

# Package ‘starnet’

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**Version** 0.0.3

**Title** Stacked Elastic Net

**Description** Implements stacked elastic net regression (Rauschenberger 2020, <doi:10.1093/bioinformatics/btaa535>). The elastic net generalises ridge and lasso regularisation (Zou 2005, <doi:10.1111/j.1467-9868.2005.00503.x>). Instead of fixing or tuning the mixing parameter alpha, we combine multiple alpha by stacked generalisation (Wolpert 1992 <doi:10.1016/S0893-6080(05)80023-1>).

**Depends** R (>= 3.0.0)

**Imports** glmnet, survival, cornet, jointnet, Matrix

**Suggests** knitr, testthat, rmarkdown

**Enhances** CVXR, mvtnorm

**VignetteBuilder** knitr

**License** GPL-3

**LazyData** true

**Language** en-GB

**RoxygenNote** 7.1.0

**URL** <https://github.com/rauschenberger/starnet>

**BugReports** <https://github.com/rauschenberger/starnet/issues>

**NeedsCompilation** no

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**Repository** CRAN

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starnet-package	<i>Stacked Elastic Net Regression</i>
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## Description

The R package `starnet` implements stacked elastic net regression. The elastic net generalises ridge and lasso regularisation. Instead of fixing or tuning the mixing parameter  $\alpha$ , we combine multiple alphas by stacked generalisation.

## Details

Use function `starnet` for model fitting. Type `library(starnet)` and then `?starnet` or `help("starnet")` to open its help file.

See the vignette for further examples. Type `vignette("starnet")` or `browseVignettes("starnet")` to open the vignette.

## References

A Rauschenberger, E Glaab, and MA van de Wiel (2020). "Predictive and interpretable models via the stacked elastic net". *Bioinformatics*. In press. doi: [10.1093/bioinformatics/btaa535](https://doi.org/10.1093/bioinformatics/btaa535). <armin.rauschenberger@uni.lu>

## Examples

```
#--- data simulation ---
n <- 50; p <- 100
y <- rnorm(n=n)
X <- matrix(rnorm(n*p),nrow=n,ncol=p)
# n samples, p features

#--- model fitting ---
object <- starnet(y=y,X=X)
# "base": one model for each alpha
# "meta": model for stacking them

#--- make predictions ---
y_hat <- predict(object,newx=X)
# one column for each alpha,
```

```
# and for tuning and stacking

#--- extract coefficients ---
coef <- coef(object)
# scalar "alpha": intercept
# vector "beta": slopes

#--- model comparison ---

loss <- cv.starnet(y=y,X=X)
# cross-validated loss for different alpha,
# and for tuning and stacking
```

---

.cv.glmnet

*glmnet::cv.glmnet*

---

## Description

Wrapper for [cv.glmnet](#), with different handling of sparsity constraints.

## Usage

```
.cv.glmnet(..., nzero)
```

## Arguments

... see [cv.glmnet](#)  
nzero maximum number of non-zero coefficients: positive integer

## Value

Object of class [cv.glmnet](#).

## Examples

```
NA
```

---

*.loss*                      *Loss*

---

**Description**

Calculate loss from predicted and observed values

**Usage**

```
.loss(y, x, family, type.measure, foldid = NULL, grouped = TRUE)
```

**Arguments**

<i>y</i>	observed values: numeric vector of length <i>n</i>
<i>x</i>	predicted values: numeric vector of length <i>n</i>
<i>family</i>	character "gaussian", "binomial", "poisson", "mgaussian", or "multinomial" (to implement: "cox")
<i>type.measure</i>	character "deviance", "mse", "mae", "class", or "auc"
<i>foldid</i>	fold identifiers: integer vector of length <i>n</i> , or NULL
<i>grouped</i>	logical (for "cox" only)

**Examples**

```
NA
```

---

*.simulate*                      *Simulation*

---

**Description**

Functions for simulating data

**Usage**

```
.simulate.block(n, p, mode, family = "gaussian")
```

**Arguments**

<i>n</i>	sample size: positive integer
<i>p</i>	dimensionality: positive integer
<i>mode</i>	character "sparse", "dense" or "mixed"
<i>family</i>	character "gaussian", "binomial" or "poisson"

**Value**

List of vector  $y$  and matrix  $X$ .

**Examples**

NA

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coef.starnet	<i>Extract Coefficients</i>
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**Description**

Extracts pooled coefficients. (The meta learners weights the coefficients from the base learners.)

**Usage**

```
## S3 method for class 'starnet'  
coef(object, nzero = NULL, ...)
```

**Arguments**

object	<a href="#">starnet</a> object
nzero	maximum number of non-zero coefficients: positive integer, or NULL
...	further arguments (not applicable)

**Value**

List of scalar  $\alpha$  and vector  $\beta$ , containing the pooled intercept and the pooled slopes, respectively.

**Examples**

```
set.seed(1)  
n <- 50; p <- 100  
y <- rnorm(n=n)  
X <- matrix(rnorm(n*p), nrow=n, ncol=p)  
object <- starnet(y=y, X=X)  
coef <- coef(object)
```

---

 cv.starnet

 Model comparison
 

---

## Description

Compares stacked elastic net, tuned elastic net, ridge and lasso.

## Usage

```
cv.starnet(
  y,
  X,
  family = "gaussian",
  nalpha = 21,
  alpha = NULL,
  nfolds.ext = 10,
  nfolds.int = 10,
  foldid.ext = NULL,
  foldid.int = NULL,
  type.measure = "deviance",
  alpha.meta = 1,
  nzero = NULL,
  intercept = NULL,
  upper.limit = NULL,
  unit.sum = NULL,
  ...
)
```

## Arguments

y	response: numeric vector of length $n$
X	covariates: numeric matrix with $n$ rows (samples) and $p$ columns (variables)
family	character "gaussian", "binomial" or "poisson"
nalpha	number of alpha values
alpha	elastic net mixing parameters: vector of length nalpha with entries between 0 (ridge) and 1 (lasso); or NULL (equidistance)
nfolds.ext, nfolds.int, foldid.ext, foldid.int	number of folds (nfolds): positive integer; fold identifiers (foldid): vector of length $n$ with entries between 1 and nfolds, or NULL, for hold-out (single split) instead of cross-validation (multiple splits): set foldid.ext to 0 for training and to 1 for testing samples
type.measure	loss function: character "deviance", "class", "mse" or "mae" (see <a href="#">cv.glmnet</a> )
alpha.meta	meta-learner: value between 0 (ridge) and 1 (lasso) for elastic net regularisation; NA for convex combination

nzero	number of non-zero coefficients: scalar/vector including positive integer(s) or NA; or NULL (no post hoc feature selection)
intercept	settings for meta-learner: logical, or NULL (intercept=!is.na(alpha.meta), upper.limit=TRUE, unit.sum=is.na(alpha.meta))
upper.limit	settings for meta-learner: logical, or NULL (intercept=!is.na(alpha.meta), upper.limit=TRUE, unit.sum=is.na(alpha.meta))
unit.sum	settings for meta-learner: logical, or NULL (intercept=!is.na(alpha.meta), upper.limit=TRUE, unit.sum=is.na(alpha.meta))
...	further arguments (not applicable)

### Value

List containing the cross-validated loss (or out-of sample loss if `nfolds.ext` equals two, and `foldid.ext` contains zeros and ones). The slot `meta` contains the loss from the stacked elastic net (`stack`), the tuned elastic net (`tune`), ridge, lasso, and the intercept-only model (`none`). The slot `base` contains the loss from the base learners. And the slot `extra` contains the loss from the restricted stacked elastic net (`stack`), lasso, and lasso-like elastic net (`enet`), with the maximum number of non-zero coefficients shown in the column name.

### Examples

```
set.seed(1)
n <- 50; p <- 20
X <- matrix(rnorm(n*p), nrow=n, ncol=p)
y <- rnorm(n=n, mean=rowSums(X[, 1:20]))
```

```
loss <- cv.starnet(y=y, X=X)
```

---

glmnet.auc

*glmnet:::auc*

---

### Description

Import of `auc` (internal function)

### Usage

```
glmnet.auc(y, prob, w)
```

### Arguments

y	observed classes
prob	predicted probabilities
w	(ignored here)

**Value**

area under the ROC curve

**Examples**

NA

---

predict.starnet	<i>Makes Predictions</i>
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---

**Description**

Predicts outcome from features with stacked model.

**Usage**

```
## S3 method for class 'starnet'
predict(object, newx, type = "response", nzero = NULL, ...)
```

**Arguments**

object	<a href="#">starnet</a> object
newx	covariates: numeric matrix with $n$ rows (samples) and $p$ columns (variables)
type	character "link" or "response"
nzero	maximum number of non-zero coefficients: positive integer, or NULL
...	further arguments (not applicable)

**Value**

Matrix of predicted values, with samples in the rows, and models in the columns. Included models are alpha (fixed elastic net), ridge (i.e.  $\alpha_0$ ), lasso (i.e.  $\alpha_1$ ), tune (tuned elastic net), stack (stacked elastic net), and none (intercept-only model).

**Examples**

```
set.seed(1)
n <- 50; p <- 100
y <- rnorm(n=n)
X <- matrix(rnorm(n*p), nrow=n, ncol=p)
object <- starnet(y=y, X=X)
y_hat <- predict(object, newx=X[c(1),, drop=FALSE])
```



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print.starnet	<i>Print Values</i>
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**Description**

Prints object of class [starnet](#).

**Usage**

```
## S3 method for class 'starnet'  
print(x, ...)
```

**Arguments**

x	<a href="#">starnet</a> object
...	further arguments (not applicable)

**Value**

Prints "stacked gaussian/binomial/poisson elastic net".

**Examples**

```
set.seed(1)  
n <- 50; p <- 100  
y <- rnorm(n=n)  
X <- matrix(rnorm(n*p), nrow=n, ncol=p)  
object <- starnet(y=y, X=X)  
print(object)
```

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starnet	<i>Stacked Elastic Net Regression</i>
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**Description**

Implements stacked elastic net regression.

**Usage**

```
starnet(  
  y,  
  X,  
  family = "gaussian",  
  nalpha = 21,  
  alpha = NULL,
```

```

  nfolds = 10,
  foldid = NULL,
  type.measure = "deviance",
  alpha.meta = 1,
  penalty.factor = NULL,
  intercept = NULL,
  upper.limit = NULL,
  unit.sum = NULL,
  ...
)

```

### Arguments

<code>y</code>	response: numeric vector of length $n$
<code>X</code>	covariates: numeric matrix with $n$ rows (samples) and $p$ columns (variables)
<code>family</code>	character "gaussian", "binomial" or "poisson"
<code>nalpha</code>	number of alpha values
<code>alpha</code>	elastic net mixing parameters: vector of length <code>nalpha</code> with entries between 0 (ridge) and 1 (lasso); or NULL (equidistance)
<code>nfolds</code>	number of folds
<code>foldid</code>	fold identifiers: vector of length $n$ with entries between 1 and <code>nfolds</code> ; or NULL (balance)
<code>type.measure</code>	loss function: character "deviance", "class", "mse" or "mae" (see <a href="#">cv.glmnet</a> )
<code>alpha.meta</code>	meta-learner: value between 0 (ridge) and 1 (lasso) for elastic net regularisation; NA for convex combination
<code>penalty.factor</code>	differential shrinkage: vector of length $n$ with entries between 0 (include) and $Inf$ (exclude), or NULL (all 1)
<code>intercept</code> , <code>upper.limit</code> , <code>unit.sum</code>	settings for meta-learner: logical, or NULL ( <code>intercept=!is.na(alpha.meta)</code> , <code>upper.limit=TRUE</code> , <code>unit.sum=is.na(alpha.meta)</code> )
<code>...</code>	further arguments passed to <a href="#">glmnet</a>

### Details

Post hoc feature selection: consider argument `nzero` in functions [coef](#) and [predict](#).

### Value

Object of class [starnet](#). The slots `base` and `meta` contain [cv.glmnet](#)-like objects, for the base and meta learners, respectively.

### References

A Rauschenberger, E Glaab, and MA van de Wiel (2020). "Predictive and interpretable models via the stacked elastic net". *Bioinformatics*. In press. doi: [10.1093/bioinformatics/btaa535](https://doi.org/10.1093/bioinformatics/btaa535). <armin.rauschenberger@uni.lu>

**Examples**

```
set.seed(1)
n <- 50; p <- 100
y <- rnorm(n=n)
X <- matrix(rnorm(n*p),nrow=n,ncol=p)
object <- starnet(y=y,X=X,family="gaussian")
```

---

weights.starnet	<i>Extract Weights</i>
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**Description**

Extracts coefficients from the meta learner, i.e. the weights for the base learners.

**Usage**

```
## S3 method for class 'starnet'
weights(object, ...)
```

**Arguments**

object	<a href="#">starnet</a> object
...	further arguments (not applicable)

**Value**

Vector containing intercept and slopes from the meta learner.

**Examples**

```
set.seed(1)
n <- 50; p <- 100
y <- rnorm(n=n)
X <- matrix(rnorm(n*p),nrow=n,ncol=p)
object <- starnet(y=y,X=X)
weights(object)
```

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