Package 'MuMIn'

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Description Model selection and model averaging based on information criteria (AICc and alike).

License GPL

Suggests lme4

LazyLoad yes

R topics documented:

`MuMIn-package` *Multi-model inference*

Description

The package `MuMIn` contains functions for (automated) model selection and model averaging based on information criteria (AIC alike).

Details

User level functions include:

`model.avg` does model averaging.

`get.models` evaluates models from the table returned by dredge.

`dredge` runs models with combinations of terms of the supplied 'global.model'.

`AICc` calculates second-order Akaike information criterion for one or several fitted model objects.

Author(s)

Kamil Bartoń `<kamil.barton@go2.pl>`

References

Burnham, K. P. and Anderson, D. R (2002) *Model selection and multimodel inference: a practical information-theoretic approach*. 2nd ed.

See Also

`AIC`, `step`

Examples

```
fm1 <- lm(Fertility ~ . , data = swiss)

dd <- dredge(fm1)
top.models.1 <- get.models(dd, subset = delta < 4)
model.avg(top.models.1) # get averaged coefficients

top.models.2 <- get.models(dd, cumsum(weight) <= .95)
model.avg(top.models.2) # get averaged coefficients

# Mixed models:
# modified example(lme)
data(Orthodont, package="nlme")
require(nlme)
fm2 <- lme(distance ~ age + Sex, data = Orthodont, random = ~ 1 | Subject,
method="ML")
dredge(fm2)
```

AICc — *Second-order Akaike Information Criterion*

Description

Calculates second-order Akaike information criterion for one or several fitted model objects (AIC for small samples).

Usage

```
AICc(object, ..., k = 2)
```

Arguments

`object`	a fitted model object
`...`	optionally more fitted model objects
`k`	the "penalty" per parameter to be used; the default `k` = 2 is the classical `AIC`

Value

If just one object is provided, returns a numeric value with the corresponding AICc; if more than one object are provided, returns a `data.frame` with rows corresponding to the objects and columns representing the number of parameters in the model (df), AICc and the `AIC`.

Author(s)

Kamil Bartoń

References

Burnham, K. P. and Anderson, D. R (2002) *Model selection and multimodel inference: a practical information-theoretic approach*. 2nd ed.

See Also

Akaike's An Information Criterion: `AIC`

Cement — *Cement hardening data*

Description

Cement hardening data from Woods et al (1939).

Usage

```
data(Cement)
```

Format

`Cement` is a data frame with 5 variables. x1-x4 are four predictor variables expressed as a percentage of weight.

X1 calcium aluminate

X2 tricalcium silicate

X3 tetracalcium alumino ferrite

X4 dicalcium silicate

y calories of heat evolved per gram of cement after 180 days of hardening

Author(s)

Kamil Bartoń

Source

Woods H., Steinour H.H., Starke H.R. (1932) Effect of composition of Portland cement on heat evolved during hardening. *Industrial & Engineering Chemistry* 24, 1207-1214

References

Burnham, K. P. and Anderson, D. R (2002) *Model selection and multimodel inference: a practical information-theoretic approach*. 2nd ed.

`dredge` *Evaluate "all possible" models*

Description

Runs models with all possible combinations of the explanatory variables in the supplied model.

Usage

```
dredge(global.model, beta = FALSE, eval = TRUE, rank = "AICc",
fixed = NULL, m.max = NA, subset, marg.ex = NULL, trace = FALSE, ...)

## S3 method for class 'model.selection':
print(x, abbrev.names = TRUE, ...)
```

Arguments

`global.model`	a fitted 'global' model object. Currently, it can be a `lm`, `glm`, `rlm`, `gam`, `gls`, `lme`, `lmer`, `sarlm` or `spautolm`, but also other types are likely to work (untested).
`beta`	logical should standardized coefficients be returned rather than normal ones?
`eval`	whether to evaluate and rank the models. If FALSE, a list of all possible model formulas is returned
`rank`	optional custom rank function (information criterion) to be used instead AICc, e.g. `QAIC` or `BIC`, See 'Details'

fixed	optional, either a single sided formula or a character vector giving names of terms to be included in all models
m.max	optional, maximum number of terms to be included in single model, defaults to the number of terms in global.model
subset	logical expression to put additional constraints for the set of models. Can contain any of the global.model terms. Run getAllTerms(global.model) to list all the terms. Complex expressions (e.g smooth functions in gam models) should be treated as non-syntactic names and enclosed in backticks (see Quotes). Mind the spacing, names must match exactly the term names in model's formula. To simply keep variables in all models, use of fixed is preferred.
marg.ex	a character vector specyfying names of variables for which NOT to check for marginality restrictions when generating model formulas. If this argument is set to TRUE, all model formulas are used (i.e. no checking). See 'Details'.
trace	if TRUE, all calls to the fitting function (i.e. updated global.model calls) are printed.
x	a model.selection object, returned by dredge.
abbrev.names	Should variable names be abbreviated when printing? (useful with many variables)
...	optional arguments for the rank function. Any can be an expression (of mode call), in which case any x within it will be substituted with a current model.

Details

Models are run one by one by calling update with modified formula argument. This method, while robust in that it can be applied to a variety of different models, is not very efficient, so may be time (and memory) consuming.

Handling interactions, dredge respects marginality constraints, so "all possible combinations" do not include models containing interactions without their respective main effects. This behaviour can be altered by marg.ex argument. It can be used to allow for simple nested designs. For example, with global model of form a / (x + z), use marg.ex = "a" and fixed = "a".

rank is found by a call to match.fun and typically is specified as a function or a symbol (e.g. a backquoted name) or a character string specifying a function to be searched for from the environment of the call to lapply.

Function rank must be able to accept model as a first argument and must always return a scalar.

Value

dredge returns an object of class model.selection, being a data.frame with models' coefficients, k, deviance/RSS, R-squared, AIC, AICc, delta and weight. This depends on a type of model. Models are ordered according to AICc (lowest on top), or by rank function if specified. The attribute "formulas" is a list containing model formulas.

Note

Make sure there is no a na.action set to na.omit in global.model. This can result with models fitted to different data sets, if there are NA's present.

Author(s)

Kamil Bartoń

See Also

get.models, model.avg. QAIC has examples of using custom rank function.

There is also subset.model.selection method.

Examples

```
# Example from Burnham and Anderson (2002), page 100:
data(Cement)
lm1 <- lm(y ~ ., data = Cement)
dd <- dredge(lm1)
subset(dd, delta < 4)

#models with delta.aicc < 4
model.avg(get.models(dd, subset = delta < 4)) # get averaged coefficients

#or as a 95% confidence set:
top.models <- get.models(dd, cumsum(weight) <= .95)

model.avg(top.models) # get averaged coefficients

#topmost model:
top.models[[1]]

## Not run:
# Examples of using 'subset':
# exclude models with with both X1 and X2
dredge(lm1, subset = !X1 | !X2)
# keep only models with X3
dredge(lm1, subset = X3)
# the same, but more effective:
dredge(lm1, fixed = ~ X3)

## End(Not run)
```

---

get.models *Get models*

Description

Gets list of models from a model.selection object

Usage

```
get.models(dd, subset = delta <= 4, ...)
```

Arguments

dd	object returned by dredge
subset	subset of models
...	additional parameters passed to update, for example, in lme/lmer one may want to use method = "REML" while using "ML" for model selection

Value

`list` of models.

Author(s)

Kamil Bartoń

See Also

`dredge`, `model.avg`

Examples

```
# Mixed models:

require(nlme)
fm2 <- lme(distance ~ age + Sex, data = Orthodont,
random = ~ 1 | Subject, method="ML")
dd2 <- dredge(fm2)

# Get top-most models, but fitted by REML:
(top.models.2 <- get.models(dd2, subset = delta < 4, method = "REML"))
```

`miscellaneous` *Helper functions*

Description

`beta.weights` - computes standardized coefficients (beta weights) for a model;

`coeffs` - extracts model coefficients;

`getAllTerms` - extracts independent variable names from a model object;

`tTable` - extracts a table of coefficients, standard errors, and p-values from a model object;

`Weights` - calculates Akaike weights (normalized relative likelihoods)

Usage

```
beta.weights(model)
coeffs(model)
getAllTerms(x, ...)
## S3 method for class 'terms':
getAllTerms(x, offset = TRUE, ...)
tTable(model, ...)
Weights(aic, ...)

cbindDataFrameList(x)
rbindDataFrameList(x)
```

Arguments

model	a fitted model object
x	a fitted model object or a formula. for *bindDataFrameList, a list of data.frames
offset	should 'offset' terms be included?
...	other arguments, not used
aic	a vector of AIC (or other information criterion) values

Details

The functions coeffs, getAllTerms and tTable provide an interface between the model and model.avg (as well as dredge). Custom methods can be written to provide support for additional classes of models. Also, a logLik method must exist for object.

Note

coeffs's value is in most cases identical to that returned by coef, the only difference is that it returns fixed effects' coefficients for mixed models.

Functions *bindDataFrameList are not exported from the name space, use MuMIn:::cbindDataFrameList to access them.

Author(s)

Kamil Bartoń

See Also

dredge

---

model.avg *Model averaging*

Description

Model averaging based on an information criterion.

Usage

```
model.avg(m1, ..., beta = FALSE, method = c("0", "NA"), rank = NULL,
rank.args = NULL, alpha = 0.05)

## S3 method for class 'averaging':
coef(object, ...)

## S3 method for class 'averaging':
predict(object, newdata, se.fit = NULL, interval = NULL,
type=NULL, ...)
```

Arguments

m1	A fitted model object or a list of such objects. See 'Details'
beta	Logical, should standardized coefficients be returned rather than normal ones?
method	If set to "0" (default), terms missing in one model are assumed to be 0's, otherwise they are omitted from the weighted average. See 'Details'.
rank	Custom rank function (information criterion) to use instead of AICc, e.g. QAIC or BIC, may be omitted if m1 is a list returned by dredge. See 'Details'.
rank.args	Optional list of arguments for the rank function. If one is an expression, an x within it is substituted with a current model.
alpha	Significance level for calculatinq confidence intervals.
object	An object returned by model.avg.
newdata	An optional data frame in which to look for variables with which to predict. If omitted, the fitted values are used.
se.fit,interval	Currently not used.
type	Ignored. Only predictions on the link scale are allowed. Warning is given if user tries something else here.
...	for model.avg - more fitted model objects, for predict - arguments to be passed to respective predict method

Details

model.avg has been tested to work with lm, glm; rlm (**MASS**); gam (**mgcv**); lme, gls (**nlme**), lmer (**lme4**), as well as with sarlm and spautolm (**spdep**). Other types are also likely to work, in particular when they inherit from the supported classes. See 'Details' section of the Miscellaneous page to see how to provide support for other types of models.

rank is found by a call to match.fun and typically is specified as a function or a symbol (e.g. a backquoted name) or a character string specifying a function to be searched for from the environment of the call to lapply.

Function rank must be able to accept model as a first argument and must always return a scalar.

predict.averaging supports method="NA" only for linear, fixed effect models. In other cases (e.g. nonlinear or mixed models), prediction is obtained using "brute force", i.e. by calling predict on each component model and weighted averaging the results, which is equivalent to assuming that missing coefficients equal zero (method="0").

Apart from predict and coef, other default methods, such as formula and residuals may be used.

Value

An object of class averaging, being a list with elements:

summary	Model table with deviance, AICc, Delta and weight.
coefficients	the model coefficients
variance	variance of coefficients
avg.model	averaged model summary (data.frame with columns: coef - averaged coefficients, var - unconditional variance estimator, ase - adjusted standard error estimator, lci, uci - unconditional confidence intervals)

`relative.importance`
: relative variable importances

`variable.codes`
: Variable names with numerical codes used in the summary

`relative.importance`
: Relative importance of variables

`weights`

`beta`
: (logical) were standardized coefficients used?

`model`
: the model matrix, analogical to one that would be used in a single model.

`residuals`
: the residuals (response minus fitted values).

Note

`predict.averaging` relies on availability of the `predict` methods for the component model classes (except for `(g)lm`).

Author(s)

Kamil Bartoń

References

Burnham, K. P. and Anderson, D. R (2002) *Model selection and multimodel inference: a practical information-theoretic approach*. 2nd ed.

See Also

`dredge`, `get.models`. `QAIC` has examples of using custom rank function.

Examples

```
require(graphics)

# Example from Burnham and Anderson (2002), page 100:
data(Cement)
lm1 <- lm(y ~ ., data = Cement)
dd <- dredge(lm1)
dd

#models with delta.aicc < 4
model.avg(get.models(dd, subset = delta < 4)) # get averaged coefficients

#or as a 95% confidence set:
top.models <- get.models(dd, cumsum(weight) <= .95)

model.avg(top.models) # get averaged coefficients

#topmost model:
top.models[[1]]

## Not run:
# using BIC (Schwarz's Bayesian criterion) to rank the models
BIC <- function(x) AIC(x, k=log(length(residuals(x))))
```

```
mav <- model.avg(top.models, rank=BIC)

## End(Not run)


# Predicted values
nseq <- function(x, len=length(x)) seq(min(x, na.rm=TRUE), max(x, na.rm=TRUE),
length=len)

# New predictors: X1 along the range of original data, other variables held
# constant at their means
newdata <- as.data.frame(lapply(lapply(Cement[1:5], mean), rep, 25))
newdata$X1 <- nseq(Cement$X1, nrow(newdata))

# Predictions from each of the models in a set:
pred <- sapply(top.models, predict, newdata=newdata)
# Add predictions from the models averaged using two methods:
pred <- cbind(pred,
averaged.0=predict(model.avg(top.models, method="0"), newdata),
averaged.NA=predict(model.avg(top.models, method="NA"), newdata)
)

matplot(x=newdata$X1, y=pred, type="l", lwd=c(rep(1,ncol(pred)-2), 2, 2),
xlab="X1", ylab="y")

legend("topleft",
legend=c(lapply(top.models, formula),
paste("Averaged model (method=", c("0", "NA"), ")", sep="")),
col=1:6, lty=1:5, lwd=c(rep(1,ncol(pred)-2), 2, 2), cex = .75
)


## Not run:
# Example with gam models (based on "example(gam)")
require(mgcv)
dat <- gamSim(1, n = 500, dist="poisson", scale=0.1)

gam1 <- gam(y ~ s(x0) + s(x1) + s(x2) +  s(x3) + (x1+x2+x3)^2,
family = poisson, data = dat, method = "REML")

cat(dQuote(getAllTerms(gam1)), "\n")

# include only models with smooth OR linear term (but not both) for each variable:
dd <- dredge(gam1, subset=(!`s(x1)` | !x1) & (!`s(x2)` | !x2) & (!`s(x3)` | !x3))
# ...this may take a while.

subset(dd, cumsum(weight) < .95)

top.models <- get.models(dd, cumsum(weight) <= .95)

newdata <- as.data.frame(lapply(lapply(dat, mean), rep, 50))
newdata$x1 <- nseq(dat$x1, nrow(newdata))
pred <- cbind(
sapply(top.models, predict, newdata=newdata),
averaged=predict(model.avg(top.models), newdata)
)
```

```
matplot(x=newdata$x1, y=pred, type="l", lwd=c(rep(1,ncol(pred)-2), 2, 2),
xlab="x1", ylab="y")

## End(Not run)
```

`par.avg` *Parameter averaging*

Description

Averages single parameter based on provided weights

Usage

```
par.avg(x, se, npar, weight, alpha = 0.05)
```

Arguments

`x`	vector of parameters
`se`	vector of standard errors
`npar`	vector giving numbers of estimated parameters
`weight`	vector of weights
`alpha`	significance level for calculatinq confidence intervals

Value

par.avg returns a vector with named elements:

`Coefficient`	model coefficients
`Variance`	unconditional variance of coefficients
`Unconditional SE`	
`Lower CI, Upper CI`	relative variable importances

Author(s)

Kamil Bartoń

References

Burnham, K. P. and Anderson, D. R (2002) *Model selection and multimodel inference: a practical information-theoretic approach*. 2nd ed.

See Also

`model.avg` for averaging models.

QAIC *Quasi AIC*

Description

Calculates "quasi AIC" for one or several fitted model objects. This function is provided just as an example of custom rank function for use with `model.avg` and `dredge`

Usage

```
QAIC(object, ..., chat)
```

Arguments

`object`	a fitted model object.
`...`	optionally more fitted model objects.
`chat`	c - hat

Details

`rank` is specified as a function or a symbol (e.g. a backquoted name) or a character string specifying a function.

Function `rank` must be able to accept model as a first argument and must always return a scalar.

Value

If just one object is provided, returns a numeric value with the corresponding QAIC; if more than one object are provided, returns a data.frame with rows corresponding to the objects.

Author(s)

Kamil Bartoń

Examples

```
# Based on "example(predict.glm)"
require(graphics)

budworm <- data.frame(ldose = rep(0:5, 2), numdead = c(1, 4, 9, 13, 18, 20, 0,
2, 6, 10, 12, 16), sex = factor(rep(c("M", "F"), c(6, 6))))
budworm$SF = cbind(numdead = budworm$numdead, numalive = 20 - budworm$numdead)

budworm.lg <- glm(SF ~ sex*ldose, data = budworm, family = quasibinomial)

plot(c(1,32), c(0,1), type = "n", xlab = "dose",
     ylab = "prob", log = "x")
text(2^budworm$ldose, budworm$numdead/20, as.character(budworm$sex))
ld <- seq(0, 5, 0.1)
lines(2^ld, predict(budworm.lg, data.frame(ldose=ld,
   sex=factor(rep("M", length(ld)), levels=levels(budworm$sex))),
   type = "response"))
```

```
lines(2^ld, predict(budworm.lg, data.frame(ldose=ld,
   sex=factor(rep("F", length(ld)), levels=levels(budworm$sex))),
   type = "response"))


dd <- dredge(budworm.lg, rank = "QAIC",
chat = summary(budworm.lg)$dispersion)
mod <- get.models(dd, seq(nrow(dd)))
budworm.avg <- model.avg(mod)
model.avg(mod[[1]], mod[[2]], rank = "QAIC", rank.args = list(chat = 1))

linkinv <- quasibinomial()$linkinv
lines(2^ld, linkinv(predict(budworm.avg, data.frame(ldose=ld,
   sex=factor(rep("M", length(ld)), levels=levels(budworm$sex))))), col=2)
lines(2^ld, linkinv(predict(budworm.avg, data.frame(ldose=ld,
   sex=factor(rep("F", length(ld)), levels=levels(budworm$sex))))), col=2)
legend("bottomright", legend=c("full", "averaged"), title="Model",
   col=1:2, lty=1)
```

`subset.model.selection` *Subsetting model selection table*

Description

Return subsets of a model selection table returned by `dredge`.

Usage

```
## S3 method for class 'model.selection':
subset(x, subset, select, recalc.weights = TRUE, ...)
## S3 method for class 'model.selection':
x[i, j, recalc.weights = TRUE, ...]
```

Arguments

`x`	a `model.selection` object to be subsetted.
`subset,select`	logical expressions indicating columns and rows to keep. See `subset`.
`i,j`	indices specifying elements to extract.
`recalc.weights`	logical value specyfying whether Akaike weights should be normalized across the new set of models to sum to one.
`...`	further arguments passed to `[.data.frame`.

Value

A `model.selection` object containing only the selected models (rows). When columns are selected (arguments `select` or `j` are provided), a plain `data.frame` is returned.

Author(s)

Kamil Bartoń

See Also

`dredge`, `subset` and `[.data.frame` for subsetting and extracting from data.frames.

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