creates a new musica object subsetted to only one value of a sample annotation

---

Description

Creates a new musica object subsetted to only one value of a sample annotation

Usage

```
subset_musica_by_annotation(musica, annot_col, annot_names)
```

Arguments

musica	A musica object.
annot_col	Annotation class to use for subsetting
annot_names	Annotational value to subset to

Value

Returns a new musica object with sample annotations, count tables, and variants subsetted to only contains samples of the specified annotation type

Examples

```
data(musica_sbs96)
annot <- read.table(system.file("extdata", "sample_annotations.txt",
  package = "musicatk"
), sep = "\t", header = TRUE)

samp_annot(musica_sbs96, "Tumor_Subtypes") <- annot$Tumor_Subtypes

musica_sbs96 <- subset_musica_by_annotation(
  musica_sbs96, "Tumor_Subtypes",
  "Lung"
)
```

---

subset_musica_by_counts

Creates a new musica subsetted to only samples with enough variants

---

Description

Creates a new musica subsetted to only samples with enough variants

Usage

```
subset_musica_by_counts(musica, table_name, num_counts)
```

Arguments

musica	A musica object.
table_name	Name of table used for subsetting
num_counts	Minimum sum count value to drop samples

Value

Returns a new musica object with sample annotations, count tables, and variants subsetted to only contains samples with the specified minimum number of counts (column sums) in the specified table

Examples

```
data(musica_sbs96)
subset_musica_by_counts(musica_sbs96, "SBS96", 20)
```

`subset_variants_by_samples` *Return sample from musica_variant object*

Description

Return sample from musica_variant object

Usage

```
subset_variants_by_samples(musica, sample_name)
```

Arguments

`musica`	A `musica` object.
`sample_name`	Sample name to subset by

Value

Returns sample data.frame subset to a single sample

Examples

```
data(musica)
subset_variants_by_samples(musica, "TCGA-94-7557-01A-11D-2122-08")
```

`subset_variant_by_type` *Subsets a variant table based on Variant Type*

Description

Subsets a variant table based on Variant Type

Usage

```
subset_variant_by_type(tab, type)
```

Arguments

`tab`	Input variant table
`type`	Variant type to return e.g. "SBS", "INS", "DEL", "DBS"

Value

Returns the input variant table subsetted to only contain variants of the specified variant type

Examples

```
data(musica)
annotate_variant_type(musica)
subset_variant_by_type(variants(musica), "SBS")
```

`tables` *Retrieve the list of count_tables from a musica object*

Description

The `count_tables` contains standard and/or custom count tables created from variants

Usage

```
tables(object)

## S4 method for signature 'musica'
tables(object)

tables(musica) <- value

## S4 replacement method for signature 'musica,list'
tables(musica) <- value
```

Arguments

`object`	A `musica` object generated by the create_musica_from_variants or create_musica_from_counts function.
`musica`	A `musica` object generated by the create_musica_from_variants or create_musica_from_counts function.
`value`	A list of `count_table` objects representing counts of motifs in samples

Value

A list of count_tables

Examples

```
data(res)
tables(res)
```

table_96 *Generates a 96 motif table based on input counts for plotting*

Description

Generates a 96 motif table based on input counts for plotting

Usage

```
table_96(sample_df)
```

Arguments

sample_df	Input counts table

Value

Returns a 96 motif summary table

table_selected *Retrieve table name used for plotting from a result_model object*

Description

The table name

Usage

```
table_selected(result)

## S4 method for signature 'result_model'
table_selected(result)
```

Arguments

result	A result_model object generated by a mutational discovery or prediction tool.

Value

Table name used for plotting

Examples

```
data(res)
model <- get_model(res, "result", "SBS96", "res")
table_selected(model)
```

umap *Retrieve umap list from a result_model, result_collection, or musica object*

Description

The umap dataframes for the model

Usage

```
umap(x, ...)

## S4 method for signature 'musica'
umap(x, result, modality, model_id)

## S4 method for signature 'result_collection'
umap(x, modality, model_id)

## S4 method for signature 'result_model'
umap(x)

umap(x, ...) <- value

## S4 replacement method for signature 'musica,matrix'
umap(x, result, modality, model_id) <- value

## S4 replacement method for signature 'result_collection,matrix'
umap(x, modality, model_id) <- value

## S4 replacement method for signature 'result_model,matrix'
umap(x) <- value
```

Arguments

x	A musica, result_collection, or result_model object generated by a mutational discovery or prediction tool.
...	Other inputs
result	Name of result from result_list to assign the umap. Used when result is a musica object.
modality	Modality to assign the umap. Used when result is a musica or result_collection object.
model_id	Model identifier to assign the umap. Used when result is a musica or result_collection object.
value	A list of umap dataframes

Value

A list of umap dataframes

Examples

```
data(res)
umap(res, "result", "SBS96", "res")
```

`variants` *Retrieve variants from a musica object*

Description

The `variants` `data.table` contains the variants and variant-level annotations

Usage

```
variants(object)

## S4 method for signature 'musica'
variants(object)

variants(musica) <- value

## S4 replacement method for signature 'musica,data.table'
variants(musica) <- value
```

Arguments

`object`	A `musica` object generated by the create_musica_from_variants or create_musica_from_counts function.
`musica`	A `musica` object generated by the create_musica_from_variants or create_musica_from_counts function
`value`	A `data.table` of mutational variants and variant-level annotations

Value

A data.table of variants

Examples

```
data(res)
variants(res)
```

`%>%` *Pipe operator*

Description

Pipe operator

Usage

```
lhs %>% rhs
```

Value

NA

Examples

```
c(1, 2) %>% barplot()
```

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