

# Package ‘jmcm’

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**Type** Package

**Title** Joint Mean-Covariance Models using 'Armadillo' and S4

**Version** 0.2.5

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**Description** Fit joint mean-covariance models for longitudinal data. The models and their components are represented using S4 classes and methods. The core computational algorithms are implemented using the 'Armadillo' C++ library for numerical linear algebra and 'RcppArmadillo' glue.

**License** GPL (>= 2)

**LazyData** TRUE

**Depends** R (>= 3.2.2)

**Imports** Formula, methods, Rcpp (>= 0.12.14)

**LinkingTo** Rcpp, RcppArmadillo (>= 0.9.900.1.0), roptim

**RoxygenNote** 6.0.1

**NeedsCompilation** yes

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**URL** <https://github.com/ypan1988/jmcm/>

**BugReports** <https://github.com/ypan1988/jmcm/issues>

**Suggests** testthat, R.rsp

**VignetteBuilder** R.rsp

**Repository** CRAN

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acd_estimation	<i>Fit Joint Mean-Covariance Models based on ACD</i>
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### Description

Fit joint mean-covariance models based on ACD.

### Usage

```
acd_estimation(m, Y, X, Z, W, start, mean, trace = FALSE, profile = TRUE,
  errormsg = FALSE, covonly = FALSE, optim_method = "default")
```

### Arguments

m	an integer vector of numbers of measurements for subject.
Y	a vector of responses for all subjects.
X	model matrix for the mean structure model.
Z	model matrix for the diagonal matrix.
W	model matrix for the lower triangular matrix.
start	starting values for the parameters in the model.
mean	when covonly is true, it is used as the given mean.
trace	the values of the objective function and the parameters are printed for all the trace'th iterations.
profile	whether parameters should be estimated sequentially using the idea of profile likelihood or not.
errormsg	whether or not the error message should be print.
covonly	estimate the covariance structure only, and use given mean.
optim_method	optimization method, choose "default" or "BFGS"(vmmin in R).

### See Also

[mcd\\_estimation](#) for joint mean covariance model fitting based on MCD, [hpc\\_estimation](#) for joint mean covariance model fitting based on HPC.

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aids	<i>Aids Data</i>
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**Description**

The aids dataset comprises a total of 2376 CD4+ cell counts for 369 HIV infected men with a follow up period of approximately eight and half year. The number of measurements for each individual varies from 1 to 12 and the times are not equally spaced. The CD4+ cell data are highly unbalanced.

**Usage**

```
data(aids)
```

**Format**

A data frame with 2376 rows and 8 variables

**Details**

- id: subject id
- time: measurement time
- cd4: CD4+ cell count

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bootcurve	<i>Plot Fitted Curves and Corresponding Confidence Interval using bootstrapping method</i>
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**Description**

Plot fitted curves and corresponding 95% confidence interval using bootstrapping method.

**Usage**

```
bootcurve(object, nboot)
```

**Arguments**

object	a fitted joint mean covariance model of class "jmcmMod", i.e., typically the result of jmcm().
nboot	number of the bootstrap replications.

## Examples

```
## Not run:  
# It may take hours for large bootstrap replications  
fit.mcd <- jmcm(I(sqrt(cd4)) | id | time ~ 1 | 1, data=aids,  
  triple = c(8, 1, 3), cov.method = 'mcd', control = jmcmControl(trace=T))  
bootcurve(fit.mcd, nboot = 1000)  
  
## End(Not run)
```

---

cattle

*Cattle Data*

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## Description

Kenward (1987) reported an experiment in which cattle were assigned randomly to two treatment groups A and B, and their body weights were recorded in kilogram. Thirty animals received treatment A and another 30 received treatment B. The animals were weighted 11 times over a 133-day period; the first 10 measurements for each animal were made at two-week intervals and the last measurement was made one week later. Since no observation was missing, it is considered to be a balanced longitudinal dataset.

## Usage

```
data(cattle)
```

## Format

A data frame with 660 rows and 4 variables

## Details

- id: subject id
- day: measurement time
- group: Treatment A or Treatment B
- weight: cattle weight

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getJMCM	<i>Extract or Get Generalized Components from a Fitted Joint Mean Covariance Model</i>
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**Description**

Extract (or "get") "components" - in a generalized sense - from a fitted joint mean covariance model from an object of class "jmcmMod".

**Usage**

```
getJMCM(object, name, sub.num)

## S3 method for class 'jmcmMod'
getJMCM(object, name = c("m", "Y", "X", "Z", "W", "D", "T",
  "Sigma", "mu", "n2loglik", "grad", "hess", "theta", "beta", "lambda", "gamma",
  "loglik", "BIC", "iter", "triple"), sub.num = 0)
```

**Arguments**

object	a fitted joint mean covariance model of class "jmcmMod", i.e., typically the result of jmcm().
name	a character vector specifying the name(s) of the "component". When sub.num is not specified or equal to 0, possible values are: "m" a vector of number of measurement for each subject "Y" response vector "X" model matrix for mean structure "Z" model matrix for covariance structure (the diagonal matrix) "W" model matrix for covariance structure (the lower triangular matrix) "theta" parameter estimates of joint mean covariance model "beta" parameter estimates for mean structure model "lambda" parameter estimates for covariace structure (the diagonal matrix) "gamma" parameter estimates for covariance structure (the lower triangular matrix) "loglik" log-likelihood, except for a constant "BIC" Bayesian information criterion "iter" number of iterations until convergence "triple" (p, d, q) When sub.num is specified, possible values are: "m" number of measurements for subject i "Y" response vector for subject i "X" model matrix of subject i for mean structure "Z" model matrix of subject i for covariance structure (the diagonal matrix)

"W" model matrix of subject i for covariance structure (the lower triangular matrix)  
 "D" the estimated diagonal matrix for subject i  
 "T" the estimated lower triangular matrix for subject i  
 "Sigma" the estimated covariance matrix for subject i  
 "mu" the estimated mean for subject i  
 "n2loglik" the estimated  $-2l(\theta)$   
 "grad" the estimated gradient  
 "hess" the estimated Hessian matrix

sub.num refer to i's subject

### Methods (by class)

- jmcmMod: Extract or Get Generalized Components from a Fitted Joint Mean Covariance Model

### Examples

```
fit.mcd <- jmcm(I(sqrt(cd4)) | id | time ~ 1 | 1, data = aids,
  triple = c(8, 1, 3), cov.method = 'mcd')

beta <- getJMCM(fit.mcd, "beta")
BIC <- getJMCM(fit.mcd, "BIC")
Di <- getJMCM(fit.mcd, "D", 10)
```

---

hpc\_estimation

*Fit Joint Mean-Covariance Models based on HPC*

---

### Description

Fit joint mean-covariance models based on HPC.

### Usage

```
hpc_estimation(m, Y, X, Z, W, start, mean, trace = FALSE, profile = TRUE,
  errormsg = FALSE, covonly = FALSE, optim_method = "default")
```

### Arguments

m an integer vector of numbers of measurements for subject.  
 Y a vector of responses for all subjects.  
 X model matrix for the mean structure model.  
 Z model matrix for the diagonal matrix.  
 W model matrix for the lower triangular matrix.  
 start starting values for the parameters in the model.

mean	when covonly is true, it is used as the given mean.
trace	the values of the objective function and the parameters are printed for all the trace'th iterations.
profile	whether parameters should be estimated sequentially using the idea of profile likelihood or not.
errormsg	whether or not the error message should be print.
covonly	estimate the covariance structure only, and use given mean.
optim_method	optimization method, choose "default" or "BFGS"(vmmin in R).

### See Also

[mcd\\_estimation](#) for joint mean covariance model fitting based on MCD, [acd\\_estimation](#) for joint mean covariance model fitting based on ACD.

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 jmcm

*Fit Joint Mean-Covariance Models*


---

### Description

Fit a joint mean-covariance model to longitudinal data, via maximum likelihood.

### Usage

```
jmcm(formula, data = NULL, triple = c(3, 3, 3), cov.method = c("mcd",
  "acd", "hpc"), optim.method = c("default", "BFGS"),
  control = jmcmControl(), start = NULL)
```

### Arguments

formula	a two-sided linear formula object describing the covariates for both the mean and covariance matrix part of the model, with the response, the corresponding subject id and measurement time on the left of a operator~, divided by vertical bars (" ").
data	a data frame containing the variables named in formula.
triple	an integer vector of length three containing the degrees of the three polynomial functions for the mean structure, the log innovation -variances and the autoregressive or moving average coefficients when 'mcd' or 'acd' is specified for cov.method. It refers to the degree for the mean structure, variances and angles when 'hpc' is specified for cov.method.
cov.method	covariance structure modelling method, choose 'mcd' (Pourahmadi 1999), 'acd' (Chen and Dunson 2013) or 'hpc' (Zhang et al. 2015).
optim.method	optimization method, choose 'default' or 'BFGS' (vmmin in R)
control	a list (of correct class, resulting from jmcmControl()) containing control parameters, see the *jmcmControl documentation for details.
start	starting values for the parameters in the model.

## References

Pan J, Pan Y (2017). "jmcm: An R Package for Joint Mean-Covariance Modeling of Longitudinal Data." *Journal of Statistical Software*, 82(9), 1–29.

## Examples

```
cattleA <- cattle[cattle$group=='A', ]
fit.mcd <- jmcm(weight | id | I(ceiling(day/14 + 1)) ~ 1 | 1,
  data=cattleA, triple = c(8, 4, 3), cov.method = 'mcd',
  control = jmcmControl(trace = TRUE, ignore.const.term = FALSE,
    original.poly.order = TRUE))
```

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 jmcmControl

*Control of Joint Mean Covariance Model Fitting*


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## Description

Construct control structures for joint mean covariance model fitting

## Usage

```
jmcmControl(trace = FALSE, profile = TRUE, ignore.const.term = TRUE,
  original.poly.order = FALSE, errormsg = FALSE)
```

## Arguments

trace	whether or not the value of the objective function and the parameters should be print on every trace'th iteration.
profile	whether or not parameters should be estimated sequentially using the idea of profile likelihood.
ignore.const.term	whether or not the constant term should be considered when calculating log-likelihood and BIC. function
original.poly.order	whether or not the original poly order p q d should be used
errormsg	whether or not the error message should be print

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jmcmMod-class	<i>Class "jmcmMod" of Fitted Joint Mean-Covariance Models.</i>
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**Description**

Class "jmcmMod" of Fitted Joint Mean-Covariance Models.

**Slots**

call the matched call

opt the optimization result returned by optimizeJmcm

args arguments m, Y, X, Z, W, time

triple an integer vector of length three containing the degrees of the three polynomial functions for the mean structure, the log innovation -variances and the autoregressive or moving average coefficients when 'mcd' or 'acd' is specified for cov.method. It refers to the mean structure, variances and angles when 'hpc' is specified for cov.method.

devcomp the deviance components list

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mcd_estimation	<i>Fit Joint Mean-Covariance Models based on MCD</i>
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**Description**

Fit joint mean-covariance models based on MCD.

**Usage**

```
mcd_estimation(m, Y, X, Z, W, start, mean, trace = FALSE, profile = TRUE,
  errormsg = FALSE, covonly = FALSE, optim_method = "default")
```

**Arguments**

m	an integer vector of numbers of measurements for subject.
Y	a vector of responses for all subjects.
X	model matrix for the mean structure model.
Z	model matrix for the diagonal matrix.
W	model matrix for the lower triangular matrix.
start	starting values for the parameters in the model.
mean	when covonly is true, it is used as the given mean.
trace	the values of the objective function and the parameters are printed for all the trace'th iterations.

profile	whether parameters should be estimated sequentially using the idea of profile likelihood or not.
errormsg	whether or not the error message should be print.
covonly	estimate the covariance structure only, and use given mean.
optim_method	optimization method, choose "default" or "BFGS"(vmmin in R).

**See Also**

[acd\\_estimation](#) for joint mean covariance model fitting based on ACD, [hpc\\_estimation](#) for joint mean covariance model fitting based on HPC.

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meanplot	<i>Plot Fitted Mean Curves</i>
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**Description**

plot fitted mean curves

**Usage**

```
meanplot(object)
```

**Arguments**

object a fitted joint mean covariance model of class "jmcmMod", i.e., typically the result of `jmcm()`.

**Examples**

```
cattleA <- cattle[cattle$group=='A', ]
fit.mcd <- jmcm(weight | id | I(ceiling(day/14 + 1)) ~ 1 | 1, data=cattleA,
  triple = c(8, 3, 4), cov.method = 'mcd')
meanplot(fit.mcd)
```

**Description**

Modular Functions for joint mean covariance model fits

**Usage**

```
ldFormula(formula, data = NULL, triple = c(3, 3, 3), cov.method = c("mcd",
  "acd", "hpc"), optim.method = c("default", "BFGS"),
  control = jmcmControl(), start = NULL)

optimizeJmcm(m, Y, X, Z, W, time, cov.method, optim.method, control, start)

mkJmcmMod(opt, args, triple, cov.method, optim.method, mc)
```

**Arguments**

formula	a two-sided linear formula object describing the covariates for both the mean and covariance matrix part of the model, with the response, the corresponding subject id and measurement time on the left of a operator~, divided by vertical bars (" ").
data	a data frame containing the variables named in formula.
triple	an integer vector of length three containing the degrees of the three polynomial functions for the mean structure, the log innovation -variances and the autoregressive or moving average coefficients when 'mcd' or 'acd' is specified for cov.method. It refers to the degree for the mean structure, variances and angles when 'hpc' is specified for cov.method.
cov.method	covariance structure modelling method, choose 'mcd' (Pourahmadi 1999), 'acd' (Chen and Dunson 2013) or 'hpc' (Zhang et al. 2015).
optim.method	optimization method, choose 'default' or 'BFGS' (vmmin in R)
control	a list (of correct class, resulting from jmcmControl()) containing control parameters, see the *jmcmControl documentation for details.
start	starting values for the parameters in the model.
m	an integer vector of number of measurements for each subject.
Y	a vector of responses for all subjects.
X	model matrix for mean structure model.
Z	model matrix for the diagonal matrix.
W	model matrix for the lower triangular matrix.
time	a vector of time from the data.
opt	optimized results returned by optimizeJmcm.
args	arguments returned by ldFormula.
mc	matched call from the calling function.

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 regressogram

*Plot Sample Regressograms and Fitted Curves*


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**Description**

Plot the sample regressograms based on the sample covariance matrix and superimpose the corresponding fitted curves to check the model fitting when the longitudinal dataset is balanced.

**Usage**

```
regressogram(object, time)
```

**Arguments**

object	a fitted joint mean covariance model of class "jmcmMod", i.e., typically the result of jmcm().
time	a vector of observation time points

**Examples**

```
cattleA <- cattle[cattle$group=='A', ]
fit.mcd <- jmcm(weight | id | I(ceiling(day/14 + 1)) ~ 1 | 1, data=cattleA,
  triple = c(8, 3, 4), cov.method = 'mcd')
regressogram(fit.mcd, time = 1:11)
```

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 show, jmcmMod-method

*Print information for jmcmMod-class*


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**Description**

Print information for jmcmMod-class

**Usage**

```
## S4 method for signature 'jmcmMod'
show(object)
```

**Arguments**

object	a fitted joint mean covariance model of class "jmcmMod", i.e., typically the result of jmcm().
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