# Package 'predictmeans'

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**Type** Package

**Title** Calculate Predicted Means for Linear Models

**Version** 0.99

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**Author** Dongwen Luo, Siva Ganesh and John Koolaard

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

**Description** This package provides functions to diagnose
and make inferences from various linear models, such as those ob-
tained 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)

**Depends** R (>= 3.0.0), lme4, nlme

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# R topics documented:

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predictmeans-package          *Calculate Predicted Means for Linear Models*

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### 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

|          |             |
|----------|-------------|
| Package: | predictmeans |
| Type:    | Package     |
| Version: | 0.99        |
| Date:    | 2014-03-13  |
| License: | GPL (>= 2)  |

### Author(s)

Dongwen Luo, Siva Ganesh and John Koolaard

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.

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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 Koolaard

## 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

model        Model object returned by aov, lm, glm, gls, lme, and lmer.

group        Name (in "quotes") for indicating how observations are deleted for Cook's distance calculation. If group!=NULL then deletions will be along levels of group variable, otherwise, will be along individual observations.

plot         A logical variable; if it is true, a plot of Cook's distance will be presented. The default is TRUE.

idn          An integer indicating the number of top Cook's distances to be labelled in the plot. The default value is 3.

newwd        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 Koolaard

## 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)
```

---

| covariatemeans | *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

```
covariatemeans(model, modelterm=NULL, covariate, level=0.05, Df=NULL,
  trans=NULL, responsen=NULL, trillis=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. |
| 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. |
| responsen | Name (in "quotes") of the back transformed response variable in the model. |
| trillis | A logical variable. If set to TRUE (default), a trillis 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 Koolaard

## 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, 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. |
| 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")
```

---

| permindex | *Permutation Index* |
|---|---|

---

## Description

This function obtains permutation index for a dataset.

## Usage

```
permindex(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 Koolaard

## Examples

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

---

| permmodels | *Permutation Test of Linear Model* |
| --- | --- |

---

## Description

This function provides permutation t-tests for coefficients of (fixed) effects and permutation F-tests for the terms in a linear model such as aov, lm, glm, gls, lme, and lmer.

## Usage

```
permmodels(model, data, block=NULL, group=NULL, covariate=NULL, nsim=4999, check=FALSE,
  exact=FALSE, fo=NULL, prt=TRUE)
```

## Arguments

| | |
| --- | --- |
| model | Model object returned by aov, lm, glm, gls, lme, and lmer. |
| 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. |
| covariate | Name(s) (in "quotes") for the covariate variable(s) in the model. |
| nsim | The number of permutations. The default is 4999. |
| check | a logical variable to indicate whether or not you want to check permutation results, the default is FALSE. |
| exact | A logical variable to indicate whether or not exact no. of permutations will be used (applicable only to free the permutation case). The default is FALSE. |
| fo | A model formula used in the model; fo!=NULL when the formula is specified by function formula. |
| prt | A logical variable to indicate whether or not to print output on the screen. The default is TRUE. |

## Value

The function produces permutation t-test table for coefficients of (fixed) effects, permutation ANOVA table for model terms and a model parameter list `permlist`, a list containing `nsim=4999` times permutation refitted `model` parameters which are used in functions `predictmeans` and `contrastmeans`.

## Author(s)

Dongwen Luo, Siva Ganesh and John Koolaard

## Examples

```
## Not run for simplifying process of submiting pkg to CRAN
#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)
#
## Permutation Test for model terms
#system.time(
#  permlme <- permmodels(model=fm, data=Oats, block="Block", group="Variety", nsim=999)
#)
#
## Permutation Test for multiple comparisons
#predictmeans(model=fm, modelterm="nitro:Variety", atvar="Variety", adj="BH",
#  permlist=permlme, plot=FALSE)
#
## Permutation Test for specified contrasts
#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(model=fm, modelterm="nitro:Variety", ctrmatrix=cm, permlist=permlme)
```

---

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, xylabel=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. |
| `xylabel` | 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)
```

---

| 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, trans = NULL, responsen=NULL,
  count=FALSE, plotord=NULL, plottitle=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". |
| 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. |
| trans | A function object for calculating the back transformed means, e.g. trans=exp. |
| responsen | 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. |
| 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.

**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 con-
fuse 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 Koolaard

**References**

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

Welham, S., Cullis, B., Gogel, B., Gilm our, 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", pair=TRUE, atvar="Variety", adj="BH")
```

---

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)
```

### 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. |

### Author(s)

Dongwen Luo, Siva Ganesh and John Koolaard

### 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"
```

# Index