

# Package ‘fmrs’

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**Type** Package

**Title** Variable Selection in Finite Mixture of AFT Regression and FMR

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**Depends** R (>= 4.0.0)

**Imports** methods, survival, stats

**Description** Provides parameter estimation as well as variable selection in Finite Mixture of Accelerated Failure Time Regression and Finite Mixture of Regression Models. Furthermore, this package provides Ridge Regression and Elastic Net.

**biocViews** Survival, Regression, DimensionReduction

**Suggests** BiocGenerics, testthat, knitr, utils

**License** GPL (>= 3)

**LazyData** TRUE

**VignetteBuilder** knitr

**BugReports** <https://github.com/shokoohi/fmrs/issues>

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|               |   |
|---------------|---|
| firms-package | <i>Variable Selection in Finite Mixture of AFT Regression and FMR</i> |
|---------------|---|

---

### Description

Provides parameter estimation and variable selection in FMRs models. The `firms.mle` method provides Maximum Likelihood Estimation for FMRs models. The `firms.tunsel` method provides component-wise tuning parameters. The `firms.varsels` method provides variable selection for FMRs models.

### firms methods

`firms.mle`, `firms.tunsel`, `firms.varsels`, `firms.gendata`.

### firms objects

`firmsfit-class`, `firmsstunpar-class`

---

|     |                   |
|-----|-------------------|
| BIC | <i>BIC method</i> |
|-----|-------------------|

---

### Description

Provides the estimated BIC of an FMRs model from an `firmsfit-class`

### Usage

```
BIC(object, ...)
```

```
## S4 method for signature 'firmsfit'
BIC(object, ...)
```

**Arguments**

object            An [fmrsfit-class](#)  
 ...                Other possible arguments

**Value**

A numeric value

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```
set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0,  0, 0,  0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
BIC(res.mle)
```

---

coefficients

*coefficients method*


---

**Description**

Provides the estimated regression coefficients from the fitted FMRs model from an [fmrsfit-class](#)

**Usage**

```
coefficients(object, ...)
```

```
## S4 method for signature 'fmrsfit'
coefficients(object, ...)
```

**Arguments**

object            An [fmrsfit-class](#)  
 ...                Other possible arguments

**Value**

A numeric array of dimension-(nCov+1)-nComp

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```
set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0,  0, 0,  0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
coefficients(res.mle)
```

---

dispersion

*dispersion method*

---

**Description**

Provides the estimated dispersions of the fitted FMRs model from an [fmrsfit-class](#)

**Usage**

```
dispersion(object, ...)

## S4 method for signature 'fmrsfit'
dispersion(object, ...)
```

**Arguments**

object            An `fmrfit-class`  
 ...              Other possible arguments

**Value**

A numeric array of dimension-(nCov+1)-nComp

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```
set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0,  0, 0,  0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
dispersion(res.mle)
```

---

fitted

*fitted method*

---

**Description**

Provides the fitted response of the fitted FMRs model from an `fmrfit-class`

**Usage**

```
fitted(object, ...)
```

## S4 method for signature 'fmrfit'  
 fitted(object, ...)

**Arguments**

object            An `fmrsfit-class`  
 ...              Other possible arguments

**Value**

A numeric array of dimension-nObs-nComp

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```
set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
head(fitted(res.mle))
```

---

fmrs.gendata

*fmrs.gendata method*

---

**Description**

Generates a data set from Finite Mixture of AFT regression models or Finite Mixture of Regression models under the specified setting.

**Usage**

```
fmrs.gendata(nObs, nComp, nCov, coeff, dispersion, mixProp, rho, umax, ...)

## S4 method for signature 'ANY'
fmrs.gendata(
  nObs,
  nComp,
```

```

    nCov,
    coeff,
    dispersion,
    mixProp,
    rho,
    umax,
    disFamily = "lnorm"
  )

```

### Arguments

|            |   |
|------------|---|
| nObs       | A numeric value represents sample size  |
| nComp      | A numeric value represents the order mixture in FMRs  |
| nCov       | A numeric value represents the number of covariates in design matrix  |
| coeff      | A vector of all regression coefficients including intercepts. It must be a vector of length $nComp * (nCov + 1)$ .  |
| dispersion | A vector of positive values for dispersion parameters of sub-distributions in FMRs models   |
| mixProp    | A vector of mixing proportions which their sum must be one  |
| rho        | A numeric value in $[-1, 1]$ which represents the correlation between covariates of design matrix   |
| umax       | A numeric value represents the upper bound in Uniform distribution for censoring  |
| ...        | Other possible options  |
| disFamily  | A sub-distribution family. The options are 'norm' for FMR models, 'lnorm' for mixture of AFT regression models with Log-Normal sub-distributions, 'weibull' for mixture of AFT regression models with Weibull sub-distributions |

### Value

A list including response, covariates and censoring variables

### Author(s)

Farhad Shokoohi <shokoohi@icloud.com>

### See Also

Other lnorm, norm, weibull: [fmrs.mle\(\)](#), [fmrs.tunsel\(\)](#), [fmrs.varsel\(\)](#)

### Examples

```

set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
REP = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c(2, 2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1, 1, 2, 0, 0, 0, 0, -1, 2, -2)

```

```

umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

```

---

fmrs.mle

*fmrs.mle method*


---

### Description

Provides MLE for Finite Mixture of Accelerated Failure Time Regression Models or Finite Mixture of Regression Models. It also provides Ridge Regression.

### Usage

```
fmrs.mle(y, delta, x, nComp, ...)
```

```
## S4 method for signature 'ANY'
```

```

fmrs.mle(
  y,
  delta,
  x,
  nComp = 2,
  disFamily = "lnorm",
  initCoeff,
  initDispersion,
  initmixProp,
  lambRidge = 0,
  nIterEM = 400,
  nIterNR = 2,
  conveps = 1e-08,
  convepsEM = 1e-08,
  convepsNR = 1e-08,
  porNR = 2,
  activeset
)

```

### Arguments

|           |   |
|-----------|---|
| y         | Responses (observations)  |
| delta     | Censoring indicator vector  |
| x         | Design matrix (covariates)  |
| nComp     | Order (Number of components) of mixture model   |
| ...       | Other possible options  |
| disFamily | A sub-distribution family. The options are 'norm' for FMR models, 'lnorm' for mixture of AFT regression models with Log-Normal sub-distributions, 'weibull' for mixture of AFT regression models with Weibull sub-distributions |
| initCoeff | Vector of initial values for regression coefficients including intercepts   |



|                |   |
|----------------|---|
| initDispersion | Vector of initial values for standard deviations  |
| initmixProp    | Vector of initial values for proportion of components   |
| lambRidge      | A positive value for tuning parameter in Ridge Regression or Elastic Net                            |
| nIterEM        | Maximum number of iterations for EM algorithm   |
| nIterNR        | Maximum number of iterations for Newton-Raphson algorithm   |
| conveps        | A positive value for avoiding NaN in computing divisions  |
| convepsEM      | A positive value for threshold of convergence in EM algorithm                                       |
| convepsNR      | A positive value for threshold of convergence in Newton-Raphson algorithm                           |
| porNR          | A positive integer for maximum number of searches in NR algorithm                                   |
| activeset      | A matrix of zero-one that shows which intercepts and covariates are active in the fitted fmrs model |

## Details

Finite mixture of AFT regression models are represented as follows. Let  $X$  be the survival time with non-negative values, and  $\mathbf{z} = (z_1, \dots, z_d)^\top$  be a  $d$ -dimensional vector of covariates that may have an effect on  $X$ . If the survival time is subject to right censoring, then the observed response time is  $T = \min\{Y, C\}$ , where  $Y = \log X$ ,  $C$  is logarithm of the censoring time and  $\delta = I_{\{y < c\}}$  is the censoring indicator. We say that  $V = (T, \delta, \mathbf{z})$  follows a finite mixture of AFT regression models of order  $K$  if the conditional density of  $(T, \delta)$  given  $\mathbf{z}$  has the form

$$f(t, \delta; \mathbf{z}, \Psi) = \sum_{k=1}^K \pi_k [f_Y(t; \theta_k(\mathbf{z}), \sigma_k)]^\delta [S_Y(t; \theta_k(\mathbf{z}), \sigma_k)]^{1-\delta} [f_C(t)]^{1-\delta} [S_C(t)]^\delta$$

where  $f_Y(\cdot)$  and  $S_Y(\cdot)$  are respectively the density and survival functions of  $Y$ ,  $f_C(\cdot)$  and  $S_C(\cdot)$  are respectively the density and survival functions of  $C$ ; and  $\theta_k(\mathbf{z}) = h(\beta_{0k} + \mathbf{z}^\top \boldsymbol{\beta}_k)$  for a known link function  $h(\cdot)$ ,  $\Psi = (\pi_1, \dots, \pi_K, \beta_{01}, \dots, \beta_{0K}, \boldsymbol{\beta}_1, \dots, \boldsymbol{\beta}_K, \sigma_1, \dots, \sigma_K)^\top$  with  $\boldsymbol{\beta}_k = (\beta_{k1}, \beta_{k2}, \dots, \beta_{kd})^\top$  and  $0 < \pi_k < 1$  with  $\sum_{k=1}^K \pi_k = 1$ . The log-likelihood of a sample of size  $n$  is formed as

$$\ell_n(\Psi) = \sum_{i=1}^n \log \sum_{k=1}^K \pi_k [f_Y(t_i, \theta_k(\mathbf{z}_i), \sigma_k)]^{\delta_i} [S_Y(t_i, \theta_k(\mathbf{z}_i), \sigma_k)]^{1-\delta_i}.$$

Note that we assume the censoring distribution is non-informative and hence won't play any role in the estimation process. We use EM and Newton-Raphson algorithms in our method to find the maximizer of above Log-Likelihood.

## Value

An `fmrsfit-class` that includes parameter estimates of the specified FMRs model

## Author(s)

Farhad Shokoohi <shokoohi@icloud.com>

## References

Shokoohi, F., Khalili, A., Asgharian, M. and Lin, S. (2016 submitted) Variable Selection in Mixture of Survival Models for Biomedical Genomic Studies

**See Also**

Other lnorm, norm, weibull: [fmrs.gendata\(\)](#), [fmrs.tunsel\(\)](#), [fmrs.varsels\(\)](#)

**Examples**

```
set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1, 1, 2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
summary(res.mle)
```

---

 fmrs.tunsel

*fmrs.tunsel method*


---

**Description**

Provides component-wise tuning parameters using BIC for Finite Mixture of Accelerated Failure Time Regression Models and Finite Mixture of Regression Models.

**Usage**

```
fmrs.tunsel(y, delta, x, nComp, ...)
```

```
## S4 method for signature 'ANY'
```

```
fmrs.tunsel(
  y,
  delta,
  x,
  nComp,
  disFamily = "lnorm",
  initCoeff,
  initDispersion,
  initmixProp,
  penFamily = "lasso",
  lambRidge = 0,
```

```

nIterEM = 2000,
nIterNR = 2,
conveps = 1e-08,
convepsEM = 1e-08,
convepsNR = 1e-08,
porNR = 2,
gamMixPor = 1,
activeset,
lambMCP,
lambSICA
)

```

### Arguments

|                |  |
|----------------|--|
| y              | Responses (observations)   |
| delta          | Censoring indicator vector   |
| x              | Design matrix (covariates)   |
| nComp          | Order (Number of components) of mixture model  |
| ...            | Other possible options   |
| disFamily      | A sub-distribution family. The options are 'norm' for FMR models, 'lnorm' for mixture of AFT regression models with Log-Normal sub-distributions, 'weibull' for mixture of AFT regression models with Weibull sub-distributions, |
| initCoeff      | Vector of initial values for regression coefficients including intercepts  |
| initDispersion | Vector of initial values for standard deviations   |
| initmixProp    | Vector of initial values for proportion of components  |
| penFamily      | Penalty name that is used in variable selection method. The available options are 'lasso', 'adplasso', 'mcp', 'scad', 'sica' and 'hard'.   |
| lambRidge      | A positive value for tuning parameter in Ridge Regression or Elastic Net   |
| nIterEM        | Maximum number of iterations for EM algorithm  |
| nIterNR        | Maximum number of iterations for Newton-Raphson algorithm  |
| conveps        | A positive value for avoiding NaN in computing divisions   |
| convepsEM      | A positive value for threshold of convergence in EM algorithm  |
| convepsNR      | A positive value for threshold of convergence in NR algorithm  |
| porNR          | A positive interger for maximum number of searches in NR algorithm   |
| gamMixPor      | Proportion of mixing parameters in the penalty. The value must be in the interval [0,1]. If gamMixPor = 0, the penalty structure is no longer mixture.   |
| activeset      | A matrix of zero-one that shows which intercepts and covariates are active in the fitted fmrs model  |
| lambMCP        | A positive numbers for mcp's extra tuning parameter  |
| lambSICA       | A positive numbers for sica's extra tuning parameter   |

### Details

The maximizer of penalized Log-Likelihood depends on selecting a set of good tuning parameters which is a rather thorny issue. We choose a value in an equally spaced set of values in  $(0, \lambda_{max})$  for a pre-specified  $\lambda_{max}$  that maximize the component-wise BIC,

$$\hat{\lambda}_k = \operatorname{argmax}_{\lambda_k} BIC_k(\lambda_k) = \operatorname{argmax}_{\lambda_k} \left\{ \ell_{k,n}^c(\hat{\Psi}_{\lambda_k,k}) - |d_{\lambda_k,k}| \log(n) \right\},$$

where  $d_{\lambda_k, k} = \{j : \hat{\beta}_{\lambda_k, k, j} \neq 0, j = 1, \dots, d\}$  is the active set excluding the intercept and  $|d_{\lambda_k, k}|$  is its size. This approach is much faster than using an nComp by nComp grid to select the set  $\lambda$  to maximize the penallized Log-Likelihood.

### Value

An `fmrstunpar`-class that includes component-wise tuning parameter estimates that can be used in variable selection procedure.

### Author(s)

Farhad Shokoohi <shokoohi@icloud.com>

### References

Shokoohi, F., Khalili, A., Asgharian, M. and Lin, S. (2016 submitted) Variable Selection in Mixture of Survival Models for Biomedical Genomic Studies

### See Also

Other lnorm, norm, weibull: `fmrs.gendata()`, `fmrs.mle()`, `fmrs.varsel()`

### Examples

```
set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0,  0, 0,  0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))

res.lam <- fmrs.tunsel(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = c(coefficients(res.mle)),
  initDispersion = dispersion(res.mle),
  initmixProp = mixProp(res.mle),
  penFamily = 'adplasso')
show(res.lam)
```

---

|             |                           |
|-------------|---------------------------|
| fmrs.varsel | <i>fmrs.varsel method</i> |
|-------------|---------------------------|

---

### Description

Provides variable selection and penalized MLE for Finite Mixture of Accelerated Failure Time Regression (FMAFTR) Models and Finite Mixture of Regression (FMR) Models. It also provide Ridge Regression and Elastic Net.

### Usage

```
fmrs.varsel(y, delta, x, nComp, ...)
```

```
## S4 method for signature 'ANY'
```

```
fmrs.varsel(
  y,
  delta,
  x,
  nComp,
  disFamily = "lnorm",
  initCoeff,
  initDispersion,
  initmixProp,
  penFamily = "lasso",
  lambPen,
  lambRidge = 0,
  nIterEM = 2000,
  nIterNR = 2,
  conveps = 1e-08,
  convepsEM = 1e-08,
  convepsNR = 1e-08,
  porNR = 2,
  gamMixPor = 1,
  activeset,
  lambMCP,
  lambSICA
)
```

### Arguments

|           |   |
|-----------|---|
| y         | Responses (observations)  |
| delta     | Censoring indicators  |
| x         | Design matrix (covariates)  |
| nComp     | Order (Number of components) of mixture model   |
| ...       | Other possible options  |
| disFamily | A sub-distribution family. The options are 'norm' for FMR models, 'lnorm' for mixture of AFT regression models with Log-Normal sub-distributions, 'weibull' for mixture of AFT regression models with Weibull sub-distributions |
| initCoeff | Vector of initial values for regression coefficients including intercepts   |

|                |  |
|----------------|--|
| initDispersion | Vector of initial values for standard deviations   |
| initmixProp    | Vector of initial values for proportion of components  |
| penFamily      | Penalty name that is used in variable selection method The available options are 'lasso', 'adplasso', 'mcp', 'scad', 'sica' and 'hard'.                |
| lambPen        | A vector of positive numbers for tuning parameters   |
| lambRidge      | A positive value for tuning parameter in Ridge Regression or Elastic Net   |
| nIterEM        | Maximum number of iterations for EM algorithm  |
| nIterNR        | Maximum number of iterations for Newton-Raphson algorithm  |
| conveps        | A positive value for avoiding NaN in computing divisions   |
| convepsEM      | A positive value for threshold of convergence in EM algorithm  |
| convepsNR      | A positive value for threshold of convergence in NR algorithm  |
| porNR          | A positive interger for maximum number of searches in NR algorithm   |
| gamMixPor      | Proportion of mixing parameters in the penalty. The value must be in the interval [0,1]. If gamMixPor = 0, the penalty structure is no longer mixture. |
| activeset      | A matrix of zero-one that shows which intercepts and covariates are active in the fitted fmrs model  |
| lambMCP        | A positive numbers for mcp's extra tuning parameter  |
| lambSICA       | A positive numbers for sica's extra tuning parameter   |

## Details

The penalized likelihood of a finite mixture of AFT regression models is written as

$$\tilde{\ell}_n(\Psi) = \ell_n(\Psi) - \mathbf{p}\lambda_n(\Psi)$$

where

$$\mathbf{p}\lambda_n(\Psi) = \sum_{k=1}^K \pi_k^\alpha \left\{ \sum_{j=1}^d p_{\lambda_{n,k}}(\beta_{kj}) \right\}.$$

In the M step of EM algorithm the function

$$\tilde{Q}(\Psi, \Psi^{(m)}) = \sum_{k=1}^K \tilde{Q}_k(\Psi_k, \Psi_k^{(m)}) = \sum_{k=1}^K \left[ Q_k(\Psi_k, \Psi_k^{(m)}) - \pi_k^\alpha \left\{ \sum_{j=1}^d p_{\lambda_{n,k}}(\beta_{kj}) \right\} \right]$$

is maximized. Since the penalty function is singular at origin, we use a local quadratic approximation (LQA) for the penalty as follows,

$$\mathbf{p}_{k,\lambda_n}^*(\beta, \beta^{(m)}) = (\pi_k^{(m)})^\alpha \sum_{j=1}^d \left\{ p_{\lambda_{n,k}}(\beta_{kj}^{(m)}) + \frac{p'_{\lambda_{n,k}}(\beta_{kj}^{(m)})}{2\beta_{kj}^{(m)}} (\beta_{kj}^2 - \beta_{kj}^{(m)2}) \right\}.$$

Therefore maximizing  $Q$  is equivalent to maximizing the function

$$Q^*(\Psi, \Psi^{(m)}) = \sum_{k=1}^K Q_k^*(\Psi_k, \Psi_k^{(m)}) = \sum_{k=1}^K \left[ Q_k(\Psi_k, \Psi_k^{(m)}) - \mathbf{p}_{k,\lambda_n}^*(\beta, \beta^{(m)}) \right].$$

In case of Log-Normal sub-distributions, the maximizers of  $Q_k$  functions are as follows. Given the data and current estimates of parameters, the maximizers are

$$\beta_k^{(m+1)} = (\mathbf{z}'\boldsymbol{\tau}_k^{(m)}\mathbf{z} + \varpi_k(\beta_{kj}^{(m)}))^{-1} \mathbf{z}'\boldsymbol{\tau}_k^{(m)}T_k^{(m)},$$

where  $\varpi_k(\beta_{kj}^{(m)}) = \text{diag} \left( \left( \pi_k^{(m+1)} \right)^\alpha \frac{p'_{\lambda_{n,k}}(\beta_{kj}^{(m)})}{\beta_{kj}^{(m)}} \right)$  and  $\sigma_k^{(m+1)}$  is equal to

$$\sigma_k^{(m+1)} = \sqrt{\frac{\sum_{i=1}^n \tau_{ik}^{(m)} (t_{ik}^{(m)} - \mathbf{z}_i \beta_k^{(m)})^2}{\sum_{i=1}^n \tau_{ik}^{(m)} [\delta_i + (1 - \delta_i) \{A(w_{ik}^{(m)})[A(w_{ik}^{(m)}) - w_{ik}^{(m)}]\}]}}.$$

For the Weibull distribution, on the other hand, we have  $\tilde{\Psi}_k^{(m+1)} = \tilde{\Psi}_k^{(m)} - 0.5^\kappa \left[ H_k^{p,(m)} \right]^{-1} I_k^{p,(m)}$ , where  $H_k^p = H_k + h(\Psi_k)$  is the penalized version of hessian matrix and  $I_k^p = I_k + h(\Psi_k) \Psi_k$  is the penalized version of vector of first derivatives evaluated at  $\tilde{\Psi}_k^{(m)}$ .

## Value

`fmrsfit-class`

## Author(s)

Farhad Shokoohi <shokoohi@icloud.com>

## References

Shokoohi, F., Khalili, A., Asgharian, M. and Lin, S. (2016 submitted) Variable Selection in Mixture of Survival Models for Biomedical Genomic Studies

## See Also

Other Inorm, norm, weibull: `fmrs.gendata()`, `fmrs.mle()`, `fmrs.tunsetl()`

## Examples

```
set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1, 1, 2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))

res.lam <- fmrs.tunsetl(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = ncomp(res.mle), disFamily = 'lnorm',
```

```

    initCoeff=c(coefficients(res.mle)),
    initDispersion = dispersion(res.mle),
    initmixProp = mixProp(res.mle),
    penFamily = 'adplasso')
res.var <- fmrs.varsel(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = ncomp(res.mle), disFamily = 'lnorm',
  initCoeff=c(coefficients(res.mle)),
  initDispersion = dispersion(res.mle),
  initmixProp = mixProp(res.mle),
  penFamily = 'adplasso',
  lambPen = slot(res.lam, 'lambPen'))

coefficients(res.var)[-1,]
round(coefficients(res.var)[-1,],5)

```

---

 fmrsfit-class

*An S4 class to represent a fitted FMRs model*


---

### Description

is an S4 class represents a fitted of FMRs model resulted from running [fmrs.mle](#) or [fmrs.varsel](#)

### Slots

y A length-nobs numeric vector  
 delta A length-nobs numeric vector  
 x A dimension-nobs-ncov numeric matrix  
 nobs A length-one numeric vector  
 ncov A length-one numeric vector  
 ncomp A length-one numeric vector  
 coefficients A length-(ncov+1)-ncomp numeric matrix  
 dispersion A length-ncomp numeric vector  
 mixProp A length-ncomp numeric vector  
 logLik A length-one numeric vector  
 BIC A length-one numeric vector  
 nIterEMconv A length-one numeric vector  
 disFamily A length-one character vector  
 penFamily A length-one character vector  
 lambPen A length-ncomp numeric vector  
 lambRidge A length-one numeric vector  
 MCPGam A length-one numeric vector  
 SICAGam A length-one numeric vector  
 model A length-one character vector  
 fitted A dimension-nobs-ncomp numeric matrix  
 residuals A dimension-nobs-ncomp numeric matrix  
 weights A dimension-nobs-ncomp numeric matrix  
 activeset A dimension-nobs-ncomp 0-1 matrix



---

|                  |   |
|------------------|---|
| fmrstunpar-class | <i>An S4 class to represent estimated optimal lambdas</i> |
|------------------|---|

---

**Description**

An S4 class to represent estimated optimal lambdas resulted from running `fmrstunsel`

**Slots**

ncomp A length-one numeric vector  
 lambPen A dimension-one-ncomp numeric array  
 MCPGam A length-one numeric vector  
 SICAGam A length-one numeric vector  
 disFamily A length-one character vector  
 penFamily A length-one character vector  
 lambRidge A length-one numeric vector  
 model A length-one character vector  
 activeset A dimension-nobs-ncomp 0-1 matrix

---

|        |                      |
|--------|----------------------|
| logLik | <i>logLik method</i> |
|--------|----------------------|

---

**Description**

Provides the estimated logLikelihood of an FMRs model from an `fmrfit-class`

**Usage**

```
logLik(object, ...)
```

```
## S4 method for signature 'fmrfit'
```

```
logLik(object, ...)
```

**Arguments**

|        |                              |
|--------|------------------------------|
| object | An <code>fmrfit-class</code> |
| ...    | Other possible arguments     |

**Value**

A numeric value

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```

set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
logLik(res.mle)

```

---

mixProp

*mixProp method*


---

**Description**

Provides the estimated mixing proportions of an FMRs model form an [fmrsfit-class](#)

**Usage**

```

mixProp(object, ...)

## S4 method for signature 'fmrsfit'
mixProp(object, ...)

```

**Arguments**

|        |                                  |
|--------|----------------------------------|
| object | An <a href="#">fmrsfit-class</a> |
| ...    | Other possible arguments         |

**Value**

A numeric vector of length-nComp

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```

set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
mixProp(res.mle)

```

---

ncomp

*ncomp method*


---

**Description**

Provides the order of an FMRs model from an [fmrsfit-class](#)

**Usage**

```

ncomp(object, ...)

## S4 method for signature 'fmrsfit'
ncomp(object, ...)

```

**Arguments**

|        |                                  |
|--------|----------------------------------|
| object | An <a href="#">fmrsfit-class</a> |
| ...    | Other possible arguments         |

**Value**

An integer value

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```

set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
ncomp(res.mle)

```

---

ncov

*ncov method*


---

**Description**

Provides the number of covariates of an FMRs model from an [fmrsfit-class](#)

**Usage**

```

ncov(object, ...)

## S4 method for signature 'fmrsfit'
ncov(object, ...)

```

**Arguments**

|        |                                  |
|--------|----------------------------------|
| object | An <a href="#">fmrsfit-class</a> |
| ...    | Other possible arguments         |

**Value**

An integer value

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```

set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
ncov(res.mle)

```

---

nobs

*nobs method*


---

**Description**

Provides the number of observations in an FMRs model from an [fmrsfit-class](#)

**Usage**

```

nobs(object, ...)

## S4 method for signature 'fmrsfit'
nobs(object, ...)

```

**Arguments**

|        |                                  |
|--------|----------------------------------|
| object | An <a href="#">fmrsfit-class</a> |
| ...    | Other possible arguments         |

**Value**

An integer value

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```

set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
nobs(res.mle)

```

residuals

*residuals method***Description**

Provides the residuals of the fitted FMRs model from an [fmrsfit-class](#)

**Usage**

```

residuals(object, ...)

## S4 method for signature 'fmrsfit'
residuals(object, ...)

```

**Arguments**

|        |                                  |
|--------|----------------------------------|
| object | An <a href="#">fmrsfit-class</a> |
| ...    | Other possible arguments         |

**Value**

A numeric array of dimension-nObs-nComp

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```

set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
head(residuals(res.mle))

```

summary

*summary method***Description**

Displays the fitted FMRs model by showing the estimated coefficients, dispersions and mixing proportions

Display the selected component-wise tuning parameters

**Usage**

```

summary(object, ...)

summary(object, ...)

## S4 method for signature 'fmrsfit'
summary(object, ...)

## S4 method for signature 'fmrstunpar'
summary(object, ...)

```

**Arguments**

object            An [fmrsfit-class](#) or [fmrstunpar-class](#)

...                Other possible arguments

**Value**

Summary of the fitted FMRs model

Summary of the selected component-wise tuning parameters

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```
set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0, 0, 0, 0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
summary(res.mle)
res.lam <- fmrs.tunsel(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = c(coefficients(res.mle)),
  initDispersion = dispersion(res.mle),
  initmixProp = mixProp(res.mle),
  penFamily = 'adplasso')
summary(res.lam)
```

---

weights

*weights method*

---

**Description**

Provides the weights of fitted observations for each observation under all components of an FMRs model



**Usage**

```
weights(object, ...)

## S4 method for signature 'fmrsfit'
weights(object, ...)
```

**Arguments**

```
object      An fmrsfit-class
...         Other possible arguments
```

**Value**

A numeric array of dimension-nObs-nComp

**Author(s)**

Farhad Shokoohi <shokoohi@icloud.com>

**Examples**

```
set.seed(1980)
nComp = 2
nCov = 10
nObs = 500
dispersion = c(1, 1)
mixProp = c(0.4, 0.6)
rho = 0.5
coeff1 = c( 2,  2, -1, -2, 1, 2, 0, 0,  0, 0,  0)
coeff2 = c(-1, -1,  1,  2, 0, 0, 0, 0, -1, 2, -2)
umax = 40

dat <- fmrs.gendata(nObs = nObs, nComp = nComp, nCov = nCov,
  coeff = c(coeff1, coeff2), dispersion = dispersion,
  mixProp = mixProp, rho = rho, umax = umax,
  disFamily = 'lnorm')

res.mle <- fmrs.mle(y = dat$y, x = dat$x, delta = dat$delta,
  nComp = nComp, disFamily = 'lnorm',
  initCoeff = rnorm(nComp*nCov+nComp),
  initDispersion = rep(1, nComp),
  initmixProp = rep(1/nComp, nComp))
head(weights(res.mle))
```

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