Package 'nnet'

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Depends R (>= 2.14.0), stats, utils

Suggests MASS

Description Software for feed-forward neural networks with a single hidden layer, and for multinomial log-linear models.

Title Feed-Forward Neural Networks and Multinomial Log-Linear Models

ByteCompile yes

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URL http://www.stats.ox.ac.uk/pub/MASS4/

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R topics documented:

class.ind *Generates Class Indicator Matrix from a Factor*

Description

Generates a class indicator function from a given factor.

Usage

```
class.ind(cl)
```

Arguments

cl	factor or vector of classes for cases.

Value

a matrix which is zero except for the column corresponding to the class.

References

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

Examples

```
# The function is currently defined as
class.ind <- function(cl)
{
  n <- length(cl)
  cl <- as.factor(cl)
  x <- matrix(0, n, length(levels(cl)) )
  x[(1:n) + n*(unclass(cl)-1)] <- 1
  dimnames(x) <- list(names(cl), levels(cl))
  x
}
```

multinom *Fit Multinomial Log-linear Models*

Description

Fits multinomial log-linear models via neural networks.

Usage

```
multinom(formula, data, weights, subset, na.action,
         contrasts = NULL, Hess = FALSE, summ = 0, censored = FALSE,
         model = FALSE, ...)
```

Arguments

formula	a formula expression as for regression models, of the form response ~ predictors. The response should be a factor or a matrix with K columns, which will be interpreted as counts for each of K classes. A log-linear model is fitted, with coefficients zero for the first class. An offset can be included: it should be a numeric matrix with K columns if the response is either a matrix with K columns or a factor with K >= 2 classes, or a numeric vector for a response factor with 2 levels. See the documentation of formula() for other details.
data	an optional data frame in which to interpret the variables occurring in formula.
weights	optional case weights in fitting.
subset	expression saying which subset of the rows of the data should be used in the fit. All observations are included by default.
na.action	a function to filter missing data.
contrasts	a list of contrasts to be used for some or all of the factors appearing as variables in the model formula.
Hess	logical for whether the Hessian (the observed/expected information matrix) should be returned.
summ	integer; if non-zero summarize by deleting duplicate rows and adjust weights. Methods 1 and 2 differ in speed (2 uses C); method 3 also combines rows with the same X and different Y, which changes the baseline for the deviance.
censored	If Y is a matrix with K columns, interpret the entries as one for possible classes, zero for impossible classes, rather than as counts.
model	logical. If true, the model frame is saved as component model of the returned object.
...	additional arguments for nnet

Details

multinom calls nnet. The variables on the rhs of the formula should be roughly scaled to [0,1] or the fit will be slow or may not converge at all.

Value

A nnet object with additional components:

deviance	the residual deviance, compared to the full saturated model (that explains individual observations exactly). Also, minus twice log-likelihood.
edf	the (effective) number of degrees of freedom used by the model
AIC	the AIC for this fit.
Hessian	(if Hess is true).
model	(if model is true).

References

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

See Also

nnet

Examples

```
options(contrasts = c("contr.treatment", "contr.poly"))
library(MASS)
example(birthwt)
(bwt.mu <- multinom(low ~ ., bwt))
```

---

nnet *Fit Neural Networks*

Description

Fit single-hidden-layer neural network, possibly with skip-layer connections.

Usage

```
nnet(x, ...)

## S3 method for class 'formula'
nnet(formula, data, weights, ...,
     subset, na.action, contrasts = NULL)

## Default S3 method:
nnet(x, y, weights, size, Wts, mask,
     linout = FALSE, entropy = FALSE, softmax = FALSE,
     censored = FALSE, skip = FALSE, rang = 0.7, decay = 0,
     maxit = 100, Hess = FALSE, trace = TRUE, MaxNWts = 1000,
     abstol = 1.0e-4, reltol = 1.0e-8, ...)
```

Arguments

formula	A formula of the form `class ~ x1 + x2 + ...`
x	matrix or data frame of x values for examples.
y	matrix or data frame of target values for examples.
weights	(case) weights for each example – if missing defaults to 1.
size	number of units in the hidden layer. Can be zero if there are skip-layer units.
data	Data frame from which variables specified in `formula` are preferentially to be taken.
subset	An index vector specifying the cases to be used in the training sample. (NOTE: If given, this argument must be named.)

na.action	A function to specify the action to be taken if NAs are found. The default action is for the procedure to fail. An alternative is na.omit, which leads to rejection of cases with missing values on any required variable. (NOTE: If given, this argument must be named.)
contrasts	a list of contrasts to be used for some or all of the factors appearing as variables in the model formula.
Wts	initial parameter vector. If missing chosen at random.
mask	logical vector indicating which parameters should be optimized (default all).
linout	switch for linear output units. Default logistic output units.
entropy	switch for entropy (= maximum conditional likelihood) fitting. Default by least-squares.
softmax	switch for softmax (log-linear model) and maximum conditional likelihood fitting. linout, entropy, softmax and censored are mutually exclusive.
censored	A variant on softmax, in which non-zero targets mean possible classes. Thus for softmax a row of (0, 1, 1) means one example each of classes 2 and 3, but for censored it means one example whose class is only known to be 2 or 3.
skip	switch to add skip-layer connections from input to output.
rang	Initial random weights on [-rang, rang]. Value about 0.5 unless the inputs are large, in which case it should be chosen so that rang * max(|x|) is about 1.
decay	parameter for weight decay. Default 0.
maxit	maximum number of iterations. Default 100.
Hess	If true, the Hessian of the measure of fit at the best set of weights found is returned as component Hessian.
trace	switch for tracing optimization. Default TRUE.
MaxNWts	The maximum allowable number of weights. There is no intrinsic limit in the code, but increasing MaxNWts will probably allow fits that are very slow and time-consuming.
abstol	Stop if the fit criterion falls below abstol, indicating an essentially perfect fit.
reltol	Stop if the optimizer is unable to reduce the fit criterion by a factor of at least 1 - reltol.
...	arguments passed to or from other methods.

Details

If the response in formula is a factor, an appropriate classification network is constructed; this has one output and entropy fit if the number of levels is two, and a number of outputs equal to the number of classes and a softmax output stage for more levels. If the response is not a factor, it is passed on unchanged to nnet.default.

Optimization is done via the BFGS method of optim.

Value

object of class `"nnet"` or `"nnet.formula"`. Mostly internal structure, but has components

`wts`	the best set of weights found
`value`	value of fitting criterion plus weight decay term.
`fitted.values`	the fitted values for the training data.
`residuals`	the residuals for the training data.
`convergence`	`1` if the maximum number of iterations was reached, otherwise `0`.

References

Ripley, B. D. (1996) *Pattern Recognition and Neural Networks.* Cambridge.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S.* Fourth edition. Springer.

See Also

`predict.nnet`, `nnetHess`

Examples

```
# use half the iris data
ir <- rbind(iris3[,,1],iris3[,,2],iris3[,,3])
targets <- class.ind( c(rep("s", 50), rep("c", 50), rep("v", 50)) )
samp <- c(sample(1:50,25), sample(51:100,25), sample(101:150,25))
ir1 <- nnet(ir[samp,], targets[samp,], size = 2, rang = 0.1,
            decay = 5e-4, maxit = 200)
test.cl <- function(true, pred) {
    true <- max.col(true)
    cres <- max.col(pred)
    table(true, cres)
}
test.cl(targets[-samp,], predict(ir1, ir[-samp,]))


# or
ird <- data.frame(rbind(iris3[,,1], iris3[,,2], iris3[,,3]),
        species = factor(c(rep("s",50), rep("c", 50), rep("v", 50))))
ir.nn2 <- nnet(species ~ ., data = ird, subset = samp, size = 2, rang = 0.1,
               decay = 5e-4, maxit = 200)
table(ird$species[-samp], predict(ir.nn2, ird[-samp,], type = "class"))
```

nnetHess *Evaluates Hessian for a Neural Network*

Description

Evaluates the Hessian (matrix of second derivatives) of the specified neural network. Normally called via argument `Hess=TRUE` to `nnet` or via `vcov.multinom`.

Usage

```
nnetHess(net, x, y, weights)
```

Arguments

`net`	object of class `nnet` as returned by `nnet`.
`x`	training data.
`y`	classes for training data.
`weights`	the (case) weights used in the `nnet` fit.

Value

square symmetric matrix of the Hessian evaluated at the weights stored in the net.

References

Ripley, B. D. (1996) *Pattern Recognition and Neural Networks.* Cambridge.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S.* Fourth edition. Springer.

See Also

`nnet`, `predict.nnet`

Examples

```
# use half the iris data
ir <- rbind(iris3[,,1], iris3[,,2], iris3[,,3])
targets <- matrix(c(rep(c(1,0,0),50), rep(c(0,1,0),50), rep(c(0,0,1),50)),
150, 3, byrow=TRUE)
samp <- c(sample(1:50,25), sample(51:100,25), sample(101:150,25))
ir1 <- nnet(ir[samp,], targets[samp,], size=2, rang=0.1, decay=5e-4, maxit=200)
eigen(nnetHess(ir1, ir[samp,], targets[samp,]), TRUE)$values
```

predict.nnet *Predict New Examples by a Trained Neural Net*

Description

Predict new examples by a trained neural net.

Usage

```
## S3 method for class 'nnet'
predict(object, newdata, type = c("raw","class"), ...)
```

Arguments

object	an object of class nnet as returned by nnet.
newdata	matrix or data frame of test examples. A vector is considered to be a row vector comprising a single case.
type	Type of output
...	arguments passed to or from other methods.

Details

This function is a method for the generic function predict() for class "nnet". It can be invoked by calling predict(x) for an object x of the appropriate class, or directly by calling predict.nnet(x) regardless of the class of the object.

Value

If type = "raw", the matrix of values returned by the trained network; if type = "class", the corresponding class (which is probably only useful if the net was generated by nnet.formula).

References

Ripley, B. D. (1996) *Pattern Recognition and Neural Networks.* Cambridge.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S.* Fourth edition. Springer.

See Also

nnet, which.is.max

Examples

```
# use half the iris data
ir <- rbind(iris3[,,1], iris3[,,2], iris3[,,3])
targets <- class.ind( c(rep("s", 50), rep("c", 50), rep("v", 50)) )
samp <- c(sample(1:50,25), sample(51:100,25), sample(101:150,25))
ir1 <- nnet(ir[samp,], targets[samp,],size = 2, rang = 0.1,
            decay = 5e-4, maxit = 200)
test.cl <- function(true, pred){
        true <- max.col(true)
        cres <- max.col(pred)
        table(true, cres)
}
test.cl(targets[-samp,], predict(ir1, ir[-samp,]))

# or
ird <- data.frame(rbind(iris3[,,1], iris3[,,2], iris3[,,3]),
        species = factor(c(rep("s",50), rep("c", 50), rep("v", 50))))
ir.nn2 <- nnet(species ~ ., data = ird, subset = samp, size = 2, rang = 0.1,
               decay = 5e-4, maxit = 200)
table(ird$species[-samp], predict(ir.nn2, ird[-samp,], type = "class"))
```

`which.is.max` *Find Maximum Position in Vector*

Description

Find the maximum position in a vector, breaking ties at random.

Usage

```
which.is.max(x)
```

Arguments

x	a vector

Details

Ties are broken at random.

Value

index of a maximal value.

References

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

See Also

max.col, which.max which takes the first of ties.

Examples

```
## Not run: ## this is incomplete
pred <- predict(nnet, test)
table(true, apply(pred, 1, which.is.max))

## End(Not run)
```

Index