

# Package ‘nnet’

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**Priority** recommended

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**Depends** R (>= 2.5.0), stats, utils

**Suggests** MASS

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**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

**License** GPL-2 | GPL-3

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## R topics documented:

class.ind . . . . .	2
multinom . . . . .	2
nnet . . . . .	4
nnetHess . . . . .	7
predict.nnet . . . . .	8
which.is.max . . . . .	9

<b>Index</b>	<b>11</b>
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class.ind	<i>Generates Class Indicator Matrix from a Factor</i>
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**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
}
```

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multinom	<i>Fit Multinomial Log-linear Models</i>
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**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 <code>response ~ predictors</code> . 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 <code>formula()</code> 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 > 2 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 <code>model</code> of the returned object.
...	additional arguments for <code>nnet</code>

## 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))
## Not run: Call:
multinom(formula = low ~ ., data = bwt)

Coefficients:
(Intercept)          age          lwt raceblack raceother
  0.823477 -0.03724311 -0.01565475  1.192371  0.7406606
  smoke      ptd      ht      ui      ftv1      ftv2+
 0.7555234 1.343648 1.913213 0.6802007 -0.4363238 0.1789888

Residual Deviance: 195.4755
AIC: 217.4755

## End(Not run)

```

---

nnet

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*Fit Neural Networks*


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**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 <code>class ~ x1 + x2 + ...</code> .
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 <code>na.omit</code> , 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. <code>linout</code> , <code>entropy</code> , <code>softmax</code> and <code>censored</code> are mutually exclusive.
censored	A variant on <code>softmax</code> , in which non-zero targets mean possible classes. Thus for <code>softmax</code> a row of (0, 1, 1) means one example each of classes 2 and 3, but for <code>censored</code> 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 <code>[-rang, rang]</code> . Value about 0.5 unless the inputs are large, in which case it should be chosen so that <code>rang * max( x )</code> 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 <code>MaxNWts</code> will probably allow fits that are very slow and time-consuming.
abstol	Stop if the fit criterion falls below <code>abstol</code> , indicating an essentially perfect fit.
reltol	Stop if the optimizer is unable to reduce the fit criterion by a factor of at least 1 - <code>reltol</code> .
...	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

<code>wts</code>	the best set of weights found
<code>value</code>	value of fitting criterion plus weight decay term.
<code>fitted.values</code>	the fitted values for the training data.
<code>residuals</code>	the residuals for the training data.
<code>convergence</code>	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"))
```

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nnetHess	<i>Evaluates Hessian for a Neural Network</i>
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---

## 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 <code>nnet</code> as returned by <code>nnet</code> .
x	training data.
y	classes for training data.
weights	the (case) weights used in the <code>nnet</code> 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

<code>object</code>	an object of class <code>nnet</code> as returned by <code>nnet</code> .
<code>newdata</code>	matrix or data frame of test examples. A vector is considered to be a row vector comprising a single case.
<code>type</code>	Type of output
<code>...</code>	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:  
pred <- predict(nnet, test)  
table(true, apply(pred,1,which.is.max))  
  
## End(Not run)
```

# Index

## \*Topic **models**

multinom, [2](#)

## \*Topic **neural**

class.ind, [2](#)

multinom, [2](#)

nnet, [4](#)

nnetHess, [7](#)

predict.nnet, [8](#)

## \*Topic **utilities**

class.ind, [2](#)

which.is.max, [9](#)

add.net (nnet), [4](#)

add1.multinom (multinom), [2](#)

anova.multinom (multinom), [2](#)

class.ind, [2](#)

coef.multinom (multinom), [2](#)

coef.nnet (nnet), [4](#)

drop1.multinom (multinom), [2](#)

eval.nn (nnet), [4](#)

extractAIC.multinom (multinom), [2](#)

formula, [3](#)

logLik.multinom (multinom), [2](#)

max.col, [10](#)

model.frame.multinom (multinom), [2](#)

multinom, [2](#)

nnet, [3](#), [4](#), [4](#), [7](#), [8](#)

nnetHess, [6](#), [7](#)

norm.net (nnet), [4](#)

optim, [6](#)

predict.multinom (multinom), [2](#)

predict.nnet, [6](#), [7](#), [8](#)

print.multinom (multinom), [2](#)

print.nnet (nnet), [4](#)

print.summary.multinom (multinom), [2](#)

print.summary.nnet (nnet), [4](#)

summary.multinom (multinom), [2](#)

summary.nnet (nnet), [4](#)

vcov.multinom (multinom), [2](#)

which.is.max, [8](#), [9](#)

which.max, [10](#)