Package ‘oem’

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Type Package
Title Orthogonalizing EM
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Description Solves penalized least squares problems for big tall data using the orthogonalizing EM algorithm of Xiong et al. (2016) <doi: 10.1080/00401706.2015.1054436>. The main fitting function is oem() and the functions cv.oem() and xval.oem() are for cross validation, the latter being an accelerated cross validation function for linear models. The big.oem() function allows for out of memory fitting.

URL https://github.com/jaredhuling/oem
BugReports https://github.com/jaredhuling/oem/issues
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big.oem

Orthogonalizing EM

Description

Orthogonalizing EM

Usage

big.oem(x, y, family = c("gaussian", "binomial"), penalty = c("elastic.net", "lasso", "ols", "mcp", "scad", "mcp.net", "scad.net", "grp.lasso", "grp.lasso.net", "grp.mcp", "grp.scad", "grp.mcp.net", "grp.scad.net", "sparse.grp.lasso"), weights = numeric(0), lambda = numeric(0), nlambda = 100L, lambda.min.ratio = NULL, alpha = 1, gamma = 3, tau = 0.5, groups = numeric(0), penalty.factor = NULL, group.weights = NULL, standardize = TRUE, intercept = TRUE, maxit = 500L, tol = 1e-07, irls.maxit = 100L, irls.tol = 0.001, compute.loss = FALSE, gigs = 4, hessian.type = c("full", "upper.bound"))

Arguments

x input big.matrix object pointing to design matrix. Each row is an observation, each column corresponds to a covariate

y numeric response vector of length nobs.

family "gaussian" for least squares problems, "binomial" for binary response. "binomial" currently not available.

penalty Specification of penalty type. Choices include:

• "elastic.net" - elastic net penalty, extra parameters: "alpha"
• "lasso" - lasso penalty

...
• "ols" - ordinary least squares
• "mcp" - minimax concave penalty, extra parameters: "gamma"
• "scad" - smoothly clipped absolute deviation, extra parameters: "gamma"
• "mcp.net" - minimax concave penalty + l2 penalty, extra parameters: "gamma", "alpha"
• "scad.net" - smoothly clipped absolute deviation + l2 penalty, extra parameters: "gamma", "alpha"
• "grp.lasso" - group lasso penalty
• "grp.lasso.net" - group lasso penalty + l2 penalty, extra parameters: "alpha"
• "grp.mcp" - group minimax concave penalty, extra parameters: "gamma"
• "grp.scad" - group smoothly clipped absolute deviation, extra parameters: "gamma"
• "grp.mcp.net" - group minimax concave penalty + l2 penalty, extra parameters: "gamma", "alpha"
• "grp.scad.net" - group smoothly clipped absolute deviation + l2 penalty, extra parameters: "gamma", "alpha"
• "sparse.grp.lasso" - sparse group lasso penalty (group lasso + lasso), extra parameters: "tau"

Careful consideration is required for the group lasso, group MCP, and group SCAD penalties. Groups as specified by the groups argument should be chosen in a sensible manner.

weights
observation weights. Not implemented yet. Defaults to 1 for each observation (setting weight vector to length 0 will default all weights to 1)

lambda
A user supplied lambda sequence. By default, the program computes its own lambda sequence based on nlambda and lambda.min.ratio. Supplying a value of lambda overrides this.

nlambda
The number of lambda values - default is 100.

lambda.min.ratio
Smallest value for lambda, as a fraction of lambda.max, the (data derived) entry value (i.e. the smallest value for which all coefficients are zero). The default depends on the sample size nobs relative to the number of variables nvars. If nobs > nvars, the default is 0.0001, close to zero. If nobs < nvars, the default is 0.01. A very small value of lambda.min.ratio will lead to a saturated fit when nobs < nvars.

alpha
mixing value for elastic.net, mcp.net, scad.net, grp.mcp.net, grp.scad.net. penalty applied is (1 - alpha) * (ridge penalty) + alpha * (lasso/mcp/mcp/grp.lasso penalty)

gamma
tuning parameter for SCAD and MCP penalties. must be >= 1

tau
mixing value for sparse.grp.lasso. penalty applied is (1 - tau) * (group lasso penalty) + tau * (lasso penalty)

groups
A vector of describing the grouping of the coefficients. See the example below. All unpenalized variables should be put in group 0
penalty.factor

Separate penalty factors can be applied to each coefficient. This is a number that multiplies lambda to allow differential shrinkage. Can be 0 for some variables, which implies no shrinkage, and that variable is always included in the model. Default is 1 for all variables.

group.weights

penalty factors applied to each group for the group lasso. Similar to penalty.factor, this is a number that multiplies lambda to allow differential shrinkage. Can be 0 for some groups, which implies no shrinkage, and that group is always included in the model. Default is sqrt(group size) for all groups.

standardize

Logical flag for x variable standardization, prior to fitting the models. The coefficients are always returned on the original scale. Default is standardize = TRUE. If variables are in the same units already, you might not wish to standardize. Keep in mind that standardization is done differently for sparse matrices, so results (when standardized) may be slightly different for a sparse matrix object and a dense matrix object.

intercept

Should intercept(s) be fitted (default = TRUE) or set to zero (FALSE)

maxit

integer. Maximum number of OEM iterations

tol

convergence tolerance for OEM iterations

irls.maxit

integer. Maximum number of IRLS iterations

irls.tol

convergence tolerance for IRLS iterations. Only used if family != "gaussian"

compute.loss

should the loss be computed for each estimated tuning parameter? Defaults to FALSE. Setting to TRUE will dramatically increase computational time

gigs

maximum number of gigs of memory available. Used to figure out how to break up calculations involving the design matrix x

hessian.type

only for logistic regression. if hessian.type = "full", then the full hessian is used. If hessian.type = "upper.bound", then an upper bound of the hessian is used. The upper bound can be dramatically faster in certain situations, ie when n > p

Value

An object with S3 class "oem"

Examples

set.seed(123)
nrows <- 50000
ncols <- 100
bkFile <- "bigmat.bk"
descFile <- "bigmat.k.desc"
bigmat <- filebacked.big.matrix(nrow=nrows, ncol=ncols, type="double",
backingfile=bkFile, backingpath=".",
descriptorfile=descFile,
dimnames=c(NULL,NULL))

# Each column value will be the column number multiplied by # samples from a standard normal distribution.
set.seed(123)
cv.oem

for (i in 1:ncols) bigmat[,i] = rnorm(nrows)*i

y <- rnorm(nrows) + bigmat[,1] - bigmat[,2]

fit <- big.oem(x = bigmat, y = y,
penalty = c("lasso", "elastic.net",
"ols",
"mcp", "scad",
"mcp.net", "scad.net",
"grp.lasso", "grp.lasso.net",
"grp.mcp", "grp.scad",
"sparse.grp.lasso"),
groups = rep(1:20, each = 5))

fit2 <- oem(x = bigmat[,], y = y,
penalty = c("lasso", "grp.lasso"),
groups = rep(1:20, each = 5))

max(abs(fit$beta[[1]] - fit2$beta[[1]]))

layout(matrix(1:2, ncol = 2))
plot(fit)
plot(fit, which.model = 2)

---

cv.oem

Orthogonalizing EM

Description

Orthogonalizing EM

Usage

cv.oem(x, y, penalty = c("elastic.net", "lasso", "ols", "mcp", "scad",
"mcp.net", "scad.net", "grp.lasso", "grp.lasso.net", "grp.mcp", "grp.scad",
"grp.mcp.net", "grp.scad.net", "sparse.grp.lasso"), weights = numeric(0),
lambda = NULL, type.measure = c("mse", "deviance", "class", "auc", "mae"),
nfolds = 10, foldid = NULL, grouped = TRUE, keep = FALSE,
parallel = FALSE, ncores = -1, ...)

Arguments

x          input matrix of dimension n x p or CsparseMatrix objects of the Matrix (sparse not yet implemented. Each row is an observation, each column corresponds to a covariate. The cv.oem() function is optimized for n > p settings and may be very slow when p > n, so please use other packages such as glmnet, ncvreg, grpreg, or gglasso when p > n or p approx n.

y          numeric response vector of length nobs.
penalty

Specification of penalty type in lowercase letters. Choices include "lasso", "ols" (Ordinary least squares, no penalty), "elastic.net", "scad", "mcp", "grp.lasso"

weights

Observation weights. Defaults to 1 for each observation (setting weight vector to length 0 will default all weights to 1)

lambda

A user supplied lambda sequence. By default, the program computes its own lambda sequence based on nlambdas and lambda.min.ratio. Supplying a value of lambda overrides this.

type.measure

Measure to evaluate for cross-validation. The default is type.measure = "deviance", which uses squared-error for gaussian models (a.k.a type.measure = "mse" there), deviance for logistic regression. type.measure = "class" applies to binomial only. type.measure = "auc" is for two-class logistic regression only. type.measure = "mse" or type.measure = "mae" (mean absolute error) can be used by all models; they measure the deviation from the fitted mean to the response.

nfolds

Number of folds for cross-validation. Default is 10. 3 is smallest value allowed.

foldid

An optional vector of values between 1 and nfolds specifying which fold each observation belongs to.

grouped

Like in glmnet, this is an experimental argument, with default TRUE, and can be ignored by most users. For all models, this refers to computing nfolds separate statistics, and then using their mean and estimated standard error to describe the CV curve. If grouped = FALSE, an error matrix is built up at the observation level from the predictions from the nfolds fits, and then summarized (does not apply to type.measure = "auc").

keep

If keep = TRUE, a prevalidated list of arrays is returned containing fitted values for each observation and each value of lambda for each model. This means these fits are computed with this observation and the rest of its fold omitted. The fold vector is also returned. Default is keep = FALSE

parallel

If TRUE, use parallel foreach to fit each fold. Must register parallel before hand, such as doMC.

ncores

Number of cores to use. If parallel = TRUE, then ncores will be automatically set to 1 to prevent conflicts

Value

An object with S3 class "cv.oem"

Examples

```r
set.seed(123)
n.obs <- 1e4
n.vars <- 100
true.beta <- c(rnorm(15, -0.25, 0.25), rep(0, n.vars - 15))
```
\begin{verbatim}
x <- matrix(rnorm(n.obs * n.vars), n.obs, n.vars)
y <- rnorm(n.obs, sd = 3) + x * true.beta

fit <- cv.oem(x = x, y = y,
            penalty = c("lasso", "grp.lasso"),
            groups = rep(1:20, each = 5))

layout(matrix(1:2, ncol = 2))
plot(fit)
plot(fit, which.model = 2)
\end{verbatim}

---

\textbf{Description}

Log likelihood function for fitted oem objects

\textbf{Usage}

\begin{verbatim}
## S3 method for class 'oem'
logLik(object, which.model = 1, ...)

## S3 method for class 'cv.oem'
logLik(object, which.model = 1, ...)

## S3 method for class 'xval.oem'
logLik(object, which.model = 1, ...)
\end{verbatim}

\textbf{Arguments}

- \texttt{object} fitted "oem" model object.
- \texttt{which.model} If multiple penalties are fit and returned in the same oem object, the which.model argument is used to specify which model to plot. For example, if the oem object "oemobj" was fit with argument \texttt{penalty = c("lasso", "grp.lasso")}, then which.model = 2 provides a plot for the group lasso model.
- \texttt{...} not used

\textbf{Examples}

set.seed(123)
n.obs <- 2000
n.vars <- 50

true.beta <- c(runif(15, -0.25, 0.25), rep(0, n.vars - 15))
Orthogonalizing EM

Description

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Usage

```r
oem(x, y, family = c("gaussian", "binomial"), penalty = c("elastic.net", "lasso", "ols", "mcp", "scad", "mcp.net", "scad.net", "grp.lasso", "grp.lasso.net", "grp.mcp", "grp.scad", "grp.mcp.net", "grp.scad.net", "sparse.grp.lasso"), weights = numeric(0), lambda = numeric(0), nlambda = 100L, lambda.min.ratio = NULL, alpha = 1, gamma = 3, tau = 0.5, groups = numeric(0), penalty.factor = NULL, group.weights = NULL, standardize = TRUE, intercept = TRUE, maxit = 500L, tol = 1e-07, irls.maxit = 100L, irls.tol = 0.001, accelerate = FALSE, ncores = -1, compute.loss = FALSE, hessian.type = c("upper.bounds", "full"))
```
Arguments

x
input matrix of dimension n x p or CsparseMatrix object of the Matrix package. Each row is an observation, each column corresponds to a covariate. The oem() function is optimized for n \( \gg \) p settings and may be very slow when p \( \gg \) n, so please use other packages such as glmnet, ncvreg, grpreg, or gglasso when p \( \gg \) n or p \( \approx \) n.

y
numeric response vector of length nobs.

family
"gaussian" for least squares problems, "binomial" for binary response.

penalty
Specification of penalty type. Choices include:
- "elastic.net" - elastic net penalty, extra parameters: "alpha"
- "lasso" - lasso penalty
- "ols" - ordinary least squares
- "mcp" - minimax concave penalty, extra parameters: "gamma"
- "scad" - smoothly clipped absolute deviation, extra parameters: "gamma"
- "mcp.net" - minimax concave penalty + l2 penalty, extra parameters: "gamma", "alpha"
- "scad.net" - smoothly clipped absolute deviation + l2 penalty, extra parameters: "gamma", "alpha"
- "grp.lasso" - group lasso penalty
- "grp.lasso.net" - group lasso penalty + l2 penalty, extra parameters: "alpha"
- "grp.mcp" - group minimax concave penalty, extra parameters: "gamma"
- "grp.scad" - group smoothly clipped absolute deviation, extra parameters: "gamma"
- "grp.mcp.net" - group minimax concave penalty + l2 penalty, extra parameters: "gamma", "alpha"
- "grp.scad.net" - group smoothly clipped absolute deviation + l2 penalty, extra parameters: "gamma", "alpha"
- "sparse.grp.lasso" - sparse group lasso penalty (group lasso + lasso), extra parameters: "tau"

Careful consideration is required for the group lasso, group MCP, and group SCAD penalties. Groups as specified by the groups argument should be chosen in a sensible manner.

weights
observation weights. Not implemented yet. Defaults to 1 for each observation (setting weight vector to length 0 will default all weights to 1)

lambda
A user supplied lambda sequence. By default, the program computes its own lambda sequence based on nlambdas and lambda.min.ratio. Supplying a value of lambda overrides this.

nlambdas
The number of lambda values. The default is 100.

lambda.min.ratio
Smallest value for lambda, as a fraction of lambda.max, the (data derived) entry value (i.e. the smallest value for which all coefficients are zero). The default depends on the sample size nobs relative to the number of variables nvars. If
nobs \geq nvars$, the default is $0.0001$, close to zero. If $nobs < nvars$, the default is $0.01$. A very small value of $\lambda_{\text{min ratio}}$ will lead to a saturated fit when $nobs < nvars$.

alpha: mixing value for elastic.net, mcp.net, scad.net, grp.mcp.net, grp.scad.net.
penalty applied is $(1 - \alpha) \times \text{ridge penalty} + \alpha \times \text{lasso/mcp/mcp/grp.lasso penalty}$

gamma: tuning parameter for SCAD and MCP penalties. must be $\geq 1$
tau: mixing value for sparse.grp.lasso. penalty applied is $(1 - \tau) \times \text{group lasso penalty} + \tau \times \text{lasso penalty}$
groups: A vector of describing the grouping of the coefficients. See the example below. All unpenalized variables should be put in group 0

penalty.factor: Separate penalty factors can be applied to each coefficient. This is a number that multiplies lambda to allow differential shrinkage. Can be 0 for some variables, which implies no shrinkage, and that variable is always included in the model. Default is 1 for all variables.
group.weights: penalty factors applied to each group for the group lasso. Similar to penalty.factor, this is a number that multiplies lambda to allow differential shrinkage. Can be 0 for some groups, which implies no shrinkage, and that group is always included in the model. Default is sqrt(group size) for all groups.

standardize: Logical flag for x variable standardization, prior to fitting the models. The coefficients are always returned on the original scale. Default is standardize = TRUE. If variables are in the same units already, you might not wish to standardize. Keep in mind that standardization is done differently for sparse matrices, so results (when standardized) may be slightly different for a sparse matrix object and a dense matrix object

intercept: Should intercept(s) be fitted (default = TRUE) or set to zero (FALSE)

maxit: integer. Maximum number of OEM iterations
tol: convergence tolerance for OEM iterations

irls.maxit: integer. Maximum number of IRLS iterations

irls.tol: convergence tolerance for IRLS iterations. Only used if family != "gaussian"

accelerate: boolean argument. Whether or not to use Nesterov acceleration with adaptive restarting

ncores: Integer scalar that specifies the number of threads to be used

compute.loss: should the loss be computed for each estimated tuning parameter? Defaults to FALSE. Setting to TRUE will dramatically increase computational time

hessian.type: only for logistic regression. if hessian.type = "full", then the full hessian is used. If hessian.type = "upper.bound", then an upper bound of the hessian is used. The upper bound can be dramatically faster in certain situations, ie when $n \gg p$

Value

An object with S3 class "oem"
References


Examples

```r
set.seed(123)
n.obs <- 1e4
n.vars <- 50

true.beta <- c(runif(15, -0.25, 0.25), rep(0, n.vars - 15))

x <- matrix(rnorm(n.obs * n.vars), n.obs, n.vars)
y <- rnorm(n.obs, sd = 3) + x %*% true.beta

fit <- oem(x = x, y = y,
penalty = c("lasso", "grp.lasso", "sparse.grp.lasso"),
groups = rep(1:10, each = 5))

layout(matrix(1:3, ncol = 3))
plot(fit)
plot(fit, which.model = 2)
plot(fit, which.model = "sparse.grp.lasso")

# the oem package has support for
# sparse design matrices

library(Matrix)

xs <- rsparsematrix(n.obs * 25, n.vars * 2, density = 0.01)
ys <- rnorm(n.obs * 25, sd = 3) + as.vector(xs %*% c(true.beta, rep(0, n.vars)))
x.dense <- as.matrix(xs)

system.time(fit <- oem(x = x.dense, y = ys,
penalty = c("lasso", "grp.lasso"),
groups = rep(1:20, each = 5), intercept = FALSE,
standardize = FALSE))

system.time(fits <- oem(x = xs, y = ys,
penalty = c("lasso", "grp.lasso"),
groups = rep(1:20, each = 5), intercept = FALSE,
standardize = FALSE, lambda = fit$lambda))

max(abs(fit$beta[[1]] - fits$beta[[1]]))
max(abs(fit$beta[[2]] - fits$beta[[2]]))

# logistic
y <- rbinom(n.obs, 1, prob = 1 / (1 + exp(-x %*% true.beta)))

system.time(res <- oem(x, y, intercept = FALSE,
penalty = c("lasso", "sparse.grp.lasso", "mcp"),
standardize = FALSE))
```

family = "binomial",
groups = rep(1:10, each = 5),
nlambda = 10,
irls.tol = 1e-3, tol = 1e-8))

layout(matrix(1:3, ncol = 3))
plot(res)
plot(res, which.model = 2)
plot(res, which.model = "mcp")

# sparse design matrix
xs <- rsparsematrix(n.obs * 2, n.vars, density = 0.01)
x.dense <- as.matrix(xs)
ys <- rbinom(n.obs * 2, 1, prob = 1 / (1 + exp(-x * true.beta)))

system.time(res.gr <- oem(x.dense, ys, intercept = FALSE,
penalty = "grp.lasso",
family = "binomial",
nlambda = 10,
groups = rep(1:5, each = 10),
irls.tol = 1e-3, tol = 1e-8))

system.time(res.gr.s <- oem(xs, ys, intercept = FALSE,
penalty = "grp.lasso",
family = "binomial",
nlambda = 10,
groups = rep(1:5, each = 10),
irls.tol = 1e-3, tol = 1e-8))

max(abs(res.gr$beta[[1]] - res.gr.s$beta[[1]]))

---

**oem.xtx**

**Orthogonalizing EM**

**Description**

Orthogonalizing EM

**Usage**

```
oem.xtx(xtx, xty, family = c("gaussian", "binomial"),
penalty = c("elastic.net", "lasso", "ols", "mcp", "scad", "mcp.net",
"scad.net", "grp.lasso", "grp.lasso.net", "grp.mcp", "grp.scad",
"grp.mcp.net", "grp.scad.net", "sparse.grp.lasso"), lambda = numeric(0),
nlambda = 100L, lambda.min.ratio = NULL, alpha = 1, gamma = 3,
tau = 0.5, groups = numeric(0), scale.factor = numeric(0),
penalty.factor = NULL, group.weights = NULL, maxit = 500L,
tol = 1e-07, irls.maxit = 100L, irls.tol = 0.001)
```
Arguments

xtx
input matrix equal to crossprod(x) / nrow(x), where x is the design matrix. It is highly recommended to scale by the number of rows in x. If xtx is scaled, xty must also be scaled or else results may be meaningless!

xty
numeric vector of length nvars. Equal to crossprod(x, y) / nobs. It is highly recommended to scale by the number of rows in x.

family
"gaussian" for least squares problems, "binomial" for binary response. (only gaussian implemented currently)

penalty
Specification of penalty type. Choices include:

- "elastic.net" - elastic net penalty, extra parameters: "alpha"
- "lasso" - lasso penalty
- "ols" - ordinary least squares
- "mcp" - minimax concave penalty, extra parameters: "gamma"
- "scad" - smoothly clipped absolute deviation, extra parameters: "gamma"
- "mcp.net" - minimax concave penalty + l2 penalty, extra parameters: "gamma", "alpha"
- "scad.net" - smoothly clipped absolute deviation + l2 penalty, extra parameters: "gamma", "alpha"
- "grp.lasso" - group lasso penalty
- "grp.lasso.net" - group lasso penalty + l2 penalty, extra parameters: "alpha"
- "grp.mcp" - group minimax concave penalty, extra parameters: "gamma"
- "grp.scad" - group smoothly clipped absolute deviation, extra parameters: "gamma"
- "grp.mcp.net" - group minimax concave penalty + l2 penalty, extra parameters: "gamma", "alpha"
- "grp.scad.net" - group smoothly clipped absolute deviation + l2 penalty, extra parameters: "gamma", "alpha"
- "sparse.grp.lasso" - sparse group lasso penalty (group lasso + lasso), extra parameters: "tau"

Careful consideration is required for the group lasso, group MCP, and group SCAD penalties. Groups as specified by the groups argument should be chosen in a sensible manner.

lambda
A user supplied lambda sequence. By default, the program computes its own lambda sequence based on nlambda and lambda.min.ratio. Supplying a value of lambda overrides this.

nlambda
The number of lambda values - default is 100.

lambda.min.ratio
Smallest value for lambda, as a fraction of lambda.max, the (data derived) entry value (i.e. the smallest value for which all coefficients are zero). The default depends on the sample size nobs relative to the number of variables nvars. The default is 0.0001

alpha
mixing value for elastic.net, mcp.net, scad.net, grp.mcp.net, grp.scad.net. penalty applied is (1 - alpha) * (ridge penalty) + alpha * (lasso/mcp/mcp/grp.lasso penalty)
gamma tuning parameter for SCAD and MCP penalties. must be $\geq 1$

tau mixing value for sparse.grp.lasso. penalty applied is $(1 - \tau) \times \text{(group lasso penalty)} + \tau \times \text{(lasso penalty)}$

groups A vector of describing the grouping of the coefficients. See the example below. All unpenalized variables should be put in group 0

scale.factor of length nvars $= ncol(xtx) = \text{length(xty)}$ for scaling columns of x. The standard deviation for each column of x is a common choice for scale.factor. Coefficients will be returned on original scale. Default is no scaling.

penalty.factor Separate penalty factors can be applied to each coefficient. This is a number that multiplies lambda to allow differential shrinkage. Can be 0 for some variables, which implies no shrinkage, and that variable is always included in the model. Default is 1 for all variables.

group.weights penalty factors applied to each group for the group lasso. Similar to penalty.factor, this is a number that multiplies lambda to allow differential shrinkage. Can be 0 for some groups, which implies no shrinkage, and that group is always included in the model. Default is $\sqrt{\text{group size}}$ for all groups.

maxit integer. Maximum number of OEM iterations

tol convergence tolerance for OEM iterations

irls.maxit integer. Maximum number of IRLS iterations

irls.tol convergence tolerance for IRLS iterations. Only used if family != "gaussian"

Value

An object with S3 class "oem"

Examples

```r
set.seed(123)
n.obs <- 1e4
n.vars <- 100

true.beta <- c(runif(15, -0.25, 0.25), rep(0, n.vars - 15))

x <- matrix(rnorm(n.obs * n.vars), n.obs, n.vars)
y <- rnorm(n.obs, sd = 3) + x %*% true.beta

fit <- oem(x = x, y = y,
    penalty = c("lasso", "elastic.net",
                "ols",
                "mcp",
                "scad",
                "mcp.net", "scad.net",
                "grp.lasso", "grp.lasso.net",
                "grp.mcp", "grp.scad",
                "sparse.grp.lasso"),
    standardize = FALSE, intercept = FALSE,
    groups = rep(1:20, each = 5))

xtx <- crossprod(x) / n.obs
```
xtv <- crossprod(x, y) / n.obs

fit.xtx <- oem.xtx(xtx = xtx, xty = xty,
    penalty = c("lasso", "elastic.net",
        "ols",
        "mcp", "scad",
        "mcp.net", "scad.net",
        "grp.lasso", "grp.lasso.net",
        "grp.mcp", "grp.scad",
        "sparse.grp.lasso"),
    groups = rep(1:20, each = 5))

max(abs(fit$beta[1][-1] - fit.xtx$beta[1]))
max(abs(fit$beta[2][-1] - fit.xtx$beta[2]))

layout(matrix(1:2, ncol = 2))
plot(fit.xtx)
plot(fit.xtx, which.model = 2)

---

## oemfit

### Deprecated functions

These functions have been renamed and deprecated in **oem**: `oemfit()` (use `oem()`), `cv.oemfit()` (use `cv.oem()`), `print.oemfit()`, `plot.oemfit()`, `predict.oemfit()`, and `coef.oemfit()`.

### Usage

```r
oemfit(formula, data = list(), lambda = NULL, nlambda = 100,
    lambda.min.ratio = NULL, tolerance = 0.001, maxIter = 1000,
    standardized = TRUE, numGroup = 1, penalty = c("lasso", "scad", "ols",
        "elastic.net", "ngarrote", "mcp"), alpha = 3, evaluate = 0,
    condition = -1)
```

```r
cv.oemfit(formula, data = list(), lambda = NULL, type.measure = c("mse",
    "mae"), ..., nfolds = 10, foldid, penalty = c("lasso", "scad",
    "elastic.net", "ngarrote", "mcp"))
```

```r
## S3 method for class 'oemfit'
plot(x, xvar = c("norm", "lambda", "loglambda", "dev"),
    xlab = iname, ylab = "Coefficients", ...)
```

```r
## S3 method for class 'oemfit'
predict(object, newx, s = NULL, type = c("response",
    "coefficients", "nonzero"), ...)
```

```r
## S3 method for class 'oemfit'
print(x, digits = max(3,getOption("digits") - 3), ...)
```
Arguments

**formula**
- an object of 'formula' (or one that can be coerced to that class): a symbolic description of the model to be fitted. The details of model specification are given under 'Details'.

**data**
- an optional data frame, list or environment (or object coercible by 'as.data.frame' to a data frame) containing the variables in the model. If not found in 'data', the variables are taken from 'environment(formula)', typically the environment from which 'oemfit' is called.

**lambda**
- A user supplied lambda sequence. Typical usage is to have the program compute its own lambda sequence based on nlambda and lambda.min.ratio. Supplying a value of lambda overrides this. WARNING: use with care. Do not supply a single value for lambda (for predictions after CV use predict() instead). Supply instead a decreasing sequence of lambda values. oemfit relies on its warms starts for speed, and its often faster to fit a whole path than compute a single fit.

**nlambda**
- The number of lambda values - default is 100.

**lambda.min.ratio**
- Smallest value for lambda, as a fraction of lambda.max, the (data derived) entry value (i.e. the smallest value for which all coefficients are zero). The default depends on the sample size nobs relative to the number of variables nvars. If nobs > nvars, the default is 0.0001, close to zero. If nobs < nvars, the default is 0.01. A very small value of lambda.min.ratio will lead to a saturated fit in the nobs < nvars case.

**tolerance**
- Convergence tolerance for OEM. Each inner OEM loop continues until the maximum change in the objective after any coefficient update is less than tolerance. Defaults value is 1E-3.

**maxIter**
- Maximum number of passes over the data for all lambda values; default is 1000.

**standardized**
- Logical flag for x variable standardization, prior to fitting the model sequence. The coefficients are always returned on the original scale. Default is standardize=TRUE. If variables are in the same units already, you might not wish to standardize.

**numGroup**
- Integer value for the number of groups to use for OEM fitting. Default is 1.

**penalty**
- type in lower letters. Different types include 'lasso', 'scad', 'ols' (ordinary least square), 'elastic-net', 'ngarrote' (non-negative garrote) and 'mcp'.

**alpha**
- alpha value for scad and mcp.

**evaluate**
- Debugging argument

**condition**
- Debugging for different ways of calculating OEM.

**type.measure**
- type.measure measure to evaluate for cross-validation. type.measure = "mse" (mean squared error) or type.measure = "mae" (mean absolute error)

**nfolds**
- number of folds for cross-validation. default is 10.

**foldid**
- an optional vector of values between 1 and nfolds specifying which fold each observation belongs to.

**x**
- fitted oemfit object
plot.oem

xvar what is on the X-axis. "norm" plots against the L1-norm of the coefficients, "lambda" against the log-lambda sequence, and "dev" against the percent deviance explained.

xlab x-axis label
ylab y-axis label
object fitted oemfit object
newx matrix of new values for x at which predictions are to be made. Must be a matrix.
s Value(s) of the penalty parameter lambda at which predictions are required. Default is the entire sequence used to create the model.
type not used.
digits significant digits in print out.

Details
The sequence of models implied by 'lambda' is fit by OEM algorithm.

Author(s)
Bin Dai

plot.oem  Plot method for Orthogonalizing EM fitted objects

Description
Plot method for Orthogonalizing EM fitted objects
Plot method for Orthogonalizing EM fitted objects

Usage
## S3 method for class 'oem'
plot(x, which.model = 1, xvar = c("norm", "lambda", "loglambda", "dev"), labsize = 0.6, xlab = iname, ylab = NULL,
     main = x$penalty[which.model], ...)

## S3 method for class 'cv.oem'
plot(x, which.model = 1, sign.lambda = 1, ...)

## S3 method for class 'xval.oem'
plot(x, which.model = 1, type = c("cv", "coefficients"),
     xvar = c("norm", "lambda", "loglambda", "dev"), labsize = 0.6,
     xlab = iname, ylab = NULL, main = x$penalty[which.model],
     sign.lambda = 1, ...)


Arguments

x  
  fitted "oem" model object

which.model  
  If multiple penalties are fit and returned in the same oem object, the which.model argument is used to specify which model to plot. For example, if the oem object "oemobj" was fit with argument penalty = c("lasso", "grp.lasso"), then which.model = 2 provides a plot for the group lasso model.

xvar  
  What is on the X-axis. "norm" plots against the L1-norm of the coefficients, "lambda" against the log-lambda sequence, and "dev" against the percent deviance explained.

lабsize  
  size of labels for variable names. If labsize = 0, then no variable names will be plotted

xlab  
  label for x-axis

ylab  
  label for y-axis

main  
  main title for plot

...  
  other graphical parameters for the plot

sign.lambda  
  Either plot against log(lambda) (default) or its negative if sign.lambda = -1.

type  
  one of "cv" or "coefficients". type = "cv" will produce a plot of cross validation results like plot.cv.oem. type = "coefficients" will produce a coefficient path plot like plot.oem()

Examples

set.seed(123)
n.obs <- 1e4
n.vars <- 100
n.obs.test <- 1e3
true.beta <- c(runif(15, -0.5, 0.5), rep(0, n.vars - 15))

x <- matrix(rnorm(n.obs * n.vars), n.obs, n.vars)
y <- rnorm(n.obs, sd = 3) + x %% true.beta

fit <- oem(x = x, y = y, penalty = c("lasso", "grp.lasso"), groups = rep(1:10, each = 10))

layout(matrix(1:2, ncol = 2))
plot(fit, which.model = 1)
plot(fit, which.model = 2)

set.seed(123)
n.obs <- 1e4
n.vars <- 100
n.obs.test <- 1e3
true.beta <- c(runif(15, -0.5, 0.5), rep(0, n.vars - 15))

x <- matrix(rnorm(n.obs * n.vars), n.obs, n.vars)
y <- rnorm(n.obs, sd = 3) + x %% true.beta
predict.cv.oem

fit <- cv.oem(x = x, y = y, penalty = c("lasso", "grp.lasso"), groups = rep(1:10, each = 10))

layout(matrix(1:2, ncol = 2))
plot(fit, which.model = 1)
plot(fit, which.model = "grp.lasso")

set.seed(123)
n.obs <- 1e4
n.vars <- 100
n.obs.test <- 1e3

true.beta <- c(runif(15, -0.5, 0.5), rep(0, n.vars - 15))

x <- matrix(rnorm(n.obs * n.vars), n.obs, n.vars)
y <- rnorm(n.obs, sd = 3) + x %*% true.beta

fit <- xval.oem(x = x, y = y, penalty = c("lasso", "grp.lasso"), groups = rep(1:10, each = 10))

layout(matrix(1:4, ncol = 2))
plot(fit, which.model = 1)
plot(fit, which.model = 2)
plot(fit, which.model = 1, type = "coef")
plot(fit, which.model = 2, type = "coef")

---

**predict.cv.oem**

*Prediction function for fitted cross validation oem objects*

**Description**

Prediction function for fitted cross validation oem objects

**Usage**

```r
## S3 method for class 'cv.oem'
predict(object, newx, which.model = "best.model",  
s = c("lambda.min", "lambda.1se"), ...)
```

**Arguments**

- **object**: fitted "cv.oem" model object
- **newx**: Matrix of new values for x at which predictions are to be made. Must be a matrix; can be sparse as in the CsparseMatrix objects of the Matrix package.
  This argument is not used for type = c("coefficients", "nonzero")
- **which.model**: If multiple penalties are fit and returned in the same oem object, the which.model argument is used to specify which model to make predictions for.
  For example, if the oem object "oemobj" was fit with argument penalty = c("lasso", "grp.lasso"),
then which.model = 2 provides predictions for the group lasso model. For predict.cv.oem(), can specify "best.model" to use the best model as estimated by cross-validation

s

Value(s) of the penalty parameter lambda at which predictions are required. Default is the entire sequence used to create the model. For predict.cv.oem(), can also specify "lambda.1se" or "lambda.min" for best lambdas estimated by cross validation

... used to pass the other arguments for predict.oem

Value

An object depending on the type argument

Examples

```r
set.seed(123)
n.obs <- 1e4
n.vars <- 100
n.obs.test <- 1e3
true.beta <- c(runif(15, -0.5, 0.5), rep(0, n.vars - 15))
x <- matrix(rnorm(n.obs * n.vars), n.obs, n.vars)
y <- rnorm(n.obs, sd = 3) + x %*% true.beta
x.test <- matrix(rnorm(n.obs.test * n.vars), n.obs.test, n.vars)
y.test <- rnorm(n.obs.test, sd = 3) + x.test %*% true.beta
fit <- cv.oem(x = x, y = y,
              penalty = c("lasso", "grp.lasso"),
              groups = rep(1:10, each = 10),
              nlambda = 10)
preds.best <- predict(fit, newx = x.test, type = "response", which.model = "best.model")
apply(preds.best, 2, function(x) mean((y.test - x) ^ 2))
preds.gl <- predict(fit, newx = x.test, type = "response", which.model = "grp.lasso")
apply(preds.gl, 2, function(x) mean((y.test - x) ^ 2))
preds.l <- predict(fit, newx = x.test, type = "response", which.model = 1)
apply(preds.l, 2, function(x) mean((y.test - x) ^ 2))
```

---

**predict.oem**

*Prediction method for Orthogonalizing EM fitted objects*

**Description**

Prediction method for Orthogonalizing EM fitted objects
predict.oem

Usage

```r
## S3 method for class 'oem'
predict(object, newx, s = NULL, which.model = 1,
         type = c("link", "response", "coefficients", "nonzero", "class"), ...)
```

Arguments

- **object**: fitted "oem" model object
- **newx**: Matrix of new values for \( x \) at which predictions are to be made. Must be a
  matrix; can be sparse as in the CsparseMatrix objects of the Matrix package.
  This argument is not used for type=c("coefficients","nonzero")
- **s**: Value(s) of the penalty parameter lambda at which predictions are required. Default
  is the entire sequence used to create the model.
- **which.model**: If multiple penalties are fit and returned in the same oem object, the
  which.model argument is used to specify which model to make predictions for. For example,
  if the oem object oemobj was fit with argument penalty = c("lasso", "grp.lasso"),
  then which.model = 2 provides predictions for the group lasso model.
- **type**: Type of prediction required. type = "link" gives the linear predictors for the
  "binomial" model; for "gaussian" models it gives the fitted values. type = "response"
  gives the fitted probabilities for "binomial". type = "coefficients" computes the
  coefficients at the requested values for \( s \). type = "class" applies
  only to "binomial" and produces the class label corresponding to the maximum
  probability.

Value

An object depending on the type argument

Examples

```r
set.seed(123)
n.obs <- 1e4
n.vars <- 100
n.obs.test <- 1e3

true.beta <- c(runif(15, -0.5, 0.5), rep(0, n.vars - 15))

x <- matrix(rnorm(n.obs * n.vars), n.obs, n.vars)
y <- rnorm(n.obs, sd = 3) + x %*% true.beta
x.test <- matrix(rnorm(n.obs.test * n.vars), n.obs.test, n.vars)
y.test <- rnorm(n.obs.test, sd = 3) + x.test %*% true.beta

fit <- oem(x = x, y = y,
         penalty = c("lasso", "grp.lasso"),
         groups = rep(1:10, each = 10),
         nlambda = 10)

preds.lasso <- predict(fit, newx = x.test, type = "response", which.model = 1)
```
predict.xval.oem <- predict(fit, newx = x.test, type = "response", which.model = 2)

apply(preds.lasso, 2, function(x) mean((y.test - x) ^ 2))
apply(preds.grp.lasso, 2, function(x) mean((y.test - x) ^ 2))

---

**predict.xval.oem**  
*Prediction function for fitted cross validation oem objects*

**Description**

Prediction function for fitted cross validation oem objects

**Usage**

```r
## S3 method for class 'xval.oem'
predict(object, newx, which.model = "best.model",
  s = c("lambda.min", "lambda.1se"), ...)
```

**Arguments**

- `object`: fitted "cv.oem" model object
- `newx`: Matrix of new values for x at which predictions are to be made. Must be a matrix; can be sparse as in the CsparseMatrix objects of the Matrix package. This argument is not used for type=c("coefficients","nonzero")
- `which.model`: If multiple penalties are fit and returned in the same oem object, the which.model argument is used to specify which model to make predictions for. For example, if the oem object "oemobj" was fit with argument penalty = c("lasso", "grp.lasso"), then which.model = .2 provides predictions for the group lasso model. For predict.cv.oem(), can specify "best.model" to use the best model as estimated by cross-validation
- `s`: Value(s) of the penalty parameter lambda at which predictions are required. Default is the entire sequence used to create the model. For predict.cv.oem, can also specify "lambda.1se" or "lambda.min" for best lambdas estimated by cross validation
- `...`: used to pass the other arguments for predict.oem()

**Value**

An object depending on the type argument
Examples

```r
set.seed(123)
n.obs <- 1e4
n.vars <- 100
n.obs.test <- 1e3
true.beta <- c(runif(15, -0.5, 0.5), rep(0, n.vars - 15))
x <- matrix(rnorm(n.obs * n.vars), n.obs, n.vars)
y <- rnorm(n.obs, sd = 3) + x %*% true.beta
x.test <- matrix(rnorm(n.obs.test * n.vars), n.obs.test, n.vars)
y.test <- rnorm(n.obs.test, sd = 3) + x.test %*% true.beta
fit <- xval.oem(x = x, y = y,
    penalty = c("lasso", "grp.lasso"),
    groups = rep(1:10, each = 10),
    nlambda = 10)
preds.best <- predict(fit, newx = x.test, type = "response", which.model = "best.model")
apply(preds.best, 2, function(x) mean((y.test - x) ^ 2))
preds.gl <- predict(fit, newx = x.test, type = "response", which.model = "grp.lasso")
apply(preds.gl, 2, function(x) mean((y.test - x) ^ 2))
preds.l <- predict(fit, newx = x.test, type = "response", which.model = 1)
apply(preds.l, 2, function(x) mean((y.test - x) ^ 2))
```

Description

print method for `summary.cv.oem` objects

Usage

```r
# S3 method for class 'summary.cv.oem'
print(x, digits, ...)
```

Arguments

- `x` a "summary.cv.oem" object
- `digits` digits to display
- `...` not used
summary.cv.oem summary method for cross validation Orthogonalizing EM fitted objects

Description
summary method for cross validation Orthogonalizing EM fitted objects

Usage
## S3 method for class 'cv.oem'
summary(object, ...)

## S3 method for class 'xval.oem'
summary(object, ...)

Arguments
- object: fitted "cv.oem" object
- ...: not used

xval.oem Orthogonalizing EM

Description
Orthogonalizing EM

Usage
xval.oem(x, y, nfolds = 10L, foldid = NULL, type.measure = c("mse",
"deviance", "class", "auc", "mae"), ncores = -1, family = c("gaussian",
"binomial"), penalty = c("elastic.net", "lasso", "ols", "mcp", "scad",
"mcp.net", "scad.net", "grp.lasso", "grp.lasso.net", "grp.mcp", "grp.scad",
"grp.mcp.net", "grp.scad.net", "sparse.grp.lasso"), weights = numeric(0),
lambda = numeric(0), nlambda = 100L, lambda.min.ratio = NULL,
alpha = 1, gamma = 3, tau = 0.5, groups = numeric(0),
penalty.factor = NULL, group.weights = NULL, standardize = TRUE,
intercept = TRUE, maxit = 500L, tol = 1e-07, irls.maxit = 100L,
irls.tol = 0.001, compute.loss = FALSE)
Arguments

\textbf{x} \hspace{1cm} \text{input matrix of dimension n x p (sparse matrices not yet implemented). Each row is an observation, each column corresponds to a covariate. The xval.oem() function is optimized for n \gg p settings and may be very slow when p > n, so please use other packages such as glmnet, ncvreg, grpreg, or gglasso when p > n or p approx n.}

\textbf{y} \hspace{1cm} \text{numeric response vector of length nobs = nrow(x).}

\textbf{nfolds} \hspace{1cm} \text{integer number of cross validation folds. 3 is the minimum number allowed. defaults to 10}

\textbf{foldid} \hspace{1cm} \text{an optional vector of values between 1 and nfold specifying which fold each observation belongs to.}

\textbf{type.measure} \hspace{1cm} \text{measure to evaluate for cross-validation. The default is type.measure = "deviance", which uses squared-error for gaussian models (a.k.a type.measure = "mse" there), deviance for logistic regression. type.measure = "class" applies to binomial only. type.measure = "auc" is for two-class logistic regression only. type.measure="mse" or type.measure="mae" (mean absolute error) can be used by all models; they measure the deviation from the fitted mean to the response.}

\textbf{ncores} \hspace{1cm} \text{Integer scalar that specifies the number of threads to be used}

\textbf{family} \hspace{1cm} \text{"gaussian" for least squares problems, "binomial" for binary response (not implemented yet).}

\textbf{penalty} \hspace{1cm} \text{Specification of penalty type. Choices include:}

- "elastic.net" - elastic net penalty, extra parameters: "alpha"
- "lasso" - lasso penalty
- "ols" - ordinary least squares
- "mcp" - minimax concave penalty, extra parameters: "gamma"
- "scad" - smoothly clipped absolute deviation, extra parameters: "gamma"
- "mcp.net" - minimax concave penalty + l2 penalty, extra parameters: "gamma", "alpha"
- "scad.net" - smoothly clipped absolute deviation + l2 penalty, extra parameters: "gamma", "alpha"
- "grp.lasso" - group lasso penalty
- "grp.lasso.net" - group lasso penalty + l2 penalty, extra parameters: "alpha"
- "grp.mcp" - group minimax concave penalty, extra parameters: "gamma"
- "grp.scad" - group smoothly clipped absolute deviation, extra parameters: "gamma"
- "grp.mcp.net" - group minimax concave penalty + l2 penalty, extra parameters: "gamma", "alpha"
- "grp.scad.net" - group smoothly clipped absolute deviation + l2 penalty, extra parameters: "gamma", "alpha"
- "sparse.grp.lasso" - sparse group lasso penalty (group lasso + lasso), extra parameters: "tau"
Careful consideration is required for the group lasso, group MCP, and group SCAD penalties. Groups as specified by the `groups` argument should be chosen in a sensible manner.

- **weights**: observation weights. Defaults to 1 for each observation (setting weight vector to length 0 will default all weights to 1).

- **lambda**: A user supplied lambda sequence. By default, the program computes its own lambda sequence based on `nlambda` and `lambda.min.ratio`. Supplying a value of lambda overrides this.

- **nlambda**: The number of lambda values - default is 100.

- **lambda.min.ratio**: Smallest value for lambda, as a fraction of `lambda.max`, the (data derived) entry value (i.e. the smallest value for which all coefficients are zero). The default depends on the sample size `nobs` relative to the number of variables `nvars`. If `nobs > nvars`, the default is 0.0001, close to zero.

- **alpha**: mixing value for `elastic.net`, `mcp.net`, `scad.net`, `grp.mcp.net`, `grp.scad.net`. Penalty applied is $(1 - \alpha) \times \text{(ridge penalty)} + \alpha \times \text{(lasso/mcp/mcp/grp.lasso penalty)}$.

- **gamma**: tuning parameter for SCAD and MCP penalties. Must be $\geq 1$.

- **tau**: mixing value for `sparse.grp.lasso`. Penalty applied is $(1 - \tau) \times \text{(group lasso penalty)} + \tau \times \text{(lasso penalty)}$.

- **groups**: A vector of describing the grouping of the coefficients. See the example below. All unpenalized variables should be put in group 0.

- **penalty.factor**: Separate penalty factors can be applied to each coefficient. This is a number that multiplies lambda to allow differential shrinkage. Can be 0 for some variables, which implies no shrinkage, and that variable is always included in the model. Default is 1 for all variables.

- **group.weights**: penalty factors applied to each group for the group lasso. Similar to `penalty.factor`, this is a number that multiplies lambda to allow differential shrinkage. Can be 0 for some groups, which implies no shrinkage, and that group is always included in the model. Default is sqrt(group size) for all groups.

- **standardize**: Logical flag for x variable standardization, prior to fitting the models. The coefficients are always returned on the original scale. Default is `standardize = TRUE`. If variables are in the same units already, you might not wish to standardize.

- **intercept**: Should intercept(s) be fitted (default = TRUE) or set to zero (FALSE).

- **maxit**: integer. Maximum number of OEM iterations.

- **tol**: convergence tolerance for OEM iterations.

- **irls.maxit**: integer. Maximum number of IRLS iterations.

- **irls.tol**: convergence tolerance for IRLS iterations. Only used if family != "gaussian".

- **compute.loss**: should the loss be computed for each estimated tuning parameter? Defaults to FALSE. Setting to TRUE will dramatically increase computational time.

**Value**

An object with S3 class "xval.oem"
Examples

```r
set.seed(123)
n.obs <- 1e4
n.vars <- 100

true.beta <- c(runif(15, -0.25, 0.25), rep(0, n.vars - 15))

x <- matrix(rnorm(n.obs * n.vars), n.obs, n.vars)
y <- rnorm(n.obs, sd = 3) + x %*% true.beta

system.time(fit <- oem(x = x, y = y,
                       penalty = c("lasso", "grp.lasso"),
                       groups = rep(1:20, each = 5)))

system.time(xfit <- xval.oem(x = x, y = y,
                             penalty = c("lasso", "grp.lasso"),
                             groups = rep(1:20, each = 5)))

system.time(xfit2 <- xval.oem(x = x, y = y,
                              penalty = c("lasso", "grp.lasso",
                                          "mcp", "scad",
                                          "mcp.net", "scad.net",
                                          "grp.lasso", "grp.lasso.net",
                                          "grp.mcp", "grp.scad",
                                          "sparse.grp.lasso"),
                              groups = rep(1:20, each = 5)))
```
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