# Package 'rIsing'

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**Type** Package

**Title** High-Dimensional Ising Model Selection

**Version** 0.1.0

**Description** Fits an Ising model to a binary dataset using L1 regularized logistic regression and extended BIC. Also includes a fast lasso logistic regression function for high-dimensional problems. Uses the 'libLBFGS' optimization library by Naoaki Okazaki.

**License** GPL (>= 2)

**Encoding** UTF-8

**LazyData** true

**Depends** R (>= 3.1.0)

**Imports** Rcpp (>= 0.12.8), data.table (>= 1.9.6)

**Suggests** igraph, IsingSampler

**LinkingTo** Rcpp, RcppEigen (>= 0.3.2.9)

**RoxygenNote** 5.0.1

**NeedsCompilation** yes

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**Repository** CRAN

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## Contents

`ising` *High-Dimensional Ising Model Selection*

## Description

Ising Model selection using L1-regularized logistic regression and extended BIC.

## Usage

```
ising(X, gamma = 0.5, min_sd = 0, nlambda = 50,
  lambda.min.ratio = 0.001, symmetrize = "mean")
```

## Arguments

| | |
|---|---|
| `X` | The design matrix. |
| `gamma` | (non-negative double) Parameter for the extended BIC (default 0.5). Higher gamma encourages sparsity. See references for more details. |
| `min_sd` | (non-negative double) Columns of `X` with standard deviation less than this value will be excluded from the graph. |
| `nlambda` | (positive integer) The number of parameters in the regularization path (default 50). A longer regularization path will likely yield more accurate results, but will take more time to run. |
| `lambda.min.ratio` | (non-negative double) The ratio `min(lambda) / max(lambda)` (default `1e-3`). |
| `symmetrize` | The method used to symmetrize the output adjacency matrix. Must be one of "min", "max", "mean" (default), or FALSE. "min" and "max" correspond to the Wainwright min/max, respectively (see reference 1). "mean" corresponds to the coefficient-wise mean of the output adjacency matrix and its transpose. If FALSE, the output matrix is not symmetrized. |

## Value

A list containing the estimated adjacency matrix (`Theta`) and the optimal regularization parameter for each node (`lambda`), as selected by extended BIC.

## References

1. Ravikumar, P., Wainwright, M. J. and Lafferty, J. D. (2010). High-dimensional Ising model selection using L1-regularized logistic regression. https://arxiv.org/pdf/1010.0311v1

2. Barber, R.F., Drton, M. (2015). High-dimensional Ising model selection with Bayesian information criteria. https://arxiv.org/pdf/1403.3374v2

## Examples

```
## Not run:
# simulate a dataset using IsingSampler
library(IsingSampler)
n = 1e3
p = 10
Theta <- matrix(sample(c(-0.5,0,0.5), replace = TRUE, size = p*p), nrow = p, ncol = p)
Theta <- Theta + t(Theta) # adjacency matrix must be symmetric
diag(Theta) <- 0
X <- unname(as.matrix(IsingSampler(n, graph = Theta, thresholds = 0, method = "direct") ))
m1 <- ising(X, symmetrize = "mean", gamma = 0.5, nlambda = 50)

# Visualize output using igraph
library(igraph)
ig <- graph_from_adjacency_matrix(m1$Theta, "undirected", weighted = TRUE, diag = FALSE)
plot.igraph(ig, vertex.color = "skyblue")

## End(Not run)
```

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`logreg` *L1 Regularized Logistic Regression*

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## Description

L1 Regularized logistic regression using OWL-QN L-BFGS-B optimization.

## Usage

```
logreg(X, y, nlambda = 50, lambda.min.ratio = 0.001, lambda = NULL,
  scale = TRUE, type = 2)
```

## Arguments

| | |
|---|---|
| `X` | The design matrix. |
| `y` | Vector of binary observations of length equal to `nrow(X)`. |
| `nlambda` | (positive integer) The number of parameters in the regularization path (default 50). |
| `lambda.min.ratio` | (non-negative double) The ratio of `max(lambda) / min(lambda)` (default `1e-3`). |
| `lambda` | A user-supplied vector of regularization parameters. Under the default option (`NULL`), the function computes a regularization path using the input data. |
| `scale` | (boolean) Whether to scale `X` before running the regression. The output parameters will always be rescaled. Use `FALSE` if `X` is already scaled. |
| `type` | (integer 1 or 2) Type 1 aggregates the input data based on repeated rows in `X`. Type 2 (default) uses the data as is, and is generally faster. Use Type 1 if the data contains several repeated rows. |

## Value

A list containing the matrix of fitted weights (`wmat`), the vector of regularization parameters, sorted in decreasing order (`lambda`), and the vector of log-likelihoods corresponding to `lambda` (`logliks`).

## Examples

```
# simulate some linear regression data
n <- 1e3
p <- 100
X <- matrix(rnorm(n*p),n,p)
wt <- sample(seq(0,9),p+1,replace = TRUE) / 10
z <- cbind(1,X) %*% wt + rnorm(n)
probs <- 1 / (1 + exp(-z))
y <- sapply(probs, function(p) rbinom(1,1,p))

m1 <- logreg(X, y)
m2 <- logreg(X, y, nlambda = 100, lambda.min.ratio = 1e-4, type = 1)

## Not run:
# Performance comparison
library(glmnet)
library(microbenchmark)
nlambda = 50; lambda.min.ratio = 1e-3
microbenchmark(
  logreg_type1 = logreg(X, y, nlambda = nlambda,
                        lambda.min.ratio = lambda.min.ratio, type = 1),
  logreg_type2 = logreg(X, y, nlambda = nlambda,
                        lambda.min.ratio = lambda.min.ratio, type = 2),
  glmnet       = glmnet(X, y, family = "binomial",
                        nlambda = nlambda, lambda.min.ratio = lambda.min.ratio),
  times = 20L
)

## End(Not run)
```

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`rIsing` *rIsing: High-Dimensional Ising Model Selection.*

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## Description

Fits an Ising model to a binary dataset using L1-regularized logistic regression and BIC. Also includes a fast lasso logistic regression function for high-dimensional problems. Uses the 'libLBFGS' optimization library by Naoki Okazaki.

## rIsing functions

- `logreg`: L1-regularized logistic regression using OWL-QN L-BFGS-B optimization.
- `Ising`: Ising Model selection using L1-regularized logistic regression and extended BIC.

# Index