

Package ‘PiChange’

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Title Pi-Change: Change Point Detection with Prior-Informed Penalties

Version 0.0.6

Description PI-Change is a prior-informed multiple change point detection method that incorporates prespecified plausible change point locations through a time-varying penalized likelihood. The method extends multiple change point detection beyond purely data-driven segmentation by allowing external knowledge about plausible change point locations to enter the objective function; see Jacobs and Chen (2026)
<[doi:10.48550/arXiv.2605.01003](https://doi.org/10.48550/arXiv.2605.01003)>.

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Depends R (>= 4.1.0)

Imports grid, ggplot2, Rcpp (>= 1.0.10), rlang, stats

LinkingTo Rcpp

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

VignetteBuilder knitr

Config/testthat/edition 3

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PiChange-package	<i>Pi-Change: Change point detection with prior-informed penalties</i>
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Description

PI-Change detects multiple change points while allowing prespecified plausible locations to lower the local penalty. A typical analysis first records the prior assumptions with `construct_penalty()` and then fits the segmentation with `pi_change()`. The fitted object retains the observations, time index, prior specification, penalty, model settings, and ordered change points.

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References

Jacobs, J. and Chen, S. (2026). "Pi-Change: A Prior-Informed Multiple Change Point Detection Algorithm." doi:10.48550/arXiv.2605.01003.

build_prior_location	<i>Build prior weights using non-overlapping center windows</i>
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Description

Build prior weights using non-overlapping center windows

Usage

`build_prior_location(n, centers, width, type = "gaussian")`

Arguments

n	Integer time series length.
centers	Numeric vector of prior centers.
width	Positive numeric width parameter.
type	Prior shape. One of "gaussian", "triangle", or "exponential".

Value

Numeric vector of prior-support weights.

changepoints	<i>Extract PI-Change change points</i>
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Description

Extract PI-Change change points

Usage

```
changepoints(object, ...)  
  
## S3 method for class 'pi_change_fit'  
changepoints(object, scale = c("index", "time"), boundaries = FALSE, ...)
```

Arguments

object	A fitted pi_change_fit object.
...	Reserved for future methods.
scale	Return observation "index" values or values on the original "time" scale.
boundaries	Include the beginning and ending boundaries.

Value

A vector of detected change point locations.

construct_penalty	<i>Construct a PI-Change penalty specification</i>
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Description

Constructs the time-varying penalty used by PI-Change and records the prior assumptions used to create it. Observed response values are not needed; supply either the number of observations (n) or their ordered time index (time). Prior widths are measured in observation positions, including when prior locations are supplied as dates.

Usage

```
construct_penalty(
  n = NULL,
  centers,
  width,
  method,
  family,
  time = NULL,
  windows = NULL,
  max_penalty = NULL,
  minimum_penalty = NULL,
  const_ratio = NULL
)
```

Arguments

n	Number of observations. Supply exactly one of n and time.
centers	Prespecified plausible change point locations. Use observation indices when supplying n, or values on the same scale as time when supplying time.
width	Positive numeric scalar or vector specifying the prior width in observation positions. A vector must have one value per center.
method	Penalty construction method: "mbic", "manual", or "const_ratio".
family	Segment distribution family: "normal" or "zag" (zero-adjusted gamma).
time	Optional strictly increasing numeric, Date , or POSIXt vector.
windows	Optional list with components L and U defining a window around each center. Values use the same scale as centers.
max_penalty, minimum_penalty	Penalty bounds required when method = "manual".
const_ratio	Positive ratio required when method = "const_ratio".

Value

A pi_penalty object containing the numeric penalty and complete prior specification.

References

Jacobs, J. and Chen, S. (2026). "Pi-Change: A Prior-Informed Multiple Change Point Detection Algorithm." doi:[10.48550/arXiv.2605.01003](https://doi.org/10.48550/arXiv.2605.01003).

Examples

```
penalty <- construct_penalty(  
  n = 80,  
  centers = 40,  
  width = 5,  
  method = "mbic",  
  family = "normal"  
)  
penalty
```

google_mobility_workplaces

Google workplace mobility summaries

Description

Processed workplace mobility summaries for the United States, New York City, the United Kingdom, and London. Values are mean percent changes from the pre-COVID baseline by date and region.

Usage

```
google_mobility_workplaces
```

Format

A data frame with columns:

date Observation date.

region Region label.

workplaces_percent_change_from_baseline Mean workplace mobility percent change from baseline.

Source

Google LLC, "Google COVID-19 Community Mobility Reports", <https://www.google.com/covid19/mobility/>, accessed July 17, 2026.

pi_change

*Detect change points with a prior-informed penalty***Description**

`pi_change()` locates change points in a univariate series using a time-varying penalty from `construct_penalty()` or a user-supplied numeric penalty. Scientific choices remain explicit: raw numeric penalties require both family and criterion; a `pi_penalty` object supplies its recorded family and can infer the "mbic" criterion when constructed by the MBIC method.

Usage

```
pi_change(
  data,
  penalty,
  family = NULL,
  criterion = NULL,
  min_seg_len = 2L,
  time = NULL
)
```

Arguments

<code>data</code>	Finite numeric vector containing the ordered series.
<code>penalty</code>	A <code>pi_penalty</code> object or numeric vector of length <code>length(data) + 1</code> .
<code>family</code>	Segment distribution family, "normal" or "zag". This is inferred from a <code>pi_penalty</code> object when omitted.
<code>criterion</code>	Segment cost criterion, "mll" or "mbic". This is inferred only for a penalty constructed with <code>method = "mbic"</code> .
<code>min_seg_len</code>	Integer minimum segment length.
<code>time</code>	Optional ordered numeric, Date , or POSIXt index. When the penalty contains a time index, that index is used by default.

Value

A `pi_change_fit` object. Use `changepoints()` to extract detected locations and `summary()` or `plot()` to inspect the fit.

References

Jacobs, J. and Chen, S. (2026). "Pi-Change: A Prior-Informed Multiple Change Point Detection Algorithm." doi:[10.48550/arXiv.2605.01003](https://doi.org/10.48550/arXiv.2605.01003).

Examples

```

set.seed(1)
x <- c(rnorm(40, 0, 0.3), rnorm(40, 2, 0.3))
penalty <- construct_penalty(
  n = length(x), centers = 40, width = 5,
  method = "mbic", family = "normal"
)
fit <- pi_change(x, penalty, min_seg_len = 10)
changepoints(fit)

```

pi_concat	<i>Evaluate concatenated Gaussian prior weights</i>
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Description

Evaluate concatenated Gaussian prior weights

Usage

```
pi_concat(t, centers, sigma, window = NULL)
```

Arguments

t	Numeric vector of locations at which to evaluate the prior.
centers	Numeric vector of prior centers.
sigma	Positive numeric scalar or vector of prior widths.
window	Optional list with components L and U.

Value

Numeric vector of prior-support weights in $[0, 1]$.

plot.pi_change_fit	<i>Plot a PI-Change fit</i>
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Description

Displays the time-varying penalty above the observed series when the fit contains a pi_penalty specification. Prior centers and detected change points use both distinct colors and line types. Horizontal fitted lines show the estimated mean within each segment.

Usage

```
## S3 method for class 'pi_change_fit'
plot(
  x,
  ...,
  xlab = NULL,
  ylab = "Observed value",
  show_prior = TRUE,
  show_fitted = TRUE,
  show_penalty = TRUE,
  data_col = "#76BDE8",
  fitted_col = "#F06292",
  changepoint_col = "#00C853",
  prior_col = "#D62728",
  penalty_col = "#D62728",
  series_linewidth = 0.5,
  fitted_linewidth = 0.5,
  vertical_linewidth = 1,
  title = "PI-Change detection"
)
```

Arguments

<code>x</code>	A fitted <code>pi_change_fit</code> object.
<code>...</code>	Reserved for future extensions.
<code>xlab, ylab</code>	Axis labels for the data-series panel.
<code>show_prior</code>	Show prespecified prior centers.
<code>show_fitted</code>	Show fitted segment means.
<code>show_penalty</code>	Show the penalty panel when a structured penalty is available.
<code>data_col, fitted_col, changepoint_col, prior_col, penalty_col</code>	Colors for the observations, segment means, detected changes, prior centers, and penalty curve.
<code>series_linewidth, fitted_linewidth, vertical_linewidth</code>	Line widths for the observed series, segment means, and vertical prior/change lines.
<code>title</code>	Optional title for the data-series panel.

Value

Invisibly, a named list containing the penalty and data ggplots when the penalty panel is displayed; otherwise, the data-series ggplot.

rzag	<i>Simulate zero-adjusted gamma observations</i>
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Description

Simulate zero-adjusted gamma observations

Usage

```
rzag(n, shape, scale, p0)
```

Arguments

n	Number of observations.
shape	Gamma shape parameter.
scale	Gamma scale parameter.
p0	Probability of observing zero.

Value

Numeric vector of simulated observations.

Examples

```
rzag(5, shape = 1, scale = 2, p0 = 0.25)
```

summary.pi_change_fit	<i>Summarize a PI-Change fit</i>
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Description

Summarize a PI-Change fit

Usage

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

Arguments

object	A fitted pi_change_fit object.
...	Reserved for future methods.

Value

A summary.pi_change_fit object with segment summaries.

wti_oil	<i>WTI Cushing spot oil prices</i>
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Description

West Texas Intermediate spot prices at Cushing, Oklahoma from 2000 through 2009, with the absolute daily price change used in the oil-price vignette.

Usage

wti_oil

Format

A data frame with columns:

date Observation date.

price WTI spot price in dollars per barrel.

abs_price_change Absolute first difference in price.

Source

U.S. Energy Information Administration, Cushing, Oklahoma WTI Spot Price FOB, available from <https://www.eia.gov/dnav/pet/hist/rwtcd.htm>.

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