Package 'rrobot'

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Type Package

Title Robust Outlier Detection for Diverse Distributions

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Description Provides robust outlier detection techniques for identifying anomalies in multivariate data, with a focus on methods that remain effective under non-Gaussian distributions. For more details see Saluja, Parlak, and Mejia (2026+) <doi:10.48550/arXiv.2505.11806>.

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URL https://github.com/mandymejia/rrobot

BugReports https://github.com/mandymejia/rrobot/issues

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alpha *Alpha parameter documentation*

Description

Alpha parameter documentation

Arguments

alpha	Significance level used to compute RD threshold (default = 0.01 for 99th percentile).

B *B parameter documentation*

Description

B parameter documentation

Arguments

B	Integer; number of bootstrap samples per imputed dataset (default = 1000).

binwidth *Binwidth parameter documentation*

Description

Binwidth parameter documentation

Arguments

binwidth	Histogram bin width (default = 0.1).

boot_quant *Boot_quant parameter documentation*

Description

Boot_quant parameter documentation

Arguments

boot_quant	Numeric; confidence level for bootstrap confidence intervals (default = 0.95, for 95% CI).

compute_RD *Compute Squared robust distance and covariance from a Subset*

Description

Calculates the robust mean, covariance matrix, and optionally robust distances using either:

- "auto" mode: automatically selects the best robust subset using covMcd
- "manual" mode: uses provided robust covariance matrix and subset indices

Usage

```
compute_RD(
  x,
  mode = c("auto", "manual"),
  cov_mcd = NULL,
  ind_incld = NULL,
  dist = TRUE
)
```

Arguments

x	A numeric matrix or data frame of dimensions T × p (observations × variables).
mode	Character string; either "auto" (default) to compute MCD internally or "manual" to use user-supplied values.
cov_mcd	Optional covariance matrix (p × p); required in "manual" mode.
ind_incld	Optional vector of row indices used to compute the robust mean; required in "manual" mode.
dist	Logical; if TRUE, compute squared robust Mahalanobis distances for all observations.

Value

A list with elements:

ind_incld Vector of row indices used to compute the robust mean and covariance.

ind_excld Vector of excluded row indices.

h Number of included observations.

xbar_star Robust mean vector (length p).

S_star Robust covariance matrix (p × p).

invcov_sqrt Matrix square root of the inverse covariance matrix (p × p).

RD Squared robust distances for all observations (length T), or NULL if dist = FALSE.

call The matched function call.

`cov_mcd` *Cov_mcd parameter documentation*

Description

Cov_mcd parameter documentation

Arguments

`cov_mcd`	Optional covariance matrix (p × p); required in "manual" mode.

`cutoff` *Cutoff parameter documentation*

Description

Cutoff parameter documentation

Arguments

`cutoff`	A numeric value indicating how many MADs away from the median to flag as outliers. The default value is set to be 4.

dist *Dist parameter documentation*

Description

Dist parameter documentation

Arguments

dist	Logical; if TRUE, compute squared robust Mahalanobis distances for all observations.

impute_method *Impute_method parameter documentation*

Description

Impute_method parameter documentation

Arguments

impute_method	Character string; imputation method for univariate outliers.

imp_data *Imp_data parameter documentation*

Description

Imp_data parameter documentation

Arguments

imp_data	A numeric matrix (T × p) of single-imputed data.

imp_datasets *Imp_datasets parameter documentation*

Description

Imp_datasets parameter documentation

Arguments

imp_datasets	A list of M numeric matrices (T × p); multiply imputed datasets.

ind_incld *Ind_incld parameter documentation*

Description

Ind_incld parameter documentation

Arguments

ind_incld	Optional vector of row indices used to compute the robust mean; required in "manual" mode.

k *K parameter documentation*

Description

K parameter documentation

Arguments

k	Integer; number of perturbation cycles per imputation (default = 10).

M *M parameter documentation*

Description

M parameter documentation

Arguments

M	Integer; number of multiply imputed datasets (default = 5).

method *Threshold_method parameter documentation*

Description

Threshold_method parameter documentation

Arguments

method	Character string; one of "all","SI","SI_boot","MI","MI_boot","F", "SHASH".

method_univOut *Method_univOut parameter documentation*

Description

Method_univOut parameter documentation

Arguments

method	Character string. One of "SHASH" or "robZ".

mode *Mode parameter documentation*

Description

Mode parameter documentation

Arguments

mode	Character string; either "auto" (default) to compute MCD internally or "manual" to use user-supplied values.

plot.RD *Plot Method for RD Analysis Results*

Description

Creates diagnostic plots for robust distance analysis results.

Usage

```
## S3 method for class 'RD'
plot(x, type = c("histogram", "imputations", "univOut"), method = NULL, ...)
```

Arguments

x	An object of class "RD" from RD() or threshold_RD().
type	Character string specifying plot type: "histogram" (default), "imputations", or "univOut".
method	Character string specifying threshold method. Auto-detected if NULL.
...	Additional arguments passed to plotting functions.

Value

A ggplot object.

quantile *Quantile parameter documentation*

Description

Quantile parameter documentation

Arguments

quantile	Numeric in (0,1) specifying the upper quantile for thresholding; the expected False Positive Rate for the chosen threshold.

RD_obj *RD_obj parameter documentation*

Description

RD_obj parameter documentation

Arguments

RD_obj	Pre-computed RD_result object from compute_RD.

RD_org_obj *RD_org_obj parameter documentation*

Description

RD_org_obj parameter documentation

Arguments

RD_org_obj	Output list from compute_RD on the original data. Must contain $RD, $S_star, and $ind_incld.

SHASH_out *SHASH-based Outlier Detection (Extended)*

Description

Detects univariate outliers using an iterative SHASH fitting process with optional pre-flagging strategies. A SHASH (Sinh-Arcsinh) distribution is fitted to the data iteratively, each time excluding candidate outliers from the fit, until the set of flagged observations converges or `maxit` is reached.

Usage

```
SHASH_out(
  x,
  thr0 = 2.58,
  thr1 = 2.58,
  thr = 4,
  tail = c("both", "upper", "lower"),
  use_iso = TRUE,
  thr_iso = 0.6,
  maxit = 100,
  weight_init = NULL
)
```

Arguments

`x`	Numeric vector. May contain `NA` values; they are excluded from fitting and propagated as `NA` in all output vectors.
`thr0`	Positive numeric scalar. Threshold for initial outlier pre-flagging when `use_iso = FALSE` (default: 2.58).
`thr1`	Positive numeric scalar. Threshold used to classify observations as inliers during iterative convergence (default: 2.58).
`thr`	Positive numeric scalar. Final threshold applied to the converged SHASH-normalised scores to declare outliers in the returned output (default: 4).
`tail`	Character string specifying which tail(s) to check for outliers. Must be one of `"both"` (default), `"upper"`, or `"lower"`. • `"upper"`: detect upper-tail outliers only. • `"lower"`: detect lower-tail outliers only. • `"both"`: detect two-sided outliers.
`use_iso`	Logical. If `TRUE` (default), uses an isolation forest (via `isotree`) to pre-screen candidate outliers before the iterative fitting loop begins.
`thr_iso`	Numeric scalar in [0, 1]. Isolation forest anomaly score threshold above which observations are treated as candidate outliers during pre-screening (default: 0.6). Only used when `use_iso = TRUE`.

`maxit` Positive integer. Maximum number of fitting iterations before the algorithm stops regardless of convergence (default: 100).

`weight_init` Optional logical vector of length `length(x)`. If supplied, these weights initialise the iterative fit directly, bypassing both the isolation forest and empirical-rule pre-screening. `TRUE` means the observation is treated as an inlier in the first iteration.

Value

A list of class `"SHASH_out"` with the following elements:

`out_idx` Integer vector. Indices of observations in `x` that were flagged as outliers at the final threshold `thr`.

`x_norm` Numeric vector. SHASH-normalised scores for every observation (same length as `x`; `NA` where `x` was `NA`).

`SHASH_coef` Named list with elements `mu`, `sigma`, `nu`, and `tau`: the fitted SHASH parameter estimates from the final iteration (sigma and tau are on the log scale, as returned by `gamlssML`).

`isotree_scores` Numeric vector of isolation forest anomaly scores (same length as `x`). `NA` when `use_iso = FALSE` or `weight_init` was supplied.

`initial_weights` Logical vector. Inlier weights used for the very first fitting iteration (same length as `x`).

`indx_iters` Integer matrix of dimensions `length(x)` × `last_iter`. Each column records which observations were flagged as outliers (value 1) during that iteration.

`norm_iters` Numeric matrix of dimensions `length(x)` × `last_iter`. Each column records the SHASH-normalised scores from that iteration.

`last_iter` Integer. The number of iterations completed before convergence or hitting `maxit`.

`converged` Logical. `TRUE` if the inlier weight vector stabilised before reaching `maxit`.

`params` List. A record of all input parameters, stored for reproducibility.

Examples

```
# --- Example 1: Synthetic data with known injected outliers ---------------
# Using rnorm lets us inject outliers at known positions so we can verify
# the function finds exactly what we planted.
set.seed(42)
x <- rnorm(200, mean = 10, sd = 2)

# Shift a handful of observations far into the upper tail
outlier_positions <- c(17, 77, seq(190, 200))
x[outlier_positions] <- x[outlier_positions] + 10

result_sim <- SHASH_out(
  x,
  thr0    = 2.58,
  thr1    = 2.58,
  thr     = 4,
  tail    = "both",
  use_iso = FALSE   # skip isolation forest to keep the example fast
```

```
)

result_sim$out_idx    # should recover positions near outlier_positions
result_sim$converged  # did the iterative fit stabilise?

# --- Example 2: Real benchmark data (Hawkins-Bradu-Kass) ------------------
# hbk is a classic outlier detection benchmark shipped with robustbase,
# which this package already imports, so it is always available.
data("hbk", package = "robustbase")

result_hbk <- SHASH_out(
  hbk$X1,
  thr0    = 2.58,
  thr1    = 2.58,
  thr     = 4,
  tail    = "both",
  use_iso = FALSE
)

result_hbk$out_idx   # flagged observations in the X1 column
result_hbk$SHASH_coef  # fitted SHASH parameters; sigma and tau are log-scale

# Which positions were flagged as outliers?
result_hbk$out_idx

# Did the algorithm converge before hitting maxit?
result_hbk$converged

# How many iterations did it take?
result_hbk$last_iter
```

`SHASH_transform` *SHASH Data Transformation*

Description

These two functions form a matched pair for transforming data between the SHASH (Sinh-Arcsinh) distribution and the standard normal distribution. `SHASH_to_normal()` maps SHASH-distributed observations onto an approximately normal scale; `normal_to_SHASH()` is the inverse.

Usage

```
SHASH_to_normal(x, mu, sigma, nu, tau)

normal_to_SHASH(x, mu, sigma, nu, tau)
```

Arguments

x	Numeric vector of values to transform.
mu	Numeric scalar. Location parameter controlling the mean of the SHASH distribution.
sigma	Numeric scalar. Spread parameter on the log scale. The function applies exp(sigma) internally, so pass the raw coefficient as returned by gamlssML(). Pass sigma = 0 to get unit spread since exp(0) = 1.
nu	Numeric scalar. Skewness parameter. A value of 0 gives a symmetric distribution.
tau	Numeric scalar. Tail-weight parameter on the log scale. Pass tau = 0 for normal-like tails since exp(0) = 1.

Value

A numeric vector of transformed values, the same length as x.

Functions

- SHASH_to_normal(): Transforms SHASH-distributed data to approximately normal data.
- normal_to_SHASH(): Transforms standard normal data back to the SHASH-distributed scale.

Examples

```
set.seed(42)
x <- rnorm(200)
x[c(17, 77)] <- x[c(17, 77)] + 5

mu <- 0; sigma <- 0; nu <- 0; tau <- 0

z <- SHASH_to_normal(x, mu = mu, sigma = sigma, nu = nu, tau = tau)
x_recovered <- normal_to_SHASH(z, mu = mu, sigma = sigma, nu = nu, tau = tau)
all.equal(x, x_recovered)
```

---

summary.F_result *Summary method for Hardin & Rocke F results*

Description

Summary method for Hardin & Rocke F results

Usage

```
## S3 method for class 'F_result'
summary(object, ...)
```

Arguments

object	An object of class "F_result" or "HR_result"
...	Additional arguments to to method-specific functions.

Value

NULL, invisibly

---

summary.MI_boot_result *Summary method for MI_boot results*

Description

Summary method for MI_boot results

Usage

```
## S3 method for class 'MI_boot_result'
summary(object, ...)
```

Arguments

object	An object of class "MI_boot_result"
...	Additional arguments to to method-specific functions.

Value

NULL, invisibly

---

summary.MI_result *Summary method for MI results*

Description

Summary method for MI results

Usage

```
## S3 method for class 'MI_result'
summary(object, ...)
```

Arguments

object	An object of class "MI_result"
...	Additional arguments to to method-specific functions.

Value

NULL, invisibly

`summary.SI_boot_result` *Summary method for SI_boot results*

Description

Summary method for SI_boot results

Usage

```
## S3 method for class 'SI_boot_result'
summary(object, ...)
```

Arguments

`object`	An object of class "SI_boot_result"
`...`	Additional arguments to to method-specific functions.

Value

NULL, invisibly

`summary.SI_result` *Summary method for SI results*

Description

Summary method for SI results

Usage

```
## S3 method for class 'SI_result'
summary(object, ...)
```

Arguments

`object`	An object of class "SI_result"
`...`	Additional arguments to to method-specific functions.

Value

NULL, invisibly

thr *Thr parameter documentation*

Description

Thr parameter documentation

Arguments

thr	Threshold multiplier for outlier detection (default = 4).

threshold_RD *Comprehensive Outlier Detection Using Robust Distance Thresholding*

Description

Performs univariate outlier detection + imputation, robust distance, and multiple thresholding methods.

Usage

```
threshold_RD(
  x,
  w = NULL,
  method = c("SI_boot", "MI", "MI_boot", "SI", "F", "SHASH", "all"),
  RD_obj = NULL,
  impute_method = "mean",
  cutoff = 4,
  trans = "SHASH",
  M = 50,
  k = 100,
  alpha = 0.01,
  quantile = 0.01,
  verbose = FALSE,
  boot_quant = 0.95,
  B = 1000
)
```

Arguments

x	A numeric matrix or data frame of dimensions T × p (observations × variables).
w	A numeric matrix (n_time × L) of low-kurtosis ICA components used as predictors (required for MI).
method	Character string; one of "all","SI","SI_boot","MI","MI_boot","F", "SHASH".

RD_obj	Pre-computed RD_result object from compute_RD.
impute_method	Character string; imputation method for univariate outliers.
cutoff	A numeric value indicating how many MADs away from the median to flag as outliers. The default value is set to be 4.
trans	Character string; transformation method, one of "SHASH" or "robZ".
M	Integer; number of multiply imputed datasets (default = 5).
k	Integer; number of perturbation cycles per imputation (default = 10).
alpha	Significance level used to compute RD threshold (default = 0.01 for 99th percentile).
quantile	Numeric in (0,1) specifying the upper quantile for thresholding; the expected False Positive Rate for the chosen threshold.
verbose	Logical; if TRUE, print progress messages.
boot_quant	Numeric; confidence level for bootstrap confidence intervals (default = 0.95, for 95% CI).
B	Integer; number of bootstrap samples per imputed dataset (default = 1000).

Value

A list with:

thresholds Result from the specific threshold method, or list of all methods if "all".

RD_obj The robust distance object from compute_RD().

call The matched function call.

`thresh_result` *Thresh_result parameter documentation*

Description

Thresh_result parameter documentation

Arguments

thresh_result	A threshold result object from any threshold method containing threshold information.

`trans` *Trans parameter documentation*

Description

Trans parameter documentation

Arguments

trans	Character string; transformation method, one of "SHASH" or "robZ".

verbose *Verbose parameter documentation*

Description

Verbose parameter documentation

Arguments

verbose	Logical; if TRUE, print progress messages.

w *W parameter documentation*

Description

W parameter documentation

Arguments

w	A numeric matrix (n_time × L) of low-kurtosis ICA components used as predictors (required for MI).

x *X parameter documentation*

Description

X parameter documentation

Arguments

x	A numeric matrix or data frame of dimensions T × p (observations × variables).

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