Package ‘sshist’

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Type Package

Title Optimal Density Estimation via Shimazaki-Shinomoto Method

Version 0.2.4

Description Implements the Shimazaki-Shinomoto method for optimizing the bin width of histograms and the bandwidth of kernel density estimators. The framework minimizes the expected Mean Integrated Squared Error (MISE) and supports both 1D and 2D distributions, fixed and locally adaptive estimators, bootstrap confidence intervals, and 'OpenMP'-accelerated 'C++' 'backends'. Ideally suited for time-dependent rate estimation and identifying intrinsic data structures. For more details see Shimazaki and Shinomoto (2007) <doi:10.1162/neco.2007.19.6.1503> and Shimazaki and Shinomoto (2010) <doi:10.1007/s10827-009-0180-4>.

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URL https://github.com/celebithil/sshist, https://www.neuralengine.org/res/histogram.html

BugReports https://github.com/celebithil/sshist/issues

Imports graphics, grDevices, Rcpp, stats

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Contents

`plot.sshist` *Plot method for sshist objects*

Description

Produces single-panel histogram with a jittered-data strip drawn BELOW the x-axis (in a reserved negative-y band), so that the jittered points do not overlap with the histogram bars.

Usage

```
## S3 method for class 'sshist'
plot(x, ...)
```

Arguments

`x`	An object of class `"sshist"`.
`...`	Additional arguments passed to `hist`.

Value

No return value; called for its side effect of producing a plot.

plot.sshist_2d *Plot method for sshist_2d objects*

Description

Draws the optimal 2D histogram as a heatmap with proper data-coordinate axes.

Usage

```
## S3 method for class 'sshist_2d'
plot(x, ...)
```

Arguments

x	An object of class "sshist_2d".
...	Additional arguments passed to image.

Value

No return value; called for its side effect of producing a plot.

plot.sskernel *Plot method for sskernel objects*

Description

Draws the optimal fixed-bandwidth kernel density curve. When bootstrap confidence intervals are stored in the object (nbs > 0), a shaded 90% band is added automatically. A rug and jittered points are drawn in a reserved strip BELOW y = 0 (so they never overlap the density curve).

Usage

```
## S3 method for class 'sskernel'
plot(x, col = "#2166ac", band_col = adjustcolor(col, alpha.f = 0.2), ...)
```

Arguments

x	An object of class "sskernel".
col	Color of the density curve (default "#2166ac").
band_col	Fill color of the confidence band.
...	Additional arguments passed to plot.default.

Value

No return value; called for its side effect of producing a plot.

plot.sskernel2d *Plot method for sskernel2d objects*

Description

Draws the 2D kernel density estimate as a heatmap with optional data overlay.

Usage

```
## S3 method for class 'sskernel2d'
plot(x, ...)
```

Arguments

x	An object of class "sskernel2d".
...	Additional arguments passed to image.

Value

No return value; called for its side effect of producing a plot.

plot.ssvkernel *Plot method for ssvkernel objects*

Description

Draws the locally adaptive kernel density curve. When bootstrap confidence intervals are stored (nbs > 0), a shaded 90% band is added. A rug and jittered points are drawn in a reserved strip BELOW y = 0 (so they never overlap the density curve).

Usage

```
## S3 method for class 'ssvkernel'
plot(
  x,
  col = "#d6604d",
  bw_col = "#4d9221",
  band_col = adjustcolor(col, alpha.f = 0.2),
  ...
)
```

Arguments

x	An object of class "ssvkernel".
col	Color of the density curve (default "#d6604d").
bw_col	Color of the local bandwidth line (default "#4d9221").
band_col	Fill color of the confidence band.
...	Additional arguments passed to plot.default.

Value

No return value; called for its side effect of producing a plot.

---

plot.ssvkernel2d *Plot method for ssvkernel2d objects*

Description

Draws the locally adaptive 2D kernel density as a heatmap with optional data point overlay.

Usage

```
## S3 method for class 'ssvkernel2d'
plot(x, ...)
```

Arguments

x	An object of class "ssvkernel2d".
...	Additional arguments passed to image.

Value

No return value; called for its side effect of producing a plot.

---

print.sshist *Print method for sshist objects*

Description

Print method for sshist objects

Usage

```
## S3 method for class 'sshist'
print(x, ...)
```

Arguments

x	An object of class "sshist".
...	Additional arguments passed to print.

Value

Returns x invisibly.

---

print.sshist_2d *Print method for sshist_2d objects*

Description

Print method for sshist_2d objects

Usage

```
## S3 method for class 'sshist_2d'
print(x, ...)
```

Arguments

x	An object of class sshist.
...	Additional arguments passed to print.

Value

Returns the input object x invisibly. The method is called for its side effect of printing a summary of the 2D Shimazaki-Shinomoto histogram optimization results, including the optimal number of bins for both X and Y dimensions, bin widths, and minimum cost value.

---

print.sskernel *Print method for sskernel objects*

Description

Print method for sskernel objects

Usage

```
## S3 method for class 'sskernel'
print(x, ...)
```

Arguments

x	An object of class "sskernel".
...	Additional arguments passed to print.

Value

Returns x invisibly.

---

print.sskernel2d *Print method for sskernel2d objects*

Description

Print method for sskernel2d objects

Usage

```
## S3 method for class 'sskernel2d'
print(x, ...)
```

Arguments

x	An object of class "sskernel2d".
...	Additional arguments passed to print.

Value

Returns x invisibly.

---

print.ssvkernel *Print method for ssvkernel objects*

Description

Print method for ssvkernel objects

Usage

```
## S3 method for class 'ssvkernel'
print(x, ...)
```

Arguments

x	An object of class "ssvkernel".
...	Additional arguments passed to print.

Value

Returns x invisibly.

`print.ssvkernel2d` *Print method for ssvkernel2d objects*

Description

Print method for ssvkernel2d objects

Usage

```
## S3 method for class 'ssvkernel2d'
print(x, ...)
```

Arguments

x	An object of class "ssvkernel2d".
...	Additional arguments passed to print.

Value

Returns x invisibly.

`sshist` *Optimal Histogram Binning (Shimazaki-Shinomoto Method)*

Description

Computes the optimal bin width and number of bins using the Shimazaki-Shinomoto (2007) method. This implementation performs an exhaustive search over candidate bin counts, exactly matching the original Python/MATLAB reference algorithms.

Usage

```
sshist(x, n_max = NULL, sn = 30, ncores = getOption("sshist.ncores", 1L))
```

Arguments

x	A numeric vector of data. NA values are silently removed.
n_max	Integer or NULL. Maximum number of bins to consider. When NULL (default) the limit is set automatically as min(500, floor(range / (2 * min_resolution)), n_samples).
sn	Integer. Number of histogram shifts used in the shift-average (default 30).
ncores	Integer. Number of OpenMP threads to use. Defaults to 1 for CRAN compliance.

Value

An object of class `"sshist"` (a named list) containing:

`opt_n` Optimal number of bins (integer).

`opt_d` Optimal bin width ($= \text{range}/N_{\text{opt}}$).

`edges` Numeric vector of $N_{\text{opt}} + 1$ break points for the optimal histogram.

`data` Cleaned (NA-removed) input data.

References

Shimazaki, H. and Shinomoto, S. (2007). A method for selecting the bin size of a time histogram. *Neural Computation*, **19**(6), 1503–1527.

`sshist_2d` *Optimal 2D Histogram Binning (Shimazaki-Shinomoto Method)*

Description

Computes the optimal number of bins for a 2-dimensional histogram using the Shimazaki-Shinomoto (2007) cost function.

Usage

```
sshist_2d(x, y = NULL, n_min = 2L, n_max = 200L)
```

Arguments

`x`	Numeric vector (X coordinates) or a 2-column matrix/data.frame.
`y`	Numeric vector (Y coordinates). Ignored if `x` is a matrix.
`n_min`	Integer. Minimum number of bins per axis (default `2`).
`n_max`	Integer or `NULL`. Maximum number of bins per axis (default `200`). Automatically clamped to the data resolution limit and the sample size.

Value

An object of class `"sshist_2d"` containing:

`opt_nx`, `opt_ny` Optimal bin counts.

`opt_dx`, `opt_dy` Optimal bin widths.

`data` Cleaned input data.

References

Shimazaki, H. and Shinomoto, S. (2007). A method for selecting the bin size of a time histogram. *Neural Computation*, **19**(6), 1503-1527. doi:10.1162/neco.2007.19.6.1503

Examples

```
set.seed(42)
x <- rnorm(500); y <- rnorm(500)

res <- sshist_2d(x, y)
plot(res)

# ggplot2
if (requireNamespace("ggplot2", quietly = TRUE)) {
  library(ggplot2)
  ggplot(data.frame(x = x, y = y), aes(x, y)) +
    geom_bin2d(bins = c(res$opt_nx, res$opt_ny)) +
    scale_fill_viridis_c() +
    ggtitle(sprintf("Optimal 2D Bins: %dx%d", res$opt_nx, res$opt_ny)) +
    theme_minimal()
}
```

---

sskernel *Optimal 1D Kernel Density Estimation (Fixed Bandwidth)*

Description

Computes the optimal global bandwidth for 1D kernel density estimation using the Shimazaki-Shinomoto method. Minimizes the expected Mean Integrated Squared Error (MISE).

Usage

```
sskernel(
  x,
  tin = NULL,
  W = NULL,
  nbs = 0,
  ncores = getOption("sshist.ncores", 1L)
)
```

Arguments

x	Numeric vector of sample data. Missing values (NA) will be removed.
tin	Optional numeric vector specifying the grid of evaluation points.
W	Optional numeric vector of bandwidths to search. If provided, the grid search is skipped.
nbs	Integer specifying the number of bootstrap samples for calculating confidence intervals.
ncores	Integer specifying the number of CPU cores to use for bootstrap (default: 1).

Value

An object of class "sskernel" containing:

x The evaluation points (same as tin).

y The optimized kernel density estimate.

optw The optimal global bandwidth.

data The original evaluated data.

confb95 (If nbs > 0) A matrix with 5th and 95th percentile bootstrap confidence intervals.

yb (If nbs > 0) A matrix of all bootstrap density samples.

---

sskernel2d *Optimal 2D Kernel Density Estimation (Fixed Bandwidth)*

Description

Computes the optimal global bandwidth for a 2D kernel density estimate based on the exact L2 risk (Mean Integrated Squared Error) minimization.

Usage

```
sskernel2d(
  x,
  y = NULL,
  W = NULL,
  n_grid = 100,
  ncores = getOption("sshist.ncores", 1L)
)
```

Arguments

x	Numeric vector for X coordinates, or a 2-column matrix containing X and Y.
y	Numeric vector for Y coordinates (required if x is a vector).
W	Optional numeric vector of bandwidths to evaluate. If NULL, a default log-spaced grid is used.
n_grid	Integer specifying the number of grid points for the output density matrix (default: 100).
ncores	Integer. Number of OpenMP threads to use. Defaults to 1 for CRAN compliance.

Value

An object of class "sskernel2d" containing:

x_grid Numeric vector of the X-axis grid points.

y_grid Numeric vector of the Y-axis grid points.

z Numeric matrix of the estimated 2D density.

opt_wx The optimal global bandwidth for the X dimension.

opt_wy The optimal global bandwidth for the Y dimension.

data A list containing the original X and Y data.

`ssvkernel` *Locally Adaptive 1D Kernel Density Estimation (Shimazaki-Shinomoto)*

Description

Computes locally adaptive bandwidths for 1D distributions following the method of Shimazaki & Shinomoto (2010). Optimizes the stiffness constant gamma via a hybrid grid and Brent search on the MISE cost.

Usage

```
ssvkernel(
  x,
  tin = NULL,
  M = 80,
  WinFunc = "Boxcar",
  nbs = 0,
  ncores = getOption("sshist.ncores", 1L)
)
```

Arguments

`x`	Numeric vector of sample points. Missing values (NA) will be removed.
`tin`	Optional numeric vector of evaluation points.
`M`	Integer, number of bandwidths to examine (default: 80).
`WinFunc`	Character string specifying the window function for local weights: "Gauss", "Boxcar", "Laplace", or "Cauchy" (default: "Boxcar").
`nbs`	Integer, number of bootstrap samples for confidence intervals. Set to 0 to skip (default: 0).
`ncores`	Integer specifying the number of CPU cores to use for bootstrap (default: 1).

Value

An object of class "ssvkernel" containing:

x The evaluation points (same as tin).

y The optimized adaptive density estimate.

optw_local_min Numeric vector of locally adaptive bandwidths evaluated at x.

optw_local_max Numeric vector of locally adaptive bandwidths evaluated at x.

gamma The optimal stiffness constant.

data The original evaluated data.

confb95 (If nbs > 0) A matrix with 5th and 95th percentile bootstrap confidence intervals.

yb (If nbs > 0) A matrix of all bootstrap density samples.

---

ssvkernel2d *Locally Adaptive 2D Kernel Density Estimation (Abramson's Method)*

Description

Computes a 2D kernel density estimate using Abramson's square-root adaptive bandwidths. The procedure is initialized by finding the optimal global bandwidth via sskernel2d.

Usage

```
ssvkernel2d(
  x,
  y = NULL,
  n_grid = 100,
  sensitivity = 0.5,
  ncores = getOption("sshist.ncores", 1L)
)
```

Arguments

x	Numeric vector for X coordinates, or a 2-column matrix containing X and Y.
y	Numeric vector for Y coordinates (required if x is a vector).
n_grid	Integer specifying the number of grid points for the output density matrix (default: 100).
sensitivity	Numeric scalar controlling the sensitivity of local bandwidths to the pilot density. A value of 0.5 (default) corresponds to Abramson's original inverse square-root law.
ncores	Integer. Number of OpenMP threads to use. Defaults to 1 for CRAN compliance.

Value

An object of class `"ssvkernel2d"` containing:

x_grid Numeric vector of the X-axis grid points.

y_grid Numeric vector of the Y-axis grid points.

z Numeric matrix of the estimated adaptive 2D density.

pilot_wx The global optimal pilot bandwidth for the X dimension.

pilot_wy The global optimal pilot bandwidth for the Y dimension.

lambda_factors Numeric vector of local scaling factors applied to each data point.

data A list containing the original X and Y data.

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