

Package ‘mvglmmRank’

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Type Package

Title Multivariate Generalized Linear Mixed Models for Ranking Sports Teams

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Imports numDeriv, methods, stats, utils, MASS

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Description Maximum likelihood estimates are obtained via an EM algorithm with either a first-order or a fully exponential Laplace approximation as documented by Broatch and Karl (2018) <[doi:10.48550/arXiv.1710.05284](https://doi.org/10.48550/arXiv.1710.05284)>, Karl, Yang, and Lohr (2014) <[doi:10.1016/j.csda.2013.11.019](https://doi.org/10.1016/j.csda.2013.11.019)>, and by Karl (2012) <[doi:10.1515/1559-0410.1471](https://doi.org/10.1515/1559-0410.1471)>. Karl and Zimmerman <[doi:10.1016/j.jspi.2020.06.004](https://doi.org/10.1016/j.jspi.2020.06.004)> use this package to illustrate how the home field effect estimator from a mixed model can be biased under nonrandom scheduling.

ByteCompile yes

LazyLoad yes

LazyData yes

License GPL-2

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mvglmmRank-package	<i>mvglmmRank: Multivariate generalized linear mixed models for ranking sports teams</i>
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Description

The package fits multivariate generalized linear mixed models for team scores, win/loss indicators, and margin-of-victory responses. Maximum likelihood estimates are obtained by an EM algorithm using either a first-order or fully exponential Laplace approximation.

Details

See [mvglmmRank](#) for the fitting interface and [game.pred](#) for printed game predictions from fitted models.

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References

Broatch, J.E. and Karl, A.T. (2018). Multivariate Generalized Linear Mixed Models for Joint Estimation of Sporting Outcomes. *Italian Journal of Applied Statistics*, 30(2), 189-211. Also available from <https://arxiv.org/abs/1710.05284>.

Karl, A.T. and Zimmerman, D.L. (2021). A Diagnostic for Bias in Linear Mixed Model Estimators Induced by Dependence Between the Random Effects and the Corresponding Model Matrix. *Journal of Statistical Planning and Inference*, 211, 107-118. doi:10.1016/j.jspi.2020.06.004.

Karl, A.T., Yang, Y. and Lohr, S. (2014). Computation of Maximum Likelihood Estimates for Multiresponse Generalized Linear Mixed Models with Non-nested, Correlated Random Effects. *Computational Statistics & Data Analysis*, 73, 146-162. doi:10.1016/j.csda.2013.11.019.

Karl, A.T. (2012). The Sensitivity of College Football Rankings to Several Modeling Choices. *Journal of Quantitative Analysis in Sports*, 8(3). doi:10.1515/15590410.1471.

binary_cre	<i>Internal function for binary model.</i>
------------	--------------------------------------------

Description

An internal function.

Usage

```
binary_cre(Z_mat = Z_mat, first.order = first.order,
           home.field, control = control)
```

Arguments

Z_mat	data frame.
first.order	logical
home.field	logical
control	list

f2008	<i>2008 FBS College Football Regular Season Data</i>
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Description

2008 FBS College Football Regular Season Data

Usage

```
data(f2008)
```

Format

A data frame with 772 observations on the following 9 variables.

home a factor
 Game.Date a POSIXlt date variable
 away a factor
 home.response a numeric vector
 home.score a numeric vector
 away.response a numeric vector
 away.score a numeric vector
 neutral.site a numeric vector
 partition a numeric vector

Source

<http://web1.ncaa.org/mfb/download.jsp?year=2008&div=IA>

Examples

```
data(f2008)
## maybe str(f2008) ; plot(f2008) ...
```

f2009

2009 FBS College Football Regular Season Data

Description

2009 FBS College Football Regular Season Data

Usage

```
data(f2009)
```

Format

A data frame with 772 observations on the following 7 variables.

home a factor
 Game.Date a POSIXlt date variable
 away a factor
 home.response a numeric vector
 home.score a numeric vector
 away.response a numeric vector
 away.score a numeric vector
 neutral.site a numeric vector
 partition a numeric vector

Source

<http://web1.ncaa.org/mfb/download.jsp?year=2009&div=IA>

Examples

```
data(f2009)
## maybe str(f2009) ; plot(f2009) ...
```

f2010

2010 FBS College Football Regular Season Data

Description

2010 FBS College Football Regular Season Data

Usage

```
data(f2010)
```

Format

A data frame with 770 observations on the following 9 variables.

home a factor

Game.Date a POSIXlt

away a factor

home.response a numeric vector

home.score a numeric vector

away.response a numeric vector

away.score a numeric vector

neutral.site a numeric vector

partition a numeric vector

Source

<http://web1.ncaa.org/mfb/download.jsp?year=2010&div=IA>

Examples

```
data(f2010)
## maybe str(f2010) ; plot(f2010) ...
```

f2011

2011 FBS College Football Regular Season Data

Description

2011 FBS College Football Regular Season Data

Usage

```
data(f2011)
```

Format

A data frame with 781 observations on the following 9 variables.

home a factor

Game.Date a POSIXlt

away a factor

home.response a numeric vector

home.score a numeric vector

away.response a numeric vector

away.score a numeric vector

neutral.site a numeric vector

partition a numeric vector

Source

<http://web1.ncaa.org/mfb/download.jsp?year=2011&div=IA>

Examples

```
data(f2011)
## maybe str(f2011) ; plot(f2011) ...
```

`f2012`*2012 FBS College Football Regular Season Data*

Description

2012 FBS College Football Regular Season Data

Usage

```
data(f2012)
```

Format

A data frame with 809 observations on the following 9 variables.

`home` a factor

`Game.Date` a POSIXlt

`away` a factor

`home.response` a numeric vector

`home.score` a numeric vector

`away.response` a numeric vector

`away.score` a numeric vector

`neutral.site` a numeric vector

`partition` a numeric vector

Source

<http://web1.ncaa.org/mfb/download.jsp?year=2012&div=IA>

Examples

```
data(f2012)
## maybe str(f2012) ; plot(f2012) ...
```

game.pred	<i>Print predictions for a future game</i>
-----------	--------------------------------------------

Description

Uses a fitted `mvglmmRank` object to print predicted scores, win probability, and/or margin of victory for a specified matchup.

Usage

```
game.pred(res, home, away, neutral.site = FALSE)
```

Arguments

res	An object of class "mvglmmRank" returned by <code>mvglmmRank</code> .
home	Character string naming the home team. The name should match a team name in the fitted object.
away	Character string naming the away team. The name should match a team name in the fitted object.
neutral.site	Logical. If TRUE and res was fit with <code>home.field = TRUE</code> using data that included neutral-site games, use the neutral-site score mean and omit the binary home-field effect in the printed prediction. If res was fit with <code>home.field = FALSE</code> , this argument has no additional effect because no home-field fixed effect was modeled.

Details

Neutral-site predictions require the training data supplied to `mvglmmRank` to contain `neutral.site = 1` games. If a fitted score model has no neutral-site mean, neutral-site score predictions may be unavailable.

Value

Prints predictions and returns NULL invisibly.

References

- Broatch, J.E. and Karl, A.T. (2018). Multivariate Generalized Linear Mixed Models for Joint Estimation of Sporting Outcomes. *Italian Journal of Applied Statistics*, 30(2), 189-211. Also available from <https://arxiv.org/abs/1710.05284>.
- Karl, A.T., Yang, Y. and Lohr, S. (2014). Computation of Maximum Likelihood Estimates for Multiresponse Generalized Linear Mixed Models with Non-nested, Correlated Random Effects. *Computational Statistics & Data Analysis*, 73, 146-162. doi:10.1016/j.csda.2013.11.019.
- Karl, A.T. (2012). The Sensitivity of College Football Rankings to Several Modeling Choices. *Journal of Quantitative Analysis in Sports*, 8(3). doi:10.1515/15590410.1471.

See Also[mvglmmRank](#)**Examples**

```
data(nfl2012)
fit <- mvglmmRank(nfl2012, method = "PB0", first.order = TRUE,
                  max.iter.EM = 1, verbose = FALSE)
game.pred(fit, home = "Denver Broncos", away = "Green Bay Packers")
```

`mvglmmRank`*Fit multivariate generalized linear mixed models for sports rankings*

Description

Fits one of several generalized linear mixed models for team scores, win/loss indicators, or margin of victory. The fitted random effects are used as team ratings.

Usage

```
mvglmmRank(
  game.data,
  method = "PB0",
  first.order = FALSE,
  home.field = TRUE,
  max.iter.EM = 1000,
  tol1 = 1e-04,
  tol2 = 1e-04,
  tolFE = 0,
  tol.n = 1e-07,
  verbose = TRUE,
  OT.flag = FALSE,
  Hessian = FALSE,
  REML.N = TRUE
)
```

Arguments

`game.data` A data frame with columns `home`, `away`, `home.response`, and `away.response`. The optional column `binary.response` should contain binary home-team outcomes; if it is omitted, `mvglmmRank()` creates a home-win indicator from the score columns. The optional column `neutral.site` should be 1 for neutral-site games and 0 otherwise; if omitted, all games are treated as non-neutral. If `OT.flag = TRUE`, `game.data` should also contain a numeric OT column with no missing values.

method	Character string naming the model to fit. Choices are "B", "P0", "P1", "N", "NB", "PB0", "PB1", "NB.mov", and "N.mov".
first.order	Logical. If TRUE, use only the first-order Laplace approximation. If FALSE, continue to the fully exponential Laplace approximation where supported.
home.field	Logical. If TRUE, include home-field fixed effects: score models use separate home and away mean scores, plus a neutral-site mean score when neutral-site games are present, and binary models include a home-field effect. If FALSE, score models use a single mean score and binary models use no fixed home-field effect. For margin-of-victory methods, home.field = FALSE omits the fixed home margin effect.
max.iter.EM	Maximum number of EM iterations.
tol1	Convergence tolerance for the first-order Laplace approximation, based on the maximum relative parameter change.
tol2	Convergence tolerance for the fully exponential Laplace approximation. Not used when first.order = TRUE.
tolFE	Intermediate convergence tolerance for the fully exponential approximation. Corrections to the random-effects covariance matrix begin after this tolerance is reached.
tol.n	Convergence tolerance for the normal models. Convergence is declared when $(l_k - l_{k-1})/l_k < tol.n$, where l_k is the log-likelihood at iteration k .
verbose	Logical. If TRUE, print iteration information.
OT.flag	Logical. If TRUE, include the numeric OT column as a score-model fixed effect. Use 0 for games without overtime.
Hessian	Logical. If TRUE, approximate the Hessian of the model parameters by central differences.
REML.N	Logical. If TRUE, use REML estimation for method = "N" and method = "N.mov".

Details

The available methods are:

"B" Binary/probit model for home win/loss indicators.

"P0" Poisson score model without a game-level random effect.

"P1" Poisson score model with a game-level random effect.

"N" Normal score model with an unstructured within-game error covariance matrix.

"NB" Joint normal score and binary/probit win/loss model.

"PB0" Joint Poisson score and binary/probit win/loss model without a game-level random effect.

"PB1" Joint Poisson score and binary/probit win/loss model with a game-level random effect.

"NB.mov" Joint normal margin-of-victory and binary/probit win/loss model.

"N.mov" Normal margin-of-victory model.

Neutral-site games are represented in `game.data$neutral.site`. Use 1 for neutral-site games and 0 otherwise. For neutral-site games, the teams may be assigned to the home and away columns arbitrarily. With `home.field = TRUE`, score models estimate a neutral-site mean score when neutral-site games are present. With `home.field = FALSE`, the home/away and neutral-site mean structure is suppressed.

Setting `first.order = TRUE` yields the first-order Laplace approximation. A partial fully exponential Laplace approximation can be obtained by setting `tol1 > tol2` and `tolFE = 0`. This applies fully exponential corrections to the vector of team ratings, but not to the covariance matrix of this vector. Karl, Yang, and Lohr (2014) show that this approach produces a large portion of the benefit of the fully exponential Laplace approximation in only a fraction of the time.

The "PB1" method is the least scalable, as its memory and computational requirements are at least quadratic in the number of teams plus the number of games.

Value

An object of class "mvgImmRank". The object is a list whose components depend on method and may include:

`n.ratings.offense`, `n.ratings.defense` Normal-model offensive and defensive ratings, or NULL.

`p.ratings.offense`, `p.ratings.defense` Poisson-model offensive and defensive ratings, or NULL.

`b.ratings` Binary/probit win-propensity ratings, or NULL.

`n.ratings.mov` Normal margin-of-victory ratings, or NULL.

`n.mean`, `p.mean`, `b.mean` Estimated fixed-effect means or home-field effects for the fitted model components.

`G`, `G.cor` Random-effects covariance and correlation matrices.

`R`, `R.cor` Normal-model error covariance and correlation matrices, or NULL.

`home.field` Logical indicating whether a home-field effect was modeled.

`Hessian` Numerical Hessian if requested, otherwise NULL.

`parameters` Vector of fitted model parameters.

`actual`, `pred`, `sresid` Observed values, fitted values, and scaled residuals where available.

`N.output` Additional normal-model matrices and covariance output for `method = "N"` and `method = "N.mov"`.

`fixed.effect.model.output` Additional fixed-effect margin-of-victory output for `method = "N.mov"`.

`method` The model method supplied by the user.

References

Broatch, J.E. and Karl, A.T. (2018). Multivariate Generalized Linear Mixed Models for Joint Estimation of Sporting Outcomes. *Italian Journal of Applied Statistics*, 30(2), 189-211. Also available from <https://arxiv.org/abs/1710.05284>.

Karl, A.T. and Zimmerman, D.L. (2021). A Diagnostic for Bias in Linear Mixed Model Estimators Induced by Dependence Between the Random Effects and the Corresponding Model Matrix. *Journal of Statistical Planning and Inference*, 211, 107-118. doi:10.1016/j.jspi.2020.06.004.

Karl, A.T., Yang, Y. and Lohr, S. (2013). Efficient Maximum Likelihood Estimation of Multiple Membership Linear Mixed Models, with an Application to Educational Value-Added Assessments. *Computational Statistics and Data Analysis*, 59, 13-27.

Karl, A.T., Yang, Y. and Lohr, S. (2014). Computation of Maximum Likelihood Estimates for Multiresponse Generalized Linear Mixed Models with Non-nested, Correlated Random Effects. *Computational Statistics & Data Analysis*, 73, 146-162. doi:10.1016/j.csda.2013.11.019.

Karl, A.T. (2012). The Sensitivity of College Football Rankings to Several Modeling Choices. *Journal of Quantitative Analysis in Sports*, 8(3). doi:10.1515/15590410.1471.

See Also

[game.pred](#)

Examples

```
data(nfl2012)
fit <- mvglmmRank(nfl2012, method = "PB0", first.order = TRUE,
                 max.iter.EM = 1, verbose = FALSE)
game.pred(fit, home = "Denver Broncos", away = "Green Bay Packers")

result <- mvglmmRank(nfl2012, method = "PB0", first.order = TRUE,
                    verbose = FALSE)
print(result)
game.pred(result, home = "Denver Broncos", away = "Green Bay Packers")
```

nba2013

2013 NBA Data

Description

2013 NBA Data

Usage

```
data(nba2013)
```

Format

A data frame with 1229 observations on the following 11 variables.

Date a factor

away a factor

home a factor

OT a factor

partition a numeric vector
neutral.site a numeric vector
ot.count a numeric vector
home.response a numeric vector
home.score a numeric vector
away.response a numeric vector
away.score a numeric vector

Source

<http://masseyratings.com/data.php>

Examples

```
data(nba2013)  
## maybe str(nba2013) ; plot(nba2013) ...
```

NB_cre

Internal Function for Normal-Binary Model

Description

Internal Function for Normal-Binary Model

Usage

```
NB_cre(Z_mat = Z_mat, first.order = first.order,  
       home.field = home.field, control = control)
```

Arguments

Z_mat	data frame
first.order	logical
home.field	logical
control	list

NB_mov	<i>Internal Function for Normal-Binary Model</i>
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Description

Internal Function for Normal-Binary Model

Usage

```
NB_mov(Z_mat = Z_mat, first.order = first.order,  
       home.field = home.field, control = control)
```

Arguments

Z_mat	data frame
first.order	logical
home.field	logical
control	list

ncaab2012	<i>2012 NCAA Division I Basketball Results</i>
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Description

2012 NCAA Division I Basketball Results

Usage

```
data(ncaab2012)
```

Format

A data frame with 5253 observations on the following 10 variables.

date	a factor
away	a factor
home	a factor
neutral.site	a numeric vector
partition	a numeric vector
home.win	a numeric vector
home.response	a numeric vector
home.score	a numeric vector
away.response	a numeric vector
away.score	a numeric vector

Source

<http://masseyratings.com/data.php>

Examples

```
data(ncaab2012)
## maybe str(ncaab2012) ; plot(ncaab2012) ...
```

nfl2012	<i>2012 NFL Regular Season Data</i>
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Description

2012 NFL Regular Season Data

Usage

```
data(nfl2012)
```

Format

A data frame with 256 observations on the following 9 variables.

Date a factor
away a factor
home a factor
neutral.site a numeric vector
home.response a numeric vector
home.score a numeric vector
away.response a numeric vector
away.score a numeric vector
partition a numeric vector

Source

<http://masseyratings.com/data.php>

Examples

```
data(nfl2012)
## maybe str(nfl2012) ; plot(nfl2012) ...
```

normal_cre	<i>Internal Function for Normal Model</i>
------------	-------------------------------------------

Description

Internal Function for Normal Model

Usage

```
normal_cre(Z_mat = Z_mat, first.order = first.order,  
           home.field = home.field, control = control)
```

Arguments

Z_mat	data frame
first.order	logical
home.field	logical
control	list

N_mov	<i>Internal Function for Normal MOV model</i>
-------	-----------------------------------------------

Description

Internal Function for Normal MOV model

Usage

```
N_mov(Z_mat = Z_mat, first.order = TRUE,  
      home.field = home.field, control = control)
```

Arguments

Z_mat	data frame
first.order	logical
home.field	logical
control	list

PB_cre

Internal Function for Poisson-binary Model

Description

Internal Function for Poisson-binary Model

Usage

```
PB_cre(Z_mat = Z_mat, first.order = first.order,  
       home.field = home.field, control = control,  
       game.effect = game.effect)
```

Arguments

Z_mat	data frame
first.order	logical
home.field	logical
control	list
game.effect	logical

poisson_cre

Internal Function for Poisson Model

Description

Internal Function for Poisson Model

Usage

```
poisson_cre(Z_mat = Z_mat, first.order = first.order,  
            control = control, game.effect = game.effect,  
            home.field = home.field)
```

Arguments

Z_mat	data frame
first.order	logical
control	logical
game.effect	logical
home.field	logical

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