

Package ‘penalizedcdf’

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Type Package

Title Estimate a Penalized Linear Model using the CDF Penalty Function

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Author Daniele Cuntrera [aut, cre],
Luigi Augugliaro [aut],
Vito M.R. Muggeo [aut]

Maintainer Daniele Cuntrera <daniele.cuntrera@unipa.it>

Description Utilize the CDF penalty function to estimate a penalized linear model.
It enables you to display some graphical representations and determine whether the Karush-Kuhn-Tucker conditions are met.
For more details about the theory, please refer to Cuntrera, D., Augugliaro, L., & Muggeo, V. M. (2022) <[doi:10.48550/arXiv.2212.08582](https://doi.org/10.48550/arXiv.2212.08582)>.

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BIC_calc	<i>BIC calculator function</i>
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Description

Function that takes the resulting values of the estimated model as input, to compute BIC

Usage

```
BIC_calc(X,  
         b.tld,  
         y,  
         n)
```

Arguments

X	The covariates' matrix
b.tld	The estimated sparse-beta
y	The response variable
n	The number of observation

Value

Returns the BIC value calculated for a single value of the tuning parameter.

Examples

```
p <- 10  
n <- 100  
X <- cbind(1, matrix(rnorm(n * p), n , p))  
b.s <- c(1, rep(0, p))  
b.s[sample(2:p, 3)] <- 1  
y <- drop(crossprod(t(X), b.s))  
out <- cdfPen(X = X, y = y)
```

```
(bic <- BIC_cdfpen(out))  
plot(out$lmb, bic, "s")
```

BIC_cdfpen	<i>BIC computation from a "cdfpen" object</i>
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Description

Calculates the BIC for all estimated models in a "cdfpen" object

Usage

```
BIC_cdfpen(object)
```

Arguments

object Object containing the results.

Value

Returns a vector containing the BIC values calculated over the entire estimated path

cdfPen	<i>Fit a Linear Model with with CDF regularization</i>
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Description

Uses the CDF penalty to estimate a linear model with the maximum penalized likelihood. The path of coefficients is computed for a grid of values for the lambda regularization parameter.

Usage

```
cdfPen(X,
       y,
       nu,
       lmb,
       nlmb = 100L,
       e = 1E-3,
       rho = 2,
       algorithm = c("lla", "opt"),
       nstep = 1E+5,
       eps = 1E-6,
       eps.lla = 1E-6,
       nstep.lla = 1E+5)
```

Arguments

X	Matrix of covariates, each row is a vector of observations. The matrix must not contain the intercept.
y	Vector of response variable.
nu	Shape parameter of the penalty. It affects the degree of the non-convexity of the penalty. If no value is specified, the smallest value that ensures a single solution will be used.
lmb	A user-supplied tuning parameter sequence.
nlmb	number of lambda values; 100 is the default value.
e	The smallest lambda value, expressed as a percentage of maximum lambda. Default value is .001.
rho	Parameter of the optimization algorithm. Default is 2.
algorithm	Approximation to be used to obtain the sparse solution.
nstep	Maximum number of iterations of the global algorithm.
eps	Convergence threshold of the global algorithm.
eps.lls	Convergence threshold of the LLA-algorithm (if used).
nstep.lls	Maximum number of iterations of the LLA-algorithm (if used).

Details

We consider a local quadratic approximation of the likelihood to treat the problem as a weighted linear model.

The choice of value assigned to ν is of fundamental importance: it affects both computational and estimation aspects. It affects the "degree of non-convexity" of the penalty and determines which of the good and bad properties of convex and non-convex penalties are obtained. Using a high value of ν ensures the uniqueness of solution, but the estimates will be biased. Conversely, a small value of ν guarantees negligible bias in the estimates. The parameter ν has the role of determining the convergence rate of non-null estimates: the lower the value, the higher the convergence rate. Using lower values of ν , the objective function will have local minima.

Value

coefficients	The coefficients fit matrix. The number of columns is equal to nlmb, and the number of rows is equal to the number of coefficients.
lmb	The vector of lambda used.
e	The smallest lambda value, expressed as a percentage of maximum lambda. Default value is .001.
rho	The parameter of the optimization algorithm used
nu	The shape parameters of the penalty used.
X	The design matrix.
y	The response.
algorithm	Approximation used

Author(s)

Daniele Cuntrera, Luigi Augugliaro, Vito Muggeo

References

Aggiungere Arxiv

Examples

```
p <- 10
n <- 100
X <- cbind(1, matrix(rnorm(n * p), n , p))
b.s <- c(1, rep(0, p))
b.s[sample(2:p, 3)] <- 1
y <- drop(crossprod(t(X), b.s))
out <- cdfPen(X = X, y = y)
```

cdfPen.fit

Fitter function for CDF penalty

Description

These are the fundamental computing algorithms that cdfPen invokes to estimate penalized linear models by varying lambda.

Usage

```
cdfPen.fit(b,
           b.tld,
           g,
           b.rho,
           H.rho,
           lmb.rho,
           nu,
           algorithm,
           nstep = 1E+5,
           eps = 1E-5,
           eps.lls = 1E-6,
           nstep.lls = 1E+5)
```

Arguments

b	Starting values of beta-vector.
b.tld	Starting values of sparse beta-vector.
g	Starting values of pseudo-variable.
b.rho	Ridge solution.

H.rho	Second part of ridge solution.
lmb.rho	Lambda-rho ratio.
nu	Shape parameter of the penalty. It affects the degree of the non-convexity of the penalty.
algorithm	Approximation to be used to obtain the sparse solution.
nstep	Maximum number of iterations of the global algorithm.
eps	Convergence threshold of the global algorithm.
eps.lls	Convergence threshold of the LLA-algorithm (if used).
nstep.lls	Maximum number of iterations of the LLA-algorithm (if used).

Value

b	Estimated beta-vector.
b.tld	Estimated sparse beta-vector.
g	Final values of pseudo-variable.
i	Number of iterations.
conv	Convergence check status (0 if converged).

Author(s)

Daniele Cuntrera, Luigi Augugliaro, Vito Muggeo

References

Aggiungere Arxiv

check_KKT	<i>Check on the condition of Karush-Kuhn-Tucker</i>
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Description

Control over Karush-Kuhn-Tucker (Karush, 1939) conditions for the estimates obtained.

Usage

```
check_KKT(obj,
           intercept = TRUE)
```

Arguments

obj	Object to be checked.
intercept	Is the intercept used in the model?

Value

grd	The value of gradient.
hx	The value of equality constraint.
glob	The global value of derivative (grd + hx).
test	Is the condition verified?
lmb	The values of lambda used in the model

Author(s)

Daniele Cuntrera, Luigi Augugliaro, Vito Muggeo

References

Karush, W. (1939). Minima of functions of several variables with inequalities as side constraints. M. Sc. Dissertation. Dept. of Mathematics, Univ. of Chicago.

Examples

```
p <- 10
n <- 100
X <- cbind(1, matrix(rnorm(n * p), n , p))
b.s <- c(1, rep(0, p))
b.s[sample(2:p, 3)] <- 1
y <- drop(crossprod(t(X), b.s))
out <- cdfPen(X = X, y = y)

KKT <- check_KKT(out)
plot(KKT$test)
```

 lla

LLA approximation for CDF penalty

Description

Linearly approximate a part of the objective function to greatly speed up computations.

Usage

```
lla(b.o,
    lmb.rho,
    bm_gm,
    nu,
    nstep.lla = 100L,
    eps.lla = 1E-6)
```

Arguments

b.o	Vector of sparse-solution.
lmb.rho	Lambda-rho ratio.
bm_gm	Vector of pseudo-solution
nu	Shape parameter of the penalty.
nstep.ll	Maximum number of iterations of the LLA-algorithm (if used).
eps.ll	Convergence threshold of the LLA-algorithm (if used).

Details

The LLA approximation allows the computationally intensive part to be treated as a weighted LASSO (Tibshirani, 1996) problem. In this way the computational effort is significantly less while maintaining satisfactory accuracy of the results. See Zou and Li (2008).

Value

b	Vector of the estimated sparse-solution.
Conv	Convergence check (0 if converged).
nstep.ll	Number of iterations done.

References

- Tibshirani, R. (1996). Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society: Series B (Methodological)*, 58(1):267–288.
- Zou, H. and Li, R. (2008). One-step sparse estimates in nonconcave penalized likelihood models. *Annals of statistics*, 36(4):1509

plot_cdfpen	<i>Plot coefficients or BIC from a "cdfpen" object</i>
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Description

Plot coefficient profile plot or BIC trend

Usage

```
plot_cdfpen(object,
            ...)
```

Arguments

object	Object to be plotted.
...	Other graphical parameters to plot.

Details

A graph showing the BIC trend or profile of coefficients is displayed.

Value

No return value

Author(s)

Daniele Cuntrera, Luigi Augugliaro, Vito Muggeo

Examples

```
p <- 10
n <- 100
X <- cbind(1, matrix(rnorm(n * p), n , p))
b.s <- c(1, rep(0, p))
b.s[sample(2:p, 3)] <- 1
y <- drop(crossprod(t(X), b.s))
out <- cdfPen(X = X, y = y)

plot_cdfpen(out)          #Coefficients' path ~ lambda
plot_cdfpen(out, "l1")   #Coefficients' path ~ L1 norm
plot_cdfpen(out, "BIC")  #BIC ~ lambda
```

plot_path

Plotter function for cdfpen class

Description

Function that takes user requests as input, to show the requested graph

Usage

```
plot_path(obj,
          lmb,
          coeff,
          type = c("path", "l1", "BIC"),
          ...)
```

Arguments

obj	Object to be plotted
lmb	lambda values used in the model
coeff	the coefficients' matrix
type	type of graph to be plotted
...	Other characteristics to be added

Value

No return value

S

Threshold function for CDF penalty

Description

Applies the threshold rule to obtain the vector of sparse estimates

Usage

```
S(bm_gm,  
  db,  
  w)
```

Arguments

bm_gm	Vector of pseudo-solution.
db	Lambda-rho ratio.
w	Weights obtained from the penalty function.

Value

The estimated coefficient

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