

Package ‘norMmix’

October 18, 2019

Version 0.0-1

Title Direct MLE for Multivariate Normal Mixture Distributions

Description Compute the MLE for multivariate normal mixtures via smart parametrization using the LDLt decomposition.

Author Nicolas Trutmann [aut, cre],
Martin Maechler [aut, ths]

Maintainer Nicolas Trutmann <nicolatr@student.ethz.ch>

Imports cluster, MASS, mvtnorm, mclust, mixtools, sfsmisc

Suggests Matrix, testthat (>= 2.1.0)

License GPL-3

Encoding UTF-8

LazyData true

NeedsCompilation no

R topics documented:

compplot	2
epfl	3
extracttimes	5
fitnMm	6
ldl	7
llmvtnorm	10
llnorMmix	10
MarronWand	11
massbic	12
massbicm	13
massplot	14
nMm2par	15
norMmix	16
norMmixMLE	17
npar	19
npar.fittednorMmix	20

nv2p	21
par2nMm	21
plot.fittednorMmix	22
plot.norMmix	23
rnorMmix	24
sllnorMmix	24
Index	26

compplot	<i>composition plot</i>
----------	-------------------------

Description

Creates a [massplot](#) like plot. Takes two [massbic](#) arrays and overlays their plots.

Usage

```
compplot(f, g, main = "unnamed")
```

Arguments

- f Array as from [massbic](#) or [massbicm](#)
- g Array as from [massbic](#) or [massbicm](#)
- main Character string to be used as title of the plot.

Details

The intended use for this function is to run [massbic](#) and [massbicm](#) with the same arguments, `string` and `DIR` and feeding the results into `compplot`, producing line plots, that can be compared against each other. Currently uses `rainbow(20)` to generate plot colors. Red, orange and green correspond to `f` and cyan, blue and purple to `g`.

Value

No return value. Intended side effect is the generation of a plot.

Note

While possible to be used as standalone, the function [epfl](#) allows for more complex generation of PDFs and is the intended use for simulations.

Author(s)

Nicolas Trutmann

See Also

[massplot](#), [epfl](#), [massbic](#), [massbicm](#)

Examples

```
##---- Should be DIRECTLY executable !! ----
##-- ==> Define data, use random,
##--or do help(data=index) for the standard data sets.

## The function is currently defined as
function (f, g, main = "unnamed")
{
  ylim <- extendrange(c(f, g))
  adj <- 0.4
  op <- sfsmisc::mult.fig(mfrow = c(2, 5), main = main, mar = 0.1 +
    c(2, 4, 4, 1))
  models <- dimnames(f)$models
  for (i in 1:10) {
    matplot(f[, i, ], lty = 1, col = adjustcolor(rainbow(20)[i],
      adj), main = models[i], type = "l", ylim = ylim)
    matplot(g[, i, ], lty = 1, col = adjustcolor(rainbow(20)[i +
      10], adj), main = models[i], type = "l", ylim = ylim,
      add = TRUE)
  }
  par(op$old.par)
}
```

epfl

evaluate and plot from file list

Description

From a list of character vectors, will apply [massbic](#), [massbicm](#) followed by [massplot](#) and [compplot](#).
Saves result of [massbicm](#)

Usage

```
epfl(files, savdir, subt = 11)
```

Arguments

files	Expected to be of type list , containing character vectors. These are assumed to be RDS filenames produced from saveRDS . They are assumed to work with massbic , meaning they contain a list with named element fit, which is the return value of fitnMm . Furthermore, all are assumed to have the same dimensions.
savdir	String specifying directory in which files are located.
subt	Number of characters to be subtracted from string in files. The default is intended for format ending in "seed=

Details

Suppose you have a directory `dir` containing RDS files. To create a list of sorted filenames, use for example the code provided here:

```
#files <- list.files(dir, pattern=".rds") # p1 <- c("pattern1a", "pattern1b") ## search patterns # p2 <-
c("pattern2a", "pattern2b")

# filelist <- list() # for (i in seq_along(p1)) # for (j in seq_along(p2)) # # for lack of AND matching,
OR match everything else and invert # r <- grep(paste(p1[-i], p2[-j], sep="|", collapse="|"), # files,
value=TRUE, invert=TRUE) # filelist[[paste0(p1[i], p2[j])]] <- r # #
```

This will create a list of character vectors, matching filenames by `p1` and `p2`.

Value

No return value. Intended side effects: Produces $3 \times \text{length}(\text{files})$ PDFs named as follows: From each entry in `files` takes first string, subtracts `subt` characters and appends `".pdf"`, `"_mcl.pdf"` and `"_comp.pdf"`

Author(s)

Nicolas Trutmann

See Also

[massplot](#), [compplot](#), [fitnMm](#)

Examples

```
##---- Should be DIRECTLY executable !! ----
##-- ==> Define data, use random,
##--or do help(data=index) for the standard data sets.

## The function is currently defined as
function (files, savdir, subt = 11)
{
  stopifnot(is.list(files), dir.exists(savdir))
  setwd(savdir)
  for (fi in files) {
    if (length(fi) == 0) {
      next
    }
    main <- substring(fi[1], 1, nchar(fi[1]) - subt)
    f <- massbic(fi, savdir)
    g <- massbicm(fi, savdir)
    pdf(file = paste0(main, ".pdf"))
    massplot(f, main = main)
    dev.off()
    pdf(file = paste0(main, "_mcl.pdf"))
    massplot(g, main = paste0(main, "_mcl"))
    dev.off()
    pdf(file = paste0(main, "_comp.pdf"))
    compplot(f, g, main = paste0(main, "_comp"))
  }
}
```

```

        dev.off()
    }
}

```

extracttimes	<i>Extract system time from fittednorMmix object</i>
--------------	--

Description

extracts array of `system.time` values from a fittednorMmix object.

Usage

```
extracttimes(object, ...)
```

Arguments

object	a fittednorMmix object.
...	currently unused

Details

a

Value

Array of size components x models x 5(return values of system.time) with dimnames: k, models and proc_time.

Author(s)

Nicolas Trutmann

See Also

`system.time`

Examples

```

##---- Should be DIRECTLY executable !! ----
##-- ==> Define data, use random,
##--or do help(data=index) for the standard data sets.

## The function is currently defined as
function (object, ...)
{
  stopifnot(inherits(object, "fittednorMmix"))
  ti <- unlist(object$NMmtime)
  na <- names(ti)[1:5]

```

```

    co <- object$k
    mo <- object$models
    ti <- c(matrix(ti, ncol = 5, byrow = TRUE))
    r <- array(ti, lengths(list(co, mo, na)))
    dimnames(r) <- list(k = co, models = mo, proc_time = na)
    class(r) <- "fittednorMmix_time"
  }
}

```

fitnMm

Fit Several Normal Mixture Models to a Dataset

Description

fitnMm() fits several multivariate normal mixture models (norMmix) to the data set x, and returns (among other info) a [list](#) of fitted [norMmix](#) objects.

Usage

```

fitnMm(x, k, models = 1:10,
      trafo = c("clr1", "logit"),
      ll = c("nmm", "mvt"),
      savdir = NULL, name = NULL,
      ...)

```

Arguments

x	data matrix, rows are observations and columns are variables
k	vector of positive integers, indicating the <i>number</i> of mixture components to fit.
models	vector of integers from 1:10, indexing models from <div style="margin-left: 40px;">c("EII", "VII", "EEI", "VEI", "EVI", "VVI", "EEE", "VEE", "EVV", "VVV")</div> which are to be fit.
trafo	a character string specifying the transform to use for the weights $w (= \pi_j)$, currently either "clr1" or "logit".
ll, ...	further arguments passed to function norMmixMLE() .
savdir	valid file path to save directory
name	name to be used when saving return value as RDS file

Value

fitnMm() returns a [list](#) with components

nMm	a list containing all fitted models
models	character vector of model (names) that were fitted.
n	number of observations of x
p	number of variables of x

Note

Given an object `r` of class `fittednorMmix`, for use with `massbic`, do:

```
saveRDS(list(fit=r))
```

See Also

`norMmixMLE()` which is called `length(k) * length(models)` times.

Examples

```
x <- rnorMmix(500, MW21)
fitnMm(x, 1:3) ## will fit all models with 1:3 components
```

ldl

LDL' Cholesky Decomposition

Description

Simple (but not too simple) R implementation of the (square root free) *LDL'* Choleksy decomposition.

Usage

```
ldl(m)
```

Arguments

`m` positive semi-definite square matrix, say of dimension $n \times n$.

Value

a `list` with two components

`L` a lower triangular matrix with diagonal entries 1.

`D` numeric vector, the *diagonal* $d_{1,1}, d_{2,2}, \dots, d_{n,n}$ of the diagonal matrix D .

See Also

`chol()` in base R, or also a “generalized LDL” decomposition, the Bunch-Kaufman, `BunchKaufman()` in (‘Recommended’) package **Matrix**.

Examples

```

(L <- rbind(c(1,0,0), c(3,1,0), c(-4,5,1)))
D <- c(4,1,9)
FF <- L %%% diag(D) %%% t(L)
FF
LL <- ldl(FF)
stopifnot(all.equal(L, LL$L),
          all.equal(D, LL$D))

## rank deficient :
FF0 <- L %%% diag(c(4,0,9)) %%% t(L)
((L0 <- ldl(FF0))) # !! now fixed with the if(Di == 0) test
## With the "trick", it works:
stopifnot(all.equal(FF0,
                    L0$L %%% diag(L0$D) %%% t(L0$L)))
## [hint: the LDL' is no longer unique when the matrix is singular]

system.time(for(i in 1:10000) ldl(FF) ) # ~ 0.2 sec

(L <- rbind(c( 1, 0, 0, 0),
            c( 3, 1, 0, 0),
            c(-4, 5, 1, 0),
            c(-2,20,-7, 1)))
D <- c(4,1, 9, 0.5)
F4 <- L %%% diag(D) %%% t(L)
F4
L4 <- ldl(F4)
stopifnot(all.equal(L, L4$L),
          all.equal(D, L4$D))

system.time(for(i in 1:10000) ldl(F4) )

## rank deficient :
F4.0 <- L %%% diag(c(4,1,9,0)) %%% t(L)
((L0 <- ldl(F4.0)))
stopifnot(all.equal(F4.0,
                    L0$L %%% diag(L0$D) %%% t(L0$L)))

F4_0 <- L %%% diag(c(4,1,0,9)) %%% t(L)
((L0 <- ldl(F4_0)))
stopifnot(all.equal(F4_0,
                    L0$L %%% diag(L0$D) %%% t(L0$L)))

## Large
mkLDL <- function(n, rF = function(n) sample.int(n), rFD = function(n) 1+ abs(rF(n))) {
  L <- diag(nrow=n)
  L[lower.tri(L)] <- rF(n*(n-1)/2)
  list(L = L, D = rFD(n))
}

```



```

(LD <- mkLDL(17))

chkLDL <- function(n, ..., verbose=FALSE, tol = 1e-14) {
  LD <- mkLDL(n, ...)
  if(verbose) cat(sprintf("n=%3d ", n))
  n <- length(D <- LD$D)
  L <- LD$L
  M <- L %%% diag(D) %%% t(L)
  r <- ldl(M)
  stopifnot(exprs = {
    all.equal(M,
              r$L %%% diag(r$D) %%% t(r$L), tol=tol)
    all.equal(L, r$L, tol=tol)
    all.equal(D, r$D, tol=tol)
  })
  if(verbose) cat("[ok]\n")
  invisible(list(LD = LD, M = M, ldl = r))
}

(chkLDL(7))

N <- 99 ## test N random cases
set.seed(101)
for(i in 1:N) {
  cat(sprintf("i=%3d, ", i))
  chkLDL(rpois(1, lambda = 20), verbose=TRUE)
}

system.time(chkLDL( 500)) # 0.62

try( ## this almost never "works":
system.time(chkLDL( 500, rF = rnorm, rFD = function(n) 10 + runif(n))) # 0.64
)

if(interactive())
  system.time(chkLDL( 600)) # 1.09
## .. then it grows quickly for (on nb-mm4)
## for n = 1000 it typically *fails*: The matrix M is typically very ill conditioned
## does not depend much on the RNG ?

"==> much better conditioned L and hence M : "
set.seed(120)
L <- as(Matrix::tril(toeplitz(exp(-(0:999)/50))), "matrix")
dimnames(L) <- NULL
D <- 10 + runif(nrow(L))
M <- L %%% diag(D) %%% t(L)
rcond(L) # 0.010006 !
rcond(M) # 9.4956e-5
if(FALSE) # ~ 4-5 sec
  system.time(r <- ldl(M))

```

llmvtnorm	<i>Log-Likelihood of Multivariate Normal Mixture Relying on mvtnorm::dmvnorm</i>
-----------	--

Description

Compute the log-likelihood of a multivariate normal mixture, by calling `dmvnorm()` (from package **mvtnorm**).

Usage

```
llmvtnorm(par, x, k,
           trafo = c("clr1", "logit"),
           model = c("EII", "VII", "EEI", "VEI", "EVI",
                    "VVI", "EEE", "VEE", "EVV", "VVV"))
```

Arguments

par	parameter vector as calculated by <code>nMm2par</code>
x	numeric data matrix (of dimension $n \times p$).
k	number of mixture components.
trafo	a character string specifying the transform to use for the weights $w (= \pi_j)$, currently either "clr1" or "logit".
model	assumed model of the distribution

Value

returns the log-likelihood (a number) of the specified model for the data (n observations) x .

See Also

`dmvnorm()` from package **mvtnorm**. Our own function, returning the same: `llnorMmix()`.

llnorMmix	<i>Log-likelihood of parameter vector given data</i>
-----------	--

Description

Calculates log-likelihood of a dataset, tx , given a normal mixture model as specified by a parameter vector. A parameter vector can be obtained by applying `nMm2par` to a `norMmix` object.

Usage

```
llnorMmix(par, tx, k,
          trafo = c("clr1", "logit"),
          model = c("EII", "VII", "EEI", "VEI", "EVI",
                    "VVI", "EEE", "VEE", "EVV", "VVV"))
```

Arguments

par	parameter vector
tx	<i>Transposed</i> numeric data matrix, i.e. $tx := t(x)$ is of dimension $p \times n$; its rows are variables and columns are observations.
k	number of mixture components.
trafo	a character string specifying the transform to use for the weights $w (= \pi_j)$, currently either "clr1" or "logit".
model	assumed distribution model of normal mixture

Value

returns the log-likelihood (a number) of the specified model for the data (n observations) x .

See Also

Our alternative function [llmvtnorm\(\)](#) (which is based on `dmvnorm()` from package [mvtnorm](#)).

MarronWand	<i>Marron-Wand-like Specific Multivariate Normal Mixture 'norMmix' Objects</i>
------------	--

Description

Nicolas Trutmann constructed multivariate versions from most of the univariate (i.e., one-dimensional) "Marron-Wand" densities as defined in CRAN package [nor1mix](#), see [MarronWand](#) (in that package).

Usage

```
## 2-dim examples:
MW21 # Gaussian
MW22 # Skewed
MW23 # Str Skew
MW24 # Kurtotic
MW25 # Outlier
MW26 # Bimodal
MW27 # Separated (bimodal)
MW28 # Asymmetric Bimodal
MW29 # Trimodal
MW210 # Claw
```

```

MW211 # Double Claw
MW212 # Asymmetric Claw
MW213 # Asymm. Double Claw
MW214 # Smooth Comb
MW215 # Trimodal

## 3-dim :
MW31
MW32
MW33
MW34

## 5 - dim:
MW51 # Gaussian

```

Examples

```

MW210
plot(MW214)

```

massbic	<i>extract BIC from .rds files</i>
---------	------------------------------------

Description

Given a filelist of RDS files, extracts BIC values from each file and returns them in an array.

Usage

```
massbic(string, DIR)
```

Arguments

```

string
DIR

```

Value

array of dimensions: components * models * files. Has attribute dims integer vector of same length as files. Correspond to dimension of dataset.

Author(s)

Nicolas Trutmann

See Also

[massbicm](#) [fitnMm](#) [massplot](#)

Examples

```
##---- Should be DIRECTLY executable !! ----
##-- ==> Define data, use random,
##--or do help(data=index) for the standard data sets.

## The function is currently defined as
function (string, DIR)
{
  nm1 <- readRDS(file = file.path(DIR, string[1]))
  cl <- nm1$fit$k
  mo <- nm1$fit$models
  val <- array(0, lengths(list(cl, mo, string)))
  dims <- vector(mode = "integer", length = length(string))
  for (i in 1:length(string)) {
    nm <- readRDS(file = file.path(DIR, string[i]))
    val[, , i] <- BIC(nm$fit)[[1]]
    dims[i] <- nm$fit$p
  }
  dimnames(val) <- list(components = cl, models = mo, simulation = string)
  attr(val, "dims") <- dims
  val
}
```

massbicm

Do mclust along .rds files from fitnMm

Description

massbicm applies [Mclust](#) along an existing fittednorMmix object, assumed to be in an RDS file in a list, named 'fit'.

Usage

```
massbicm(string, DIR)
```

Arguments

string
DIR

Examples

```
##---- Should be DIRECTLY executable !! ----
##-- ==> Define data, use random,
##--or do help(data=index) for the standard data sets.

## The function is currently defined as
function (string, DIR)
{
```

```

nm <- readRDS(file.path(DIR, string[1]))
cl <- nm$fit$k
mo <- nm$fit$models
valm <- array(0, lengths(list(cl, mo, string)))
dims <- vector(mode = "integer", length = length(string))
for (i in 1:length(string)) {
  nm <- readRDS(file.path(DIR, string[i]))
  x <- nm$fit$x
  valm[, , i] <- mclust::Mclust(x, G = cl, modelNames = mo)$BIC
  dims[i] <- nm$fit$p
}
dimnames(valm) <- list(components = cl, models = mo, files = string)
attr(valm, "dims") <- dims
-valm
}

```

massplot

plot from massbic

Description

plots the result of [massbic](#) and [massbicm](#)

Usage

```
massplot(f, main = "unnamed")
```

Arguments

f
main

Examples

```

##---- Should be DIRECTLY executable !! ----
##-- ==> Define data, use random,
##--or do help(data=index) for the standard data sets.

## The function is currently defined as
function (f, main = "unnamed")
{
  ran <- extendrange(f)
  size <- dim(f)[3]
  cl <- as.numeric(dimnames(f)$components)
  p <- attr(f, "dims")
  adj <- exp(-0.002 * size)
  models <- mods()
  op <- sfsmisc::mult.fig(mfrow = c(4, 5), main = main, mar = 0.1 +
    c(2, 4, 4, 1))
  for (i in 1:10) {

```

```

    if (!is.null(p)) {
      matplot(f[, i, ], lty = 1, col = adjustcolor(rainbow(10)[i],
        adj), type = "l", ylim = ran, main = models[i])
      axis(3, at = seq_along(cl), labels = npar(cl, p[1],
        models[i]))
    }
    else {
      matplot(f[, i, ], lty = 1, col = adjustcolor(rainbow(10)[i],
        adj), main = models[i], type = "l", ylim = ran)
    }
  }
  for (i in 1:10) {
    boxplot(t(f[, i, ]), lty = 1, col = adjustcolor(rainbow(10)[i],
      0.4), main = models[i], type = "l", ylim = ran)
  }
  par(op$old.par)
}

```

nMm2par

Multivariate Normal Mixture Model to parameter for MLE

Description

From a "norMmix"(-like) object, return the numeric parameter vector in our MLE parametrization.

Usage

```

nMm2par(obj, trafo = c("clr1", "logit"),
  model = c("EII", "VII", "EEI", "VEI", "EVI",
    "VVI", "EEE", "VEE", "EVV", "VVV"),
  meanFUN = mean)

```

Arguments

obj	a list containing sig: covariance matrix array, mu: mean vector matrix, w: = weights, k: = number of components, p: = dimension
trafo	a character string specifying the transform to use for the weights $w (= \pi_j)$, currently either "clr1" or "logit".
model	a character string specifying the (Sigma) model, one of those listed above.
meanFUN	a function to compute a mean (of variances typically).

Details

This transformation forms a vector from the parameters of a normal mixture. These consist of weights, means and covariance matrices. Weights are transformed according to 'trafo' param; means are unchanged.

Cov mats are given as D and L from the LDLt decomposition

See Also

the *inverse* function of `nMm2par()` is `par2nMm()`.

Examples

```
A <- MW24
if(FALSE) # currently fails __FIXME__
nMm2par(A, trafo = "clr1", model = A$model)
```

norMmix

Constructor for Multivariate Normal Mixture Objects

Description

`norMmix()` creates a multivariate normal (aka Gaussian) mixture object, conceptually a mixture of k multivariate (p -dimensional) Gaussians $\mathcal{N}(\mu_j, \Sigma_j)$, for $j = 1, \dots, k$.

Usage

```
norMmix(mu, Sigma = NULL, weight = rep(1/k, k), name = NULL,
        model = c("EII", "VII", "EEI", "VEI", "EVI",
                  "VVI", "EEE", "VEE", "EVV", "VVV"))
```

Arguments

<code>mu</code>	matrix of means. should mu be a vector it will assume k=1 to circumvent this behavoiur use <code>as.matrix(mu)</code> beforehand
<code>Sigma</code>	array of covariance matrices
<code>weight</code>	weights of mixture model components
<code>name</code>	gives the option of naming mixture
<code>model</code>	see desc

Value

currently, a [list](#) of class "norMmix", with a name attribute and components

model	three-letter character string, specifying the Sigma-parametrization
mu	(p x k) matrix of component means $\mu[,j], j = 1, \dots, k$.
Sigma	(p x p x k) array of component Covariance matrices $\Sigma[, , j]$.
weight	p-vector of mixture probability weights; non-negative, summing to one: <code>sum(weight) == 1</code> .
k	integer, the number of components
dim	integer, the dimension p .

Author(s)

Nicolas Trutmann

References

__ TODO __

See Also

[norMmixMLE\(\)](#) to fit such mixture models to data (an $n \times p$ matrix).

“Marron-Wand”-like examples (for testing, etc), such as [MW21](#).

Examples

```
# TODO
```

norMmixMLE	<i>Maximum Likelihood Estimation for Multivariate Normal Mixture Models</i>
------------	---

Description

Direct Maximum Likelihood Estimation (MLE) for multivariate normal mixture models "[norMmix](#)". Starting from a [clara](#) (package [cluster](#)) clustering plus one M-step, or alternatively from the default start of (package) [mclust](#), perform direct likelihood maximization via [optim\(\)](#).

Usage

```

norMmixMLE(x, k,
  model = c("EII", "VII", "EEI", "VEI", "EVI",
            "VVI", "EEE", "VEE", "EVV", "VVV"),
  ini = c("clara", "mclVVV"),
  trafo = c("clr1", "logit"),
  ll = c("nmm", "mvt"),
  method = "BFGS", maxit = 100, trace = 2,
  optREPORT = 10, reltol = sqrt(.Machine$double.eps),
  samples = 128, sampsize = ssClaraL, traceClara = 0,
  ...)

ssClaraL(n, k, p)

```

Arguments

x	numeric [n x p] matrix
k	positive number of components
model	a character string, specifying the model (for the k covariance matrices) to be assumed.
ini	a character string specifying the initialization step.
trafo	a character string specifying the transform to use for the weights $w (= \pi_j)$, currently either "clr1" or "logit".
ll	a string specifying the method to be used for the likelihood computation; the default, "nmm" uses <code>llnorMmix()</code> , whereas "mvt" uses <code>llmvtnorm()</code> which is based on the MV normal density from package mvtnorm .
method, maxit, trace, optREPORT, reltol, ...	arguments for tuning the optimizer <code>optim(*, method=method, control = list(...))</code> .
samples, sampsize, traceClara	if ini = "clara", arguments for <code>clara()</code> (package cluster). Note that clara's help page emphasizes that larger and more samples should be used typically. Here, sampsize may be a number <i>or</i> as by default a function (n,k,p) determining the size of the subsamples as a function of the problem dimensionalities.
n,p	matrix dimensions <code>nrow(x)</code> and <code>ncol(x)</code> .

Details

Uses clara() and one M-step from EM-algorithm to initialize parameters after that uses general optimizer optim() to calculate ML.

Value

norMmixMLE returns an object of **class** "norMmixMLE" which is a **list** with components

norMmix	the " norMmix " object corresponding to the specified model and the fitted (MLE) parameter vector.
---------	---

optr	the [r]eturn value of <code>optim()</code> .
npar	the number of free parameter, a function of $(p, k, model)$.
n	the sample size, i.e., the number of observations or rows of x .
cond	the result of <code>parcond(. .)</code> , that is the ratio of sample size over parameter count.

Examples

```
str(MW214)
set.seed(105)
x <- rnorMmix(1000, MW214)
## Fitting assuming we know the true parametric model
fm1 <- norMmixMLE(x, k = 6, model = "VII")
if(interactive()) ## Fitting "wrong" overparametrized model: typically need more iterations:
  fmW <- norMmixMLE(x, k = 7, model = "VVV", maxit = 200) # default maxit=100 is often too small
```

npar	<i>Number of Free Parameters of Multivariate Normal Mixture Models</i>
------	--

Description

`npar()` returns an integer (vector, if p or k is) with the number of free parameters of the corresponding model, which is also the `length(.)` of the parameter vector in our parametrization, see `nMm2par()`.

Usage

```
npar(k, p, model = c("EII", "VII", "EEI", "VEI", "EVI",
                    "VVI", "EEE", "VEE", "EVV", "VVV"))
```

Arguments

k	number of mixture components
p	dimension of data space, i.e., number of variables (aka “features”).
model	a <code>character</code> string. One of the 10 models above, see also ‘Description’.

Examples

```
(m <- eval(formals(npar)$model)) # list of 10 models w/ differing Sigma
# A nice table for a given 'p' and all models, all k in 1:8
sapply(m, npar, k=setNames(1:8), p = 20)
```

npar.fittednorMmix	<i>Extract degrees of freedom from fittednorMmix</i>
--------------------	--

Description

Extracts a matrix of equal shape as object's BIC values.

Usage

```
npar.fittednorMmix(object, ...)
```

Arguments

object	object of class fittednorMmix
...	

Author(s)

Nicolas Trutmann

Examples

```
##---- Should be DIRECTLY executable !! ----
##-- ==> Define data, use random,
##--or do help(data=index) for the standard data sets.

## The function is currently defined as
function (obj)
{
  stopifnot(inherits(obj, "fittednorMmix"))
  k <- obj$k
  p <- obj$p
  models <- obj$models
  val <- matrix(0, length(k), length(models))
  rownames(val) <- k
  colnames(val) <- models
  for (i in seq_along(k)) {
    for (j in seq_along(models)) {
      val[i, j] <- npar(k[i], p, models[j])
    }
  }
  val
}
```

nv2p

Wrapper function for nMm objs

Description

nc2p returns same as [nMm2par](#), using obj\$model as default.

Usage

```
nc2p(obj)
```

Arguments

obj an "[norMmix](#)" object.

Value

the same as [nMm2par](#)(.), see there.

Examples

```
str(MW213)
nc2p(MW213)
```

par2nMm

Transform Parameter Vector to Multivariate Normal Mixture

Description

Transforms the (numeric) parameter vector of our MLE parametrization of a multivariate normal mixture model into the corresponding [list](#) of components determining the model. Additionally (partly redundantly), the dimension p and number of components k need to be specified as well.

Usage

```
par2nMm(par, p, k, model = c("EII", "VII", "EEI", "VEI", "EVI",
                             "VVI", "EEE", "VEE", "EVV", "VVV"),
        , trafo = c("clr1", "logit")
        , name = sprintf("model = %s , components = %s", model, k)
        )
```

Arguments

par	the model parameter numeric vector.
p	dimension of data space, i.e., number of variables (aka “features”).
k	the number of mixture components, a positive integer.
model	a character string, one of those listed; see nMm2par() ’s documentation.
trafo	a character string specifying the transform to use for the weights $w (= \pi_j)$, currently either “clr1” or “logit”.
name	a character string naming the norMmix return value.

Value

returns a [list](#) with components

weight	..
mu	..
Sigma	..
k	..
dim	..

See Also

This is the inverse function of [nMm2par\(\)](#).

Examples

```
## TODO: Show to get the list, and then how to get a norMmix() object from the list
```

plot.fittednorMmix	<i>Plot method for the class fittednorMmix</i>
--------------------	--

Description

This is the S3 method for plotting the results of [fitnMm](#)

Usage

```
## S3 method for class 'fittednorMmix'
plot(x, main="unnamed", plotbest=FALSE, ...)
```

Arguments

x	object of class “fittednorMmix”
main	plot title
plotbest	logical, determines whether to plot BIC values or best fitted model. See Details.
...	further arguments to be passed to plot if plotbest=TRUE, and matplot if FALSE

Details

This plot method has two main capabilities, selected by the argument `plotbest`. If `plotbest` is `TRUE`, then the model will be plotted using the `plot.norMmix` method with added points of the fitted data. And if `plotbest` is `FALSE`, then the `BIC` values will be plotted using `matplot`

See Also

`fitnMm`, `norMmix`, `plot.norMmix`

`plot.norMmix`

Plot Method for "norMmix" Objects

Description

This is the S3 method for plotting "`norMmix`" objects.

Usage

```
## S3 method for class 'norMmix'
plot(x, y=NULL, ...)
```

Arguments

<code>x</code>	an R object inheriting from " <code>norMmix</code> ".
<code>y</code>	further data matrix, first 2 columns will be plotted by " <code>points</code> "
<code>...</code>	further arguments to be passed to " <code>plot</code> "

Value

`plot.norMmix` returns invisibly coordinates of bounding ellipses of distribution.

Examples

```
plot(MW212) ## and add a finite sample realization:
points(rnorMmix(n=500, MW212))

## or:
x <- points(rnorMmix(n=500, MW212))
plot(MW212, x)
```

 rnorMmix

Random Sample from Multivariate Normal Mixture Distribution

Description

Draw n (p -dimensional) observations randomly from the multivariate normal mixture distribution specified by `obj`.

Usage

```
rnorMmix(n, obj, index = FALSE, permute = TRUE)
```

Arguments

<code>n</code>	sample size, non-negative.
<code>obj</code>	a " norMmix " object
<code>index</code>	store the clustering information as first column
<code>permute</code>	logical indicating if the observations should be randomly permuted after creation "cluster by cluster".

Value

n p -dimensional observations, as numeric $n \times p$ matrix.

Author(s)

Nicolas Trutmann

See Also

[rmultinom](#)

 sllnorMmix

Simple wrapper for Log-Likelihood Function or Multivariate Normal Mixture

Description

`sllnorMmix()` returns a number, the log-likelihood of the data `x`, given a normal mixture `obj`.

Usage

```
sllnorMmix(x, obj, trafo=c("clr1", "logit"))
```


Arguments

x	data matrix .
obj	an R object of class " norMmix ".
trafo	a character string specifying the transform to use for the weights, see llnorMmix .

Details

Calculates log-likelihood of a dataset, x, given a normal mixture model; just a simplified wrapper for [llnorMmix](#). Removes functionality in favor of ease of use.

Examples

```
set.seed(2019)
x <- rnorMmix(400, MW27)
sllnorMmix(x, MW27) # -1986.315
```

Index

- *Topic **datasets**
 - MarronWand, [11](#)
- *Topic **distributions**
 - norMmix, [16](#)
- *Topic **distribution**
 - MarronWand, [11](#)
- *Topic **hplot**
 - plot.norMmix, [23](#)
- *Topic **misc**
 - nv2p, [21](#)
- BIC, [23](#)
- BunchKaufman, [7](#)
- character, [6](#), [10](#), [11](#), [15](#), [17–19](#), [22](#), [25](#)
- chol, [7](#)
- clara, [17](#), [18](#)
- class, [18](#)
- complot, [2](#), [3](#), [4](#)
- dmvnorm, [10](#)
- epfl, [2](#), [3](#)
- extracttimes, [5](#)
- files, [3](#)
- fitnMm, [3](#), [4](#), [6](#), [12](#), [22](#), [23](#)
- function, [15](#), [18](#)
- ldl, [7](#)
- length, [19](#)
- list, [3](#), [6](#), [7](#), [15](#), [17](#), [18](#), [21](#), [22](#)
- llmvtnorm, [10](#), [11](#), [18](#)
- llnorMmix, [10](#), [10](#), [18](#), [25](#)
- MarronWand, [11](#), [11](#)
- massbic, [2](#), [3](#), [7](#), [12](#), [14](#)
- massbicm, [2](#), [3](#), [12](#), [13](#), [14](#)
- massplot, [2–4](#), [12](#), [14](#)
- matplot, [22](#), [23](#)
- matrix, [10](#), [25](#)
- McIust, [13](#)
- MW21, [17](#)
- MW21 (MarronWand), [11](#)
- MW210 (MarronWand), [11](#)
- MW211 (MarronWand), [11](#)
- MW212 (MarronWand), [11](#)
- MW213 (MarronWand), [11](#)
- MW214 (MarronWand), [11](#)
- MW215 (MarronWand), [11](#)
- MW22 (MarronWand), [11](#)
- MW23 (MarronWand), [11](#)
- MW24 (MarronWand), [11](#)
- MW25 (MarronWand), [11](#)
- MW26 (MarronWand), [11](#)
- MW27 (MarronWand), [11](#)
- MW28 (MarronWand), [11](#)
- MW29 (MarronWand), [11](#)
- MW31 (MarronWand), [11](#)
- MW32 (MarronWand), [11](#)
- MW33 (MarronWand), [11](#)
- MW34 (MarronWand), [11](#)
- MW51 (MarronWand), [11](#)
- nc2p (nv2p), [21](#)
- ncol, [18](#)
- nMm2par, [10](#), [15](#), [19](#), [21](#), [22](#)
- norMmix, [6](#), [10](#), [15](#), [16](#), [17](#), [18](#), [21–25](#)
- norMmixMLE, [6](#), [7](#), [17](#), [17](#)
- npar, [19](#)
- npar.fittednorMmix, [20](#)
- nrow, [18](#)
- nv2p, [21](#)
- optim, [17–19](#)
- par2nMm, [16](#), [21](#)
- plot, [22](#), [23](#)
- plot.fittednorMmix, [22](#)
- plot.norMmix, [23](#), [23](#)
- points, [23](#)

`rmultinom`, [24](#)

`rnorMmix`, [24](#)

`saveRDS`, [3](#)

`sllnorMmix`, [24](#)

`ssClaraL (norMmixMLE)`, [17](#)

`system.time`, [5](#)