

Package ‘msda’

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Title Multi-Class Sparse Discriminant Analysis

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Depends Matrix, MASS

Imports methods

Description Efficient procedures for computing a new Multi-Class Sparse Discriminant Analysis method that estimates all discriminant directions simultaneously. It is an implementation of the work proposed by Mai, Q., Yang, Y., and Zou, H. (2019) <[doi:10.5705/ss.202016.0117](https://doi.org/10.5705/ss.202016.0117)>.

LazyData yes

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URL <https://github.com/archer-yang-lab/msda>

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cv.msda

*Cross-validation for msda***Description**

Does k-fold cross-validation for msda, returns a value for lambda.

Usage

```
cv.msda(x, y, nfolds = 5, lambda = NULL, lambda.opt = "min", ...)
```

Arguments

x	matrix of predictors, of dimension $N \times p$; each row is an observation vector.
y	response variable. This argument should be a factor for classification.
nfolds	number of folds - default is 5. Although nfolds can be as large as the sample size (leave-one-out CV), it is not recommended for large datasets. Smallest value allowable is nfolds=3.
lambda	optional user-supplied lambda sequence; default is NULL, and msda chooses its own sequence.
lambda.opt	If choose "min", the smallest lambda that gives minimum cross validation error cvm will be returned. If choose "max", the largest lambda that gives minimum cross validation error cvm will be returned.
...	other arguments that can be passed to msda.

Details

The function runs [msda](#) nfolds+1 times; the first to get the lambda sequence, and then the remainder to compute the fit with each of the folds omitted. The average error and standard deviation over the folds are computed.

Value

an object of class [cv.msda](#) is returned, which is a list with the ingredients of the cross-validation fit.

lambda	the values of lambda used in the fits.
cvm	the mean cross-validated error - a vector of length length(lambda).
cvsd	estimate of standard error of cvm.
lambda.min	the optimal value of lambda that gives minimum cross validation error cvm.
lambda.1se	the largest value of lambda such that error is within 1 standard error of the minimum.
msda.fit	a fitted msda object for the full data.

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References

Mai, Q.*, Yang, Y.*, and Zou, H. (2014), "Multiclass Sparse Discriminant Analysis." Submitted to *Journal of the American Statistical Association*. (* co-first author)

URL: <https://github.com/archer-yang-lab/msda>

See Also

[msda](#)

Examples

```
data(GDS1615)
x<-GDS1615$x
y<-GDS1615$y
obj.cv<-cv.msda(x=x,y=y,nfolds=5,lambda.opt="max")
lambda.min<-obj.cv$lambda.min
id.min<-which(obj.cv$lambda==lambda.min)
pred<-predict(obj.cv$msda.fit,x)[,id.min]
```

GDS1615

GDS1615 data introduced in Burczynski et al. (2012).

Description

The dataset is a subset of the dataset available on Gene Expression Omnibus with the accession number GDS1615. The original dataset contains 22283 gene expression levels and the disease states of the observed subjects. In Mai, Yang and Zou, the dimension of the original dataset was first reduced to 127 by F-test screening.

Usage

```
data(GDS1615)
```

Value

This data frame contains the following:

x	gene expression levels.
y	Disease state that is coded as 1,2,3. 1: normal; 2: ulcerative colitis; 3: Crohn's disease.

References

M. E. Burczynski, R. L. Peterson, N. C. Twine, K. A. Zuberek, B. J. Brodeur, L. Casciotti, V. Maganti, P. S. Reddy, A. Strahs, F. Immermann, W. Spinelli, U. Schwertschlag, A. M. Slager, M. M. Cotreau, and A. J. Dorner. (2012), "Molecular classification of crohn's disease and ulcerative colitis patients using transcriptional profiles in peripheral blood mononuclear cells". *Journal of Molecular Diagnostics*, 8:51–61.

Mai, Q.*, Yang, Y.*, and Zou, H. (2014), "Multiclass Sparse Discriminant Analysis." Submitted to *Journal of the American Statistical Association*. (* co-first author)

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Examples

```
data(GDS1615)
```

msda	<i>Fits a regularization path for Multi-Class Sparse Discriminant Analysis</i>
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Description

Fits a regularization path for Multi-Class Sparse Discriminant Analysis at a sequence of regularization parameters `lambda`.

Usage

```
msda(x, y, nlambda = 100,
     lambda.factor = ifelse((nobs - nclass) <= nvars, 0.2, 0.001),
     lambda = NULL, dfmax = nobs, pmax = min(dfmax * 2 + 20, nvars),
     pf = rep(1, nvars), eps = 1e-04, maxit = 1e+06, sml = 1e-06,
     verbose = FALSE, perturb = NULL)
```

Arguments

<code>x</code>	matrix of predictors, of dimension $N \times p$; each row is an observation vector.
<code>y</code>	response variable. This argument should be a factor for classification.
<code>nlambda</code>	the number of <code>lambda</code> values - default is 100.
<code>lambda.factor</code>	The factor for getting the minimal <code>lambda</code> in <code>lambda</code> sequence, where $\min(\lambda) = \lambda.factor * \max(\lambda)$. $\max(\lambda)$ is the smallest value of <code>lambda</code> for which all coefficients are zero. The default depends on the relationship between N (the number of rows in the matrix of predictors) and p (the number of predictors). If $N > p$, the default is 0.0001, close to zero. If $N < p$, the default is 0.2. A very small value of <code>lambda.factor</code> will lead to a saturated fit. It takes no effect if there is user-defined <code>lambda</code> sequence.

lambda	a user supplied lambda sequence. Typically, by leaving this option unspecified users can have the program compute its own lambda sequence based on <code>nlambda</code> and <code>lambda.factor</code> . Supplying a value of <code>lambda</code> overrides this. It is better to supply a decreasing sequence of lambda values than a single (small) value, if not, the program will sort user-defined lambda sequence in decreasing order automatically.
dfmax	limit the maximum number of variables in the model. Useful for very large p , if a partial path is desired. Default is n .
pmax	limit the maximum number of variables ever to be nonzero. For example once β enters the model, no matter how many times it exits or re-enters model through the path, it will be counted only once. Default is $\min(dfmax * 1.2, p)$.
pf	L1 penalty factor of length p . Separate L1 penalty weights can be applied to each coefficient of θ to allow differential L1 shrinkage. Can be 0 for some variables, which implies no L1 shrinkage, and results in that variable always being included in the model. Default is 1 for all variables (and implicitly infinity for variables listed in <code>exclude</code>).
eps	convergence threshold for coordinate descent. Each inner coordinate descent loop continues until the relative change in any coefficient. Defaults value is $1e-8$.
maxit	maximum number of outer-loop iterations allowed at fixed lambda value. Default is $1e6$. If models do not converge, consider increasing <code>maxit</code> .
sml	threshold for testing the convergence of the objective function.
verbose	whether to print out computation progress. The default is FALSE.
perturb	a scalar number. If it is specified, the number will be added to each diagonal element of the sigma matrix as perturbation. The default is NULL.

Details

Note that for computing speed reason, if models are not converging or running slow, consider increasing `eps` and `sml`, or decreasing `nlambda`, or increasing `lambda.factor` before increasing `maxit`. Users can also reduce `dfmax` to limit the maximum number of variables in the model.

Value

An object with S3 class `msda`.

theta	a list of <code>length(lambda)</code> for fitted coefficients theta, each one corresponding to one lambda value, each stored as a sparse matrix (<code>dgCMatrix</code> class, the standard class for sparse numeric matrices in the <code>Matrix</code> package.). To convert it into normal type matrix use <code>as.matrix()</code> .
df	the number of nonzero coefficients for each value of lambda.
obj	the fitted value of the objective function for each value of lambda.
dim	dimension of each coefficient matrix at each lambda.
lambda	the actual sequence of lambda values used.
x	matrix of predictors.

y	response variable.
npasses	total number of iterations (the most inner loop) summed over all lambda values
jerr	error flag, for warnings and errors, 0 if no error.
sigma	estimated sigma matrix.
delta	estimated delta matrix. $\text{delta}[k] = \mu[k] - \mu[1]$.
mu	estimated mu vector.
prior	prior probability that y belong to class k, estimated by $\text{mean}(y \text{ that belong to } k)$.
call	the call that produced this object

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References

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URL: <https://github.com/archer-yang-lab/msda>

See Also

cv.msda, predict.msda

Examples

```
data(GDS1615)
x<-GDS1615$x
y<-GDS1615$y
obj <- msda(x = x, y = y)
```

plot.msda

Plot coefficients from a "msda" object

Description

Produces a coefficient profile plot of the coefficient paths for a fitted `msda` object.

Usage

```
## S3 method for class 'msda'
plot(x, xvar = c("norm", "lambda"), ...)
```

Arguments

x	fitted msda model
xvar	the variable on the X-axis. The option "norm" plots the coefficients against the L1-norm of the coefficients, and the option "lambda" plots the coefficient against the log-lambda sequence.
...	other graphical parameters to plot

Details

A coefficient profile plot is produced.

Value

No return value, called for side effects

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References

Mai, Q.*, Yang, Y.*, and Zou, H. (2014), "Multiclass Sparse Discriminant Analysis." Submitted to *Journal of the American Statistical Association*. (* co-first author)
 URL: <https://github.com/archer-yang-lab/msda>

Examples

```
data(GDS1615)
x<-GDS1615$x
y<-GDS1615$y
obj <- msda(x = x, y = y)
plot(obj)
```

predict.msda	<i>make predictions from a "msda" object.</i>
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Description

This functions predicts class labels from a fitted [msda](#) object.

Usage

```
## S3 method for class 'msda'
predict(object, newx, ...)
```

Arguments

object	fitted msda model object.
newx	matrix of new values for x at which predictions are to be made. NOTE: newx must be a matrix, predict function does not accept a vector or other formats of newx.
...	Not used. Other arguments to predict.

Value

predicted class label(s) at the entire sequence of the penalty parameter lambda used to create the model.

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References

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URL: <https://github.com/archer-yang-lab/msda>

See Also

[msda](#)

Examples

```
data(GDS1615)
x<-GDS1615$x
y<-GDS1615$y
obj <- msda(x = x, y = y)
pred<-predict(obj,x)
```

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