Package ‘multgee’

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Author Anestis Touloumis [aut, cre] (<https://orcid.org/0000-0002-5965-1639>)

Maintainer Anestis Touloumis <A.Touloumis@brighton.ac.uk>

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`multgee-package` *A GEE Solver For Correlated Nominal Or Ordinal Multinomial Responses*

Description

A generalized estimating equations (GEE) solver for fitting marginal regression models with correlated nominal or ordinal multinomial responses based on a local odds ratios parameterization for the association structure.

Details

The package contains two functions that fit GEE models for correlated multinomial responses; ordLORgee for an ordinal response scale and nomLORgee for a nominal response scale.

The main arguments in both functions are: (i) an optional data frame (`data`), (ii) a model formula (`formula`), (iii) a cluster identifier variable (`id`) and (iv) an optional vector that identifies the order of the observations within each cluster (`repeated`).

Options for the marginal model in the function ordLORgee include cumulative link models or an adjacent categories logit model. A marginal baseline category logit model is offered in the function nomLORgee. For the form of the linear predictor in these models, see the `Details` sections in nomLORgee and ordLORgee.

The association structure among the correlated multinomial responses is expressed via marginalized local odds ratios (*Touloumis et al., 2013*). The estimating procedure for the local odds ratios can be summarized as follows: For each level pair of the `repeated` variable, the available responses are aggregated across clusters to form a square marginalized contingency table. Treating these tables as independent, an RC-G(1) type model (*Becker and Clogg, 1989*) is fitted in order to estimate the marginalized local odds ratios. The `LORstr` argument determines the form of the marginalized local odds ratios structure. Since the general RC-G(1) model is closely related to the family of association models (*Goodman, 1985*), one can instead fit an association model to each of the marginalized contingency tables by setting `LORem="2way"`.

If the underlying association pattern does not change dramatically across the level pairs of `repeated` then parsimonious marginalized local odds ratios should sufficiently approximate the true underlying association structure. To assess the underlying association structure, one might use the utility function intrinsic.pars.

Instead of estimating the local odds ratios structure, a user-defined structure can be provided by setting `LORstr="fixed"`. In this case, the utility function matrixLOR is useful in constructing the required `LORterm` argument.

The function waldts provides a goodness-of-fit test between two nested GEE models based on a Wald test statistic.

Author(s)

Anestis Touloumis Maintainer: Anestis Touloumis <A.Touloumis@brighton.ac.uk>

References

Becker, M. and Clogg, C. (1989) Analysis of sets of two-way contingency tables using association models. *Journal of the American Statistical Association* **84**, 142–151.

Goodman, L. (1985) The analysis of cross-classified data having ordered and/or unordered categories: Association models, correlation models, and asymmetry models for contingency tables with or without missing entries. *The Annals of Statistics* **13**, 10–69.

Touloumis, A., Agresti, A. and Kateri, M. (2013) GEE for multinomial responses using a local odds ratios parameterization. *Biometrics* **69**, 633–640.

Touloumis, A. (2015) R Package multgee: A Generalized Estimating Equations Solver for Multinomial Responses. *Journal of Statistical Software* **64**, 1–14.

`arthritis` *Rheumatoid Arthritis Clinical Trial*

Description

Rheumatoid self-assessment scores for 302 patients, measured on a five-level ordinal response scale at three follow-up times.

Usage

```
arthritis
```

Format

A data frame with 906 observations on the following 7 variables:

id Patient identifier variable.

y Self-assessment score of rheumatoid arthritis measured on a five-level ordinal response scale.

sex Coded as (1) for female and (2) for male.

age Recorded at the baseline.

trt Treatment group variable, coded as (1) for the placebo group and (2) for the drug group.

baseline Self-assessment score of rheumatoid arthritis at the baseline.

time Follow-up time recorded in months.

Source

Lipsitz, S.R. and Kim, K. and Zhao, L. (1994) Analysis of repeated categorical data using generalized estimating equations. *Statistics in Medicine*, **13**, 1149–1163.

Examples

```
data(arthritis)
str(arthritis)
```

`confint.LORgee` *Confidence Intervals for Model Parameters*

Description

Computes confidence intervals for one or more parameters in a fitted LORgee model.

Usage

```
## S3 method for class 'LORgee'
confint(object, parm, level = 0.95, method = "robust",
  ...)
```

Arguments

`object`	a fitted model LORgee object.
`parm`	a specification of which parameters are to be given confidence intervals, either a vector of numbers or a vector of names. If missing, all parameters are considered.
`level`	the confidence level required.
`method`	character indicating whether the sandwich (robust) covariance matrix (`method = "robust"`) or the model–based (naive) covariance matrix (`method = "naive"`) should be used for calculating the confidence intervals.
`...`	additional argument(s) for methods.

Details

The (Wald-type) confidence intervals are calculated using either the sandwich (robust) or the model-based (naive) covariance matrix.

Value

A matrix (or vector) with columns giving lower and upper confidence limits for each parameter. These will be labelled as `(1-level)/2` and `1 - (1-level)/2` in % (by default 2.5% and 97.5%).

Examples

```
fitmod <- ordLORgee(formula = y ~ factor(time) + factor(trt) + factor(baseline),
  data = arthritis, id = id, LORstr = "uniform", repeated = time)
confint(fitmod)
```

---

gee_criteria — *Variable and Covariance Selection Criteria*

Description

Reports commonly used criteria for variable selection and for selecting the "working" association structure for one or several fitted models from the `multgee` package.

Usage

```
gee_criteria(object, ...)
```

Arguments

`object`	an object of the class `LORgee`.
`...`	optionally more objects of the class `LORgee`.

Details

The Quasi Information Criterion (QIC), the Correlation Information Criterion (CIC) and the Rotnitzky and Jewell Criterion (RJC) are used for selecting the best association structure. The QICu criterion is used for selecting the best subset of covariates. When choosing among GEE models with different association structures but with the same subset of covariates, the model with the smallest value of QIC, CIC or RJC should be preffered. When choosing between GEE models with different number of covariates, the model with the smallest QICu value should be preferred.

Value

A vector or matrix with the QIC, QICu, CIC, RJC and the number of regression parameters (including intercepts).

Author(s)

Anestis Touloumis

References

Hin, L.Y. and Wang, Y.G. (2009) Working correlation structure identification in generalized estimating equations. *Statistics in Medicine* **28**, 642–658.

Pan, W. (2001) Akaike's information criterion in generalized estimating equations. *Biometrics* **57**, 120–125.

Rotnitzky, A. and Jewell, N.P. (1990) Hypothesis testing of regression parameters in semiparametric generalized linear models for cluster correlated data. *Biometrika* **77**, 485–497.

See Also

nomLORgee and ordLORgee.

Examples

```
data(arthritis)
fitmod <- ordLORgee(formula = y ~ factor(time) + factor(trt) + factor(baseline),
data = arthritis, id = id, repeated = time, LORstr = "uniform")
fitmod1 <- update(fitmod, formula = .~. + age + factor(sex))
gee_criteria(fitmod, fitmod1)
```

`housing` *Homeless Data*

Description

Housing status for 362 severely mentally ill homeless subjects measured at baseline and at three follow-up times.

Usage

```
housing
```

Format

A data frame with 1448 observations on the following 4 variables:

id Subject identifier variable.

y Housing status response, coded as (1) for street living, (2) for community living and (3) for independent housing.

time Time recorded in months.

sec Section 8 rent certificate indicator.

Source

Hulrburt M.S., Wood, P.A. and Hough, R.L. (1996) Providing independent housing for the homeless mentally ill: a novel approach to evaluating longitudinal housing patterns. *Journal of Community Psychology*, **24**, 291–310.

Examples

```
data(housing)
str(housing)
```

intrinsic.pars — *Intrinsic Parameters Estimation*

Description

Utility function to assess the underlying association pattern.

Usage

```
intrinsic.pars(y = y, data = parent.frame(), id = id, repeated = NULL,
  rscale = "ordinal")
```

Arguments

`y`	a vector that identifies the response vector of the desired marginal model.
`data`	an optional data frame containing the variables provided in `y`, `id` and `repeated`.
`id`	a vector that identifies the clusters.
`repeated`	an optional vector that identifies the order of observations within each cluster.
`rscale`	a character string that indicates the nature of the response scale. Options include `"ordinal"` or `"nominal"`.

Details

Simulation studies in *Touloumis et al. (2013)* suggested that if the range of the intrinsic parameter estimates is small then simple local odds ratios structures should adequately approximate the association pattern. Otherwise more complicated structures should be employed.

The intrinsic parameters are estimated under the heterogeneous linear-by-linear association model (*Agresti, 2013*) for ordinal response categories and under the RC-G(1) model (*Becker and Clogg, 1989*) with homogeneous score parameters for nominal response categories.

A detailed description of the arguments `id` and `repeated` can be found in the Details section of nomLORgee or ordLORgee.

Value

Returns a numerical vector with the estimated intrinsic parameters.

Author(s)

Anestis Touloumis

References

Agresti, A. (2013) *Categorical Data Analysis*. New York: John Wiley and Sons, Inc., 3rd Edition.

Becker, M. and Clogg, C. (1989) Analysis of sets of two-way contingency tables using association models. *Journal of the American Statistical Association* **84**, 142–151.

Touloumis, A., Agresti, A. and Kateri, M. (2013) GEE for multinomial responses using a local odds ratios parameterization. *Biometrics* **69**, 633–640.

See Also

nomLORgee and ordLORgee.

Examples

```
data(arthritis)
intrinsic.pars(y, arthritis, id, time, rscale = "ordinal")
## The intrinsic parameters do not vary much. The 'uniform' local odds ratios
## structure might be a good approximation for the association pattern.

set.seed(1)
data(housing)
intrinsic.pars(y, housing, id, time, rscale = "nominal")
## The intrinsic parameters vary. The 'RC' local odds ratios structure
## might be a good approximation for the association pattern.
```

`ipfp.control` *IPFP Control*

Description

Control variables for the Iterative Proportion Fitting Procedure function `ipfp`.

Usage

```
ipfp.control(tol = 1e-06, maxit = 200)
```

Arguments

`tol`	positive convergence tolerance. The algorithm converges when the absolute difference between the observed and the given row or column totals is less than or equal to `tol`.
`maxit`	positive integer that indicates the maximum number of iterations.

Note

Currently the function `ipfp` is internal.

Author(s)

Anestis Touloumis

See Also

nomLORgee and ordLORgee.

LORgee_control — *Control For The GEE Solver*

Description

Control variables for the GEE solver in the nomLORgee and ordLORgee functions.

Usage

```
LORgee_control(tolerance = 0.001, maxiter = 15, verbose = FALSE,
  TRACE = FALSE)
```

Arguments

`tolerance`	positive convergence tolerance. The algorithm converges when the maximum of the absolute relative difference in parameter estimates is less than or equal to `tolerance`.
`maxiter`	positive integer that indicates the maximum number of iterations in the Fisher-scoring iterative algorithm.
`verbose`	logical that indicates if output should be printed at each iteration.
`TRACE`	logical that indicates if the parameter estimates and the convergence criterion at each iteration should be saved.

Author(s)

Anestis Touloumis

See Also

nomLORgee and ordLORgee.

Examples

```
data(arthritis)
fitmod <- ordLORgee(y ~ factor(trt) + factor(baseline) + factor(time),
  data = arthritis, id = id, repeated = time)

## A one-step GEE estimator
fitmod1 <- update(fitmod, control = LORgee_control(maxiter = 1))
coef(fitmod)
coef(fitmod1)
```

matrixLOR *Creating A Probability Matrix With Specified Local Odds Ratios*

Description

Utility function to create a square probability matrix that satisfies the specified local odds ratios structure.

Usage

```
matrixLOR(x)
```

Arguments

x	a square matrix with positive entries that describes the desired local odds ratios matrix.

Details

It is designed to ease the construction of the argument `LORterm` in the nomLORgee and ordLORgee functions.

Value

Returns a square probability matrix that satisfies the local odds ratios structure defined by `x`.

Warning

Caution is needed for local odds ratios close to zero.

Author(s)

Anestis Touloumis

See Also

nomLORgee and ordLORgee.

Examples

```
## Illustrating the construction of a "fixed" local odds ratios structure
## using the arthritis dataset. Here, we assume a uniform local odds ratios
## structure equal to 2 for each time pair.

## Create the uniform local odds ratios structure.
lorterm <- matrixLOR(matrix(2, 4, 4))

## Create the LORterm argument.
lorterm <- c(lorterm)
```

```
lorterm <- matrix(c(lorterm), 3, 25, TRUE)

## Fit the marginal model.
data(arthritis)
fitmod <- ordLORgee(y ~ factor(trt) + factor(time) + factor(baseline),
  data = arthritis, id = id, repeated = time, LORstr = "fixed",
  LORterm = lorterm)
fitmod
```

---

nomLORgee *Marginal Models For Correlated Nominal Multinomial Responses*

Description

Solving the generalized estimating equations for correlated nominal multinomial responses assuming a baseline category logit model for the marginal probabilities.

Usage

```
nomLORgee(formula = formula(data), data = parent.frame(), id = id,
  repeated = NULL, bstart = NULL, LORstr = "time.exch", LORem = "3way",
  LORterm = NULL, add = 0, homogeneous = TRUE,
  control = LORgee_control(), ipfp.ctrl = ipfp.control(), IM = "solve")
```

Arguments

`formula`	a formula expression as for other regression models for multinomial responses. An intercept term must be included.
`data`	an optional data frame containing the variables provided in `formula`, `id` and `repeated`.
`id`	a vector that identifies the clusters.
`repeated`	an optional vector that identifies the order of observations within each cluster.
`bstart`	a vector that includes an initial estimate for the marginal regression parameter vector.
`LORstr`	a character string that indicates the marginalized local odds ratios structure. Options include `"independence"`, `"time.exch"`, `"RC"` or `"fixed"`.
`LORem`	a character string that indicates if the marginalized local odds ratios structure is estimated simultaneously (`"3way"`) or independently at each level pair of `repeated` (`"2way"`).
`LORterm`	a matrix that satisfies the user-defined local odds ratios structure. It is ignored unless `LORstr="fixed"`.
`add`	a positive constant to be added at each cell of the full marginalized contingency table in the presence of zero observed counts.

homogeneous	a logical that indicates homogeneous score parameters when LORstr="time.exch" or "RC".
control	a vector that specifies the control variables for the GEE solver.
ipfp.ctrl	a vector that specifies the control variables for the function ipfp.
IM	a character string that indicates the method used for inverting a matrix. Options include "solve", "qr.solve" or "cholesky".

Details

The data must be provided in case level or equivalently in 'long' format. See details about the 'long' format in the function reshape.

A term of the form offset(expression) is allowed in the right hand side of formula.

The default set for the response categories is $\{1,\ldots,J\}$, where $J > 2$ is the maximum observed response category. If otherwise, the function recodes the observed response categories onto this set.

The J-th response category is treated as baseline.

The default set for the id labels is $\{1,\ldots,N\}$, where N is the sample size. If otherwise, the function recodes the given labels onto this set.

The argument repeated can be ignored only when data is written in such a way that the t-th observation in each cluster is recorded at the t-th measurement occasion. If this is not the case, then the user must provide repeated. The suggested set for the levels of repeated is $\{1,\ldots,T\}$, where T is the number of observed levels. If otherwise, the function recodes the given levels onto this set.

The variables id and repeated do not need to be pre-sorted. Instead the function reshapes data in an ascending order of id and repeated.

The fitted marginal baseline category logit model is

$$log \frac{Pr(Y_{it}=j|x_{it})}{Pr(Y_{it}=J|x_{it})} = \beta_{j0} + \beta^{'}_j x_{it}$$

where Y_{it} is the t-th multinomial response for cluster i, x_{it} is the associated covariates vector, β_{j0} is the j-th response category specific intercept and β_j is the j-th response category specific parameter vector.

The formula is easier to read from either the Vignette or the Reference Manual (both available here).

The LORterm argument must be an L x J^2 matrix, where L is the number of level pairs of repeated. These are ordered as $(1,2),(1,3),...,(1,T),(2,3),...,(T-1,T)$ and the rows of LORterm are supposed to preserve this order. Each row is assumed to contain the vectorized form of a probability table that satisfies the desired local odds ratios structure.

Value

Returns an object of the class "LORgee". This has components:

call	the matched call.
title	title for the GEE model.
version	the current version of the GEE solver.
link	the marginal link function.

`local.odds.ratios`
: the marginalized local odds ratios structure variables.

`terms` the `terms` structure describing the marginal model.

`contrasts` the `contrasts` used for the factors.

`nobs` the number of observations.

`convergence` the values of the convergence variables.

`coefficients` the estimated regression parameter vector of the marginal model.

`linear.pred` the estimated linear predictor of the marginal regression model. The j-th column corresponds to the j-th response category.

`fitted.values` the estimated fitted values of the marginal regression model. The j-th column corresponds to the j-th response category.

`residuals` the residuals of the marginal regression model based on the binary responses. The j-th column corresponds to the j-th response category.

`y` the multinomial response variables.

`id` the `id` variable.

`max.id` the number of clusters.

`clusz` the number of observations within each cluster.

`robust.variance`
: the estimated sandwich (robust) covariance matrix.

`naive.variance` the estimated model-based (naive) covariance matrix.

`xnames` the regression coefficients' symbolic names.

`categories` the number of observed response categories.

`occasions` the levels of the `repeated` variable.

`LORgee_control` the control values for the GEE solver.

`ipfp.control` the control values for the function `ipfp`.

`inverse.method` the method used for inverting matrices.

`adding.constant`
: the value used for `add`.

`pvalue` the p-value based on a Wald test that no covariates are statistically significant.

Generic coef, summary, print, fitted and residuals methods are available. The `pvalue of the Null model` corresponds to the hypothesis $H_0 : \beta_1 = ... = \beta_{J-1} = 0$ based on the Wald test statistic.

Author(s)

Anestis Touloumis

References

Touloumis, A. (2011) *GEE for multinomial responses*. PhD dissertation, University of Florida.

Touloumis, A., Agresti, A. and Kateri, M. (2013) GEE for multinomial responses using a local odds ratios parameterization. *Biometrics* **69**, 633–640.

Touloumis, A. (2015) R Package multgee: A Generalized Estimating Equations Solver for Multinomial Responses. *Journal of Statistical Software* **64**, 1–14.

See Also

For an ordinal response scale use the function ordLORgee.

Examples

```
## See the interpretation in Touloumis (2011).
data(housing)
fitmod <- nomLORgee(y ~ factor(time) * sec, data = housing, id = id,
                    repeated = time)
summary(fitmod)
```

---

ordLORgee *Marginal Models For Correlated Ordinal Multinomial Responses*

Description

Solving the generalized estimating equations for correlated ordinal multinomial responses assuming a cumulative link model or an adjacent categories logit model for the marginal probabilities.

Usage

```
ordLORgee(formula = formula(data), data = parent.frame(), id = id,
  repeated = NULL, link = "logit", bstart = NULL,
  LORstr = "category.exch", LORem = "3way", LORterm = NULL, add = 0,
  homogeneous = TRUE, restricted = FALSE, control = LORgee_control(),
  ipfp.ctrl = ipfp.control(), IM = "solve")
```

Arguments

`formula`	a formula expression as for other regression models for multinomial responses. An intercept term must be included.
`data`	an optional data frame containing the variables provided in `formula`, `id` and `repeated`.
`id`	a vector that identifies the clusters.
`repeated`	an optional vector that identifies the order of observations within each cluster.
`link`	a character string that specifies the link function. Options include `"logit"`, `"probit"`, `"cauchit"`, `"cloglog"` or `"acl"`.
`bstart`	a vector that includes an initial estimate for the marginal regression parameter vector.
`LORstr`	a character string that indicates the marginalized local odds ratios structure. Options include `"independence"`, `"uniform"`, `"category.exch"`, `"time.exch"`, `"RC"` or `"fixed"`.
`LORem`	a character string that indicates if the marginalized local odds ratios structure is estimated simultaneously (`"3way"`) or independently at each level pair of `repeated` (`"2way"`).

LORterm	a matrix that satisfies the user-defined local odds ratios structure. It is ignored unless LORstr="fixed".
add	a positive constant to be added at each cell of the full marginalized contingency table in the presence of zero observed counts.
homogeneous	a logical that indicates homogeneous score parameters when LORstr="time.exch" or "RC".
restricted	a logical that indicates monotone score parameters when LORstr="time.exch" or "RC".
control	a vector that specifies the control variables for the GEE solver.
ipfp.ctrl	a vector that specifies the control variables for the function ipfp.
IM	a character string that indicates the method used for inverting a matrix. Options include "solve", "qr.solve" or "cholesky".

Details

The data must be provided in case level or equivalently in 'long' format. See details about the 'long' format in the function reshape.

A term of the form offset(expression) is allowed in the right hand side of formula.

The default set for the response categories is $\{1, \ldots, J\}$, where $J > 2$ is the maximum observed response category. If otherwise, the function recodes the observed response categories onto this set.

The J-th response category is omitted.

The default set for the id labels is $\{1, \ldots, N\}$, where N is the sample size. If otherwise, the function recodes the given labels onto this set.

The argument repeated can be ignored only when data is written in such a way that the t-th observation in each cluster is recorded at the t-th measurement occasion. If this is not the case, then the user must provide repeated. The suggested set for the levels of repeated is $\{1, \ldots, T\}$, where T is the number of observed levels. If otherwise, the function recodes the given levels onto this set.

The variables id and repeated do not need to be pre-sorted. Instead the function reshapes data in an ascending order of id and repeated.

The fitted marginal cumulative link model is

$$Pr(Y_{it} \leq j | x_{it}) = F(\beta_{j0} + \beta^{'} x_{it})$$

where Y_{it} is the t-th multinomial response for cluster i, x_{it} is the associated covariates vector, F is the cumulative distribution function determined by link, β_{j0} is the j-th response category specific intercept and β is the marginal regression parameter vector excluding intercepts.

The marginal adjacent categories logit model

$$log \frac{Pr(Y_{it} = j | x_{it})}{Pr(Y_{it} = j + 1 | x_{it})} = \beta_{j0} + \beta^{'} x_{it}$$

is fitted if and only if link="acl". In contrast to a marginal cumulative link model, here the intercepts do not need to be monotone increasing.

The formulae are easier to read from either the Vignette or the Reference Manual (both available here).

The `LORterm` argument must be an L x J^2 matrix, where L is the number of level pairs of `repeated`. These are ordered as $(1,2),(1,3),\ldots,(1,T),(2,3),\ldots,(T-1,T)$ and the rows of `LORterm` are supposed to preserve this order. Each row is assumed to contain the vectorized form of a probability table that satisfies the desired local odds ratios structure.

Value

Returns an object of the class `"LORgee"`. This has components:

`call`	the matched call.
`title`	title for the GEE model.
`version`	the current version of the GEE solver.
`link`	the marginal link function.
`local.odds.ratios`	the marginalized local odds ratios structure variables.
`terms`	the `terms` structure describing the model.
`contrasts`	the `contrasts` used for the factors.
`nobs`	the number of observations.
`convergence`	the values of the convergence variables.
`coefficients`	the estimated regression parameter vector of the marginal model.
`linear.pred`	the estimated linear predictor of the marginal regression model. The j-th column corresponds to the j-th response category.
`fitted.values`	the estimated fitted values of the marginal regression model. The j-th column corresponds to the j-th response category.
`residuals`	the residuals of the marginal regression model. The j-th column corresponds to the j-th response category.
`y`	the multinomial response variables.
`id`	the `id` variable.
`max.id`	the number of clusters.
`clusz`	the number of observations within each cluster.
`robust.variance`	the estimated sandwich (robust) covariance matrix.
`naive.variance`	the estimated model-based (naive) covariance matrix.
`xnames`	the regression coefficients' symbolic names.
`categories`	the number of observed response categories.
`occasions`	the levels of the `repeated` variable.
`LORgee_control`	the control values for the GEE solver.
`ipfp.control`	the control values for the function `ipfp`.
`inverse.method`	the method used for inverting matrices.
`adding.constant`	the value used for `add`.
`pvalue`	the p-value based on a Wald test that no covariates are statistically significant.

Generic coef, summary, print, fitted and residuals methods are available. The `pvalue of the Null model` corresponds to the hypothesis $H_0 : \beta = 0$ based on the Wald test statistic.

Author(s)

Anestis Touloumis

References

Touloumis, A., Agresti, A. and Kateri, M. (2013) GEE for multinomial responses using a local odds ratios parameterization. *Biometrics*, **69**, 633-640.

Touloumis, A. (2015) R Package multgee: A Generalized Estimating Equations Solver for Multinomial Responses. *Journal of Statistical Software*, **64**, 1-14.

See Also

For a nominal response scale use the function nomLORgee.

Examples

```
data(arthritis)
intrinsic.pars(y, arthritis, id, time)
fitmod <- ordLORgee(formula = y ~ factor(time) + factor(trt) + factor(baseline),
  data = arthritis, id = id, repeated = time, LORstr = "uniform")
summary(fitmod)
```

---

vcov.LORgee *Calculate Variance-Covariance Matrix for a Fitted LORgee Object.*

Description

Returns the variance-covariance matrix of the main parameters of a fitted model LORgee object.

Usage

```
## S3 method for class 'LORgee'
vcov(object, method = "robust", ...)
```

Arguments

`object`	a fitted model LORgee object.
`method`	character indicating whether the sandwich (robust) covariance matrix (`method = "robust"`) or the model–based (naive) covariance matrix (`method = "naive"`) should be returned.
`...`	additional argument(s) for methods.

Details

Default is to obtain the estimated sandwich (robust) covariance matrix and `method = "naive"` obtains the estimated model-based (naive) covariance matrix

Value

A matrix of the estimated covariances between the parameter estimates in the linear predictor of the GEE model. This should have row and column names corresponding to the parameter names given by the coef method.

Examples

```
fitmod <- ordLORgee(formula = y ~ factor(time) + factor(trt) + factor(baseline),
  data = arthritis, id = id, repeated = time, LORstr = "uniform")
vcov(fitmod, method = "robust")
vcov(fitmod, method = "naive")
```

`waldts` *Wald Test of Nested GEE Models*

Description

Comparing two nested GEE models by carrying out a Wald test.

Usage

```
waldts(object0, object1)
```

Arguments

`object0`	A GEE model of the class "`LORgee`".
`object1`	A GEE model of the class "`LORgee`".

Details

The two GEE models implied by `object0` and `object1` must be nested.

Author(s)

Anestis Touloumis

Examples

```
data(housing)
set.seed(1)
fitmod1 <- nomLORgee(y ~ factor(time) * sec, data = housing, id = id,
  repeated = time)
set.seed(1)
fitmod0 <- update(fitmod1, formula = y ~ factor(time) + sec)
waldts(fitmod0, fitmod1)
```

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