

# Package ‘norMmix’

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**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.

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

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**License** GPL-3

**Encoding** UTF-8

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**Depends** R (>= 3.5.0)

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

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## Description

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

## Usage

```
compplot(f, g, h=NULL, main = NULL, adj = 1/dim(f)[3],
         col = nMmcols[1:3], mar = 0.1 + c(1.4, 2, 3, 1),
         compnames = c("clara", "mclVVV", "Mclust"),
         oma=c(7,0,2.8,0), pars=TRUE,
         ...)
```

## Arguments

f	Array as from <a href="#">massbic</a> or <a href="#">massbim</a>
g	Array as from <a href="#">massbic</a> or <a href="#">massbim</a>
h	Optional third array.
main	Character string to be used as title of the plot.
adj	Adjustment for alpha value of the plot color.
col	Color of plot.
mar	Margin space adjustment
compnames	Names to be used for legend. Set to NULL to supress.
oma	Margin parameter. See par.
pars	Logical, whether to display number of parameters on top of plot.
...	further arguments passed on to <a href="#">matplot</a>

## Details

The intended use for this function is to run [massbic](#) and [massbim](#) 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**

```
## TODO: add example
```

---

dfnMm

*Number of Free Parameters of Multivariate Normal Mixture Models*


---

**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**

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

**Arguments**

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

**Examples**

```
(m <- eval(formals(dfnMm)$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, dfnMm, k=setNames(1:8), p = 20)
```

---

epfl	<i>evaluate and plot from file list</i>
------	---

---

## Description

From a list of character vectors, will apply `massbic`, `massbicm` followed by `massplot` and `compplot`. Saves result of `massbicm`

## Usage

```
epfl(files, savdir, sublt = 11, ...)
```

## Arguments

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

## 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*length(files)` PDFs named as follows: From each entry in `files` takes first string, subtracts `sublt` characters and appends `".pdf"`, `"_mc1.pdf"` and `"_comp.pdf"`

## Author(s)

Nicolas Trutmann

**See Also**

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

**Examples**

```
# TODO: add example
```

---

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**

```
data(fSMI.12, package="norMmix")
extracttimes(fSMI.12)[, , 1] ## user.self entry of system.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 <a href="#">character</a> string specifying the transform to use for the weights $w (= \pi_j)$ , currently either "clr1" or "logit".
ll, ...	further arguments passed to function <a href="#">norMmixMLE()</a> .
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 <a href="#">list</a> containing all fitted models
models	<a href="#">character</a> 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, 1:2, models=1:4) ## will fit models 1:4 with 1:3 components
```

fSMI.12

*Model selection of the SMI.12 dataset from the [SMI.12](#) package.*

**Description**

Result of `fitnMm(SMI.12, k=1:8, ini="clara", maxit=1e4, optREPORT=1e4)`

**Usage**

```
data("fSMI.12")
```

**Format**

The format is: List of 7 \$ nMm :List of 80 ..- attr(\*, "dim")= int [1:2] 8 10 ..- attr(\*, "dimnames")=List of 2 \$ nMmtime:List of 80 ..- attr(\*, "dim")= int [1:2] 8 10 ..- attr(\*, "dimnames")=List of 2 \$ k : int [1:8] 1 2 3 4 5 6 7 8 \$ models : chr [1:10] "EII" "VII" "EEI" "VEI" ... \$ n : int 141 \$ p : int 20 \$ x : num [1:141, 1:20] 16.1 15.7 15.7 16.1 16.6 ... ..- attr(\*, "dimnames")=List of 2 - attr(\*, "class")= chr "fittednorMmix"

**Examples**

```
data(fSMI.12)
## maybe str(fSMI.12) ; plot(fSMI.12) ...
```

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</i> mvtnorm::dmvnorm
-----------	---

---

## 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

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

**Examples**

```
set.seed(1); x <- rnorMmix(50, MW29)
para <- nMm2par(MW29, model=MW29$model)

llmvtnorm(para, x, 2, model=MW29$model)
# [1] -236.2295
```

llnorMmix

*Log-likelihood of parameter vector given data***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 <a href="#">character</a> 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`).

**Examples**

```
set.seed(1); tx <- t(rnorMmix(50, MW29))
para <- nMm2par(MW29, model=MW29$model)

llnorMmix(para, tx, 2, model=MW29$model)
# [1] -236.2295
```

---

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	<i>plot from massbic</i>
----------	--------------------------

---

## Description

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

## Usage

```
massplot(f, main = "unnamed", adj = exp(-0.002 * size),
         col = nMmcols[1], mar = 0.1 + c(1.4, 2, 3, 1), ...)
```

## Arguments

f	Result of <a href="#">massbic</a>
main	Character string, title of plot.
adj	Alpha adjustment for plot color.
col	Plot color.
mar	A numerical vector of the form 'c(bottom, left, top, right)'.
...	Further parameters, passed to <a href="#">matplot</a>

## 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 (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)
}

```

nc2p

*Wrapper function for [nMm2par](#)***Description**

nc2p returns same as [nMm2par](#), using object\$model and trafo="clr1" as defaults.

**Usage**

```
nc2p(object)
```

**Arguments**

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

**Value**

the same as [nMm2par](#). Real valued vector of length 1.

```
nMm2par(object, trafo="clr1", model=object$model)
```

**Examples**

```

str(MW213)
nc2p(MW213)
# [1] 0.0000000 0.0000000 0.0000000 30.0000000 30.0000000 0.3465736
# [7] 0.5493061 0.3465736 -0.5493061 3.0000000 2.0000000
nMm2par(MW213, trafo="clr1", model=MW213$model)
# [1] 0.0000000 0.0000000 0.0000000 30.0000000 30.0000000 0.3465736
# [7] 0.5493061 0.3465736 -0.5493061 3.0000000 2.0000000

```



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**

[nc2p](#) simplified wrapper function.

the *inverse* function of nMm2par() is [par2nMm\(\)](#).

**Examples**

```
A <- MW24
nMm2par(A, trafo = "clr1", model = A$model)
# [1] -0.3465736 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
# [7] -2.3025851
```

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**

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

**Value**

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

model	three-letter <a href="#">character</a> string, specifying the Sigma-parametrization
mu	( $p \times k$ ) matrix of component means $\mu[, j]$ , $j = 1, \dots, k$ .
Sigma	( $p \times p \times k$ ) array of component Covariance matrices $\Sigma[, , j]$ .
weight	$p$ -vector of mixture probability weights; non-negative, summing to one: $\text{sum}(\text{weight}) == 1$ .
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
```

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

<code>x</code>	numeric [n x p] matrix
<code>k</code>	positive number of components
<code>model</code>	a <a href="#">character</a> string, specifying the model (for the k covariance matrices) to be assumed.
<code>ini</code>	a <a href="#">character</a> string specifying the initialization step.
<code>trafo</code>	a <a href="#">character</a> string specifying the transform to use for the weights $w (= \pi_j)$ , currently either “ <code>clr1</code> ” or “ <code>logit</code> ”.
<code>ll</code>	a string specifying the method to be used for the likelihood computation; the default, “ <code>nmm</code> ” uses <code>llnorMmix()</code> , whereas “ <code>mvt</code> ” uses <code>llmvtnorm()</code> which is based on the MV normal density from package <code>mvtnorm</code> .

```

method, maxit, trace, optREPORT, reltol, ...
    arguments for tuning the optimizer optim(*, method=method, control = list(...)).
samples, sampsize, traceClara
    if ini = "clara", arguments for clara() (package cluster). Note that clara's
    help page emphasizes that larger and more samples should be used typically.
    Here, sampsize may be a number or as by default a function(n,k,p) deter-
    mining the size of the subsamples as a function of the problem dimensionalities.
n,p
    matrix dimensions nrow(x) and ncol(x).

```

### 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

<code>norMmix</code>	the " <code>norMmix</code> " object corresponding to the specified model and the fitted (MLE) parameter vector.
<code>optr</code>	the [r]eturn value of <code>optim()</code> .
<code>npar</code>	the number of free parameter, a function of $(p, k, model)$ .
<code>n</code>	the sample size, i.e., the number of observations or rows of <code>x</code> .
<code>cond</code>	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

---

*Extract degrees of freedom from objects of the `norMmix` package*


---

### Description

This function is generic; method functions can be written to handle specific classes of objects. The following classes have methods written for them:

```

norMmix
norMmixMLE
fittednorMmix

```

**Usage**

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

**Arguments**

<code>object</code>	Any object from the list in the Description.
<code>...</code>	In place to leave room for further arguments. None of the methods for the listed classes take arguments beyond <code>object</code> .

**Value**

<code>norMmix</code>	Integer vector of length 1.
<code>norMmixMLE</code>	Integer vector of length 1.
<code>fittednorMmix</code>	Integer matrix with dimnames set to <code>k</code> and <code>models</code> .

**Author(s)**

Nicolas Trutmann

**Examples**

```
data(fSMI.12)
npar(fSMI.12)

npar(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 <a href="#">character</a> string, one of those listed; see <a href="#">nMm2par()</a> ’s documentation.
trafo	a <a href="#">character</a> string specifying the transform to use for the weights $w (= \pi_j)$ , currently either “clr1” or “logit”.
name	a <a href="#">character</a> string naming the <a href="#">norMmix</a> 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
str(MW213)
# List of 6
# $ model : chr "VVV"
# $ mu    : num [1:2, 1:2] 0 0 30 30
# $ Sigma : num [1:2, 1:2, 1:2] 1 3 3 11 3 6 6 13
# $ weight: num [1:2] 0.5 0.5
# $ k     : int 2
# $ dim   : int 2
# - attr(*, "name")= chr "#13 test VVV"
# - attr(*, "class")= chr "norMmix"
# NULL
para <- nMm2par(MW213, model="EEE")
par2nMm(para, 2, 2, model="EEE")
```

---

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 <a href="#">plot</a> if plotbest=TRUE, and <a href="#">matplot</a> 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](#)

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plot.norMmix	<i>Plot Method for "norMmix" Objects</i>
--------------	--

---

### Description

This is the S3 method for plotting "[norMmix](#)" objects.

### Usage

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

### Arguments

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

**Value**

plot.rnormMmix returns invisibly coordinates of bounding ellipses of distribution.

**Examples**

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

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

rnormMmix

*Random Sample from Multivariate Normal Mixture Distribution***Description**

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

**Usage**

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

**Arguments**

n	sample size, non-negative.
obj	a "rnormMmix" object
index	Logical, store the clustering information as first column
permute	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](#)



**Examples**

```
x <- rnorMmix(500, MW213)
plot(x)
x <- rnorMmix(500, MW213, index=TRUE)
plot(x[, -1], col=x[, 1]) ## using index column to color components
```

---

sllnorMmix	<i>Simple wrapper for Log-Likelihood Function or Multivariate Normal Mixture</i>
------------	--

---

**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 <a href="#">matrix</a> .
obj	an R object of class " <a href="#">norMmix</a> ".
trafo	a <a href="#">character</a> string specifying the transform to use for the weights, see <a href="#">llnorMmix</a> .

**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
```

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