## Package ‘hermiter’

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**Title**  
Efficient Sequential and Batch Estimation of Univariate and Bivariate Probability Density Functions and Cumulative Distribution Functions along with Quantiles (Univariate) and Spearman's Correlation (Bivariate)

**Version** 2.1.0

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**Description**  

**License** MIT + file LICENSE

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Efficient Sequential and Batch Estimation of Univariate and Bivariate Probability Density Functions and Cumulative Distribution Functions along with Quantiles (Univariate) and Spearman's Correlation (Bivariate)

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Standardizes the observation x and updates the online moment inputs

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**cum_prob**

**Description**

This method calculates the cumulative probability at a vector of x values in the univariate case. In the bivariate case, the method calculates the probability density values for a matrix of x values, each row of which represents a 2-d point.

**Usage**

`cum_prob(this, x, clipped, accelerate_series = TRUE)`

**Arguments**

- **this**: A hermite_estimator_univar or hermite_estimator_bivar object.
- **x**: A numeric vector (univariate) or a numeric matrix (bivariate). Values at which to calculate the cumulative probability.
- **clipped**: A boolean value. This value determines whether cumulative probabilities are clipped to lie between 0 and 1.
- **accelerate_series**: A boolean value. This value determines whether Hermite series acceleration is applied.

**Details**

The object must be updated with observations prior to the use of the method.

**Value**

A numeric vector of cumulative probability values.

**Examples**

```r
hermite_est <- hermite_estimator(N = 10, standardize = TRUE, est_type="univariate")
hermite_est <- update_batch(hermite_est, rnorm(30))
cdf_est <- cum_prob(hermite_est, c(0, 0.5, 1))
hermite_est <- hermite_estimator(N = 10, standardize = TRUE, est_type="bivariate")
hermite_est <- update_batch(hermite_est, x = matrix(rnorm(60), nrow=30, ncol=2,byrow=TRUE))
cdf_est <- cum_prob(hermite_est, matrix(c(0,0,0.5,0.5,1,1),nrow=3, ncol=2,byrow=TRUE))
```
cum_prob.hermite_estimator_bivar

Estimates the cumulative probabilities for a matrix of 2-d x values

Description

This method calculates the cumulative probability values for a matrix of 2-d x vector values using the hermite_estimator_bivar object (this).

Usage

```r
## S3 method for class 'hermite_estimator_bivar'
cum_prob(this, x, clipped = FALSE, accelerate_series = FALSE)
```

Arguments

- `this`: A hermite_estimator_bivar object.
- `x`: A numeric matrix. Each row corresponds to a 2-d coordinate.
- `clipped`: A boolean value. This value determines whether cumulative probabilities are clipped to lie within the range [0,1].
- `accelerate_series`: A boolean value. Series acceleration has not yet been implemented for bivariate estimators.

Details

The object must be updated with observations prior to the use of this method.

Value

A numeric vector of cumulative probability values.

Examples

```r
ermite_est <- hermite_estimator_bivar(N = 10, standardize = TRUE)
ermite_est <- update_batch(hermite_est, matrix(rnorm(30*2), nrow=30,
ncol=2, byrow = TRUE))
cdf_est <- cum_prob(hermite_est, matrix(c(0, 0, 1, 1, 2, 2), nrow=3, ncol=2,
byrow = TRUE))
```
cum_prob.hermite_estimator_univar

*Estimates the cumulative probability for a vector of x values*

**Description**

This method calculates the cumulative probability values at a vector of x values using the hermite_estimator_univar object (this).

**Usage**

```r
## S3 method for class 'hermite_estimator_univar'
cum_prob(this, x, clipped = FALSE, accelerate_series = TRUE)
```

**Arguments**

- **this**: A hermite_estimator_univar object.
- **x**: A numeric vector. Values at which to estimate the cumulative probability
- **clipped**: A boolean value. This value determines whether cumulative probabilities are clipped to lie within the range \([0,1]\).
- **accelerate_series**: A boolean value. This value determines whether Hermite series acceleration is applied.

**Details**

The object must be updated with observations prior to the use of this method.

**Value**

A numeric vector of cumulative probability values.

**Examples**

```r
hermite_est <- hermite_estimator_univar(N = 10, standardize = TRUE)
hermite_est <- update_batch(hermite_est, rnorm(30))
cdf_est <- cum_prob(hermite_est, c(0, 0.5, 1))
```
dens

Estimates the probability density at one or more x values

Description

This method calculates the probability density values at a vector of x values in the univariate case. In the bivariate case, the method calculates the probability density values for a matrix of x values, each row of which represents a 2-d point.

Usage

dens(this, x, clipped, accelerate_series = TRUE)

Arguments

this  A hermite_estimator_univar or hermite_estimator_bivar object.
x     A numeric vector (univariate) or a numeric matrix (bivariate) of values at which to calculate the probability density.
clipped  A boolean value. This value determines whether probability densities are clipped to be bigger than zero.
accelerate_series  A boolean value. This value determines whether Hermite series acceleration is applied.

Details

The object must be updated with observations prior to the use of the method.

Value

A numeric vector of probability density values.

Examples

hermite_est <- hermite_estimator(N = 10, standardize = TRUE, est_type="univariate")
hermite_est <- update_batch(hermite_est, rnorm(30))
pdf_est <- dens(hermite_est, c(0, 0.5, 1))
hermite_est <- hermite_estimator(N = 10, standardize = TRUE, est_type="bivariate")
hermite_est <- update_batch(hermite_est, x = matrix(rnorm(60), nrow=30, ncol=2, byrow=TRUE))
pdf_est <- dens(hermite_est, matrix(c(0,0,0.5,0.5,1,1),nrow=3, ncol=2, byrow=TRUE))
dens.hermite_estimator_bivar

Estimates the probability densities for a matrix of 2-d x values

Description

This method calculates the probability density values for a matrix of 2-d x vector values using the hermite_estimator_bivar object (this).

Usage

## S3 method for class 'hermite_estimator_bivar'
dens(this, x, clipped = FALSE, accelerate_series = FALSE)

Arguments

this A hermite_estimator_bivar object.
x A numeric matrix. Each row corresponds to a 2-d coordinate.
clipped A boolean value. This value determines whether probability densities are clipped to be bigger than zero.
accelerate_series A boolean value. Series acceleration has not yet been implemented for bivariate estimators.

Details

The object must be updated with observations prior to the use of the method.

Value

A numeric vector of probability density values.

Examples

hermite_est <- hermite_estimator_bivar(N = 10, standardize = TRUE)
hermite_est <- update_batch(hermite_est, matrix(rnorm(30*2), nrow=30, ncol=2, byrow = TRUE))
cdf_est <- dens(hermite_est, matrix(c(0, 0, 1, 1, 2, 2), nrow=3, ncol=2, byrow = TRUE))
dens.hermite_estimator_univar

Estimates the probability density for a vector of x values

Description

This method calculates the probability density values at a vector of x values using the hermite_estimator_univar object (this).

Usage

## S3 method for class 'hermite_estimator_univar'
dens(this, x, clipped = FALSE, accelerate_series = TRUE)

Arguments

- `this`: A hermite_estimator_univar object.
- `x`: A numeric vector. Values at which to estimate the probability density.
- `clipped`: A boolean value. This value determines whether probability densities are clipped to be bigger than zero.
- `accelerate_series`: A boolean value. This value determines whether Hermite series acceleration is applied.

Details

The object must be updated with observations prior to the use of the method.

Value

A numeric vector of probability density values.

Examples

hermite_est <- hermite_estimator_univar(N = 10, standardize = TRUE)
hermite_est <- update_batch(hermite_est, rnorm(30))
pdf_est <- dens(hermite_est, c(0, 0.5, 1))
gauss_hermite_quad_100

Calculates $\int_{-\infty}^{\infty} f(x)e^{-x^2}dx$ using Gauss-Hermite quadrature with 100 terms.

Description

Calculates $\int_{-\infty}^{\infty} f(x)e^{-x^2}dx$ using Gauss-Hermite quadrature with 100 terms.

Usage

gauss_hermite_quad_100(f)

Arguments

f A function.

Value

A numeric value.

hermite_estimator

A class to sequentially estimate univariate and bivariate pdfs and cdfs along with quantile functions in the univariate setting and nonparametric correlations in the bivariate setting.

Description

The hermite_estimator class provides a unified interface to the univariate and bivariate Hermite series based estimators, leveraging generic methods and multiple dispatch. Methods are included for the sequential or one-pass batch estimation of the full probability density function and cumulative distribution function in the univariate and bivariate settings. Sequential or one-pass batch estimation methods are also provided for the full quantile function in the univariate setting and the Spearman’s rank correlation estimator in the bivariate setting.

Usage

hermite_estimator(
  N = 30,
  standardize = TRUE,
  exp_weight_lambda = NA,
  est_type = "univariate"
)
Arguments

N An integer between 0 and 75. The Hermite series based estimator is truncated at N+1 terms.
standardize A boolean value. Determines whether the observations are standardized, a transformation which often improves performance.
exp_weight_lambda A numerical value between 0 and 1. This parameter controls the exponential weighting of the Hermite series based estimator. If this parameter is NA, no exponential weighting is applied.
est_type A string value. Options are "univariate" or "bivariate".

Value

An S3 object of class hermite_estimator_univar or hermite_estimator_bivar.

Author(s)

Michael Stephanou <michael.stephanou@gmail.com>

Examples

hermite_est <- hermite_estimator(N = 30, standardize = TRUE, est_type="univariate")

hermite_estimator_bivar
A class to sequentially estimate bivariate pdfs, cdfs and nonparametric correlations

Description

This method constructs an S3 object with methods for nonparametric estimation of bivariate pdfs and cdfs along with nonparametric correlations.

Usage

hermite_estimator_bivar(N = 30, standardize = TRUE, exp_weight_lambda = NA)

Arguments

N An integer between 0 and 75. The Hermite series based estimator is truncated at N+1 terms.
standardize A boolean value. Determines whether the observations are standardized, a transformation which often improves performance.
exp_weight_lambda A numerical value between 0 and 1. This parameter controls the exponential weighting of the Hermite series based estimator. If this parameter is NA, no exponential weighting is applied.
The hermite_estimator_bivar class allows the sequential or one-pass batch estimation of the full bi-variate probability density function and cumulative distribution function along with the Spearman’s rank correlation coefficient. It is well suited to streaming data (both stationary and non-stationary) and to efficient estimation in the context of massive or distributed data sets. Indeed, estimators constructed on different subsets of a distributed data set can be consistently merged.

Value

An S3 object of class hermite_estimator_bivar, with methods for density function and distribution function estimation along with Spearman’s rank correlation estimation.

Author(s)

Michael Stephanou <michael.stephanou@gmail.com>

Examples

hermite_est <- hermite_estimator_bivar(N = 30, standardize = TRUE)

A class to sequentially estimate univariate pdfs, cdfs and quantile functions

Description

This method constructs an S3 object with associated methods for univariate nonparametric estimation of pdfs, cdfs and quantiles.

Usage

hermite_estimator_univar(N = 30, standardize = TRUE, exp_weight_lambda = NA)

Arguments

N An integer between 0 and 75. The Hermite series based estimator is truncated at N+1 terms.
standardize A boolean value. Determines whether the observations are standardized, a transformation which often improves performance.
exp_weight_lambda A numerical value between 0 and 1. This parameter controls the exponential weighting of the Hermite series based estimator. If this parameter is NA, no exponential weighting is applied.
Details

The hermite_estimator_univar class allows the sequential or one-pass batch estimation of the full probability density function, cumulative distribution function and quantile function. It is well suited to streaming data (both stationary and non-stationary) and to efficient estimation in the context of massive or distributed data sets. Indeed, estimators constructed on different subsets of a distributed data set can be consistently merged.

Value

An S3 object of class hermite_estimator_univar, with methods for density function, distribution function and quantile function estimation.

Author(s)

Michael Stephanou <michael.stephanou@gmail.com>

Examples

hermite_est <- hermite_estimator_univar(N = 30, standardize = TRUE)

Description

The method calculates the orthonormal Hermite functions, \( h_k(x) \) from \( k = 0, \ldots, N \) for the vector of values, \( x \).

Usage

hermite_function(N, x, normalization)

Arguments

N  An integer number.

x  A numeric vector.

normalization  A numeric vector of normalization factors generated by the hermite_normalization function.

Value

A numeric matrix with \( N+1 \) rows and \( \text{length}(x) \) columns.

Author(s)

Michael Stephanou <michael.stephanou@gmail.com>
### hermite_function_N

**Convenience function to output orthonormal Hermite functions**

The method calculates the orthonormal Hermite functions, \( h_k(x) \) from \( k = 0, \ldots, N \) for the vector of values, \( x \).

#### Usage

```r
ermite_function_N(N, x, normalization_hermite = NULL)
```

#### Arguments

- **N**: An integer number.
- **x**: A numeric vector.
- **normalization_hermite**: A numeric vector. A vector of normalization values necessary in the calculation of the Hermite functions.

#### Value

A numeric matrix with \( N+1 \) rows and length(\( x \)) columns.

### hermite_function_sum

**Outputs the sum of orthonormal Hermite functions**

The method calculates the sum of orthonormal Hermite functions, \( \sum_i h_k(x_i) \) from \( k = 0, \ldots, N \) for the vector of values, \( x \).

#### Usage

```r
ermite_function_sum(N, x, normalization)
```

#### Arguments

- **N**: An integer number.
- **x**: A numeric vector.
- **normalization**: A numeric vector of normalization factors generated by the `hermite_normalization` function.
hermite_function_sum_N

Convenience function to output the sum of orthonormal Hermite functions. The method calculates the sum of orthonormal Hermite functions, $\sum_i h_k(x_i)$ from $k = 0, \ldots, N$ for the vector of values, $x$.

Description

Convenience function to output the sum of orthonormal Hermite functions.

The method calculates the sum of orthonormal Hermite functions, $\sum_i h_k(x_i)$ from $k = 0, \ldots, N$ for the vector of values, $x$.

Usage

hermite_function_sum_N(N, x, normalization_hermite = NULL)

Arguments

N An integer number.

x A numeric vector.

normalization_hermite A numeric vector of normalization factors generated by the hermite_normalization function.

Value

A numeric vector of length N+1.
hermite_integral_val

Outputs lower integral of the orthonormal Hermite functions

Description
The method calculates $\int_{-\infty}^{x} h_k(t)\,dt$ for $k = 0, \ldots, N$ and the vector of values $x$.

Usage
hermite_integral_val(N, x, hermite_function_mat)

Arguments
- $N$ An integer number.
- $x$ A numeric vector.
- hermite_function_mat A numeric matrix of Hermite function values generated by the function hermite_function.

Value
A numeric matrix with $N+1$ rows and length($x$) columns.

Author(s)
Michael Stephanou <michael.stephanou@gmail.com>

hermite_integral_val_upper

Outputs upper integral of the orthonormal Hermite functions

Description
The method calculates $\int_{x}^{\infty} h_k(t)\,dt$ for $k = 0, \ldots, N$ and the vector of values $x$.

Usage
hermite_integral_val_upper(N, x, hermite_function_mat)

Arguments
- $N$ An integer number.
- $x$ A numeric vector.
- hermite_function_mat A numeric matrix of Hermite function values generated by the function hermite_function.
Value

A numeric matrix with N+1 rows and length(x) columns.

Author(s)

Michael Stephanou <michael.stephanou@gmail.com>

---

**hermite_int_full**

Convenience function to output the integral of the orthonormal Hermite functions on the full domain

---

**Description**

The method calculates \( \int_{-\infty}^{\infty} h_k(t) dt \) for \( k = 0, \ldots, N \).

**Usage**

`hermite_int_full(N)`

**Arguments**

- **N**
  
  An integer number.

**Value**

A numeric matrix with N+1 rows and 1 columns.

---

**hermite_int_full_domain**

Outputs integral of the orthonormal Hermite functions on the full domain

---

**Description**

The method calculates \( \int_{-\infty}^{\infty} h_k(t) dt \) for \( k = 0, \ldots, N \).

**Usage**

`hermite_int_full_domain(N)`

**Arguments**

- **N**
  
  An integer number.

**Value**

A numeric matrix with N+1 rows and 1 columns.
**hermite_int_lower**

*Convenience function to output a definite integral of the orthonormal Hermite functions*

**Description**

The method calculates \( \int_{-\infty}^{x} h_k(t) \, dt \) for \( k = 0, \ldots, N \) and the vector of values \( x \).

**Usage**

```r
hermite_int_lower(
  N,
  x,
  hermite_function_matrix = NULL,
  normalization_hermite = NULL
)
```

**Arguments**

- **N**
  - An integer number.
- **x**
  - A numeric vector.
- **hermite_function_matrix**
  - A numeric matrix. A matrix of Hermite function values.
- **normalization_hermite**
  - A numeric vector. A vector of normalization values necessary in the calculation of the Hermite functions.

**Value**

A numeric matrix with \( N+1 \) rows and length(\( x \)) columns.

---

**hermite_int_upper**

*Convenience function to output a definite integral of the orthonormal Hermite functions*

**Description**

The method calculates \( \int_{x}^{\infty} h_k(t) \, dt \) for \( k = 0, \ldots, N \) and the vector of values \( x \).
Usage

hermite_int_upper(
  N,
  x,
  hermite_function_matrix = NULL,
  normalization_hermite = NULL
)

Arguments

N  An integer number.

x  A numeric vector.

hermite_function_matrix
  A numeric matrix. A matrix of Hermite function values.

normalization_hermite
  A numeric vector. A vector of normalization values necessary in the calculation
  of the Hermite functions.

Value

A numeric matrix with N+1 rows and length(x) columns.

---

hermite_normalization  Outputs Hermite normalization factors

Description

The method returns numeric normalization factors that, when multiplied by the physicist Hermite
polynomials $H_k(x)$, yield orthonormal Hermite functions $h_k(x)$ for $k = 0, \ldots, N$.

Usage

hermite_normalization(N)

Arguments

N  An integer number.

Value

A numeric vector of length N+1

Author(s)

Michael Stephanou <michael.stephanou@gmail.com>
hermite_normalization_N

Convenience function to output Hermite normalization factors

Description
The method returns numeric normalization factors that, when multiplied by the physicist Hermite polynomials $H_k(x)$, yield orthonormal Hermite functions $h_k(x)$ for $k = 0, \ldots, N$.

Usage
hermite_normalization_N(N)

Arguments
N An integer number.

Value
A numeric vector of length N+1

Author(s)
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hermite_polynomial Outputs physicist version of Hermite Polynomials

Description
The method calculates the physicist version of Hermite polynomials, $H_k(x)$ from $k = 0, \ldots, N$ for the vector of values, x.

Usage
hermite_polynomial(N, x)

Arguments
N An integer number.
x A numeric vector.

Value
A numeric matrix with N+1 rows and length(x) columns.
**hermite_polynomial_N**

Convenience function to output physicist Hermite polynomials. The method calculates the physicist version of Hermite polynomials, $H_k(x)$ from $k = 0, \ldots, N$ for the vector of values, $x$.

**Description**

Convenience function to output physicist Hermite polynomials.

The method calculates the physicist version of Hermite polynomials, $H_k(x)$ from $k = 0, \ldots, N$ for the vector of values, $x$.

**Usage**

hermite_polynomial_N(N, x)

**Arguments**

- **N** An integer number.
- **x** A numeric vector.

**Value**

A numeric matrix with $N+1$ rows and length($x$) columns.

---

**kendall**

Estimates the Kendall rank correlation coefficient.

**Description**

This method calculates the Kendall rank correlation coefficient value. It is only applicable to the bivariate Hermite estimator i.e. est_type = "bivariate".

**Usage**

kendall(this, clipped = FALSE)

**Arguments**

- **this** A hermite_estimator_bivar object.
- **clipped** A boolean value. Indicates whether to clip the Kendall rank correlation estimates to lie between -1 and 1.
kendall.hermite_estimator_bivar

Details
The object must be updated with observations prior to the use of this method.

Value
A numeric value.

Examples
hermite_est <- hermite_estimator_bivar(N = 10, standardize = TRUE, est_type="bivariate")
hermite_est <- update_batch(hermite_est, matrix(rnorm(30*2), nrow=30, ncol=2, byrow = TRUE))
kendall_est <- kendall(hermite_est)

kendall.hermite_estimator_bivar
Estimates the Kendall rank correlation coefficient

Description
This method calculates the Kendall rank correlation coefficient value using the hermite_estimator_bivar object (this).

Usage
## S3 method for class 'hermite_estimator_bivar'
kendall(this, clipped = FALSE)

Arguments
this A hermite_estimator_bivar object.
clipped A boolean value. Indicates whether to clip the Kendall rank correlation estimates to lie between -1 and 1.

Details
The object must be updated with observations prior to the use of this method.

Value
A numeric value.

Examples
hermite_est <- hermite_estimator_bivar(N = 10, standardize = TRUE)
hermite_est <- update_batch(hermite_est, matrix(rnorm(30*2), nrow=30, ncol=2, byrow = TRUE))
kendall_est <- kendall(hermite_est)
**merge_hermite**  
*Merges a list of Hermite estimators*

**Description**
Note that the estimators must be of the same type to be merged i.e. all estimators must have a consistent est_type, either "univariate" or "bivariate". In addition, the N and standardize arguments must be the same for all estimators in order to merge them. Finally, note that exponentially weighted estimators cannot be merged. If the Hermite estimators are not standardized, the merged estimator will be exactly equivalent to constructing a single estimator on the data set formed by combining the data sets used to update the respective hermite_estimator inputs. If the input Hermite estimators are standardized however, then the equivalence will be approximate but still accurate in most cases.

**Usage**
```r
merge_hermite(hermite_estimators)
```

**Arguments**

*hermite_estimators*
A list of hermite_estimator_univar or hermite_estimator_bivar objects.

**Value**
An object of class hermite_estimator_univar or hermite_estimator_bivar.

**Examples**
```r
hermite_est_1 <- hermite_estimator(N = 10, standardize = FALSE)
hermite_est_1 <- update_batch(hermite_est_1, rnorm(30))
hermite_est_2 <- hermite_estimator(N = 10, standardize = FALSE)
hermite_est_2 <- update_batch(hermite_est_2, rnorm(30))
hermite_merged <- merge_hermite(list(hermite_est_1, hermite_est_2))
```

**merge_hermite_bivar**  
*Merges a list of bivariate Hermite estimators*

**Description**
This method allows a list of Hermite based estimators of class hermite_estimator_bivar to be consistently merged.

**Usage**
```r
merge_hermite_bivar(hermite_estimators)
```
merge_hermite_univar

Arguments

hermite_estimators
A list of hermite_estimator_bivar objects.

Details

Note that the N and standardize arguments must be the same for all estimators in order to merge them. In addition, note that exponentially weighted estimators cannot be merged. If the Hermite estimators are not standardized, the merged estimator will be exactly equivalent to constructing a single estimator on the data set formed by combining the data sets used to update the respective hermite_estimator_bivar inputs. If the input Hermite estimators are standardized however, then the equivalence will be approximate but still accurate in most cases.

Value

An object of class hermite_estimator_bivar.

merge_hermite_univar  Merges a list of Hermite estimators

Description

This method allows a list of Hermite based estimators of class hermite_estimator_univar to be consistently merged.

Usage

merge_hermite_univar(hermite_estimators)

Arguments

hermite_estimators
A list of hermite_estimator_univar objects.

Details

Note that the N and standardize arguments must be the same for all estimators in order to merge them. In addition, note that exponentially weighted estimators cannot be merged. If the Hermite estimators are not standardized, the merged estimator will be exactly equivalent to constructing a single estimator on the data set formed by combining the data sets used to update the respective hermite_estimator_univar inputs. If the input Hermite estimators are standardized however, then the equivalence will be approximate but still accurate in most cases.

Value

An object of class hermite_estimator_univar.
merge_moments_and_count_univar

Examples

```r
ermite_est_1 <- hermite_estimator_univar(N = 10, standardize = FALSE)
ermite_est_1 <- update_batch(hermite_est_1, rnorm(30))
ermite_est_2 <- hermite_estimator_univar(N = 10, standardize = FALSE)
ermite_est_2 <- update_batch(hermite_est_2, rnorm(30))
hermite_merged <- merge_hermite(list(hermite_est_1, hermite_est_2))
```

merge_moments_and_count_bivar

Internal method to consistently merge the number of observations, means and variances of two bivariate Hermite estimators

Description


Usage

```r
merge_moments_and_count_bivar(hermite_estimator1, hermite_estimator2)
```

Arguments

- `hermite_estimator1`: A hermite_estimator_bivar object.
- `hermite_estimator2`: A hermite_estimator_bivar object.

Value

An object of class hermite_estimator_bivar

merge_moments_and_count_univar

Internal method to consistently merge the number of observations, means and variances of two Hermite estimators

Description

Usage

merge_moments_and_count_univar(hermite_estimator1, hermite_estimator2)

Arguments

hermite_estimator1
   A hermite_estimator_univar object.

hermite_estimator2
   A hermite_estimator_univar object.

Value

An object of class hermite_estimator_univar.

Description

Note that the estimators must be of the same type to be merged i.e. both estimators must have a consistent est_type, either "univariate" or "bivariate". In addition, the N and standardize arguments must be the same for both estimators in order to merge them. Finally, note that exponentially weighted estimators cannot be merged. If the Hermite estimators are not standardized, the merged estimator will be exactly equivalent to constructing a single estimator on the data set formed by combining the data sets used to update the respective hermite_estimator inputs. If the input Hermite estimators are standardized however, then the equivalence will be approximate but still accurate in most cases.

Usage

merge_pair(this, hermite_estimator_other)

Arguments

this
   A hermite_estimator_univar or hermite_estimator_bivar object. The first Hermite series based estimator.

hermite_estimator_other
   A hermite_estimator_univar or hermite_estimator_bivar object. The second Hermite series based estimator.

Value

An object of class hermite_estimator_univar or hermite_estimator_bivar.
Examples

hermite_est_1 <- hermite_estimator(N = 10, standardize = FALSE)
hermite_est_1 <- update_batch(hermite_est_1, rnorm(30))
hermite_est_2 <- hermite_estimator(N = 10, standardize = FALSE)
hermite_est_2 <- update_batch(hermite_est_2, rnorm(30))
hermite_merged <- merge_pair(hermite_est_1, hermite_est_2)

merge_pair.hermite_estimator_bivar

Merges two bivariate Hermite estimators

Description

This method allows a pair of Hermite based estimators of class hermite_estimator_bivar to be consistently merged.

Usage

## S3 method for class 'hermite_estimator_bivar'
merge_pair(this, hermite_estimator_other)

Arguments

this

A hermite_estimator_bivar object. The first Hermite series based estimator.

hermite_estimator_other

A hermite_estimator_bivar object. The second Hermite series based estimator.

Details

Note that the N and standardize arguments must be the same for the two estimators in order to merge them. In addition, note that exponentially weighted estimators cannot be merged. If the Hermite estimators are not standardized, the merged estimator will be exactly equivalent to constructing a single estimator on the data set formed by combining the data sets used to update the respective hermite_estimator_bivar inputs. If the input Hermite estimators are standardized however, then the equivalence will be approximate but still accurate in most cases.

Value

An object of class hermite_estimator_bivar.
merge_pair.hermite_estimator_univar

Merges two Hermite estimators

Description

This method allows a pair of Hermite based estimators of class hermite_estimator_univar to be consistently merged.

Usage

```r
## S3 method for class 'hermite_estimator_univar'
merge_pair(this, hermite_estimator_other)
```

Arguments

- **this**: A hermite_estimator_univar object. The first Hermite series based estimator.
- **hermite_estimator_other**: A hermite_estimator_univar object. The second Hermite series based estimator.

Details

Note that the `N` and `standardize` arguments must be the same for the two estimators in order to merge them. In addition, note that exponentially weighted estimators cannot be merged. If the Hermite estimators are not standardized, the merged estimator will be exactly equivalent to constructing a single estimator on the data set formed by combining the data sets used to update the respective hermite_estimator_univar inputs. If the input Hermite estimators are standardized however, then the equivalence will be approximate but still accurate in most cases.

Value

An object of class hermite_estimator_univar.

Examples

```r
hermite_est_1 <- hermite_estimator_univar(N = 10, standardize = FALSE)
hermite_est_1 <- update_batch(hermite_est_1, rnorm(30))
hermite_est_2 <- hermite_estimator_univar(N = 10, standardize = FALSE)
hermite_est_2 <- update_batch(hermite_est_2, rnorm(30))
hermite_merged <- merge_pair(hermite_est_1, hermite_est_2)
```
merge_standardized_helper_bivar

Internal method to merge a list of standardized bivariate Hermite estimators

Description
Internal method to merge a list of standardized bivariate Hermite estimators

Usage
merge_standardized_helper_bivar(hermite_estimators)

Arguments
hermite_estimators
A list of hermite_estimator_bivar objects.

Value
An object of class hermite_estimator_bivar.

merge_standardized_helper_univar

Internal method to merge a list of standardized Hermite estimators

Description
Internal method to merge a list of standardized Hermite estimators

Usage
merge_standardized_helper_univar(hermite_estimators)

Arguments
hermite_estimators
A list of hermite_estimator_univar objects.

Value
An object of class hermite_estimator_univar.
print.hermite_estimator_bivar

Prints bivariate hermite_estimator object.

Description

Prints bivariate hermite_estimator object.

Usage

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

Arguments

- `x` A hermite_estimator_bivar object.
- `...` Other arguments passed on to methods used in printing.

Examples

```r
hermite_est <- hermite_estimator_bivar(N = 10, standardize = TRUE)
print(hermite_est)
```

print.hermite_estimator_univar

Prints univariate hermite_estimator object.

Description

Prints univariate hermite_estimator object.

Usage

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

Arguments

- `x` A hermite_estimator_univar object.
- `...` Other arguments passed on to methods used in printing.

Examples

```r
hermite_est <- hermite_estimator_univar(N = 10, standardize = TRUE)
print(hermite_est)
```
quant

Estimates the quantiles at a vector of probability values

Description

This method utilizes the estimator (13) in paper Stephanou, Michael, Varughese, Melvin and Iain Macdonald. "Sequential quantiles via Hermite series density estimation." Electronic Journal of Statistics 11.1 (2017): 570-607 <doi:10.1214/17-EJS1245>, with some modifications to improve the stability of numerical root finding. Note that this method is only applicable to the univariate Hermite estimator i.e. est_type = "univariate".

Usage

quant(this, p, algorithm = "interpolate", accelerate_series = TRUE)

Arguments

this
A hermite_estimator_univar object.

p
A numeric vector. A vector of probability values.

algorithm
A string. Two possible values ‘interpolate’ which is faster but may be less accurate or ‘bisection’ which is slower but potentially more accurate.

accelerate_series

Value

A numeric vector. The vector of quantile values associated with the probabilities p.

Examples

hermite_est <- hermite_estimator(N = 10, standardize = TRUE, est_type="univariate")
hermite_est <- update_batch(hermite_est, rnorm(30))
quant_est <- quant(hermite_est, c(0.25, 0.5, 0.75))
quant.hermite_estimator_univar

Estimates the quantiles at a vector of probability values

Description


Usage

```r
## S3 method for class 'Var'
quant(this, p, algorithm = "interpolate", accelerate_series = TRUE)
```

Arguments

- `this`: A hermite_estimator_univar object.
- `p`: A numeric vector. A vector of probability values.
- `algorithm`: A string. Two possible values ‘interpolate’ which is faster but may be less accurate or ‘bisection’ which is slower but potentially more accurate.

Value

A numeric vector. The vector of quantile values associated with the probabilities p.

Examples

```r
hermite_est <- hermite_estimator_univar(N = 10, standardize = TRUE)
hermite_est <- update_batch(hermite_est, rnorm(30))
quant_est <- quant(hermite_est, c(0.25, 0.5, 0.75))
```
spearmans

Estimates the Spearman’s rank correlation coefficient

Description

This method calculates the Spearman’s rank correlation coefficient value. It is only applicable to
the bivariate Hermite estimator i.e. est_type = "bivariate".

Usage

```
spearmans(this, clipped = FALSE)
```

Arguments

- **this**: A hermite_estimator_bivar object.
- **clipped**: A boolean value. Indicates whether to clip Spearman’s rank correlation esti-
  mates to lie between -1 and 1.

Details

The object must be updated with observations prior to the use of this method.

Value

A numeric value.

Examples

```r
hermite_est <- hermite_estimator(N = 10, standardize = TRUE,
est_type="bivariate")
hermite_est <- update_batch(hermite_est, matrix(rnorm(30*2), nrow=30,
ncol=2, byrow = TRUE))
spearmans_est <- spearmans(hermite_est)
```

---

spearmans.hermite_estimator_bivar

Estimates the Spearman’s rank correlation coefficient

Description

This method calculates the Spearman’s rank correlation coefficient value using the hermite_estimator_bivar
object (this).

Usage

```
### S3 method for class 'hermite_estimator_bivar'
spearmans(this, clipped = FALSE)
```
standardizeInputs

Arguments

this A hermite_estimator_bivar object.
clipped A boolean value. Indicates whether to clip Spearman’s rank correlation estimates to lie between -1 and 1.

Details


The object must be updated with observations prior to the use of this method.

Value

A numeric value.

Examples

hermite_est <- hermite_estimator_bivar(N = 10, standardize = TRUE)
hermite_est <- update_batch(hermite_est, matrix(rnorm(30*2), nrow=30, ncol=2, byrow = TRUE))
spearmans_est <- spearmans(hermite_est)

standardizeInputs A numeric vector. The first element is the updated mean. The second element is the updated variance times n_obs. The third element is the updated, standardized value of x.

Description

Standardizes the observation x and updates the online moment inputs

Usage

standardizeInputs(x, n_obs, current_mean, current_var)

Arguments

x A numeric value.
n_obs A numeric value. The number of observations.
current_mean A numeric value.
current_var A numeric value.

Value

A numeric vector. The first element is the updated mean. The second element is the updated variance times n_obs. The third element is the updated, standardized value of x.
**standardizeInputsEW**  
*Standardizes the observation x and updates the online moment inputs*

**Description**

The online moments are updated via exponential weighting.

**Usage**

```
standardizeInputsEW(x, n_obs, lambda, current_mean, current_var)
```

**Arguments**

- **x**  
  A numeric value.
- **n_obs**  
  A numeric value. The number of observations.
- **lambda**  
  A numeric value.
- **current_mean**  
  A numeric value.
- **current_var**  
  A numeric value.

**Value**

A numeric vector. The first element is the updated mean. The second element is the updated variance times n_obs. The third element is the updated, standardized value of x.

**Author(s)**

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---

**summary.hermite_estimator_bivar**

*Summarizes bivariate hermite_estimator object.*

**Description**

Outputs key parameters of a bivariate hermite_estimator object along with estimates of the mean and standard deviation of the first and second dimensions of the bivariate data that the object has been updated with. Also outputs the Spearman’s Rho and Kendall Tau of the bivariate data that the object has been updated with.
summary.hermite_estimator_univar

Usage

## S3 method for class 'hermite_estimator_bivar'
summary(object, digits = max(3, getOption("digits") - 3), ...)

Arguments

object A hermite_estimator_bivar object.
digits A numeric value. Number of digits to round to.
... Other arguments passed on to methods used in summary.

Examples

hermite_est <- hermite_estimator_bivar(N = 10, standardize = TRUE)
hermite_est <- update_batch(hermite_est, matrix(rnorm(30*2), nrow=30, ncol=2, byrow = TRUE))
summary(hermite_est)

summary.hermite_estimator_univar

    Summarizes univariate hermite_estimator object.

Usage

## S3 method for class 'hermite_estimator_univar'
summary(object, digits = max(3, getOption("digits") - 3), ...)

Arguments

object A hermite_estimator_univar object.
digits A numeric value. Number of digits to round to.
... Other arguments passed on to methods used in summary.

Examples

hermite_est <- hermite_estimator_univar(N = 10, standardize = TRUE)
hermite_est <- update_batch(hermite_est, rnorm(30))
summary(hermite_est)
update_batch.hermite_estimator_bivar

Updates the Hermite series based estimator with a batch of data

Description

This method can be applied in one-pass batch estimation settings. This method cannot be used with an exponentially weighted estimator.

Usage

update_batch(this, x)

Arguments

- **this**: A hermite_estimator_univar or hermite_estimator_bivar object.
- **x**: A numeric vector or a numeric matrix. Note that for univariate estimators, x is a numeric vector of observations to be incorporated. For bivariate estimators, x is a numeric matrix with n rows for n observations and 2 columns.

Value

An object of class hermite_estimator_univar or hermite_estimator_bivar.

Examples

```r
hermite_est <- hermite_estimator(N = 10, standardize = TRUE, est_type="univariate")
hermite_est <- update_batch(hermite_est, x = c(1, 2))
hermite_est <- hermite_estimator(N = 10, standardize = TRUE, est_type="bivariate")
hermite_est <- update_batch(hermite_est, x = matrix(c(1,1,2,2,3,3), nrow=3, ncol=2,byrow=TRUE))
```

update_batch.hermite_estimator_bivar

Updates the Hermite series based estimator with a batch of data

Description

This method can be applied in one-pass batch estimation settings. This method cannot be used with an exponentially weighted estimator.

Usage

```r
## S3 method for class 'hermite_estimator_bivar'
update_batch(this, x)
```
Arguments

- **this**: A hermite_estimator_bivar object.
- **x**: A numeric matrix. A matrix of bivariate observations to be incorporated into the estimator. Each row corresponds to a single bivariate observation.

Value

An object of class hermite_estimator_bivar.

Examples

```r
hermite_estimator <- hermite_estimator_bivar(N = 10, standardize = TRUE)
hermite_estimator <- update_batch(hermite_estimator, x = matrix(c(1, 2, 3, 4, 5, 6), nrow=3, ncol=2, byrow = TRUE))
```

---

**update_batch.hermite_estimator_univar**

*Updates the Hermite series based estimator with a batch of data*

Description

This method can be applied in one-pass batch estimation settings. This method cannot be used with an exponentially weighted estimator.

Usage

```r
## S3 method for class 'hermite_estimator_univar'
update_batch(this, x)
```

Arguments

- **this**: A hermite_estimator_univar object.
- **x**: A numeric vector. A vector of observations to be incorporated into the estimator.

Value

An object of class hermite_estimator_univar.

Examples

```r
hermite_est <- hermite_estimator_univar(N = 10, standardize = TRUE)
hermite_est <- update_batch(hermite_est, x = c(1, 2))
```
**Description**

This method can be applied in sequential estimation settings.

**Usage**

```r
update_sequential(this, x)
```

**Arguments**

- `this`: A `hermite_estimator_univar` or `hermite_estimator_bivar` object.
- `x`: A numeric value or vector. An observation to be incorporated into the estimator. Note that for univariate estimators, `x` is a numeric value whereas for bivariate estimators, `x` is a numeric vector of length 2.

**Value**

An object of class `hermite_estimator_univar` or `hermite_estimator_bivar`.

**Examples**

```r
hermite_est <- hermite_estimator(N = 10, standardize = TRUE,
est_type = "univariate")
hermite_est <- update_sequential(hermite_est, x = 2)
hermite_est <- hermite_estimator(N = 10, standardize = TRUE,
est_type = "bivariate")
hermite_est <- update_sequential(hermite_est, x = c(1,2))
```
Arguments

this  A hermite_estimator_bivar object.
x     A numeric vector of length 2. A bivariate observation to be incorporated into the estimator.

Value

An object of class hermite_estimator_bivar.

Examples

hermite_estimator <- hermite_estimator_bivar(N = 10, standardize = TRUE)
hermite_estimator <- update_sequential(hermite_estimator, x = c(1,2))
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