

Package ‘geess’

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Type Package

Title Modified Generalized Estimating Equations for Small-Sample Data

Version 1.0.2

Maintainer Ryota Ishii <r.ishii0808@gmail.com>

Description Analyze small-sample clustered or longitudinal data using modified generalized estimating equations with bias-adjusted covariance estimator. The package provides any combination of three modified generalized estimating equations and 11 bias-adjusted covariance estimators.

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Imports MASS (>= 7.3-45)

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Author Ryota Ishii [aut, cre],
Kazushi Maruo [ctb],
Masahiko Gosho [ctb]

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Contents

geess	2
sqrtmat	5

Index	7
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geess

*Modified Generalized Estimating Equations for Small-Sample Data***Description**

geess is an extension of geessbin package (Ishii et al., 2024). geess analyzes small-sample clustered or longitudinal data using modified generalized estimating equations (GEE) with bias-adjusted covariance estimator. This function provides any combination of three GEE methods (conventional and two modified GEE methods) and 12 covariance estimators (unadjusted and 11 bias-adjusted estimators).

Usage

```
geess(
  formula,
  family = gaussian,
  data = parent.frame(),
  id = NULL,
  corstr = "independence",
  repeated = NULL,
  beta.method = "GEE",
  SE.method = "SA",
  b = NULL,
  maxitr = 50,
  tol = 1e-05,
  scale.fix = FALSE,
  conf.level = 0.95
)
```

Arguments

formula	Object of class formula: symbolic description of model to be fitted (see documentation of <code>lm</code> and <code>formula</code> for details).
family	Description of the error distribution and link function to be used in the model. The gaussian family accepts the identity link function. The binomial family accepts the links logit and probit. The poisson family accepts the log link function.
data	Data frame.
id	Vector that identifies the subjects or clusters (NULL by default).
corstr	Working correlation structure. The following are permitted: "independence", "exchangeable", "ar1", and "unstructured" ("independence" by default).
repeated	Vector that identifies repeatedly measured variable within each subject or cluster. If repeated = NULL, as is the case in function <code>gee</code> , data are assumed to be sorted so that observations on a cluster are contiguous rows for all entities in the formula.

<code>beta.method</code>	Method for estimating regression parameters (see Details section). The following are permitted: "GEE", "PGEE", and "BCGEE" ("GEE" by default).
<code>SE.method</code>	Method for estimating standard errors (see Details section). The following are permitted: "SA", "MK", "KC", "MD", "FG", "PA", "GS", "MB", "WL", "WB", "FW", and "FZ" ("SA" by default).
<code>b</code>	Numeric vector specifying initial values of regression coefficients. If <code>b = NULL</code> (default value), the initial values are calculated using the ordinary or Firth logistic regression assuming that all the observations are independent.
<code>maxitr</code>	Maximum number of iterations (50 by default).
<code>tol</code>	Tolerance used in fitting algorithm ($1e-5$ by default).
<code>scale.fix</code>	Logical variable; if TRUE, the scale parameter is fixed at 1 (FALSE by default).
<code>conf.level</code>	Numeric value of confidence level for confidence intervals (0.95 by default).

Details

Details of `beta.method` are as follows:

- "GEE" is the conventional GEE method (Liang and Zeger, 1986)
- "BCGEE" is the bias-corrected GEE method (Paul and Zhang, 2014; Lunardon and Scharfstein, 2017)
- "PGEE" is the bias reduction of the GEE method obtained by adding a Firth-type penalty term to the estimating equation (Mondol and Rahman, 2019)

Details of `SE.method` are as follows:

- "SA" is the unadjusted sandwich variance estimator (Liang and Zeger, 1986)
- "MK" is the MacKinnon and White estimator (MacKinnon and White, 1985)
- "KC" is the Kauermann and Carroll estimator (Kauermann and Carroll, 2001)
- "MD" is the Mancl and DeRouen estimator (Mancl and DeRouen, 2001)
- "FG" is the Fay and Graubard estimator (Fay and Graubard, 2001)
- "PA" is the Pan estimator (Pan, 2001)
- "GS" is the Gosho et al. estimator (Gosho et al., 2014)
- "MB" is the Morel et al. estimator (Morel et al., 2003)
- "WL" is the Wang and Long estimator (Wang and Long, 2011)
- "WB" is the Westgate and Burchett estimator (Westgate and Burchett, 2016)
- "FW" is the Ford and Wastgate estimator (Ford and Wastgate, 2017)
- "FZ" is the Fan et al. estimator (Fan et al., 2013)

Descriptions and performances of some of the above methods in the case of binary outcomes can be found in Gosho et al. (2023).

Value

The object of class "geess" representing the results of modified generalized estimating equations with bias-adjusted covariance estimators. Generic function `summary` provides details of the results.

References

- Fan, C., and Zhang, D., and Zhang, C. H. (2013). A comparison of bias-corrected covariance estimators for generalized estimating equations. *Journal of Biopharmaceutical Statistics*, 23, 1172–1187, doi:10.1080/10543406.2013.813521.
- Fay, M. P. and Graubard, B. I. (2001). Small-sample adjustments for Wald-type tests using sandwich estimators. *Biometrics*, 57, 1198–1206, doi:10.1111/j.0006341X.2001.01198.x.
- Ford, W. P. and Westgate, P. M. (2017). Improved standard error estimator for maintaining the validity of inference in cluster randomized trials with a small number of clusters. *Biometrical Journal*, 59, 478–495, doi:10.1002/bimj.201600182.
- Goshio, M., Ishii, R., Noma, H., and Maruo, K. (2023). A comparison of bias-adjusted generalized estimating equations for sparse binary data in small-sample longitudinal studies. *Statistics in Medicine*, 42, 2711–2727, doi:10.1002/sim.9744.
- Goshio, M., Sato, T., and Takeuchi, H. (2014). Robust covariance estimator for small-sample adjustment in the generalized estimating equations: A simulation study. *Science Journal of Applied Mathematics and Statistics*, 2, 20–25, doi:10.11648/j.sjams.20140201.13.
- Ishii, R., Ohigashi, T., Maruo, K., and Goshio, M. (2024). geessbin: an R package for analyzing small-sample binary data using modified generalized estimating equations with bias-adjusted covariance estimators. *BMC Medical Research Methodology*, 24, 277, doi:10.1186/s12874024023682.
- Kauermann, G. and Carroll, R. J. (2001). A note on the efficiency of sandwich covariance matrix estimation. *Journal of the American Statistical Association*, 96, 1387–1396, doi:10.1198/016214501753382309.
- Liang, K. and Zeger, S. (1986). Longitudinal data analysis using generalized linear models. *Biometrika*, 73, 13–22, doi:10.1093/biomet/73.1.13.
- Lunardon, N. and Scharfstein, D. (2017). Comment on ‘Small sample GEE estimation of regression parameters for longitudinal data’. *Statistics in Medicine*, 36, 3596–3600, doi:10.1002/sim.7366.
- MacKinnon, J. G. and White, H. (1985). Some heteroskedasticity-consistent covariance matrix estimators with improved finite sample properties. *Journal of Econometrics*, 29, 305–325, doi:10.1016/03044076(85)901587.
- Mancl, L. A. and DeRouen, T. A. (2001). A covariance estimator for GEE with improved small-sample properties. *Biometrics*, 57, 126–134, doi:10.1111/j.0006341X.2001.00126.x.
- Mondol, M. H. and Rahman, M. S. (2019). Bias-reduced and separation-proof GEE with small or sparse longitudinal binary data. *Statistics in Medicine*, 38, 2544–2560, doi:10.1002/

sim.8126.

- Morel, J. G., Bokossa, M. C., and Neerchal, N. K. (2003). Small sample correlation for the variance of GEE estimators. *Biometrical Journal*, 45, 395–409, doi:10.1002/bimj.200390021.
- Pan, W. (2001). On the robust variance estimator in generalised estimating equations. *Biometrika*, 88, 901–906, doi:10.1093/biomet/88.3.901.
- Paul, S. and Zhang, X. (2014). Small sample GEE estimation of regression parameters for longitudinal data. *Statistics in Medicine*, 33, 3869–3881, doi:10.1002/sim.6198.
- Wang, M. and Long, Q. (2011). Modified robust variance estimator for generalized estimating equations with improved small-sample performance. *Statistics in Medicine*, 30, 1278–1291, doi:10.1002/sim.4150.
- Westgate, P. M. and Burchett, W. W. (2016). Improving power in small-sample longitudinal studies when using generalized estimating equations. *Statistics in Medicine*, 35, 3733–3744, doi:10.1002/sim.6967.

Examples

```
library(geess)
library(MASS)

# analysis of longitudinal count data using BCg GEE method with Morel et al. covariance estimator
res <- geess(formula = y ~ trt + period + lbase + lage,
             family = poisson, data = epil, id = subject,
             repeated = period, corstr = "unstructured",
             beta.method = "BCGEE", SE.method = "MB")

print(res)

# hypothesis tests for regression coefficients
summary(res)
```

sqrtmat

Square root of nonsymmetric matrix

Description

sqrtmat is used to calculate the square root of $E_i - H_{ii}$, which is an adjustment factor in Kauermann and Carroll-type method.

Usage

```
sqrtmat(M)
```

Arguments

M Square matrix whose square root is to be computed.

Value

The square root of M

References

Kauermann, G. and Carroll, R. J. (2001). A note on the efficiency of sandwich covariance matrix estimation. *Journal of the American Statistical Association*, 96, 1387–1396, doi:[10.1198/016214501753382309](https://doi.org/10.1198/016214501753382309).

Index

geess, [2](#)

sqrmat, [5](#)