Package: mvglmmRank (via r-universe)

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Type Package

Title Multivariate Generalized Linear Mixed Models for Ranking Sports Teams

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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>, Karl, Yang, and Lohr (2014) <doi:10.1016/j.csda.2013.11.019>, and by Karl (2012) <doi:10.1515/1559-0410.1471>. Karl and Zimmerman <doi: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

Encoding UTF-8

NeedsCompilation no

Author Andrew T. Karl [cre, aut] (ORCID: <https://orcid.org/0000-0002-5933-8706>), Jennifer Broatch [aut]

Maintainer Andrew T. Karl <akarl@asu.edu>

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Contents

`mvglmmRank-package` *mvglmmRank: Multivariate generalized linear mixed models for ranking sports teams*

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.

Author(s)

Maintainer: Andrew T. Karl <akarl@asu.edu> (ORCID)

Authors:

- Andrew T. Karl <akarl@asu.edu> (ORCID)
- Jennifer Broatch

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.

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binary_cre *Internal function for binary model.*

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 *2008 FBS College Football Regular Season Data*

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` *Print predictions for a future game*

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 `mvglmmRank`.
`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 `home.field = TRUE` 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 `home.field = FALSE`, 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 `"mvglmmRank"`. 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")
```

N_mov *Internal Function for Normal MOV model*

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

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 *Internal Function for Normal-Binary Model*

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

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) ...
```

ncaab2012 *2012 NCAA Division I Basketball Results*

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 *2012 NFL Regular Season Data*

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 *Internal Function for Normal Model*

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

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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