

Package ‘predictmeans’

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Author Dongwen Luo, Siva Ganesh and John Koolgaard

Maintainer Dongwen Luo <dongwen.luo@agresearch.co.nz>

Description Providing functions to diagnose and make inferences from various linear models, such as those obtained from 'aov', 'lm', 'glm', 'gls', 'lme', and 'lmer'. Inferences include predicted means and standard errors, contrasts, multiple comparisons, permutation tests and graphs.

License GPL (>= 2)

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predictmeans-package *Calculate Predicted Means for Linear Models*

Description

This package provides functions to diagnose and make inferences from various linear models, such as those obtained from 'aov', 'lm', 'glm', 'gls', 'lme', and 'lmer'. Inferences include predicted means and standard errors, contrasts, multiple comparisons, permutation tests and graphs.

Details

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Author(s)

Dongwen Luo, Siva Ganesh and John Koolgaard

Maintainer: Dongwen Luo <dongwen.luo@agresearch.co.nz>

References

Welham, S., Cullis, B., Gogel, B., Gilmour, A., & Thompson, R. (2004), *Prediction in linear mixed models*, Australian and New Zealand Journal of Statistics, 46(3), 325-347.

anovalmer *ANOVA of a Linear Mixed Effects Model produced by lmer function*

Description

This function provides ANOVA of a linear mixed effects model for lmer object with model terms' denominate degree of freedom estimated by Kenward-Roger method.

Usage

```
anovalmer(model, DDF=NULL)
```

Arguments

model Model object returned by lmer.
 Df Model terms' denominate degree of freedom specified by user.

Value

ANOVA table.

Author(s)

Dongwen Luo, Siva Ganesh and John Koolgaard

Examples

```
## Not run for simplifying process of submitting pkg to CRAN
library(predictmeans)
Oats$nitro <- factor(Oats$nitro)
fm <- lmer(yield ~ nitro*Variety+(1|Block/Variety), data=Oats)
anova1mer(fm)
```

 contrastmeans

Linear Contrast Tests for a Linear Model

Description

Performs t-tests (or permuted t-tests) of specified contrasts for linear models obtained from functions aov, lm, glm, gls, lme, or lmer.

Usage

```
contrastmeans(model, modelterm, ctrmatrix, ctrnames=NULL, adj="none", Df, permlist)
```

Arguments

model Model object returned by aov, lm, glm, gls, lme, and lmer.
 modelterm Name (in "quotes") for indicating which factor term's contrast to be calculated. The modelterm must be given exactly as it appears in the printed model, e.g. "A" or "A:B".
 ctrmatrix A specified contrast matrix. If ctrmatrix is missing, the programe will ask user to enter it.
 ctrnames Names of the specified contrasts, e.g. c("A vs D", "C vs B", ...)
 adj Name (in "quote") for indicating a method for adjusting p-values of pairwise comparisons. The choices are "none", "tukey", "holm", "hochberg", "hommel", "bonferroni", "BH", "BY" and "fdr". The default method is "none".

Df	A denominator degree of freedom for modelterm. (For glmer models the Df needs to be specified, while for the other models, Df is obtained from the fitted model automatically).
permlist	A model parameter list containing nsim parameters produced by the function permmodels. When permlist != NULL, the option Df will be non-functional. This is a key option for the permutation test.

Value

There are two components in the output which are

Table	A table showing t-test results for the specified linear contrasts.
K	A contrast matrix.

Author(s)

Dongwen Luo, Siva Ganesh and John Koolgaard

References

Torsten Hothorn, Frank Bretz and Peter Westfall (2008), *Simultaneous Inference in General Parametric Models*. *Biometrical*, Journal 50(3), 346–363.

Examples

```
library(predictmeans)
# ftable(xtabs(yield ~ Block+Variety+nitro, data=Oats))
Oats$nitro <- factor(Oats$nitro)
fm <- lme(yield ~ nitro*Variety, random=~1|Block/Variety, data=Oats)
# library(lme4)
# fm <- lmer(yield ~ nitro*Variety+(1|Block/Variety), data=Oats)

## Not run:
## The contrast has a contrast matrix as follows:
#   0:Golden Rain 0:Marvellous 0:Victory
#[1,]           -1           0           1
#[2,]            0           0           1
#   0.2:Golden Rain 0.2:Marvellous 0.2:Victory
#[1,]            0           0           0
#[2,]            0           0           0
#   0.4:Golden Rain 0.4:Marvellous 0.4:Victory
#[1,]            0           0           0
#[2,]            0           -1          0
#   0.6:Golden Rain 0.6:Marvellous 0.6:Victory
#[1,]            0           0           0
#[2,]            0           0           0

# 1. Enter above contrast matrix into a pop up window, then close the window
# contrastmeans(fm, "nitro:Variety")

# 2. Construct the contrast matrix directly
```

```
cm <- rbind(c(-1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0),
           c(0, 0, 1, 0, 0, 0, 0, -1, 0, 0, 0, 0))
contrastmeans(fm, "nitro:Variety", ctrmatrix=cm)
```

CookD

Calculates and plots Cook's distances for a Linear (Mixed) Model

Description

This function produces Cook's distance plots for a linear model obtained from functions `aov`, `lm`, `glm`, `gls`, `lme`, or `lmer`.

Usage

```
CookD(model, group=NULL, plot=TRUE, idn=3, newwd=TRUE)
```

Arguments

<code>model</code>	Model object returned by <code>aov</code> , <code>lm</code> , <code>glm</code> , <code>gls</code> , <code>lme</code> , and <code>lmer</code> .
<code>group</code>	Name (in "quotes") for indicating how observations are deleted for Cook's distance calculation. If <code>group!=NULL</code> then deletions will be along levels of group variable, otherwise, will be along individual observations.
<code>plot</code>	A logical variable; if it is true, a plot of Cook's distance will be presented. The default is TRUE.
<code>idn</code>	An integer indicating the number of top Cook's distances to be labelled in the plot. The default value is 3.
<code>newwd</code>	A logical variable to indicate whether to print graph in a new window. The default value is TRUE.

Author(s)

Dongwen Luo, Siva Ganesh and John Koolgaard

Examples

```
library(predictmeans)
Oats$nitro <- factor(Oats$nitro)
fm <- lme(yield ~ nitro*Variety, random=~1|Block/Variety, data=Oats)
# library(lme4)
# fm <- lmer(yield ~ nitro*Variety+(1|Block/Variety), data=Oats)
CookD(fm)
```

covariatemmeans *Predicted Means of a Linear Model with Covariate Variable(s)*

Description

This function obtains predicted means with graph for a new set of covariate values.

Usage

```
covariatemmeans(model, modelterm=NULL, covariate, as.is=FALSE, level=0.05, Df=NULL,
  trans=NULL, transOff=0, responsen=NULL, trellis=TRUE, plotord=NULL, mtitle=NULL,
  ci=TRUE, point=TRUE, jitterv=0, newwd=TRUE)
```

Arguments

model	Model object returned by aov, lm, glm, gls, lme, and lmer.
modelterm	Name (in "quotes") for indicating which factor term's predicted mean to be calculated. The modelterm must be given exactly as it appears in the printed model, e.g. "A" or "A:B".
covariate	Name(s) (in "quotes") of the covariate variable(s) in the model.
as.is	A logic value to specify wheather or not using original covariate values, the default is FALSE.
level	A significant level for calculating confident interval. The default value is 0.05.
Df	A degree of freedom for calculating CI of predicted means (you can manually specified Df here). For the above models, Df is obtained from the function automatically.
trans	A function object for calculating the back transformed means, e.g. trans=exp.
transOff	When you use trans=exp(x+1), then transOff=1, the default is 0.
responsen	Name (in "quotes") of the back transformed response variable in the model.
trellis	A logical variable. If set to TRUE (default), a trellis plots of predicted means with CI will be drawn.
plotord	A numeric vector specifying the order of plotting for two or three way interaction (e.g. plotord = c(2, 1, 3) will put the second variable in modelterm on the X axis, the first variable as the grouping variable, and the third one as the panel variable). The defaults are c(1, 2) and c(1, 2, 3) for two and three way interactions.
mtitle	The main title in the graph.
ci	A logical variable to indicate whether to print confidence interval. The default value is TRUE.
point	A logical variable to indicate whether to print raw data points. The default value is TRUE.
jitterv	A degree of jitter in x and y direction in the graph. The default is zero.
newwd	A logical variable to indicate whether to print graph in a new window. The default value is TRUE.

Value

Predicted Means

A table of predicted means.

Author(s)

Dongwen Luo, Siva Ganesh and John Koolgaard

Examples

```
library(predictmeans)
data(Oats, package="nlme")
fm <- lme(yield ~ nitro*Variety, random=~1|Block/Variety, data=Oats)
# library(lme4)
# fm <- lmer(yield ~ nitro*Variety+(1|Block/Variety), data=Oats)
covariatemeans(fm, "Variety", covariate="nitro")
```

Kmatrix

Matrix of Coefficients in a Linear Model

Description

This function obtains a matrix of coefficients for parametric models such as aov, lm, glm, gls, lme, and lmer.

Usage

```
Kmatrix(model, modelterm, covariate=NULL, as.is=FALSE, prtnum=FALSE)
```

Arguments

model	Model object returned by aov, lm, glm, gls, lme, and lmer.
modelterm	Name (in "quotes") for indicating which model term's predicted mean to be calculated. The modelterm must be given exactly as it appears in the printed model, e.g. "A" or "A:B".
covariate	A numerical vector to specify values of covariates for calculating predicted means, default values are the means of the associated covariates. It also can be the name of covariate in the model.
as.is	A logic value to specify wheather or not using original covariate values, the default is FALSE.
prtnum	An option for printing covariate info on the screen or not. The default is FALSE.

Value

K	Coefficients matrix
fctnames	A model frame contains factor(s) info in the model.
response	The name of response variable in the model.

Author(s)

This function heavily depends on the codes from package "lsmeans".

References

Welham, S., Cullis, B., Gogel, B., Gilmour, A., & Thompson, R. (2004), *Prediction in linear mixed models*, Australian and New Zealand Journal of Statistics, 46(3), 325-347.

Examples

```
library(predictmeans)
# library(lme4)
# fm <- lmer(yield ~ nitro*Variety+(1|Block/Variety), data=Oats)
fm <- lme(yield ~ nitro*Variety, random=~1|Block/Variety, data=Oats)
Kmatrix(fm, "Variety", prtnum=TRUE)
Kmatrix(fm, "Variety", 0.5, prtnum=TRUE)
# Kmatrix(fm, "Variety", "nitro")
```

permanova.lmer

Permutation ANOVA for lmer Model

Description

This function provides permutation ANOVA for lmer model.

Usage

```
permanova.lmer(model, perms = 999, ncore=3, drop=TRUE)
```

Arguments

model	Model object returned by lmer.
perms	Number of permutation, the default value is 999.
ncore	Number of core for parallel computing, the default value is 3.
drop	Drop or add model term sequentially, the default value is TRUE.

Value

Permutation ANOVA table.

Author(s)

Dongwen Luo, Siva Ganesh and John Koolaard

Examples

```

library(predictmeans)
Oats$nitro <- factor(Oats$nitro)
fm <- lmer(yield ~ nitro*Variety+(1|Block/Variety), data=Oats)

## Permutation Test for model terms
# permanova.lmer(fm)
# permanova.lmer(fm, drop=FALSE)
## Compare to F test
# fm0 <- lme(yield ~ nitro*Variety, random=~1|Block/Variety, data=Oats)
# anova(fm0)

```

perindex

*Permutation Index***Description**

This function obtains permutation index for a dataset.

Usage

```
perindex(data, block=NULL, group=NULL, nsim=4999)
```

Arguments

data	Data object used in the model fitting.
block	Name (in "quotes") for the blocking factor in the data.
group	Name (in "quotes") for the group factor in the data.
nsim	The number of permutations. The default is 4999.

Value

A matrix has 'nsim' columns of permuted index.

Author(s)

Dongwen Luo, Siva Ganesh and John Koolgaard

Examples

```

library(predictmeans)
block <- rep(1:3, each=12)
group <- rep(rep(1:3, each=4), 3)
data <- data.frame(block, group)
cbind(data, perindex(data, block="block", group="group", nsim=5))
# Permute group as a whole within each block first,
# then permute obs within each group.
cbind(data, perindex(data, block="block", nsim=5))

```

```

# Permute obs within each block only.
cbind(data, permindex(data, group="group", nsim=5))
# Permute groups as a whole block first,
# then permute obs within each group.
cbind(data, permindex(data, nsim=5)) # Free permutation.

```

permlmer

Permutation Test of random or fixed effects for lmer model.

Description

This function provides permutation tests for the terms in a linear mixed model of lmer.

Usage

```
permlmer(lmer0, lmer1, perms = 999, ncore=3, plot=TRUE)
```

Arguments

lmer0	lmer model under H0, note that lmer0 model must nest within lmer1 model.
lmer1	lmer model under H1, note that lmer0 model must nest within lmer1 model.
perms	Number of permutation, the default value is 999.
ncore	Number of core for parallel computing, the default value is 3.
plot	Plot permutation distribution or not, the default value is TRUE.

Value

Permutation p-value.

Author(s)

Dongwen Luo, Siva Ganesh and John Koolgaard

References

Oliver E. Lee and Thomas M. Braun (2012), *Permutation Tests for Random Effects in Linear Mixed Models*. *Biometrics*, Journal 68(2).

Examples

```

# library(predictmeans)
## Test random effects
# fm1 <- lmer(Reaction ~ Days + (Days | Subject), sleepstudy)
# fm2 <- lmer(Reaction ~ Days + (Days || Subject), sleepstudy)
# fm3 <- update(fm1, . ~ . - (Days | Subject) + (1 | Subject))
# anova(fm1, fm2, fm3)
# permlmer(fm3, fm2)
# permlmer(fm2, fm1)

```

```
## Test fixed effects
# Oats$nitro <- factor(Oats$nitro)
# fm0 <- lmer(yield ~ nitro+Variety+(1|Block/Variety), data=Oats)
# fm <- lmer(yield ~ nitro*Variety+(1|Block/Variety), data=Oats)
# permlmer(fm0, fm)
```

PMplot

Level Plot of a Matrix of p-values.

Description

Creates a plot of p-values of pairwise comparisons.

Usage

```
PMplot(pmatrix, level=0.05, mtitle=NULL, xlabel=NULL, margin=5, legendx=0.73,
newwd=TRUE)
```

Arguments

pmatrix	A matrix with p-values from pairwise comparisons. (This is a lower triangle matrix.)
level	The level of p-value to be highlighted. Default is 0.05.
mtitle	The main title in the graph.
xlabel	The x and y labels in the graph.
margin	A value for specifying x and y margins in the graph. The default value is 5.
legendx	A value for specifying x coordinate of legend. The default value is 0.73.
newwd	A logical variable to indicate whether to print graph in a new window. The default is TRUE.

Author(s)

Dongwen Luo, Siva Ganesh and John Koolaard

Examples

```
library(predictmeans)
set.seed(2013)
pvalues <- runif(28)
pmatrix <- matrix(0,8,8)
pmatrix[lower.tri(pmatrix)] <- pvalues
round(pmatrix, 4)
PMplot(pmatrix)

Oats$nitro <- factor(Oats$nitro)
fm <- lmer(yield ~ nitro*Variety+(1|Block/Variety), data=Oats)
```

```
predictout <- predictmeans(fm, "nitro:Variety", atvar="Variety", adj="BH", barplot=TRUE)
PMplot(predictout$p_valueMatrix)
```

predictmeans

Predicted Means of a Linear Model

Description

This function obtains predicted means, SE of means, SED of means, LSDs and plots of means with Stder bar or LSD bar for parametric models such as aov, lm, glm, gls, lme, and lmer. The function also perfomrs pairwise comparisons and permutation tests.

Usage

```
predictmeans(model, modelterm, pairwise=FALSE, atvar=NULL, adj="none", Df=NULL,
  level=0.05, covariate=NULL, letterdecr=TRUE, trans = NULL, transOff = 0,
  responsen=NULL, count=FALSE, plotord=NULL, plottitle=NULL, plotxlab=NULL,
  plotylab=NULL, mplot=TRUE, barplot=FALSE, pplot=TRUE, bkplot=TRUE, plot=TRUE,
  jitterv=0, basesz=12, prtnum=TRUE, newwd=TRUE, permlist=NULL)
```

Arguments

model	Model object returned by aov, lm, glm, gls, lme, and lmer.
modelterm	Name (in "quotes") for indicating which factor term's predicted mean to be calculated. The modelterm must be given exactly as it appears in the printed model, e.g. "A" or "A:B".
pairwise	An option for showing pair-wise LSDs and p-values, or not. The default is FALSE.
atvar	When pairwise = TRUE, a quoted name indicating within levels of which variable in modelterm the multiple comparison will be performed.
adj	Name (in "quote") for indicating a method for adjusting p-values of pairwise comparisons. The choices are "none", "tukey", "holm", "hochberg", "hommel", "bonferroni", "BH", "BY" and "fdr". The default method is "none". Note that LSD can't be adjusted except for "bonferroni" method.
Df	A degree of freedom for calculating LSD. For the above models, Df is obtained from the function automatically.
level	A significant level for calculating LSD. The default value is 0.05.
covariate	A numerical vector to specify values of covariates for calculating predicted means. The default values are the means of the associated covariates.
letterdecr	A logical variable to indicate whether to print letters for multiple comparisons by decreasing order. The default is TRUE.
trans	A function object for calculating the back transformed means, e.g. trans=exp.
transOff	When you use trans=exp(x+1), then transOff=1, the default is 0.

responen	Name (in "quotes") of the back transformed response variable in the model.
count	An option for indicating the back transformed mean values are counts or not. The default is FALSE.
plotord	A numeric vector specifying the order of plotting for two or three way interaction (e.g. plotord = c(2, 1, 3) will put the second variable in modelterm on the X axis, the first variable as the grouping variable, and the third one as the panel variable). The defaults are c(1, 2) and c(1, 2, 3) for two and three way interactions.
plottitle	A character vector specifying the main title for plot(s). The default is NULL.
plotxlab	A character vector specifying the x label for plot(s). The default is NULL.
plotylab	A character vector specifying the y label for plot(s). The default is NULL.
mplot	An option for drawing a means plot, or not. The default is TRUE.
barplot	An option for drawing a bar chart, or not. The default is FALSE.
pplot	An option for drawing a p-values plot, or not when there are more than six p-values. The default is TRUE.
bkplot	An option for drawing back transformed plot, or not. The default is TRUE.
plot	An option for drawing plots, or not. The default is TRUE.
jitterv	A degree of jitter in x and y direction in the back transformed means graph. The default is zero.
basesz	The base font size. The default is 12.
prtnum	An option for printing covariate information on the screen, or not. The default is TRUE.
newwd	A logical variable to indicate whether to print graph in a new window. The default is TRUE.
permlist	A model parameter list produced by the function permmodels. When permlist != NULL, the option Df will be non-functional. This is a key option for pairwise comparisons via permutation tests.

Value

Predicted Means	A table of predicted means.
Standard Error of Means	A table of standard errors of predicted means.
Standard Error of Differences	Standard errors of differences between predicted means.
LSD	Least significant differences between predicted means.
Back Transformed Means	When trans!=NULL, a table of back transformed means with CIs are shown.
Pairwise p-value	A matrix with t-values above the diagonal and p-values below the diagonal, or matrix of pairwise comparison p-values for each level of atvar.

```

predictmeansPlot
    ggplot of predicted means.
predictmeansBKPlot
    ggplot of back transformed means.
predictmeansBarPlot
    gg bar plot of predicted means.
p_valueMatrix  p_value matrix for pairwise comparison.

```

Note

The predictmeans function becomes confused if a factor or covariate is changed to the other in a model formula. Consequently, formulae that include calls `as.factor`, `factor`, or `numeric` (e.g. `as.factor(income)`) will cause errors. Instead, create the modified variables outside of the model formula (e.g., `fincome <- as.factor(income)`) and then use them in the model formula.

Factors cannot have colons in level names (e.g., "level:A"); the predictmeans function will confuse the colons with interactions; rename levels to avoid colons.

For predictmeans function, it is assumed that methods `coef`, `vcov`, `model.matrix`, `model.frame` and `terms` are available for `model`.

Author(s)

Dongwen Luo, Siva Ganesh and John Koolgaard

References

Torsten Hothorn, Frank Bretz and Peter Westfall (2008), *Simultaneous Inference in General Parametric Models*. *Biometrical*, Journal 50(3), 346–363.

Welham, S., Cullis, B., Gogel, B., Gilmore, A., & Thompson, R. (2004), *Prediction in linear mixed models*, Australian and New Zealand Journal of Statistics, 46(3), 325-347.

Examples

```

library(predictmeans)
ftable(xtabs(yield ~ Block+Variety+nitro, data=Oats))
Oats$nitro <- factor(Oats$nitro)
fm <- lme(yield ~ nitro*Variety, random=~1|Block/Variety, data=Oats)
# library(lme4)
# fm <- lmer(yield ~ nitro*Variety+(1|Block/Variety), data=Oats)
predictmeans(fm, "nitro", adj="BH")
predictmeans(fm, "nitro:Variety", atvar="Variety", adj="BH")
predictout <- predictmeans(fm, "nitro:Variety", atvar="Variety", adj="BH", barplot=TRUE)
names(predictout)
print(predictout$predictmeansPlot)
print(predictout$predictmeansBarPlot)

```

residplot

*Diagnostic Plots for a Linear (Mixed) Model***Description**

This function produces diagnostic plots for linear models including 'aov', 'lm', 'glm', 'gls', 'lme' and 'lmer'.

Usage

```
residplot(model, group = "none", level = 1, slope = FALSE, id = FALSE, newwd=TRUE,
          ask=FALSE)
```

Arguments

model	Model object returned by aov, lm, glm, gls, lme, and lmer.
group	Name (in "quotes") for indicating the variable used to show grouping in the residual vs predicted plot. If variable is a term in the model, then group will be a name of the variable such as group="A", otherwise group will be the actual variable such as group=data\$A.
level	An integer 1, 2, etc. used to specify a level of the random effect for plotting. The default value is 1.
slope	A logical variable. If set to TRUE, a Q-Q plot of random slope will be drawn.
id	A logical variable. If set to TRUE, outliers in the residual vs fitted plot can be identified interactively.
newwd	A logical variable to indicate whether to print graph in a new window. The default is TRUE.
ask	logical. If TRUE (and the R session is interactive) the user is asked for input, before a new figure is drawn.

Author(s)

Dongwen Luo, Siva Ganesh and John Koolgaard

Examples

```
## Note that the order of levels of nested random effects is oposite
## between lme and lmer objects.

library(predictmeans)
Oats$nitro <- factor(Oats$nitro)
fm <- lme(yield ~ nitro*Variety, random=~1|Block/Variety, data=Oats)
residplot(fm, level=2) #lme: level=2 for random effect "Block:Variety"

# Not Run
# library(lme4)
# fm <- lmer(yield ~ nitro*Variety+(1|Block/Variety), data=Oats)
# residplot(fm) # lmer: By default level=1 for random effect "Block:Variety"
```

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