

Package ‘DebiasInfer’

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Type Package

Title Efficient Inference on High-Dimensional Linear Model with Missing Outcomes

Version 0.2

Description A statistically and computationally efficient debiasing method for conducting valid inference on the high-dimensional linear regression function with missing outcomes.
The reference paper is Zhang, Giessing, and Chen (2023) <[doi:10.48550/arXiv.2309.06429](https://doi.org/10.48550/arXiv.2309.06429)>.

URL <https://github.com/zhangyk8/Debias-Infer/>

BugReports <https://github.com/zhangyk8/Debias-Infer/issues>

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Imports CVXR, caret, stats

Suggests MASS, glmnet

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NeedsCompilation no

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Contents

DebiasProg	2
DebiasProgCV	3
DualCD	5
DualObj	7
SoftThres	9
Index	10

DebiasProg

The proposed debiasing (primal) program.

Description

This function implements our proposed debiasing (primal) program that solves for the weights for correcting the Lasso pilot estimate.

Usage

```
DebiasProg(X, x, Pi, gamma_n = 0.1)
```

Arguments

X	The input design $n \times d$ matrix.
x	The current query point, which is a $1 \times d$ array.
Pi	An $n \times n$ diagonal matrix with (estimated) propensity scores as its diagonal entries.
gamma_n	The regularization parameter " γ/n ". (Default: $\gamma_n=0.1$.)

Value

The estimated weights by our debiasing program, which is a n -dim vector.

Author(s)

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References

Zhang, Y., Giessing, A. and Chen, Y.-C. (2023) *Efficient Inference on High-Dimensional Linear Model with Missing Outcomes*. <https://arxiv.org/abs/2309.06429>.

Fu, A., Narasimhan, B. and Boyd, S. (2017) *CVXR: An R Package for Disciplined Convex Optimization*. *Journal of Statistical Software* 94 (14): 1–34. doi: [10.18637/jss.v094.i14](https://doi.org/10.18637/jss.v094.i14).

Examples

```
require(MASS)
require(glmnet)
d = 1000
n = 900

Sigma = array(0, dim = c(d,d)) + diag(d)
rho = 0.1
for(i in 1:(d-1)){
  for(j in (i+1):d){
    if ((j < i+6) | (j > i+d-6)){
```

```

        Sigma[i,j] = rho
        Sigma[j,i] = rho
    }
}
}
sig = 1

## Current query point
x_cur = rep(0, d)
x_cur[c(1, 2, 3, 7, 8)] = c(1, 1/2, 1/4, 1/2, 1/8)
x_cur = array(x_cur, dim = c(1,d))

## True regression coefficient
s_beta = 5
beta_0 = rep(0, d)
beta_0[1:s_beta] = sqrt(5)

## Generate the design matrix and outcomes
X_sim = mvrnorm(n, mu = rep(0, d), Sigma)
eps_err_sim = sig * rnorm(n)
Y_sim = drop(X_sim %*% beta_0) + eps_err_sim

obs_prob = 1 / (1 + exp(-1 + X_sim[, 7] - X_sim[, 8]))
R_sim = rep(1, n)
R_sim[runif(n) >= obs_prob] = 0

## Estimate the propensity scores via the Lasso-type generalized linear model
zeta = 5*sqrt(log(d)/n)/n
lr1 = glmnet(X_sim, R_sim, family = "binomial", alpha = 1, lambda = zeta,
             standardize = TRUE, thresh=1e-6)
prop_score = drop(predict(lr1, newx = X_sim, type = "response"))

## Estimate the debiasing weights
w_obs = DebiasProg(X_sim, x_cur, Pi=diag(prop_score), gamma_n = 0.1)

```

DebiasProgCV

The proposed debiasing (primal) program with cross-validation.

Description

This function implements our proposed debiasing program that selects the tuning parameter " γ/n " by cross-validation and returns the final debiasing weights.

Usage

```
DebiasProgCV(X, x, prop_score, gamma_lst = NULL, cv_fold = 5, cv_rule = "1se")
```

Arguments

<code>X</code>	The input design $n \times d$ matrix.
<code>x</code>	The current query point, which is a $1 \times d$ array.
<code>prop_score</code>	An n -dim numeric vector with (estimated) propensity scores as its entries.
<code>gamma_lst</code>	A numeric vector with candidate values for the regularization parameter " γ/n ". (Default: <code>gamma_lst=NULL</code> . Then, <code>gamma_lst</code> contains 41 equally spacing value between 0.001 and $\max(\text{abs}(x))$.)
<code>cv_fold</code>	The number of folds for cross-validation on the dual program. (Default: <code>cv_fold=5</code> .)
<code>cv_rule</code>	The criteria/rules for selecting the final value of the regularization parameter " γ/n " in the dual program. (Default: <code>cv_rule="lse"</code> . The candidate choices include "lse", "minfeas", and "mincv".)

Value

A list that contains three elements.

<code>w_obs</code>	The final estimated weights by our debiasing program.
<code>ll_obs</code>	The final value of the solution to our debiasing dual program.
<code>gamma_n_opt</code>	The final value of the tuning parameter " γ/n " selected by cross-validation.

Author(s)

Yikun Zhang, <yikunzhang@foxmail.com>

References

Zhang, Y., Giessing, A. and Chen, Y.-C. (2023) *Efficient Inference on High-Dimensional Linear Model with Missing Outcomes*. <https://arxiv.org/abs/2309.06429>.

Examples

```
require(MASS)
require(glmnet)
d = 1000
n = 900

Sigma = array(0, dim = c(d,d)) + diag(d)
rho = 0.1
for(i in 1:(d-1)){
  for(j in (i+1):d){
    if ((j < i+6) | (j > i+d-6)){
      Sigma[i,j] = rho
      Sigma[j,i] = rho
    }
  }
}
sig = 1
```

```

## Current query point
x_cur = rep(0, d)
x_cur[c(1, 2, 3, 7, 8)] = c(1, 1/2, 1/4, 1/2, 1/8)
x_cur = array(x_cur, dim = c(1,d))

## True regression coefficient
s_beta = 5
beta_0 = rep(0, d)
beta_0[1:s_beta] = sqrt(5)

## Generate the design matrix and outcomes
X_sim = mvrnorm(n, mu = rep(0, d), Sigma)
eps_err_sim = sig * rnorm(n)
Y_sim = drop(X_sim %*% beta_0) + eps_err_sim

obs_prob = 1 / (1 + exp(-1 + X_sim[, 7] - X_sim[, 8]))
R_sim = rep(1, n)
R_sim[runif(n) >= obs_prob] = 0

## Estimate the propensity scores via the Lasso-type generalized linear model
zeta = 5*sqrt(log(d)/n)/n
lr1 = glmnet(X_sim, R_sim, family = "binomial", alpha = 1, lambda = zeta,
             standardize = TRUE, thresh=1e-6)
prop_score = drop(predict(lr1, newx = X_sim, type = "response"))

## Estimate the debiasing weights with the tuning parameter selected by cross-validations.
deb_res = DebiasProgCV(X_sim, x_cur, prop_score, gamma_lst = c(0.1, 0.5, 1),
                      cv_fold = 5, cv_rule = '1se')

```

DualCD

Coordinate descent algorithm for solving the dual form of our debiasing program.

Description

This function implements the coordinate descent algorithm for the debiasing dual program. More details can be found in Appendix A of our paper.

Usage

```

DualCD(
  X,
  x,
  Pi = NULL,
  gamma_n = 0.05,
  ll_init = NULL,
  eps = 1e-09,
  max_iter = 5000
)

```

Arguments

<code>X</code>	The input design $n \times d$ matrix.
<code>x</code>	The current query point, which is a $1 \times d$ array.
<code>Pi</code>	An $n \times n$ diagonal matrix with (estimated) propensity scores as its diagonal entries.
<code>gamma_n</code>	The regularization parameter " γ/n ". (Default: <code>gamma_n=0.05</code> .)
<code>ll_init</code>	The initial value of the dual solution vector. (Default: <code>ll_init=NULL</code> . Then, the vector with all-one entries is used.)
<code>eps</code>	The tolerance value for convergence. (Default: <code>eps=1e-9</code> .)
<code>max_iter</code>	The maximum number of coordinate descent iterations. (Default: <code>max_iter=5000</code> .)

Value

The solution vector to our dual debiasing program.

Author(s)

Yikun Zhang, <yikunzhang@foxmail.com>

References

Zhang, Y., Giessing, A. and Chen, Y.-C. (2023) *Efficient Inference on High-Dimensional Linear Model with Missing Outcomes*. <https://arxiv.org/abs/2309.06429>.

Examples

```
require(MASS)
require(glmnet)
d = 1000
n = 900

Sigma = array(0, dim = c(d,d)) + diag(d)
rho = 0.1
for(i in 1:(d-1)){
  for(j in (i+1):d){
    if ((j < i+6) | (j > i+d-6)){
      Sigma[i,j] = rho
      Sigma[j,i] = rho
    }
  }
}
sig = 1

## Current query point
x_cur = rep(0, d)
x_cur[c(1, 2, 3, 7, 8)] = c(1, 1/2, 1/4, 1/2, 1/8)
x_cur = array(x_cur, dim = c(1,d))

## True regression coefficient
```

```

s_beta = 5
beta_0 = rep(0, d)
beta_0[1:s_beta] = sqrt(5)

## Generate the design matrix and outcomes
X_sim = mvrnorm(n, mu = rep(0, d), Sigma)
eps_err_sim = sig * rnorm(n)
Y_sim = drop(X_sim %*% beta_0) + eps_err_sim

obs_prob = 1 / (1 + exp(-1 + X_sim[, 7] - X_sim[, 8]))
R_sim = rep(1, n)
R_sim[runif(n) >= obs_prob] = 0

## Estimate the propensity scores via the Lasso-type generalized linear model
zeta = 5*sqrt(log(d)/n)/n
lr1 = glmnet(X_sim, R_sim, family = "binomial", alpha = 1, lambda = zeta,
             standardize = TRUE, thresh=1e-6)
prop_score = drop(predict(lr1, newx = X_sim, type = "response"))

## Solve the debiasing dual program
ll_cur = DualCD(X_sim, x_cur, Pi = diag(prop_score), gamma_n = 0.1, ll_init = NULL,
               eps=1e-9, max_iter = 5000)

```

DualObj

*The objective function of the debiasing dual program.***Description**

This function computes the objective function value of the debiasing dual program.

Usage

```
DualObj(X, x, Pi, ll_cur, gamma_n = 0.05)
```

Arguments

<code>X</code>	The input design $n \times d$ matrix.
<code>x</code>	The current query point, which is a $1 \times d$ array.
<code>Pi</code>	An $n \times n$ diagonal matrix with (estimated) propensity scores as its diagonal entries.
<code>ll_cur</code>	The current value of the dual solution vector.
<code>gamma_n</code>	The regularization parameter " γ/n ". (Default: <code>gamma_n=0.1</code> .)

Value

The value of the objective function of our dual debiasing program.

Author(s)

Yikun Zhang, <yikunzhang@foxmail.com>

References

Zhang, Y., Giessing, A. and Chen, Y.-C. (2023) *Efficient Inference on High-Dimensional Linear Model with Missing Outcomes*. <https://arxiv.org/abs/2309.06429>.

Examples

```
require(MASS)
require(glmnet)
d = 1000
n = 900

Sigma = array(0, dim = c(d,d)) + diag(d)
rho = 0.1
for(i in 1:(d-1)){
  for(j in (i+1):d){
    if ((j < i+6) | (j > i+d-6)){
      Sigma[i,j] = rho
      Sigma[j,i] = rho
    }
  }
}
sig = 1

## Current query point
x_cur = rep(0, d)
x_cur[c(1, 2, 3, 7, 8)] = c(1, 1/2, 1/4, 1/2, 1/8)
x_cur = array(x_cur, dim = c(1,d))

## True regression coefficient
s_beta = 5
beta_0 = rep(0, d)
beta_0[1:s_beta] = sqrt(5)

## Generate the design matrix and outcomes
X_sim = mvrnorm(n, mu = rep(0, d), Sigma)
eps_err_sim = sig * rnorm(n)
Y_sim = drop(X_sim %*% beta_0) + eps_err_sim

obs_prob = 1 / (1 + exp(-1 + X_sim[, 7] - X_sim[, 8]))
R_sim = rep(1, n)
R_sim[runif(n) >= obs_prob] = 0

## Estimate the propensity scores via the Lasso-type generalized linear model
zeta = 5*sqrt(log(d)/n)/n
lr1 = glmnet(X_sim, R_sim, family = "binomial", alpha = 1, lambda = zeta,
             standardize = TRUE, thresh=1e-6)
prop_score = drop(predict(lr1, newx = X_sim, type = "response"))
```



```

## Solve the debiasing dual program and estimate the dual objective function value
ll_cur = DualCD(X_sim, x_cur, Pi = diag(prop_score), gamma_n = 0.1, ll_init = NULL,
               eps=1e-9, max_iter = 5000)
dual_val = DualObj(X_sim, x_cur, Pi=diag(prop_score), ll_cur=ll_cur, gamma_n=0.1)

```

SoftThres

The soft-thresholding function

Description

This function implements the soft-threshold operator $S_\lambda(x) = \text{sign}(x) \cdot (x - \lambda)_+$.

Usage

```
SoftThres(theta, lamb)
```

Arguments

theta	The input numeric vector.
lamb	The thresholding parameter.

Value

The resulting vector after soft-thresholding.

Author(s)

Yikun Zhang, <yikunzhang@foxmail.com>

Examples

```

a = c(1,2,4,6)
SoftThres(theta=a, lamb=3)

```

Index

- * **CV**
 - DebiasProgCV, [3](#)
- * **debiasing**
 - DebiasProg, [2](#)
 - DebiasProgCV, [3](#)
 - DualCD, [5](#)
- * **dual**
 - DualCD, [5](#)
- * **primal**
 - DebiasProg, [2](#)
- * **program**
 - DebiasProg, [2](#)
 - DebiasProgCV, [3](#)
 - DualCD, [5](#)
- * **utility**
 - DualObj, [7](#)
 - SoftThres, [9](#)
- * **with**
 - DebiasProgCV, [3](#)

DebiasProg, [2](#)
DebiasProgCV, [3](#)
DualCD, [5](#)
DualObj, [7](#)

SoftThres, [9](#)