# Package: dsdp (via r-universe)

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**Title** Density Estimation with Semidefinite Programming

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**Description** The models of probability density functions are Gaussian or exponential distributions with polynomial correction terms. Using a maximum likelihood method, 'dsdp' computes parameters of Gaussian or exponential distributions together with degrees of polynomials by a grid search, and coefficient of polynomials by a variant of semidefinite programming. It adopts Akaike Information Criterion for model selection. See a vignette for a tutorial and more on our 'Github' repository <https://github.com/tsuchiya-lab/dsdp/>.

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cdf_expmodel *Cumulative distribution function of Expomemtial-based model*

## Description

A cumulative distribution function(CDF) of Exponential-based model. To access parameters and coefficients in an object `emodel` of a class `expmodel`, use `emodel$result[k, "lmd1"]`, `emodel$coeffs[[k]]` for some index `k`. This index appears in the leftmost column of estimation table generated by `summary(emodel)`.

## Usage

```
cdf_expmodel(coeff, lmd, x)
```

## Arguments

| | |
|---|---|
| `coeff` | A coefficient vector in increasing order of degrees; the first element is 0th degree, ..., and last element is the largest degree of coefficients. |
| `lmd` | A rate parameter, which is positive. |
| `x` | A numeric vector of input. |

## Value

A numeric vector of CDF of an exponential-based model.

## See Also

`expmodel()` `summary.expmodel()` `estimate.expmodel()` `func.expmodel()` `cdf_expmodel()`

## Examples

```
## Create an object of `expmodel`
emodel <- expmodel(mixexpgamma$n200)
## Estimate with degree 4 and rate parameter 2.0
emodel <- estimate(emodel, 4, 2.0)
## Input vector
x <- seq(0, 12, 0.1)
## Output of PDF in above estimation
yv <- cdf_expmodel(emodel$coeffs[[1]], emodel$result[1, "lmd1"], x)
```

cdf_gaussmodel *Cumulative distribution function of Gaussian-based model*

## Description

A cumulative distribution function(CDF) of Gaussian-based model. To access parameters and coefficients in an object gmodel of a class gaussmodel, use gmodel$result[k, "mu1"], gmodel$result[k, "sig1"], gmodel$coeffs[[k]] for some index k. This index appears in the leftmost column of estimation table generated by summary(gmodel).

## Usage

```
cdf_gaussmodel(coeff, mu, sig, x)
```

## Arguments

| | |
|---|---|
| coeff | A coefficient vector in increasing order of degrees; the first element is 0th degree, ..., and last element is the largest degree of coefficients. |
| mu | A mean of Gaussian distribution. |
| sig | A standard deviation of Gaussian distribution, which is positive. |
| x | A numeric input vector. |

## Value

A numeric vector of CDF of Gaussian-based model.

## See Also

gaussmodel() summary.gaussmodel() estimate.gaussmodel() func.gaussmodel() pdf_gaussmodel()

## Examples

```
## Create an object of `gaussmodel`
gmodel <- gaussmodel(mix2gauss$n200)
## Estimate with a degree 6, a mean 0, and standard deviations 0.5
gmodel <- estimate(gmodel, 6, 0, 0.5)
## Input vector
x <- seq(-3, 3, 0.1)
## Output of PDF in above estimation
yv <- cdf_gaussmodel(gmodel$coeffs[[1]], gmodel$result[1, "mu1"],
 gmodel$result[1, "sig1"], x)
```

## databinning *Reduce a data set to representatives of bins and their frequencies*

### Description

Reduce a data set to a named list of 'values' and 'freq', which are representatives of bins and their frequencies, respectively.

### Usage

```
databinning(data, bins = 40)
```

### Arguments

| | |
|---|---|
| data | A numeric vector of a data set. |
| bins | A positive integer to represent the number of bins. |

### Value

A named list of values and freq whose length is bins.

### See Also

base::rle()

### Examples

```
rlst <- databinning(mix2gauss$n200)
```

## datastats *Compute the mean and the standard deviation of a data set*

### Description

Compute the mean and the standard deviation of a data set represented by the pair of the numeric vectors data and optionally its frequency vector freq.

### Usage

```
datastats(data, freq = NULL)
```

### Arguments

| | |
|---|---|
| data | A numeric vector of a data set. |
| freq | A frequency vector corresponding to the data vector. The default value is NULL, which means all frequencies are one. |

## Value

The mean and the standard deviation of a data set.

## See Also

`histmean()`

## Examples

```
## Without a frequency data
datastats(mix2gauss$n200)
## With a frequency data
datastats(mix2gaussHist$n200p, mix2gaussHist$n200f)
```

---

# dsdp *dsdp: Density Estimation using Semidefinite Programming*

---

## Description

Density estimation with Semidefinite Programming. The models of probability density functions are Gaussian or exponential distributions with polynomial correction terms. Using a maximum likelihood method, it computes parameters of Gaussian or exponential distributions together with degrees of polynomials by a grid search, and coefficients of polynomials by a variant of semidefinite programming. It adopts Akaike Information Criterion for model selection. See vignettes for tutorials and more information.

---

# estimate *Generic Method for estimation*

---

## Description

This is a generic S3 method for estimation.

## Usage

```
estimate(model, ...)
```

## Arguments

| | |
|---|---|
| `model` | An instance of a class model to be estimated. |
| `...` | additional arguments affecting the `estimate` produced. |

## Value

An instance of a model with estimated data.

`estimate.expmodel` *Estimate Exponential-based model* `expmodel`

## Description

Estimates Exponential-based model `expmodel` among parameter vectors, `deglist`, `lmdlist`. Then it sorts the results by AIC.

## Usage

```
## S3 method for class 'expmodel'
estimate(
  model,
  deglist = deglist,
  lmdlist = lmdlist,
  recompute = FALSE,
  stepsize = NULL,
  verbose = FALSE,
  ...
)
```

## Arguments

| | |
|---|---|
| `model` | An object of `expmodel` class. |
| `deglist` | A vector of degrees of polynomials. The element should be positive integers. |
| `lmdlist` | A vector of rate parameters of Exponential-based models. The element should be larger than 0. |
| `recompute` | If `TRUE`, recomputes the results for better estimation and accuracy. Parameters whose accuracies had been already attained sufficiently, namely around 1.0e-6, are not included in candidates for recomputing. |
| `stepsize` | A vector in descending order whose values are between 0 and 1. If a small step size is supplied, it can attain successful estimates, but it might take more iterations. |
| `verbose` | If `TRUE`, it shows the detailed message of SDP solver. |
| `...` | Arguments to be passed to or from other methods. |

## Value

A `expmodel` object including the estimates. Those estimates are stored in `model$result` with `data.frame` format and `model$coeffs` in `list` format.

## See Also

`expmodel()` `summary.expmodel()` `plot.expmodel()`

## Examples

```
## Create an expmodel object
emodel <- expmodel(mixexpgamma$n200)
## Estimate a model with parameters
emodel <- estimate(emodel, deglist=c(4,5), lmdlist=c(0.5, 1, 2))
```

---

`estimate.gaussmodel` *Estimate Gaussian-based model* `gaussmodel`

---

## Description

Estimates Gaussian-based model `gaussmodel` among parameter vectors, `deglist`, `mulist`, `sdlist`. Then it sorts the results by AIC.

## Usage

```
## S3 method for class 'gaussmodel'
estimate(
  model,
  deglist = deglist,
  mulist = mulist,
  sdlist = sdlist,
  scaling = FALSE,
  recompute = FALSE,
  stepsize = NULL,
  verbose = FALSE,
  ...
)
```

## Arguments

| | |
|---|---|
| `model` | An object of a `gaussmodel` class. |
| `deglist` | A vector of degrees of polynomials. The element should be positive even numbers. |
| `mulist` | A vector of means for Gaussian-based models. |
| `sdlist` | A vector of standard deviations for Gaussian-based models. The element should be larger than 0. |
| `scaling` | A logical scalar, which indicates whether or not it scales means and standard deviations in `mulist` and `sdlist`. The default value is `FALSE`. |
| `recompute` | If `TRUE`, recomputes the results for better estimation and accuracy. Parameters whose accuracies had been already attained sufficiently, namely around 1.0e-6, are not included in candidates for recomputing. |
| `stepsize` | A vector in descending order whose values are between 0 and 1. If a small step size is supplied, it can attain successful estimates, but it might take more iterations. |
| `verbose` | If `TRUE`, it shows the detailed message of SDP solver. |
| `...` | Arguments to be passed to or from other methods. |

## Value

A `gaussmodel` object including the estimates. Those estimates are stored in `model$result` with `data.frame` format and `model$coeffs` in `list` format.

## See Also

`gaussmodel()` `summary.gaussmodel()` `plot.gaussmodel()`

## Examples

```
## Create an `gaussmodel` object
gmodel <- gaussmodel(mix2gauss$n200)
## Estimate a model with parameters
gmodel <- estimate(gmodel, deglist=c(2, 4), mulist=c(0.0, 0.2),
             sdlist=c(0.75, 1.0))
```

---

`eval_poly` *Evaluate a polynomial*

---

## Description

Evaluate the polynomial whose coefficients are represented in `coeff` vector. The order of the coefficient is an increasing order, i.e., `coeff[1]` is a constant term, and `coeff[2]` is a coefficient of 1st degree term, etc. Evaluation is done using Horner's method.

## Usage

```
eval_poly(coeff, x)
```

## Arguments

| | |
|---|---|
| `coeff` | A coefficient vector in increasing order of degrees; the first element is 0th degree, ..., and the last element is the largest degree of coefficients. |
| `x` | A numeric input vector. |

## Value

A vector of values of a polynomial whose coefficient is `coeff`.

## See Also

`pdf_gaussmodel()` `pdf_expmodel()` `cdf_gaussmodel()` `cdf_expmodel()`

## Examples

```
## Evaluate a polynomial x^2 - 2x + 2 with x = 1, 2, 3.
## 0th, 1st, 2nd degree of coefficients
coeff <- c(2, -2, 1)
x <- c(1, 2, 3)
eval_poly(coeff, x)
```

exp_est *Estimate coefficients of a polynomial in Exponential-based Model*

## Description

Estimate coefficients of a polynomial in Exponential-based model:

$$\mathrm{poly}(x;\alpha)\mathrm{Exp}(x;\lambda)$$

, where $\alpha$ is a coefficient vector, $\lambda$ is a rate parameter of an exponential distribution:

$$\mathrm{Exp}(x;\lambda) := \lambda e^{-\lambda x}$$

.

Using `data` and optionally its frequencies `freq`, and a degree of a polynomial, a rate parameter `lmd` of an exponential distribution, it computes the coefficients of polynomial, along with Akaike Information Criterion(AIC) and an accuracy information from underlying SDP solver. In general, the smaller the AIC is, the better the model is. An `accuracy` around `1e-7` is a good indication for a computational result of coefficients estimation.

## Usage

```
exp_est(deg, lmd, data, freq, verbose, stepvec)
```

## Arguments

| | |
|---|---|
| `deg` | A degree of polynomial, which is positive even integer. |
| `lmd` | A rate parameter of an exponential distribution, which is positive. |
| `data` | A numeric vector of a data set to be estimated. |
| `freq` | A numeric vector of frequencies for a data set `data`. The default value is `NULL`, which indicates that all frequencies are equally one. If `freq` is not `NULL`, then it should be the same length as `data`, and all values should be positive integers. |
| `verbose` | If `TRUE`, it shows a detail information about SDP solver. |
| `stepvec` | It designates the stepsize for SDP solver. If the problem is easy, i.e., the number of a data set are small and a degree of a polynomial is small, then, for example, `0.9` might be ok. If it looks difficult, then `c(0.5, 0.3)` might work. |

## Value

A `list` of `deg, lmd, aic, accuracy, coefficient vector`

## See Also

`estimate.expmodel()`

## Examples

```
rlst <- exp_est(3, 1.0, mixexpgamma$n200, NULL, FALSE, c(0.7, 0.4))
```

expmodel *Constructor for S3 class* expmodel

## Description

This function is a constructor for S3 class expmodel, which represents Exponential-based model. It usually takes data and optionally freq as arguments and also optionally stepsize Members of interest in practice are result and coeffs, which maintain the information of estimates and coefficients of polynomials, respectively.

## Usage

```
expmodel(data = data, freq = NULL, stepsize = c(0.5, 0.3))
```

## Arguments

| | |
|---|---|
| data | A nonnegative numeric vector of a data set to be estimated. |
| freq | A frequency vector corresponding to the data vector. The default value is NULL, which means all frequencies are one. If supplied, the length of a vector should be same as data and each element should be a nonnegative integer. |
| stepsize | A numeric vector whose element is larger than 0 and smaller than 1, and decreasing order. The default value is c(0.5, 0.3). If you encounter numerical difficulties, decreasing its values, for example, to c(0.4, 0.2), might help to estimate a model. |

## Value

An object of Exponential-based model expmodel.

## See Also

summary.expmodel() plot.expmodel() estimate.expmodel()

## Examples

```
## Create `expmodel` object from a data set `mixexpgamma$n200`.
 emodel <- expmodel(mixexpgamma$n200)
## Create `expmodel` object from a data set `mixExpGammaHist$n800p` and
## its frequencies `mixExpGammaHist$n800f`.
 emodel <- expmodel(mixExpGammaHist$n800p, mixExpGammaHist$n800f)
```

## func *Generic Method for evaluate the estimate*

### Description

This is a generic S3 method for estimate.

### Usage

```
func(model, x, ...)
```

### Arguments

| | |
|---|---|
| model | An instance of a class model to be evaluated. |
| x | A numeric vector for input. |
| ... | additional arguments affecting the func produced. |

### Value

An evaluation of x with model.

## func.expmodel *Return the evaluation of a vector with Exponential-based model*

### Description

Evaluate an input vector x with Exponential-based model and return its vector. By default, it evaluate with the best model and its density, but it can designate the model by index and also can evaluate with a cumulative distribution.

### Usage

```
## S3 method for class 'expmodel'
func(model, x, cdf = FALSE, n = 1, ...)
```

### Arguments

| | |
|---|---|
| model | expmodel object. |
| x | A numeric vector to be evaluated with a distribution. |
| cdf | A logical scalar whether the evaluation is done with a cumulative distribution or not. A default value is FALSE, which means that the evaluation is done with a density. |
| n | The index indicates the estimates. 1, by default, is the best estimate, and 2 is the 2nd best, etc. |
| ... | Arguments to be passed to or from other methods. |

## Value

A numeric vector of the evaluatio of input vector x with a model.

## See Also

expmodel() summary.expmodel() plot.expmodel() estimate.expmodel() pdf_expmodel() cdf_expmodel()

## Examples

```
## Create an `expmodel` object
emodel <- expmodel(mixexpgamma$n200)
## Estimate an model with parameters
emodel <- estimate(emodel, deglist=5, lmdlist=3.75)
## A vector for input
x <- seq(0, 14, by=0.1)
## Density function
y <- func(emodel, x)
## Cumulative distribution
y <- func(emodel, x, cdf=TRUE)
```

---

# func.gaussmodel *Return the evaluation of a vector with Gaussian-based model*

---

## Description

Evaluate an input vector x with Gaussian-based model and return its vector. By default, it evaluate with the best model and its density, but it can designate the model by index and also can evaluate with a cumulative distribution.

## Usage

```
## S3 method for class 'gaussmodel'
func(model, x, cdf = FALSE, n = 1, scaling = FALSE, ...)
```

## Arguments

| | |
|---|---|
| model | gaussmodel object. |
| x | A numeric vector to be evaluated with a distribution. |
| cdf | A logical scalar whether the evaluation is done with a cumulative distribution or not. A default value is FALSE, which means that the evaluation is done with a density. |
| n | The index indicates the estimates. 1, by default, is the best estimate, and 2 is the 2nd best, etc. |
| scaling | A logical scalar, which indicates whether or not it scales means and standard deviations in mulist and sdlist. The default value is FALSE. |
| ... | Arguments to be passed to or from other methods. |

## Value

A numeric vector of the evaluatio of input vector x with a model.

## See Also

gaussmodel() summary.gaussmodel() plot.gaussmodel() estimate.gaussmodel() pdf_gaussmodel() cdf_gaussmodel()

## Examples

```
## Create an `gaussmodel` object
gmodel <- gaussmodel(mix2gauss$n200)
## Estimate an model with parameters
gmodel <- estimate(gmodel, deglist=4, mulist=0.15, sdlist=0.73)
## A vector for input
x <- seq(-4, 4, by=0.1)
## Density function
y <- func(gmodel, x)
## Cumulative distribution
y <- func(gmodel, x, cdf=TRUE)
```

---

# gauss_est *Estimate coefficients of a polynomial in Gaussian-based model*

---

## Description

Estimate coefficients of a polynomial in Gaussian-based model:

$$\mathrm{poly}(x, \alpha) N(x; \mu, \sigma^2)$$

, where $\alpha$ is a coefficient vector, $\mu$ and $\sigma$ are a mean and a standard deviation of Gaussian distribution:

$$N(x; \mu, \sigma^2) := \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$

Using data and optionally its frequencies freq, and a degree of a polynomial, a mean mu and a standard deviation sig of Gausian distribution, it computes the coefficients of a polynomial, along with Akaike Information Criterion(AIC) and an accuracy information from an underlying SDP solver. In general, the smaller the AIC is, the better the model is. An accuracy around 1e-7 is a good indication for a computational result of coefficients estimation.

## Usage

```
gauss_est(deg, mu, sig, data, freq, verbose, stepsize)
```

### Arguments

| | |
|---|---|
| deg | A degree of polynomial, which is positive even integer. |
| mu | A mean of Gaussian distribution. |
| sig | A standard deviation of Gaussian distribution, which is positive. |
| data | A numeric vector of a data set to be estimated. |
| freq | A numeric vector of frequencies for a data set data. The default value is NULL, which indicates that all frequencies are equally one. If freq is not NULL, then it should be the same length as data, and all values should be positive integers. |
| verbose | If TRUE, it shows a detail information about SDP solver. |
| stepsize | It designates the stepsize for SDP solver. If the problem is easy, i.e., the number of a data set are small and a degree of a polynomial is small, then, for example, 0.9 might be ok. If it looks difficult, then c(0.5, 0.3) might work. |

### Value

A list of deg, mu, sig, aic, accuracy, coefficient vector.

### See Also

estimate.gaussmodel()

### Examples

```
rlst <- gauss_est(4, 0, 1, mix2gauss$n200, NULL, FALSE, c(0.7, 0.4))
```

---

## gaussmodel *Constructor for S3 class* gaussmodel

---

### Description

This function is a constructor for S3 class gaussmodel, which represents Gaussian-based model. It usually takes data and optionally freq as arguments and also optionally stepsize. Members of interest in practice are result and coeffs, which maintain the information of estimates and coefficients of polynomials, respectively.

### Usage

```
gaussmodel(data = data, freq = NULL, stepsize = c(0.5, 0.3))
```

### Arguments

| | |
|---|---|
| data | A numeric vector of a data set to be estimated. |
| freq | A frequency vector corresponding to the data vector. The default value is NULL, which means all frequencies are one. If supplied, the length of a vector should be same as data and each element should be a nonnegative integer. |
| stepsize | A numeric vector whose element is larger than 0 and smaller than 1, and decreasing order. The default value is c(0.5, 0.3). If you encounter numerical difficulties, decreasing its values, for example, to c(0.4, 0.2), might help to estimate a model. |

### Value

An object of Gaussian-based model gaussmodel.

### See Also

summary.gaussmodel() plot.gaussmodel() estimate.gaussmodel()

### Examples

```
## Create `gaussmodel` object from a data set `mix2gauss$n200`.
 gmodel <- gaussmodel(mix2gauss$n200)
## Create `gaussmodel` object from a data set `mix2gaussHist$n200p` and
## its frequencies `mix2gaussHist$n200f`.
 gmodel <- gaussmodel(mix2gaussHist$n200p, mix2gaussHist$n200f)
```

---

## histmean *Compute the mean of a data set*

---

### Description

Compute the mean of a data set represented by the pair of the numeric vectors data and optionally its frequency vector freq.

### Usage

```
histmean(data, freq = NULL)
```

### Arguments

| | |
|---|---|
| data | A numeric vector of a data set. |
| freq | A frequency vector corresponding to the data vector. The default value is NULL, which means all frequencies are one. |

### Value

The mean of a data set.

## See Also

datastats()

## Examples

```
## Without a frequency data
histmean(mix2gauss$n200)
## With a frequency data
histmean(mix2gaussHist$n200p, mix2gaussHist$n200f)
```

---

# igamma *Incomplete Gamma Function*

---

## Description

Evaluate an incomplete gamma function:

$$\gamma(a, x) = \int_0^x t^{a-1} e^{-t} dt,$$

using SLATEC dgami in https://netlib.org/slatec/. When ($x > 0$ and $a \geq 0$) or ($x \geq 0$ and $a > 0$), compute the result, otherwise the value is NaN.

## Usage

```
igamma(a, x)
```

## Arguments

| | |
|---|---|
| a | A positive numeric vector. |
| x | A nonnegative numeric vector with same length as a. length. |

## Value

A vector of values of an incomplete gamma function.

## See Also

igammac()

## Examples

```
igamma(1, 1)
```

## igammac *Complementary Incomplete Gamma Function*

### Description

Evaluate an complementary incomplete gamma function:

$$\gamma^*(a,x) = \int_x^\infty t^{a-1}e^{-t}dt,$$

using SLATEC dgamic in https://netlib.org/slatec/. When ($x > 0$ and $a \geq 0$) or ($x \geq 0$ and $a > 0$), compute the result, otherwise the value is NaN.

### Usage

```
igammac(a, x)
```

### Arguments

| | |
|---|---|
| a | A numeric vector. |
| x | A nonnegative numeric vector with same length as a. |

### Value

A vector of values of a complementary incomplete gamma function.

### See Also

igamma()

### Examples

```
igammac(1, 1)
```

## mix2gauss *Datasets of Mixture of 2 Gaussian Distributions*

### Description

Dataset generated by mixture of 2 Gaussian Distributions whose density is:

$$\frac{0.3}{\sqrt{2\pi 0.5^2}}\exp\left(\frac{(x+1)^2}{2\cdot 0.5^2}\right) + \frac{0.7}{\sqrt{2\pi 0.5^2}}\exp\left(\frac{(x-1)^2}{2\cdot 0.5^2}\right)$$

.

## Usage

```
mix2gauss
```

## Format

A list of numeric vectors of Bimodal Gaussian Mixture Model.

**n200** A numeric vector with 200 elements.

**n400** A numeric vector with 400 elements.

**n600** A numeric vector with 600 elements.

**n800** A numeric vector with 800 elements.

**n1000** A numeric vector with 1000 elements.

**n1200** A numeric vector with 1200 elements.

## Source

`mix2gauss_gen()`

---

# mix2gauss_fun *A density function of mixed Gaussian distributions*

---

## Description

A density function of mixed Gaussian distributions whose density is:

$$\frac{0.3}{\sqrt{2\pi 0.5^2}} \exp\left(\frac{(x+1)^2}{2 \cdot 0.5^2}\right) + \frac{0.7}{\sqrt{2\pi 0.5^2}} \exp\left(\frac{(x-1)^2}{2 \cdot 0.5^2}\right)$$

.

## Usage

```
mix2gauss_fun(x)
```

## Arguments

| | |
|---|---|
| x | A numeric vector for arguments of a density function. |

## Value

A numeric vector of probabilities for a given argument `x`.

## See Also

`mix2gauss_gen()`

`mix2gauss_gen` *Generate mixed Gaussian random numbers*

## Description

Generate mix gaussian random numbers whose density is:

$$\frac{0.3}{\sqrt{2\pi 0.5^2}} \exp\left(\frac{(x+1)^2}{2 \cdot 0.5^2}\right) + \frac{0.7}{\sqrt{2\pi 0.5^2}} \exp\left(\frac{(x-1)^2}{2 \cdot 0.5^2}\right)$$

.

## Usage

```
mix2gauss_gen(n = 100, seed = NULL)
```

## Arguments

| | |
|---|---|
| `n` | The number of random numbers. |
| `seed` | A seed for random number generator. |

## Value

A numeric vector of random numbers whose a density is described in Description.

## See Also

`mix2gauss_fun()`

`mix2gaussHist` *Dataset of Mixture of 2 Gaussian Distributions: Histogram version*

## Description

Dataset of Mixture of 2 Gaussian Distributions, histogram version, whose density is:

$$\frac{0.3}{\sqrt{2\pi 0.5^2}} \exp\left(\frac{(x+1)^2}{2 \cdot 0.5^2}\right) + \frac{0.7}{\sqrt{2\pi 0.5^2}} \exp\left(\frac{(x-1)^2}{2 \cdot 0.5^2}\right)$$

.

## Usage

```
mix2gaussHist
```

## Format

A list of numeric vectors of Bimodal Gaussian Mixture Model.

**n200** A numeric vector with 200 elements.

**n200p** Histogram sample data with 25 bins.

**n200f** Histogram frequency data with 25 bins.

**n400** A numeric vector with 400 elements.

**n400p** Histogram sample data with 50 bins.

**n400f** Histogram frequency data with 50 bins.

**n800** A numeric vector with 800 elements.

**n800p** Histogram sample data with 100 bins.

**n800f** Histogram frequency data with 100 bins.

## Source

`mix2gauss_gen()` `databinning()`

---

`mix3gauss` *Datasets of Mixture of 3 Gaussian Distributions*

---

## Description

Datasets generated by Mixture of 3 Gaussian Distributions whose density is proportional to:

$$\exp(\frac{x^2}{2}) + 5\exp(\frac{(x-1)^2}{0.2}) + 3\exp(\frac{(x-1)^2}{0.5}).$$

## Usage

```
mix3gauss
```

## Format

A list of numeric vectors of Unimodal Gaussian Asymmetric Mixture Model.

**n200** A numeric vector with 200 elements.

**n400** A numeric vector with 400 elements.

**n600** A numeric vector with 600 elements.

**n800** A numeric vector with 800 elements.

**n1000** A numeric vector with 1000 elements.

**n1200** A numeric vector with 1200 elements.

## Source

`mix3gauss_gen()`

## mix3gauss_fun *A density function of mixed gaussian distribution*

### Description

A density function proportional to:

$$\exp(\frac{x^2}{2}) + 5\exp(\frac{(x-1)^2}{0.2}) + 3\exp(\frac{(x-1)^2}{0.5}).$$

### Usage

```
mix3gauss_fun(x)
```

### Arguments

| | |
|---|---|
| x | A numeric vector for arguments of a density function. |

### Value

A numeric vector of probabilities for a given argument x.

### See Also

mix3gauss_gen()

## mix3gauss_gen *Generate Mixed Gaussian Random Numbers*

### Description

A random number generator whose density function is proportional to:

$$\exp(\frac{x^2}{2}) + 5\exp(\frac{(x-1)^2}{0.2}) + 3\exp(\frac{(x-1)^2}{0.5}).$$

### Usage

```
mix3gauss_gen(n = 100, seed = NULL)
```

### Arguments

| | |
|---|---|
| n | The number of random numbers. |
| seed | A seed for random number generator. |

### Value

A numeric vector of probabilities for a given argument x.

## See Also

mix3gauss_fun()

---

mixexpgamma *Dataset of Mixture of Exponential Distribution and Gamma Distribution*

---

## Description

Dataset of mixture of exponential distribution and gamma distribution whose density is:

$$0.2(2e^{-2x}) + 0.8\frac{x^3}{3!}e^{-x}.$$

## Usage

```
mixexpgamma
```

## Format

A list of numeric vectors of Mixture of Exponential and Gamma distribution Model.

**n200** A numeric vector with 200 elements.

**n400** A numeric vector with 400 elements.

**n600** A numeric vector with 600 elements.

**n800** A numeric vector with 800 elements.

**n1000** A numeric vector with 1000 elements.

**n1200** A numeric vector with 1200 elements.

## Source

mixexpgamma_gen()

---

mixexpgamma_fun *A density function of Mixed Exponential and Gamma Distributions*

---

## Description

A density function of

$$0.2(2e^{-2x}) + 0.8\frac{x^3}{3!}e^{-x}.$$

## Usage

```
mixexpgamma_fun(x)
```

### Arguments

| | |
|---|---|
| x | A numeric vector for arguments of a density function. |

### Value

A numeric vector of probabilities for a given argument x.

### See Also

mixexpgamma_gen()

---

## mixexpgamma_gen *Generate random numbers of Mixed Exponential and Gamma Distributions*

---

### Description

Generate random numbers whose density function:

$$0.2(2e^{-2x}) + 0.8\frac{x^3}{3!}e^{-x}.$$

### Usage

```
mixexpgamma_gen(n = 100, seed = NULL)
```

### Arguments

| | |
|---|---|
| n | The number of random numbers. |
| seed | A seed for random number generator. |

### Value

A numeric vector of probabilities for a given argument x.

### See Also

mixexpgamma_fun()

## mixExpGammaHist *Dataset of Mixture of Exponential Distribution and Gamma Distribution: Histogram Version*

### Description

Dataset of mixture of exponential distribution and gamma distribution, histogram version, whose density is:

$$0.2(2e^{-2x}) + 0.8\frac{x^3}{3!}e^{-x}.$$

### Usage

```
mixExpGammaHist
```

### Format

A list of numeric vectors of Mixture of Exponential and Gamma distribution Model.

**n200** A numeric vector with 200 elements.

**n200p** Histogram sample data with 25 bins.

**n200f** Histogram frequency data with 25 bins.

**n400** A numeric vector with 400 elements.

**n400p** Histogram sample data with 50 bins.

**n400f** Histogram frequency data with 50 bins.

**n800** A numeric vector with 800 elements.

**n800p** Histogram sample data with 100 bins.

**n800f** Histogram frequency data with 100 bins.

### Source

`mix2gauss_gen()` `databinning()`

## pdf_expmodel *Probability density function of Exponential-based model*

### Description

A probability density function(PDF) of Exponential-based model. It is an underlying routine for `plot.expmodel` to compute the values of PDF. To access parameters and coefficients in an object `emodel` of a class `expmodel`, use `emodel$result[k, "lmd1"]`, `emodel$coeffs[[k]]` for some index `k`. This index appears in the leftmost column of estimation table generated by `summary(emodel)`.

### Usage

```
pdf_expmodel(coeff, lmd, x)
```

### Arguments

| | |
|---|---|
| coeff | A coefficient vector in increasing order of degrees; the first element is 0th degree, ..., and last element is the largest degree of coefficients. |
| lmd | A rate parameter of an exponential distribution, which is positive. |
| x | A numeric input vector. |

### Value

A numeric vector of PDF of an exponential-based model.

### See Also

expmodel() summary.expmodel() estimate.expmodel() func.expmodel() plot.expmodel() cdf_expmodel()

### Examples

```
## Create an object of `expmodel`
emodel <- expmodel(mixexpgamma$n200)
## Estimate with degree 4 and rate parameter 2.0
emodel <- estimate(emodel, 4, 2.0)
## Input vector
x <- seq(0, 12, 0.1)
## Output of PDF in above estimation
yv <- pdf_expmodel(emodel$coeffs[[1]], emodel$result[1, "lmd1"], x)
```

---

## pdf_gaussmodel *Probability density function of Gaussian-based model*

---

### Description

A probability density function(PDF) of a Gaussian model. It is an underlying routine for plot.gaussmodel to compute the values of PDF. To access parameters and coefficients in an object gmodel of a class gaussmodel, use gmodel$result[k, "mu1"], gmodel$result[k, "sig1"], gmodel$coeffs[[k]] for some index k. This index appears in the leftmost column of estimation table generated by summary(gmodel).

### Usage

```
pdf_gaussmodel(coeff, mu, sig, x)
```

### Arguments

| | |
|---|---|
| coeff | A coefficient vector in increasing order of degrees; the first element is 0th degree, ..., and last element is the largest degree of coefficients. |
| mu | A mean of Gaussian distribution. |
| sig | A standard deviation of Gaussian distribution, which is positive. |
| x | A numeric input vector. |

### Value

A numeric vector of PDF of Gaussian-based distribution.

### See Also

gaussmodel() summary.gaussmodel() estimate.gaussmodel() func.gaussmodel() plot.gaussmodel() cdf_gaussmodel()

### Examples

```
## Create an object of `gaussmodel`
gmodel <- gaussmodel(mix2gauss$n200)
## Estimate with a degree 6, a mean 0, and standard deviations 0.5
gmodel <- estimate(gmodel, 6, 0, 0.5)
## Input vector
x <- seq(-3, 3, 0.1)
## Output of PDF in above estimation
yv <- pdf_gaussmodel(gmodel$coeffs[[1]], gmodel$result[1, "mu1"],
 gmodel$result[1, "sig1"], x)
```

---

## plot.expmodel *Plot a histogram and estimated densities/distributions of Exponential-based model object*

---

### Description

Plot the histogram and, if available, estimated densities or cumulative distributions of expmodel object.

### Usage

```
## S3 method for class 'expmodel'
plot(
  x,
  cum = FALSE,
  nmax = 4,
  graphs = NULL,
  bins = 40,
  hist = TRUE,
```

```
  linesize = 1,
  ...
)
```

## Arguments

| | |
|---|---|
| x | expmodel object. |
| cum | A logical scalar, whether or not it plots cumulative histogram/distributions instead of plain histogram/densities. Default value is FALSE. |
| nmax | A maximum number of estimates to be plotted in the graph. The default value is 4. |
| graphs | A vector of indices to be displayed in the graph. These indices appear in the leftmost column of the table in summary.expmodel. The default value is NULL, and if it is not NULL, only the estimated densities designated by graphs option appear, and nmax is ignored. |
| bins | A number of bins of the histogram. |
| hist | A logical scalar. If TRUE, display a histogram, otherwise not. The default value is TRUE. |
| linesize | A positive numeric scalar, which indicates the thickness of lines. The default value is 1. |
| ... | Arguments to be passed to or from other methods. |

## Value

A ggplot2 object.

## See Also

expmodel() summary.expmodel() func.expmodel() pdf_expmodel() cdf_expmodel()

## Examples

```
## Create `expmodel` object from a data set mixexpgamma$n200
emodel <- expmodel(mixexpgamma$n200)
## Plot it (histogram only)
plot(emodel)
```

---

# plot.gaussmodel *Plot a histogram and estimated densities/distributions of Gaussian-based model object*

---

## Description

Plot the histogram and, if available, estimated densities or cumulative distributions of gaussmodel object.

## Usage

```
## S3 method for class 'gaussmodel'
plot(
  x,
  cum = FALSE,
  nmax = 4,
  graphs = NULL,
  bins = 40,
  hist = TRUE,
  scaling = FALSE,
  linesize = 1,
  ...
)
```

## Arguments

| | |
|---|---|
| x | gaussmodel object. |
| cum | A logical scalar, whether or not it plots cumulative histogram/distributions instead of plain histogram/densities. Default value is FALSE. |
| nmax | A maximum number of estimates to be plotted in the graph. The default value is 4. |
| graphs | A vector of indices to be displayed in the graph. These indices appear in the leftmost column of the table in estimate.gaussmodel. The default value is NULL, and if it is not NULL, only the estimated densities designated by graphs option appear, and nmax is ignored. |
| bins | A number of bins of the histogram. |
| hist | A logical scalar. If TRUE, display a histogram, otherwise not. The default value is TRUE. |
| scaling | A logical scalar, which indicates whether or not it scales means and standard deviations in mulist and sdlist. The default value is FALSE. |
| linesize | A positive numeric scalar, which indicates the thickness of lines. The default value is 1. |
| ... | Arguments to be passed to or from other methods. |

## Value

A ggplot2 object.

## See Also

gaussmodel() summary.gaussmodel() func.gaussmodel() pdf_gaussmodel() cdf_gaussmodel()

## Examples

```
## Create `gaussmodel` object from a data set mix2gauss$n200
gmodel <- gaussmodel(mix2gauss$n200)
## Plot it (histogram only)
plot(gmodel)
```

polyaxb *Substitute a coefficient of polynomial*

## Description

Substitute a coefficient of a polynomial with a*x + b. For a polynomial with a coefficient vector $poly(x; coeff)$, compute the coefficient vector of

$$poly(a * x + b; coeff).$$

## Usage

```
polyaxb(coeff, c, a, b)
```

## Arguments

| | |
|---|---|
| coeff | A coefficient vector in increasing order of degrees; the first element is 0th degree, ..., and the last element is the largest degree of coefficients. |
| c | A multiple factor of constant to be applied to all coefficients. |
| a | A coefficient of 1st degree of a*x + b. |
| b | A coefficient of 0th degree of a*x + b. |

## Value

A substituted coefficient.

## See Also

eval_poly()

## Examples

```
coeff <- c(2, -2, 1)
a <- 1.1
b <- 1.2
coeff1 <- c(b, a)
coeff2 <- polyaxb(coeff, 1, a, b)
xv <- c(1, 2, 3)
## a*x + b
yv1 <- eval_poly(coeff1, xv)
## polynomial(a*x + b, coeff)
yv2 <- eval_poly(coeff, yv1)
## polynomial(x, coeff2)
yv <- eval_poly(coeff2, xv)
## This value is nearly 0 in the presence of rounding errors
yv - yv2
```

## printf *printf*

### Description

printf

### Usage

```
printf(...)
```

### Arguments

| | |
|---|---|
| ... | Any number of arguments to be printed. |

### Value

None.

## summary.expmodel *Summary of Exponential-based* expmodel *object.*

### Description

Summary of expmodel object, including a mean and quantiles. If some estimation has done, also print out estimates, up to nmax number of them.

### Usage

```
## S3 method for class 'expmodel'
summary(object, nmax = 10, estonly = FALSE, ...)
```

### Arguments

| | |
|---|---|
| object | expmodel object. |
| nmax | A number of estimates to show in the summary. The default is 10. |
| estonly | Show only the results of estimates. The default value is FALSE. |
| ... | Arguments to be passed to or from other methods. |

### Value

None.

### See Also

expmodel() plot.expmodel() estimate.expmodel()

## Examples

```
## Create expmodel object from a data set mixexpgamma$n200
emodel <- expmodel(mixexpgamma$n200)
## Print a summary of an object
summary(emodel)
```

---

summary.gaussmodel *Summary of Gaussian-based model* gaussmodel *object*

---

## Description

Summary of gaussmodel object, including a mean and a standard deviation and quantiles. If some estimation has done, also print out estimates, up to nmax number of them.

## Usage

```
## S3 method for class 'gaussmodel'
summary(object, nmax = 10, estonly = FALSE, ...)
```

## Arguments

| | |
|---|---|
| object | gaussmodel object. |
| nmax | A number of estimates to show in the summary. The default is 10. |
| estonly | Show only the results of estimates. The default value is FALSE. |
| ... | Arguments to be passed to or from other methods. |

## Value

None.

## See Also

gaussmodel() plot.gaussmodel() estimate.gaussmodel()

## Examples

```
## Create gaussmodel object from a data set mix2gauss$n200
gmodel <- gaussmodel(mix2gauss$n200)
## Print a summary of an object
summary(gmodel)
```

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