Package 'sccomp'

May 5, 2025

Title Tests differences in cell-type proportion for single-cell data, robust to outliers

Version 2.0.0

Description A robust and outlier-aware method for testing differences in cell-type proportion in single-cell data. This model can infer changes in tissue composition and heterogeneity, and can produce realistic data simulations based on any existing dataset. This model can also transfer knowledge from a large set of integrated datasets to increase accuracy further.

License GPL-3

URL https://github.com/MangiolaLaboratory/sccomp

BugReports https://github.com/MangiolaLaboratory/sccomp/issues

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`counts_obj` *counts_obj*

Description

A tidy example dataset containing cell counts per cell group (cluster), sample, and phenotype for differential analysis. This dataset represents the counts of cells in various phenotypes and cell groups across multiple samples.

Usage

```
data(counts_obj)
```

Format

A tidy data frame with the following columns:

- **sample**: Factor, representing the sample identifier.
- **type**: Factor, indicating the sample type (e.g., benign, cancerous).
- **phenotype**: Factor, representing the cell phenotype (e.g., B_cell, HSC, etc.).
- **count**: Integer, representing the number of cells for each cell group within each sample.
- **cell_group**: Factor, representing the cell group (e.g., BM, B1, Dm, etc.).

Value

A `tibble` representing cell counts per cluster, with columns for sample, type, phenotype, cell group, and counts.

`get_output_samples` *Get Output Samples from a Stan Fit Object*

Description

This function retrieves the number of output samples from a Stan fit object, supporting different methods (MHC and Variational) based on the available data within the object.

Usage

```
get_output_samples(fit)
```

Arguments

`fit`	A `stanfit` object, which is the result of fitting a model via Stan.

Value

The number of output samples used in the Stan model. Returns from MHC if available, otherwise from Variational inference.

Examples

```
# Assuming 'fit' is a stanfit object obtained from running a Stan model
print("samples_count = get_output_samples(fit)")
```

multipanel_theme *multipanel_theme*

Description

A custom ggplot2 theme used for creating publication-quality multi-panel plots. This theme modifies the appearance of plots by adjusting text sizes, spacing between panels, and axis formatting, ensuring better readability for complex figures.

Usage

```
data(multipanel_theme)
```

Format

A ggplot2 theme with the following adjustments:

- **text**: Font size adjustments for plot titles, axis labels, and legend text.
- **panel.spacing**: Adjusts the spacing between panels in multi-panel plots.
- **axis.text**: Customises axis text appearance for better readability.

Value

A ggplot2 theme object.

---

no_significance_df *no_significance_df*

Description

A small example dataset containing cell counts across samples, conditions, and cell groups. This dataset is used to demonstrate the use of sccomp functions in scenarios where there is no significant difference in cell composition between conditions.

Usage

```
data(no_significance_df)
```

Format

A tibble with the following columns:

- **sample**: Character. Identifier for each sample.
- **condition**: Character. Experimental condition or group (e.g., "X" or "Y").
- **cell_group**: Character. Cell group or cell type (e.g., "A", "B").
- **count**: Numeric. Count of cells in the given sample, condition, and cell group.

Value

A tibble with 34 rows and 4 columns: `sample`, `condition`, `cell_group`, and `count`.

Examples

```
data(no_significance_df)
head(no_significance_df)
```

`plot.sccomp_tbl` *plot*

Description

This function plots a summary of the results of the model.

Usage

```
## S3 method for class 'sccomp_tbl'
plot(
  x,
  significance_threshold = 0.05,
  test_composition_above_logit_fold_change = attr(.data,
    "test_composition_above_logit_fold_change"),
  ...
)
```

Arguments

`x`	A tibble including a cell_group name column | sample name column | read counts column | factor columns | Pvalue column | a significance column
`significance_threshold`	Numeric value specifying the significance threshold for highlighting differences. Default is 0.025.
`test_composition_above_logit_fold_change`	A positive integer. It is the effect threshold used for the hypothesis test. A value of 0.2 correspond to a change in cell proportion of 10% for a cell type with baseline proportion of 50%. That is, a cell type goes from 45% to 50%. When the baseline proportion is closer to 0 or 1 this effect thrshold has consistent value in the logit uncontrained scale.
`...`	For internal use

Value

A `ggplot`

Examples

```
print("cmdstanr is needed to run this example.")
# Note: Before running the example, ensure that the 'cmdstanr' package is installed:
# install.packages("cmdstanr", repos = c("https://stan-dev.r-universe.dev/", getOption("repos")))


  if (instantiate::stan_cmdstan_exists()) {
    data("counts_obj")

    estimate = sccomp_estimate(
      counts_obj,
      ~ type, ~1, sample, cell_group, count,
      cores = 1
    )

    # estimate |> plot()
  }
```

`plot_1D_intervals` *Plot 1D Intervals for Cell-group Effects*

Description

This function creates a series of 1D interval plots for cell-group effects, highlighting significant differences based on a given significance threshold.

Usage

```
plot_1D_intervals(
  .data,
  significance_threshold = 0.05,
  test_composition_above_logit_fold_change = attr(.data,
    "test_composition_above_logit_fold_change")
)
```

Arguments

`.data`	Data frame containing the main data.
`significance_threshold`	Numeric value specifying the significance threshold for highlighting differences.
`test_composition_above_logit_fold_change`	A positive integer. It is the effect threshold used for the hypothesis test. A value of 0.2 correspond to a change in cell proportion of 10% for a cell type with baseline proportion of 50%. That is, a cell type goes from 45% to 50%. When the baseline proportion is closer to 0 or 1 this effect thrshold has consistent value in the logit uncontrained scale.

Value

A combined plot of 1D interval plots.

Examples

```
print("cmdstanr is needed to run this example.")


  if (instantiate::stan_cmdstan_exists()) {
    data("counts_obj")

    estimate <- sccomp_estimate(
      counts_obj,
      ~ type,
      ~1,
      sample,
      cell_group,
      count,
      cores = 1
    ) |>
    sccomp_test()

  # Example usage:
  my_plot = plot_1D_intervals(estimate)

  }
```

`plot_2D_intervals` *Plot 2D Intervals for Mean-Variance Association*

Description

This function creates a 2D interval plot for mean-variance association, highlighting significant differences based on a given significance threshold.

Usage

```
plot_2D_intervals(
  .data,
  significance_threshold = 0.05,
  test_composition_above_logit_fold_change = attr(.data,
    "test_composition_above_logit_fold_change")
)
```

Arguments

.data	Data frame containing the main data.
significance_threshold	Numeric value specifying the significance threshold for highlighting differences. Default is 0.025.
test_composition_above_logit_fold_change	A positive integer. It is the effect threshold used for the hypothesis test. A value of 0.2 correspond to a change in cell proportion of 10% for a cell type with baseline proportion of 50%. That is, a cell type goes from 45% to 50%. When the baseline proportion is closer to 0 or 1 this effect thrshold has consistent value in the logit uncontrained scale.

Value

A ggplot object representing the 2D interval plot.

Examples

```
print("cmdstanr is needed to run this example.")


  if (instantiate::stan_cmdstan_exists()) {
    data("counts_obj")

    estimate <- sccomp_estimate(
      counts_obj,
      ~ type,
      ~type,
      sample,
      cell_group,
      count,
      cores = 1
    ) |>
    sccomp_test()

  # Example usage:
  my_plot = plot_2D_intervals(estimate)

  }
```

---

plot_scatterplot *Plot Scatterplot of Cell-group Proportion*

Description

This function creates a scatterplot of cell-group proportions, optionally highlighting significant differences based on a given significance threshold.

Usage

```
plot_scatterplot(
  .data,
  data_proportion,
  factor_of_interest,
  .cell_group,
  .sample,
  significance_threshold = 0.05,
  my_theme
)
```

Arguments

`.data`	Data frame containing the main data.
`data_proportion`	Data frame containing proportions of cell groups.
`factor_of_interest`	A factor indicating the biological condition of interest.
`.cell_group`	The cell group to be analysed.
`.sample`	The sample identifier.
`significance_threshold`	Numeric value specifying the significance threshold for highlighting differences. Default is 0.025.
`my_theme`	A ggplot2 theme object to be applied to the plot.

Value

A ggplot object representing the scatterplot.

Examples

```
# Example usage:
# plot_scatterplot(.data, data_proportion, "condition", "cell_group", "sample", 0.025, theme_minimal())
```

`sccomp_boxplot` *sccomp_boxplot*

Description

Creates a boxplot visualization of the model results from `sccomp`. This function plots the estimated cell proportions across samples, highlighting significant changes in cell composition according to a specified factor.

Usage

```
sccomp_boxplot(
  .data,
  factor,
  significance_threshold = 0.05,
  test_composition_above_logit_fold_change = attr(.data,
    "test_composition_above_logit_fold_change"),
  remove_unwanted_effects = FALSE
)
```

Arguments

.data	A tibble containing the results from sccomp_estimate and sccomp_test, including the columns: cell_group name, sample name, read counts, factor(s), p-values, and significance indicators.
factor	A character string specifying the factor of interest included in the model for stratifying the boxplot.
significance_threshold	A numeric value indicating the False Discovery Rate (FDR) threshold for labeling significant cell-groups. Defaults to 0.05.
test_composition_above_logit_fold_change	A positive numeric value representing the effect size threshold used in the hypothesis test. A value of 0.2 corresponds to a change in cell proportion of approximately 10% for a cell type with a baseline proportion of 50% (e.g., from 45% to 55%). This threshold is consistent on the logit-unconstrained scale, even when the baseline proportion is close to 0 or 1.
remove_unwanted_effects	A logical value indicating whether to remove unwanted variation from the data before plotting. Defaults to FALSE.

Value

A ggplot object representing the boxplot of cell proportions across samples, stratified by the specified factor.

Examples

```
print("cmdstanr is needed to run this example.")
# Note: Before running the example, ensure that the 'cmdstanr' package is installed:
# install.packages("cmdstanr", repos = c("https://stan-dev.r-universe.dev/", getOption("repos")))


if (instantiate::stan_cmdstan_exists()) {
    data("counts_obj")

    estimate <- sccomp_estimate(
      counts_obj,
      formula_composition = ~ type,
      formula_variability = ~ 1,
```

```
    .sample = sample,
    .cell_group = cell_group,
    .count = count,
    cores = 1
  ) |>
  sccomp_test()

  # Plot the boxplot of estimated cell proportions
  sccomp_boxplot(
      .data = estimate,
      factor = "type",
      significance_threshold = 0.05
  )
}
```

`sccomp_calculate_residuals` *Calculate Residuals Between Observed and Predicted Proportions*

Description

`sccomp_calculate_residuals` computes the residuals between observed cell group proportions and the predicted proportions from a fitted `sccomp` model. This function is useful for assessing model fit and identifying cell groups or samples where the model may not adequately capture the observed data. The residuals are calculated as the difference between the observed proportions and the predicted mean proportions from the model.

Usage

```
sccomp_calculate_residuals(.data)
```

Arguments

`.data`	A tibble of class `sccomp_tbl`, which is the result of `sccomp_estimate()`. This tibble contains the fitted model and associated data necessary for calculating residuals.

Details

The function performs the following steps:

1. Extracts the predicted mean proportions for each cell group and sample using `sccomp_predict()`.
2. Calculates the observed proportions from the original count data.
3. Computes residuals by subtracting the predicted proportions from the observed proportions.
4. Returns a tibble containing the sample, cell group, residuals, and exposure (total counts per sample).

Value

A tibble (`tbl`) with the following columns:

- **sample** - A character column representing the sample identifiers.
- **cell_group** - A character column representing the cell group identifiers.
- **residuals** - A numeric column representing the residuals, calculated as the difference between observed and predicted proportions.
- **exposure** - A numeric column representing the total counts (sum of counts across cell groups) for each sample.

Examples

```
  if (instantiate::stan_cmdstan_exists() && .Platform$OS.type == "unix") {
# Load example data
data("counts_obj")

# Fit the sccomp model
estimates <- sccomp_estimate(
  counts_obj,
  formula_composition = ~ type,
  formula_variability = ~1,
  .sample = sample,
  .cell_group = cell_group,
  .count = count,
  approximate_posterior_inference = "all",
  cores = 1
)

# Calculate residuals
residuals <- sccomp_calculate_residuals(estimates)

# View the residuals
print(residuals)
}
```

`sccomp_estimate` *Main Function for SCCOMP Estimate*

Description

The `sccomp_estimate` function performs linear modeling on a table of cell counts or proportions, which includes a cell-group identifier, sample identifier, abundance (counts or proportions), and factors (continuous or discrete). The user can define a linear model using an R formula, where the first factor is the factor of interest. Alternatively, `sccomp` accepts single-cell data containers (e.g., Seurat, SingleCellExperiment, cell metadata, or group-size) and derives the count data from cell metadata.

Usage

```
sccomp_estimate(
  .data,
  formula_composition = ~1,
  formula_variability = ~1,
  .sample,
  .cell_group,
  .abundance = NULL,
  cores = detectCores(),
  bimodal_mean_variability_association = FALSE,
  percent_false_positive = 5,
  inference_method = "pathfinder",
  prior_mean = list(intercept = c(0, 1), coefficients = c(0, 1)),
 prior_overdispersion_mean_association = list(intercept = c(5, 2), slope = c(0, 0.6),
    standard_deviation = c(10, 20)),
  .sample_cell_group_pairs_to_exclude = NULL,
  output_directory = "sccomp_draws_files",
  verbose = TRUE,
  enable_loo = FALSE,
  noise_model = "multi_beta_binomial",
  exclude_priors = FALSE,
  use_data = TRUE,
  mcmc_seed = sample(1e+05, 1),
  max_sampling_iterations = 20000,
  pass_fit = TRUE,
  sig_figs = 9,
  ...,
  .count = NULL,
  approximate_posterior_inference = NULL,
  variational_inference = NULL
)
```

Arguments

`.data`	A tibble including cell_group name column, sample name column, abundance column (counts or proportions), and factor columns.
`formula_composition`	A formula describing the model for differential abundance.
`formula_variability`	A formula describing the model for differential variability.
`.sample`	A column name as a symbol for the sample identifier.
`.cell_group`	A column name as a symbol for the cell-group identifier.
`.abundance`	A column name as a symbol for the cell-group abundance, which can be counts (> 0) or proportions (between 0 and 1, summing to 1 across `.cell_group`).
`cores`	Number of cores to use for parallel calculations.
`bimodal_mean_variability_association`	Logical, whether to model mean-variability as bimodal.

percent_false_positive
: A real number between 0 and 100 for outlier identification.

inference_method
: Character string specifying the inference method to use ('pathfinder', 'hmc', or 'variational').

prior_mean
: A list specifying prior knowledge about the mean distribution, including intercept and coefficients.

prior_overdispersion_mean_association
: A list specifying prior knowledge about mean/variability association.

.sample_cell_group_pairs_to_exclude
: A column name indicating sample/cell-group pairs to exclude.

output_directory
: A character string specifying the output directory for Stan draws.

verbose
: Logical, whether to print progression details.

enable_loo
: Logical, whether to enable model comparison using the LOO package.

noise_model
: A character string specifying the noise model (e.g., 'multi_beta_binomial').

exclude_priors
: Logical, whether to run a prior-free model.

use_data
: Logical, whether to run the model data-free.

mcmc_seed
: An integer seed for MCMC reproducibility.

max_sampling_iterations
: Integer to limit the maximum number of iterations for large datasets.

pass_fit
: Logical, whether to include the Stan fit as an attribute in the output.

sig_figs
: Number of significant figures to use for Stan model output. Default is 9.

...
: Additional arguments passed to the `cmdstanr::sample` function.

.count
: DEPRECATED. Use .abundance instead.

approximate_posterior_inference
: DEPRECATED. Use inference_method instead.

variational_inference
: DEPRECATED. Use inference_method instead.

Value

A tibble (`tbl`) with the following columns:

- cell_group - The cell groups being tested.
- parameter - The parameter being estimated from the design matrix described by the input `formula_composition` and `formula_variability`.
- factor - The covariate factor in the formula, if applicable (e.g., not present for Intercept or contrasts).
- c_lower - Lower (2.5%) quantile of the posterior distribution for a composition (c) parameter.
- c_effect - Mean of the posterior distribution for a composition (c) parameter.
- c_upper - Upper (97.5%) quantile of the posterior distribution for a composition (c) parameter.

- c_pH0 - Probability of the null hypothesis (no difference) for a composition (c). This is not a p-value.
- c_FDR - False-discovery rate of the null hypothesis for a composition (c).
- c_n_eff - Effective sample size for a composition (c) parameter.
- c_R_k_hat - R statistic for a composition (c) parameter, should be within 0.05 of 1.0.
- v_lower - Lower (2.5%) quantile of the posterior distribution for a variability (v) parameter.
- v_effect - Mean of the posterior distribution for a variability (v) parameter.
- v_upper - Upper (97.5%) quantile of the posterior distribution for a variability (v) parameter.
- v_pH0 - Probability of the null hypothesis for a variability (v).
- v_FDR - False-discovery rate of the null hypothesis for a variability (v).
- v_n_eff - Effective sample size for a variability (v) parameter.
- v_R_k_hat - R statistic for a variability (v) parameter.
- count_data - Nested input count data.

Examples

```
print("cmdstanr is needed to run this example.")
# Note: Before running the example, ensure that the 'cmdstanr' package is installed:
# install.packages("cmdstanr", repos = c("https://stan-dev.r-universe.dev/", getOption("repos")))


  if (instantiate::stan_cmdstan_exists()) {
    data("counts_obj")

    estimate <- sccomp_estimate(
      counts_obj,
      ~ type,
      ~1,
      sample,
      cell_group,
      count,
      cores = 1
    )

    # Note!
    # If counts are available, do not use proportion.
    # Using proportion ignores the high uncertainty of low counts

    estimate_proportion <- sccomp_estimate(
       counts_obj,
       ~ type,
       ~1,
       sample,
       cell_group,
       proportion,
       cores = 1
     )
```

```
}
```

`sccomp_predict` *sccomp_predict*

Description

This function replicates counts from a real-world dataset.

Usage

```
sccomp_predict(
  fit,
  formula_composition = NULL,
  new_data = NULL,
  number_of_draws = 500,
  mcmc_seed = sample(1e+05, 1),
  summary_instead_of_draws = TRUE
)
```

Arguments

`fit`	The result of sccomp_estimate.
`formula_composition`	A formula. The formula describing the model for differential abundance, for example ~treatment. This formula can be a sub-formula of your estimated model; in this case all other factor will be factored out.
`new_data`	A sample-wise data frame including the column that represent the factors in your formula. If you want to predict proportions for 10 samples, there should be 10 rows. T
`number_of_draws`	An integer. How may copies of the data you want to draw from the model joint posterior distribution.
`mcmc_seed`	An integer. Used for Markov-chain Monte Carlo reproducibility. By default a random number is sampled from 1 to 999999. This itself can be controlled by set.seed()
`summary_instead_of_draws`	Return the summary values (i.e. mean and quantiles) of the predicted proportions, or return single draws. Single draws can be helful to better analyse the uncertainty of the prediction.

Value

A tibble (tbl) with the following columns:

- **cell_group** - A character column representing the cell group being tested.
- **sample** - A factor column representing the sample name for which the predictions are made.
- **proportion_mean** - A numeric column representing the predicted mean proportions from the model.
- **proportion_lower** - A numeric column representing the lower bound (2.5%) of the 95% credible interval for the predicted proportions.
- **proportion_upper** - A numeric column representing the upper bound (97.5%) of the 95% credible interval for the predicted proportions.

Examples

```
print("cmdstanr is needed to run this example.")
# Note: Before running the example, ensure that the 'cmdstanr' package is installed:
# install.packages("cmdstanr", repos = c("https://stan-dev.r-universe.dev/", getOption("repos")))


  if (instantiate::stan_cmdstan_exists() && .Platform$OS.type == "unix") {
    data("counts_obj")

    sccomp_estimate(
      counts_obj,
      ~ type, ~1, sample, cell_group, count,
      cores = 1
    ) |>
    sccomp_predict()
  }
```

`sccomp_proportional_fold_change` *Calculate Proportional Fold Change from sccomp Estimated Effects*

Description

This function calculates the proportional fold change between two conditions using the estimated effects from a sccomp model. The fold changes are derived from the model's posterior predictions rather than raw counts, providing a more robust estimate that accounts for the model's uncertainty and covariate effects.

Note! This statistic is descriptive and should not be used to define significance - use sccomp_test() for that. While fold changes in proportions are easier to interpret than changes in logit space, they are not linear (the same proportional change has different meaning for rare vs abundant cell types). In contrast, the logit scale used internally by sccomp provides linear effects that are more appropriate for statistical inference.

Usage

```
sccomp_proportional_fold_change(.data, formula_composition, from, to)
```

Arguments

.data	A sccomp estimate object (of class 'sccomp_tbl') obtained from running sccomp_estimate(). This object contains the fitted model and estimated effects.
formula_composition	The formula specifying which model effects to use for calculating fold changes. This should match or be a subset of the formula used in the original sccomp_estimate() call.
from	Character string specifying the reference/control condition (e.g., "benign").
to	Character string specifying the comparison condition (e.g., "cancer").

Value

A tibble with the following columns:

- cell_group - The cell group identifier
- proportion_fold_change - The estimated fold change in proportions between conditions. Positive values indicate increases, negative values indicate decreases.
- average_uncertainty - The average uncertainty in the fold change estimate, derived from the credible intervals
- statement - A text description of the fold change, including the direction and the estimated proportions

Examples

```
print("cmdstanr is needed to run this example.")
# Note: Before running the example, ensure that the 'cmdstanr' package is installed:
# install.packages("cmdstanr", repos = c("https://stan-dev.r-universe.dev/", getOption("repos")))



if (instantiate::stan_cmdstan_exists()) {
  # Load example data
  data("counts_obj")

  # First estimate the composition effects
  estimate <- sccomp_estimate(
      counts_obj,
      ~ type,
      ~1,
      sample,
      cell_group,
      count,
      cores = 1
  )
```

```
  # Calculate proportional fold changes from the estimated effects
  estimate |>
  sccomp_proportional_fold_change(
    formula_composition = ~  type,
    from = "benign",
    to = "cancer"
  )
}
```

`sccomp_remove_outliers` *sccomp_remove_outliers main*

Description

The `sccomp_remove_outliers` function takes as input a table of cell counts with columns for cell-group identifier, sample identifier, integer count, and factors (continuous or discrete). The user can define a linear model using an input R formula, where the first factor is the factor of interest. Alternatively, `sccomp` accepts single-cell data containers (e.g., Seurat, SingleCellExperiment, cell metadata, or group-size) and derives the count data from cell metadata.

Usage

```
sccomp_remove_outliers(
  .estimate,
  percent_false_positive = 5,
  cores = detectCores(),
  inference_method = attr(.estimate, "inference_method"),
  output_directory = "sccomp_draws_files",
  verbose = TRUE,
  mcmc_seed = sample(1e+05, 1),
  max_sampling_iterations = 20000,
  enable_loo = FALSE,
  sig_figs = 9,
  approximate_posterior_inference = NULL,
  variational_inference = NULL,
  ...
)
```

Arguments

`.estimate`	A tibble including a cell_group name column, sample name column, read counts column (optional depending on the input class), and factor columns.
`percent_false_positive`	A real number between 0 and 100 (not inclusive), used to identify outliers with a specific false positive rate.

cores Integer, the number of cores to be used for parallel calculations.

inference_method
Character string specifying the inference method to use ('pathfinder', 'hmc', or 'variational').

output_directory
A character string specifying the output directory for Stan draws.

verbose Logical, whether to print progression details.

mcmc_seed Integer, used for Markov-chain Monte Carlo reproducibility. By default, a random number is sampled from 1 to 999999.

max_sampling_iterations
Integer, limits the maximum number of iterations in case a large dataset is used, to limit computation time.

enable_loo Logical, whether to enable model comparison using the R package LOO. This is useful for comparing fits between models, similar to ANOVA.

sig_figs Number of significant figures to use for Stan model output. Default is 9.

approximate_posterior_inference
DEPRECATED, use the variational_inference argument.

variational_inference
DEPRECATED Logical, whether to use variational Bayes for posterior inference. It is faster and convenient. Setting this argument to FALSE runs full Bayesian (Hamiltonian Monte Carlo) inference, which is slower but the gold standard.

... Additional arguments passed to the cmdstanr::sample function.

Value

A tibble (tbl), with the following columns:

- cell_group - The cell groups being tested.
- parameter - The parameter being estimated from the design matrix described by the input formula_composition and formula_variability.
- factor - The covariate factor in the formula, if applicable (e.g., not present for Intercept or contrasts).
- c_lower - Lower (2.5%) quantile of the posterior distribution for a composition (c) parameter.
- c_effect - Mean of the posterior distribution for a composition (c) parameter.
- c_upper - Upper (97.5%) quantile of the posterior distribution for a composition (c) parameter.
- c_n_eff - Effective sample size, the number of independent draws in the sample. The higher, the better.
- c_R_k_hat - R statistic, a measure of chain equilibrium, should be within 0.05 of 1.0.
- v_lower - Lower (2.5%) quantile of the posterior distribution for a variability (v) parameter.
- v_effect - Mean of the posterior distribution for a variability (v) parameter.
- v_upper - Upper (97.5%) quantile of the posterior distribution for a variability (v) parameter.
- v_n_eff - Effective sample size for a variability (v) parameter.
- v_R_k_hat - R statistic for a variability (v) parameter, a measure of chain equilibrium.
- count_data - Nested input count data.

Examples

```
print("cmdstanr is needed to run this example.")
# Note: Before running the example, ensure that the 'cmdstanr' package is installed:
# install.packages("cmdstanr", repos = c("https://stan-dev.r-universe.dev/", getOption("repos")))


  if (instantiate::stan_cmdstan_exists()) {
    data("counts_obj")

    estimate = sccomp_estimate(
      counts_obj,
      ~ type,
      ~1,
      sample,
      cell_group,
      count,
      cores = 1
    ) |>
    sccomp_remove_outliers(cores = 1)
  }
```

`sccomp_remove_unwanted_variation` *sccomp_remove_unwanted_variation*

Description

This function uses the model to remove unwanted variation from a dataset using the estimates of the model. For example, if you fit your data with the formula ~ `factor_1` + `factor_2` and use the formula ~ `factor_1` to remove unwanted variation, the `factor_2` effect will be factored out.

Usage

```
sccomp_remove_unwanted_variation(
  .data,
  formula_composition_keep = NULL,
  formula_composition = NULL,
  formula_variability = NULL,
  cores = detectCores()
)
```

Arguments

`.data`	A tibble. The result of `sccomp_estimate`.

formula_composition_keep
: A formula. The formula describing the model for differential abundance, for example ~type. In this case, only the effect of the type factor will be preserved, while all other factors will be factored out.

formula_composition
: DEPRECATED. Use formula_composition_keep instead.

formula_variability
: DEPRECATED. Use formula_variability_keep instead.

cores
: Integer, the number of cores to be used for parallel calculations.

Value

A tibble (tbl) with the following columns:

- **sample** - A character column representing the sample name for which data was adjusted.
- **cell_group** - A character column representing the cell group being tested.
- **adjusted_proportion** - A numeric column representing the adjusted proportion after removing unwanted variation.
- **adjusted_counts** - A numeric column representing the adjusted counts after removing unwanted variation.
- **logit_residuals** - A numeric column representing the logit residuals calculated after adjustment.

Examples

```
print("cmdstanr is needed to run this example.")
# Note: Before running the example, ensure that the 'cmdstanr' package is installed:
# install.packages("cmdstanr", repos = c("https://stan-dev.r-universe.dev/", getOption("repos")))


  if (instantiate::stan_cmdstan_exists()) {
    data("counts_obj")

    estimates = sccomp_estimate(
      counts_obj,
      ~ type, ~1, sample, cell_group, count,
      cores = 1
    ) |>
    sccomp_remove_unwanted_variation()
  }
```

sccomp_replicate *sccomp_replicate*

Description

This function replicates counts from a real-world dataset.

Usage

```
sccomp_replicate(
  fit,
  formula_composition = NULL,
  formula_variability = NULL,
  number_of_draws = 1,
  mcmc_seed = sample(1e+05, 1)
)
```

Arguments

fit	The result of sccomp_estimate.
formula_composition	A formula. The formula describing the model for differential abundance, for example ~treatment. This formula can be a sub-formula of your estimated model; in this case all other factor will be factored out.
formula_variability	A formula. The formula describing the model for differential variability, for example ~treatment. In most cases, if differentially variability is of interest, the formula should only include the factor of interest as a large anount of data is needed to define variability depending to each factors. This formula can be a sub-formula of your estimated model; in this case all other factor will be factored out.
number_of_draws	An integer. How may copies of the data you want to draw from the model joint posterior distribution.
mcmc_seed	An integer. Used for Markov-chain Monte Carlo reproducibility. By default a random number is sampled from 1 to 999999. This itself can be controlled by set.seed()

Value

A tibble `tbl` with cell_group-wise statistics

A tibble (`tbl`), with the following columns:

- **cell_group** - A character column representing the cell group being tested.
- **sample** - A factor column representing the sample name from which data was generated.

- **generated_proportions** - A numeric column representing the proportions generated from the model.
- **generated_counts** - An integer column representing the counts generated from the model.
- **replicate** - An integer column representing the replicate number, where each row corresponds to a different replicate of the data.

Examples

```
print("cmdstanr is needed to run this example.")
# Note: Before running the example, ensure that the 'cmdstanr' package is installed:
# install.packages("cmdstanr", repos = c("https://stan-dev.r-universe.dev/", getOption("repos")))


  if (instantiate::stan_cmdstan_exists() && .Platform$OS.type == "unix") {
    data("counts_obj")

    sccomp_estimate(
      counts_obj,
      ~ type, ~1, sample, cell_group, count,
      cores = 1
    ) |>
    sccomp_replicate()
  }
```

`sccomp_test` *sccomp_test*

Description

This function test contrasts from a sccomp result.

Usage

```
sccomp_test(
  .data,
  contrasts = NULL,
  percent_false_positive = 5,
  test_composition_above_logit_fold_change = 0.1,
  pass_fit = TRUE
)
```

Arguments

`.data`	A tibble. The result of sccomp_estimate.
`contrasts`	A vector of character strings. For example if your formula is `~ 0 + treatment` and the factor treatment has values `yes` and `no`, your contrast could be "constrasts = c(treatmentyes - treatmentno)".

`percent_false_positive`
: A real between 0 and 100 non included. This used to identify outliers with a specific false positive rate.

`test_composition_above_logit_fold_change`
: A positive integer. It is the effect threshold used for the hypothesis test. A value of 0.2 correspond to a change in cell proportion of 10% for a cell type with baseline proportion of 50%. That is, a cell type goes from 45% to 50%. When the baseline proportion is closer to 0 or 1 this effect thrshold has consistent value in the logit uncontrained scale.

`pass_fit`
: A boolean. Whether to pass the Stan fit as attribute in the output. Because the Stan fit can be very large, setting this to FALSE can be used to lower the memory imprint to save the output.

Value

A tibble (`tbl`), with the following columns:

- cell_group - The cell groups being tested.
- parameter - The parameter being estimated from the design matrix described by the input formula_composition and formula_variability.
- factor - The covariate factor in the formula, if applicable (e.g., not present for Intercept or contrasts).
- c_lower - Lower (2.5%) quantile of the posterior distribution for a composition (c) parameter.
- c_effect - Mean of the posterior distribution for a composition (c) parameter.
- c_upper - Upper (97.5%) quantile of the posterior distribution for a composition (c) parameter.
- c_pH0 - Probability of the c_effect being smaller or bigger than the `test_composition_above_logit_fold_change` argument.
- c_FDR - False discovery rate of the c_effect being smaller or bigger than the `test_composition_above_logit_fold_c` argument. False discovery rate for Bayesian models is calculated differently from frequentists models, as detailed in Mangiola et al, PNAS 2023.
- c_n_eff - Effective sample size, the number of independent draws in the sample. The higher, the better.
- c_R_k_hat - R statistic, a measure of chain equilibrium, should be within 0.05 of 1.0.
- v_lower - Lower (2.5%) quantile of the posterior distribution for a variability (v) parameter.
- v_effect - Mean of the posterior distribution for a variability (v) parameter.
- v_upper - Upper (97.5%) quantile of the posterior distribution for a variability (v) parameter.
- v_pH0 - Probability of the v_effect being smaller or bigger than the `test_composition_above_logit_fold_change` argument.
- v_FDR - False discovery rate of the v_effect being smaller or bigger than the `test_composition_above_logit_fold_c` argument. False discovery rate for Bayesian models is calculated differently from frequentists models, as detailed in Mangiola et al, PNAS 2023.
- v_n_eff - Effective sample size for a variability (v) parameter.
- v_R_k_hat - R statistic for a variability (v) parameter, a measure of chain equilibrium.
- count_data - Nested input count data.

#'

Examples

```
print("cmdstanr is needed to run this example.")
# Note: Before running the example, ensure that the 'cmdstanr' package is installed:
# install.packages("cmdstanr", repos = c("https://stan-dev.r-universe.dev/", getOption("repos")))


  if (instantiate::stan_cmdstan_exists()) {
    data("counts_obj")

    estimates = sccomp_estimate(
      counts_obj,
      ~ 0 + type, ~1, sample, cell_group, count,
      cores = 1
    ) |>
    sccomp_test("typecancer - typebenign")
  }
```

`sce_obj` *sce_obj*

Description

Example `SingleCellExperiment` object containing gene expression data for 106,297 cells across two assays: counts and logcounts. The object includes metadata and assay data for RNA expression, which can be used directly in differential analysis functions like `sccomp_glm`.

Usage

```
data(sce_obj)
```

Format

A `SingleCellExperiment` object with the following structure:

- **assays**: Two assays: counts (raw RNA counts) and logcounts (log-transformed counts).
- **rowData**: No additional row-level metadata is present.
- **colData**: Metadata for each cell, including six fields: sample, type, nFeature_RNA, ident, and others.
- **dim**: 1 feature and 106,297 cells.
- **colnames**: Cell identifiers for all 106,297 cells.

Value

A `SingleCellExperiment` object containing single-cell RNA expression data.

seurat_obj *seurat_obj*

Description

Example `Seurat` object containing gene expression data for 106,297 cells across a single assay. The object includes RNA counts and data layers, but no variable features are defined. This dataset can be directly used with functions like `sccomp_glm` for differential abundance analysis.

Usage

```
data(seurat_obj)
```

Format

A `Seurat` object with the following structure:

- **assays**: Contains gene expression data. The active assay is `RNA`, with 1 feature and no variable features.
- **layers**: Two layers: counts and data, representing raw and processed RNA expression values, respectively.
- **samples**: 106,297 samples (cells) within the RNA assay.

Value

A `Seurat` object containing single-cell RNA expression data.

simulate_data *simulate_data*

Description

This function simulates counts from a linear model.

Usage

```
simulate_data(
  .data,
  .estimate_object,
  formula_composition,
  formula_variability = NULL,
  .sample = NULL,
  .cell_group = NULL,
  .coefficients = NULL,
  variability_multiplier = 5,
```

```
  number_of_draws = 1,
  mcmc_seed = sample(1e+05, 1),
  cores = detectCores(),
  sig_figs = 9
)
```

Arguments

`.data`	A tibble including a cell_group name column	sample name column	read counts column	factor columns	Pvalue column	a significance column
`.estimate_object`	The result of sccomp_estimate execution. This is used for sampling from real-data properties.
`formula_composition`	A formula. The sample formula used to perform the differential cell_group abundance analysis
`formula_variability`	A formula. The formula describing the model for differential variability, for example ~treatment. In most cases, if differentially variability is of interest, the formula should only include the factor of interest as a large anount of data is needed to define variability depending to each factors.
`.sample`	A column name as symbol. The sample identifier
`.cell_group`	A column name as symbol. The cell_group identifier
`.coefficients`	The column names for coefficients, for example, c(b_0, b_1)
`variability_multiplier`	A real scalar. This can be used for artificially increasing the variability of the simulation for benchmarking purposes.
`number_of_draws`	An integer. How may copies of the data you want to draw from the model joint posterior distribution.
`mcmc_seed`	An integer. Used for Markov-chain Monte Carlo reproducibility. By default a random number is sampled from 1 to 999999. This itself can be controlled by set.seed()#' @param cores Integer, the number of cores to be used for parallel calculations.
`cores`	Integer, the number of cores to be used for parallel calculations.
`sig_figs`	Number of significant figures to use for Stan model output. Default is 9.

Value

A tibble (`tbl`) with the following columns:

- **sample** - A character column representing the sample name.
- **type** - A factor column representing the type of the sample.
- **phenotype** - A factor column representing the phenotype in the data.
- **count** - An integer column representing the original cell counts.

- **cell_group** - A character column representing the cell group identifier.
- **b_0** - A numeric column representing the first coefficient used for simulation.
- **b_1** - A numeric column representing the second coefficient used for simulation.
- **generated_proportions** - A numeric column representing the generated proportions from the simulation.
- **generated_counts** - An integer column representing the generated cell counts from the simulation.
- **replicate** - An integer column representing the replicate number for each draw from the posterior distribution.

Examples

```
print("cmdstanr is needed to run this example.")
# Note: Before running the example, ensure that the 'cmdstanr' package is installed:
# install.packages("cmdstanr", repos = c("https://stan-dev.r-universe.dev/", getOption("repos")))


  if (instantiate::stan_cmdstan_exists()) {
    data("counts_obj")
    library(dplyr)

    estimate = sccomp_estimate(
      counts_obj,
      ~ type, ~1, sample, cell_group, count,
      cores = 1
    )

   # Set coefficients for cell_groups. In this case all coefficients are 0 for simplicity.
    counts_obj = counts_obj |> mutate(b_0 = 0, b_1 = 0)

    # Simulate data
    simulate_data(counts_obj, estimate, ~type, ~1, sample, cell_group, c(b_0, b_1))
  }
```

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