

Package: AGCA4extremes (via r-universe)

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Title Anchored Geodesic Component Analysis for Extremes

Version 0.1.0

Description Implements anchored geodesic component analysis for multivariate extremes. The package provides Pareto and rank-Pareto marginal standardization, top-k angular extraction, anchored eigensolutions, reconstruction, diagnostics, nonparametric bootstrap tools, and plotting methods for benchmark-relative angular variation.

License GPL-3

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agca

Fit anchored geodesic component analysis

Description

agca() is the main user interface. It standardizes margins, extracts large-radius observations, resolves the anchor, and fits anchored geodesic components to the resulting angular directions.

Usage

```
agca(
  x,
  k = NULL,
  threshold = NULL,
  margin = c("rank_pareto", "pareto", "none"),
  cdf = NULL,
```

```

    anchor = "canonical",
    p = NULL,
    decluster = NULL,
    bootstrap = NULL,
    keep_data = FALSE,
    ties_method = "average",
    seed = NULL
  )

```

Arguments

x	Numeric matrix or data frame. Larger values are treated as more extreme in each margin.
k	Number of largest radial observations to retain. Specify either k or threshold.
threshold	Radial threshold for selecting extremes.
margin	Marginal standardization method. The default "rank_pareto" uses empirical ranks. Use "pareto" with cdf, or "none" for already standardized observations.
cdf	Optional CDF function or list of CDF functions for margin = "pareto".
anchor	"canonical", "frechet", "principal", or a numeric anchor vector.
p	Working reconstruction rank. Defaults to the full tangent rank.
decluster	Optional. Use NULL for no declustering, TRUE for runs declustering with run = 1, a nonnegative integer run length, or a list with component run.
bootstrap	Optional integer number of bootstrap resamples.
keep_data	Logical. If TRUE, store the standardized data matrix in the returned object.
ties_method	Tie method used by rank_pareto() .
seed	Optional random seed used when bootstrap is supplied.

Value

An object of class "agca_fit".

Examples

```

data(agca_10d_simulation)
x <- agca_10d_simulation[paste0("X", 1:10)]
fit <- agca(x, k = 100, p = 3)
fit
agca_rank_summary(fit)

```

agca_10d_simulation	<i>Simulated 10-dimensional AGCA example</i>
---------------------	--

Description

A package-owned simulated heavy-tailed sample from the 10-dimensional design used in *Anchored Geodesic Analysis for Multivariate Extremes*. Variables X1–X8 share a low-dimensional logistic-block extremal mechanism. Variables X9 and X10 contain independent Pareto sources, creating near-axis extreme regimes alongside the shared low-rank angular structure.

Usage

```
data(agca_10d_simulation)
```

Format

A data frame with 10,000 rows and 11 columns. Columns X1, ..., X10 are positive heavy-tailed observations. Column regime is a latent factor identifying the dominant source for the observation: shared low-rank, axis 9, or axis 10.

Source

Simulated by data-row/simulate_data.R using [simulate_agca_10d\(\)](#).

agca_fit_directions	<i>Fit AGCA to angular directions</i>
---------------------	---------------------------------------

Description

Fit AGCA to angular directions

Usage

```
agca_fit_directions(g, anchor = "canonical", p = NULL, normalize = TRUE)
```

Arguments

g	Matrix of angular directions.
anchor	"canonical", "frechet", "principal", or a numeric anchor vector.
p	Working reconstruction rank. Defaults to the full tangent rank.
normalize	Logical. If TRUE, rows of g are normalized first.

Value

An object of class "agca_fit".

agca_rank_summary	<i>AGCA rank summary</i>
-------------------	--------------------------

Description

AGCA rank summary

Usage

```
agca_rank_summary(fit)
```

Arguments

`fit` An object returned by `agca()` or `agca_fit_directions()`.

Value

A data frame with rank, residual risk, and variation explained.

agca_reconstruct	<i>Reconstruct angular directions from leading AGCA components</i>
------------------	--

Description

Reconstruct angular directions from leading AGCA components

Usage

```
agca_reconstruct(fit, p = fit$p)
```

Arguments

`fit` An object returned by `agca()` or `agca_fit_directions()`.
`p` Reconstruction rank.

Value

A matrix of reconstructed angular directions.

agca_residual_risk	<i>Residual risk by AGCA rank</i>
--------------------	-----------------------------------

Description

Residual risk by AGCA rank

Usage

```
agca_residual_risk(fit, max_rank = length(fit$eigenvalues))
```

Arguments

fit	An object returned by agca() or agca_fit_directions() .
max_rank	Maximum rank to report.

Value

A numeric vector indexed by ranks 0:max_rank.

agca_standardize	<i>Marginal standardization for AGCA</i>
------------------	--

Description

Marginal standardization for AGCA

Usage

```
agca_standardize(
  x,
  margin = c("rank_pareto", "pareto", "none"),
  cdf = NULL,
  ties_method = "average"
)
```

Arguments

x	A numeric matrix or data frame.
margin	Standardization method: "rank_pareto" (default), "pareto" for supplied CDFs, or "none" for already standardized data.
cdf	Optional CDF function or list of CDF functions for margin = "pareto".
ties_method	Tie method used by rank_pareto() .

Value

A numeric matrix.

agca_variation_explained	<i>Anchored variation explained</i>
--------------------------	-------------------------------------

Description

Anchored variation explained

Usage

```
agca_variation_explained(fit)
```

Arguments

fit An object returned by `agca()` or `agca_fit_directions()`.

Value

Cumulative anchored variation explained by each rank.

anchor_sensitivity	<i>Anchor sensitivity diagnostics</i>
--------------------	---------------------------------------

Description

Anchor sensitivity diagnostics

Usage

```
anchor_sensitivity(x, k, anchors = c("canonical", "frechet", "principal"), ...)
```

Arguments

x Numeric matrix or data frame.
k Number of top radial observations.
anchors Character vector of anchors to compare.
... Additional arguments passed to `agca()`.

Value

A data frame of rank summaries across anchors.

anchored_departures	<i>Anchored departures</i>
---------------------	----------------------------

Description

Computes the anchor coordinate and tangent departure $u_\mu(g) = (I - \mu\mu^\top)g$.

Usage

```
anchored_departures(g, mu, normalize = TRUE)
```

Arguments

g	A numeric matrix of directions.
mu	Anchor direction.
normalize	Logical. If TRUE, rows of g are normalized first.

Value

A list with normalized directions, anchor, anchor coordinates, and anchored departures.

angular_functional_error	<i>Functional approximation errors from angular reconstruction</i>
--------------------------	--

Description

Computes mean angular functional values on the fitted and reconstructed directions for a collection of portfolio weights.

Usage

```
angular_functional_error(fit, weights, ranks = fit$p, power = 1, cap = Inf)
```

Arguments

fit	An object returned by agca() or agca_fit_directions() .
weights	A numeric vector or matrix. Rows are portfolios.
ranks	Integer vector of AGCA ranks.
power	Power applied to positive portfolio exposures.
cap	Optional finite cap applied to the powered exposure.

Value

A data frame with original, reconstructed, and relative errors.

bootstrap_agca	<i>Nonparametric AGCA bootstrap</i>
----------------	-------------------------------------

Description

Resamples fitted angular directions and recomputes AGCA diagnostics.

Usage

```
bootstrap_agca(
  fit,
  B = 199L,
  ranks = NULL,
  fixed_anchor = TRUE,
  anchor = "canonical",
  seed = NULL
)
```

Arguments

fit	An object returned by <code>agca()</code> or <code>agca_fit_directions()</code> .
B	Number of bootstrap resamples.
ranks	Integer ranks to summarize.
fixed_anchor	Logical. If TRUE, keep the fitted anchor fixed. Otherwise refit the requested anchor type.
anchor	Anchor used when <code>fixed_anchor = FALSE</code> .
seed	Optional random seed.

Value

An object of class "agca_bootstrap".

canonical_anchor	<i>Canonical anchor</i>
------------------	-------------------------

Description

Canonical anchor

Usage

```
canonical_anchor(d)
```

Arguments

d Ambient dimension.

Value

The balanced direction $d^{-1/2}(1, \dots, 1)$.

decluster_runs	<i>Runs declustering for radial extremes</i>
----------------	--

Description

Exceedances are split into clusters separated by more than run consecutive non-exceedances. The representative of each cluster is the observation with the largest radius.

Usage

```
decluster_runs(x, k = NULL, threshold = NULL, run = 1L)
```

Arguments

x A numeric matrix of standardized observations.
k, threshold Top-k count or radial threshold used to define exceedances.
run Nonnegative run length.

Value

A list like [tail_directions\(\)](#), with one index per cluster.

frechet_anchor	<i>Spherical Frechet anchor</i>
----------------	---------------------------------

Description

Computes a Karcher-mean approximation to the spherical Frechet mean.

Usage

```
frechet_anchor(g, normalize = TRUE, max_iter = 100L, tol = 1e-10)
```

Arguments

g Matrix of angular directions.
normalize Logical. If TRUE, rows are normalized first.
max_iter Maximum number of iterations.
tol Convergence tolerance for the tangent update norm.

Value

A unit vector.

normalize_rows	<i>Normalize matrix rows</i>
----------------	------------------------------

Description

Normalize matrix rows

Usage

```
normalize_rows(x)
```

Arguments

`x` A numeric matrix with nonzero rows.

Value

A numeric matrix whose rows have Euclidean norm one.

pareto_from_cdf	<i>Pareto marginal standardization from supplied CDFs</i>
-----------------	---

Description

Pareto marginal standardization from supplied CDFs

Usage

```
pareto_from_cdf(x, cdf, eps = 1e-12)
```

Arguments

`x` A numeric matrix or data frame.

`cdf` A function applied to every margin, or a list of one CDF function per margin. Each CDF must return values in $[0, 1]$.

`eps` Tail clipping constant used to avoid zero and infinite values.

Value

A numeric matrix with standard Pareto margins.

plot.agca_bootstrap	<i>Plot AGCA bootstrap summaries</i>
---------------------	--------------------------------------

Description

Plot AGCA bootstrap summaries

Usage

```
## S3 method for class 'agca_bootstrap'
plot(x, statistic = c("variation_explained", "residual_risk"), ...)
```

Arguments

x	An object returned by bootstrap_agca() .
statistic	Statistic to plot.
...	Additional graphical arguments.

Value

Invisibly returns x.

plot.agca_fit	<i>Plot AGCA output</i>
---------------	-------------------------

Description

Plot AGCA output

Usage

```
## S3 method for class 'agca_fit'
plot(x, type = c("variation", "scree", "scores", "loadings"), p = 1L, ...)
```

Arguments

x	An object returned by agca() or agca_fit_directions() .
type	Plot type: eigenvalue scree plot, cumulative variation, first two scores, or loadings.
p	Component index used for the loadings plot.
...	Additional graphical arguments.

Value

Invisibly returns x.

principal_anchor	<i>Principal angular anchor</i>
------------------	---------------------------------

Description

Principal angular anchor

Usage

```
principal_anchor(g, normalize = TRUE)
```

Arguments

g	Matrix of angular directions.
normalize	Logical. If TRUE, rows are normalized first.

Value

The leading eigenvector of the angular second-moment matrix, oriented to have positive sum.

rank_pareto	<i>Rank-Pareto marginal standardization</i>
-------------	---

Description

Transforms each margin to empirical standard Pareto scores using $(n + 1)/(n + 1 - rank)$. Larger observations are treated as more extreme.

Usage

```
rank_pareto(x, ties_method = "average")
```

Arguments

x	A numeric matrix or data frame.
ties_method	Tie method passed to base::rank() .

Value

A numeric matrix with standard Pareto-like margins.

row_norms	<i>Row Euclidean norms</i>
-----------	----------------------------

Description

Row Euclidean norms

Usage

```
row_norms(x)
```

Arguments

x A numeric matrix.

Value

A numeric vector containing one Euclidean norm per row.

simulate_agca_10d	<i>Simulate the 10-dimensional AGCA example design</i>
-------------------	--

Description

Generates the 10-dimensional heavy-tailed design used as the package example. Variables X1–X8 share a low-dimensional logistic-block extremal mechanism. Variables X9 and X10 contain independent Pareto sources, so selected extremes include near-axis regimes in addition to the shared low-rank angular structure.

Usage

```
simulate_agca_10d(
  n = 10000L,
  seed = NULL,
  theta = 0.45,
  tau = 0.25,
  axis9_scale = 1,
  axis10_scale = 1
)
```

Arguments

n	Number of observations.
seed	Optional random seed.
theta	Logistic dependence parameter in $(0, 1)$.
tau	Nonnegative finite-threshold noise scale.
axis9_scale, axis10_scale	Positive scales for the independent Pareto sources in variables X9 and X10.

Value

A data frame with variables X1, ..., X10 and a factor regime giving the dominant latent source for each observation.

Examples

```
x <- simulate_agca_10d(n = 500, seed = 1)
fit <- agca(x[paste0("X", 1:10)], k = 75, p = 3)
agca_rank_summary(fit)
```

sphere_distance	<i>Spherical geodesic distance</i>
-----------------	------------------------------------

Description

Computes great-circle distances on the unit sphere. If y has one row and x has several rows, the single direction in y is recycled.

Usage

```
sphere_distance(x, y, normalize = TRUE)
```

Arguments

x, y	Numeric matrices with the same number of columns.
normalize	Logical. If TRUE, rows are normalized before distances are computed.

Value

A numeric vector of geodesic distances in radians.

summary.agca_bootstrap	<i>Summarize AGCA bootstrap output</i>
------------------------	--

Description

Summarize AGCA bootstrap output

Usage

```
## S3 method for class 'agca_bootstrap'  
summary(object, probs = c(0.025, 0.5, 0.975), ...)
```

Arguments

object	An object returned by <code>bootstrap_agca()</code> .
probs	Quantile probabilities.
...	Unused.

Value

A data frame of bootstrap summaries by rank.

tail_directions	<i>Top-k angular directions</i>
-----------------	---------------------------------

Description

Top-k angular directions

Usage

```
tail_directions(x, k = NULL, threshold = NULL)
```

Arguments

x	A numeric matrix of standardized observations.
k	Number of largest radii to retain. Specify either k or threshold.
threshold	Radial threshold. Observations with radius greater than threshold are retained.

Value

A list containing angular directions, radii, selected indices, and the threshold.

threshold_stability	<i>Threshold stability diagnostics</i>
---------------------	--

Description

Threshold stability diagnostics

Usage

```
threshold_stability(x, k, ...)
```

Arguments

x	Numeric matrix or data frame.
k	Integer vector of top-k values.
...	Additional arguments passed to agca() .

Value

A data frame of rank summaries across thresholds.

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