Package: pc (via r-universe)

May 26, 2026

Title Pattern Causality Analysis

Version 0.3

Description Infer causation from observational data through pattern causality analysis (PC), with original algorithm for time series data from Stavroglou et al. (2020) <doi:10.1073/pnas.1918269117>, as well as methodological extensions for spatial cross-sectional data introduced by Zhang & Wang (2025) <doi:10.1080/13658816.2025.2581207>, together with a systematic description proposed in Lyu et al. (2026) <doi:10.1016/j.compenvurbsys.2026.102435>.

License GPL-3

Encoding UTF-8

URL https://stscl.github.io/pc/, https://github.com/stscl/pc

BugReports https://github.com/stscl/pc/issues

Depends R (>= 4.1.0)

LinkingTo Rcpp, RcppThread

Imports ggplot2, methods, sdsfun, sf, stats, terra

Suggests Rcpp, RcppThread, readr, infoxtr, spEDM, tEDM, knitr, rmarkdown

VignetteBuilder knitr

Config/roxygen2/markdown TRUE

Config/roxygen2/version 8.0.0

Config/pak/sysreqs libabsl-dev cmake libgdal-dev gdal-bin libgeos-dev libssl-dev libproj-dev libsqlite3-dev libudunits2-dev

Repository https://stscl.r-universe.dev

Date/Publication 2026-05-26 08:56:10 UTC

RemoteUrl https://github.com/stscl/pc

RemoteRef HEAD

RemoteSha 0a1c5b46aa61ddec5c7f2d13ed39f01dcc67c598

Contents

fnn 2
ops 4
pc 6

Index **10**

---

fnn *False Nearest Neighbors*

Description

False Nearest Neighbors

Usage

```
## S4 method for signature 'data.frame'
fnn(
  data,
  target,
  E = 10,
  k = 1,
  tau = 1,
  style = 1,
  lib = NULL,
  pred = NULL,
  dist.metric = c("euclidean", "manhattan", "maximum"),
  rt = 10,
  eps = NULL,
  threads = length(E),
  higher.parallel = TRUE,
  ...
)

## S4 method for signature 'sf'
fnn(
  data,
  target,
  E = 10,
  k = 1,
  tau = 1,
  style = 1,
  lib = NULL,
  pred = NULL,
  dist.metric = c("euclidean", "manhattan", "maximum"),
  rt = 10,
  eps = NULL,
```

```
  threads = length(E),
  higher.parallel = TRUE,
  detrend = FALSE,
  nb = NULL,
  ...
)

## S4 method for signature 'SpatRaster'
fnn(
  data,
  target,
  E = 10,
  k = 1,
  tau = 1,
  style = 1,
  lib = NULL,
  pred = NULL,
  dist.metric = c("euclidean", "manhattan", "maximum"),
  rt = 10,
  eps = NULL,
  threads = length(E),
  higher.parallel = TRUE,
  detrend = FALSE,
  ...
)
```

Arguments

data	Observation data.
target	Integer of column indice for the target variable.
E	(optional) Embedding dimensions.
k	(optional) Number of nearest neighbors used for evaluation.
tau	(optional) Step of lag.
style	(optional) Embedding style (0 includes current state, 1 excludes it).
lib	(optional) Libraries indices.
pred	(optional) Predictions indices.
dist.metric	(optional) Distance measure to be used.
rt	(optional) Relative distance threshold.
eps	(optional) Absolute distance threshold.
threads	(optional) Number of threads used.
higher.parallel	(optional) Whether to use a higher level of parallelism.
...	Additional arguments to absorb unused inputs in method dispatch.
detrend	(optional) Whether to remove the linear trend.
nb	(optional) Neighbours list.

Value

A vector.

References

Kennel, M.B., Brown, R., Abarbanel, H.D.I., 1992. Determining embedding dimension for phase-space reconstruction using a geometrical construction. Physical Review A 45, 3403–3411.

Examples

```
crash = sf::read_sf(system.file("case/crash.gpkg", package = "pc"))
pc::fnn(crash, 1, threads = 1)
```

---

ops *Optimal Parameter Search for Pattern Causality*

Description

Optimal Parameter Search for Pattern Causality

Usage

```
## S4 method for signature 'data.frame'
ops(
  data,
  target,
  source,
  E = 3:5,
  k = E,
  tau = 1,
  style = 1,
  lib = NULL,
  pred = NULL,
  maximize = c("dark", "positive", "negative"),
  dist.metric = c("euclidean", "manhattan", "maximum"),
  zero.tolerance = max(k),
  relative = TRUE,
  weighted = TRUE,
  threads = length(E),
  higher.parallel = TRUE,
  h = 0,
  ...
)

## S4 method for signature 'sf'
ops(
```

```
  data,
  target,
  source,
  E = 3:5,
  k = E + 1,
  tau = 1,
  style = 1,
  lib = NULL,
  pred = NULL,
  maximize = c("dark", "positive", "negative"),
  dist.metric = c("euclidean", "manhattan", "maximum"),
  zero.tolerance = max(k),
  relative = TRUE,
  weighted = TRUE,
  threads = length(E),
  higher.parallel = TRUE,
  detrend = FALSE,
  nb = NULL,
  ...
)

## S4 method for signature 'SpatRaster'
ops(
  data,
  target,
  source,
  E = 3:5,
  k = E + 1,
  tau = 1,
  style = 1,
  lib = NULL,
  pred = NULL,
  maximize = c("positive", "negative", "dark"),
  dist.metric = c("euclidean", "manhattan", "maximum"),
  zero.tolerance = max(k),
  relative = TRUE,
  weighted = TRUE,
  threads = length(E),
  higher.parallel = TRUE,
  detrend = FALSE,
  ...
)
```

Arguments

data	Observation data.
target	Integer of column indice for the target variable.
source	Integer of column indice for the source variable.

E	(optional) Embedding dimensions.
k	(optional) Number of nearest neighbors used for projection.
tau	(optional) Step of lag.
style	(optional) Embedding style (0 includes current state, 1 excludes it).
lib	(optional) Libraries indices.
pred	(optional) Predictions indices.
maximize	(optional) Causality metric to maximize: one of "positive", "negative", or "dark".
dist.metric	(optional) Distance measure to be used.
zero.tolerance	(optional) Maximum number of zeros tolerated in signature space.
relative	(optional) Whether to calculate relative changes in embedding.
weighted	(optional) Whether to weight causal strength.
threads	(optional) Number of threads used.
higher.parallel	(optional) Whether to use a higher level of parallelism.
h	(optional) Prediction horizon.
...	Additional arguments to absorb unused inputs in method dispatch.
detrend	(optional) Whether to remove the linear trend.
nb	(optional) Neighbours list.

Value

A list.

param The selected optimal parameter combination.

xmap A data.frame containing cross-mapping performance across parameter settings.

Examples

```
crash = sf::read_sf(system.file("case/crash.gpkg", package = "pc"))
pc::ops(crash, 1, 2, E = 3:10, maximize = "positive", threads = 1)
```

---

pc *Pattern Causality*

Description

Pattern Causality

Usage

```
## S4 method for signature 'data.frame'
pc(
  data,
  target,
  source,
  libsizes = NULL,
  E = 3,
  k = E,
  tau = 1,
  style = 1,
  lib = NULL,
  pred = NULL,
  boot = 99,
  replace = FALSE,
  seed = 42L,
  dist.metric = c("euclidean", "manhattan", "maximum"),
  zero.tolerance = max(k),
  relative = TRUE,
  weighted = TRUE,
  threads = length(libsizes),
  higher.parallel = TRUE,
  verbose = TRUE,
  h = 0,
  ...
)

## S4 method for signature 'sf'
pc(
  data,
  target,
  source,
  libsizes = NULL,
  E = 3,
  k = E + 1,
  tau = 1,
  style = 1,
  lib = NULL,
  pred = NULL,
  boot = 99,
  replace = FALSE,
  seed = 42L,
  dist.metric = c("euclidean", "manhattan", "maximum"),
  zero.tolerance = max(k),
  relative = TRUE,
  weighted = TRUE,
  threads = length(libsizes),
  higher.parallel = TRUE,
```

```
  verbose = TRUE,
  detrend = FALSE,
  nb = NULL,
  ...
)

## S4 method for signature 'SpatRaster'
pc(
  data,
  target,
  source,
  libsizes = NULL,
  E = 3,
  k = E + 1,
  tau = 1,
  style = 1,
  lib = NULL,
  pred = NULL,
  boot = 99,
  replace = FALSE,
  seed = 42L,
  dist.metric = c("euclidean", "manhattan", "maximum"),
  zero.tolerance = max(k),
  relative = TRUE,
  weighted = TRUE,
  threads = length(libsizes),
  higher.parallel = TRUE,
  verbose = TRUE,
  detrend = FALSE,
  ...
)
```

Arguments

data	Observation data.
target	Integer of column indice for the target variable.
source	Integer of column indice for the source variable.
libsizes	(optional) Number of observations used.
E	(optional) Embedding dimensions.
k	(optional) Number of nearest neighbors used for projection.
tau	(optional) Step of lag.
style	(optional) Embedding style (0 includes current state, 1 excludes it).
lib	(optional) Libraries indices.
pred	(optional) Predictions indices.
boot	(optional) Number of bootstraps to perform.
replace	(optional) Should sampling be with replacement?

seed	(optional) Random seed.
dist.metric	(optional) Distance measure to be used.
zero.tolerance	(optional) Maximum number of zeros tolerated in signature space.
relative	(optional) Whether to calculate relative changes in embedding.
weighted	(optional) Whether to weight causal strength.
threads	(optional) Number of threads used.
higher.parallel	(optional) Whether to use a higher level of parallelism.
verbose	(optional) Whether to show the progress bar.
h	(optional) Prediction horizon.
...	Additional arguments to absorb unused inputs in method dispatch.
detrend	(optional) Whether to remove the linear trend.
nb	(optional) Neighbours list.

Value

A list.

causality A data.frame of causality results. When `libsizes` is `NULL`, it contains per-sample causality estimates; otherwise, it contains causality results evaluated across different library sizes.

summary A data.frame summarizing overall causality metrics. Only returned when `libsizes` is `NULL`.

References

Stavroglou, S.K., Pantelous, A.A., Stanley, H.E., Zuev, K.M., 2020. Unveiling causal interactions in complex systems. Proceedings of the National Academy of Sciences 117, 7599–7605.

Examples

```
crash = sf::read_sf(system.file("case/crash.gpkg", package = "pc"))
p1 = pc::pc(crash, 1, 2, E = 8, k = 8, threads = 1)
print(p1)
plot(p1)

# convergence diagnostics
p2 = pc::pc(crash, 1, 2, libsizes = seq(10,172,40), E = 8, k = 8, threads = 1)
print(p2)
plot(p2)
```

Index

fnn, 2
fnn,data.frame-method *(fnn)*, 2
fnn,sf-method *(fnn)*, 2
fnn,SpatRaster-method *(fnn)*, 2

ops, 4
ops,data.frame-method *(ops)*, 4
ops,sf-method *(ops)*, 4
ops,SpatRaster-method *(ops)*, 4

pc, 6
pc,data.frame-method *(pc)*, 6
pc,sf-method *(pc)*, 6
pc,SpatRaster-method *(pc)*, 6