Package ‘lmridge’

August 22, 2018

Type Package

Title Linear Ridge Regression with Ridge Penalty and Ridge Statistics

Version 1.2

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Description Linear ridge regression coefficient's estimation and testing with different ridge related measures such as MSE, R-squared etc.
REFERENCES
i. Hoerl and Kennard (1970) <doi:10.2307/1267351>
ii. Halawa and El-Bassiouni (2000) <doi:10.1080/00949650008812006>
iii. Imdadullah, Aslam, and Saima (2017)
iv. Marquardt (1970) <doi:10.2307/1267205>.

License GPL (>= 2.0)

LazyData TRUE

Depends R (>= 3.4), stats

Imports graphics

BugReports http://rfaqs.com/contact

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NeedsCompilation no

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Repository CRAN

Date/Publication 2018-08-22 16:20:03 UTC

R topics documented:

`lmridge-package` *Linear Ridge Regression*

Description

R package for fitting linear ridge regression models.

Details

This package contains functions for fitting linear ridge regression models, including functions for computation of different ridge related statistics (such as MSE, Var-Cov matrix, effective degrees of freedom and condition numbers), estimation of biasing parameter from different researchers, testing of ridge coefficients, model selection criteria, residuals, predicted values and fitted values. The package also includes function for plotting of ridge coefficients and different ridge statistics for selection of optimal value of biasing parameters K.

For a complete list of functions, use `library(help="lmridge")`.

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

bias.plot *Bias Variance and MSE Trade-off Plot*

Description

Trade-off between bias, variance and MSE of the linear ridge regression against vector or scalar value of biasing parameter K (see Kalivas and Palmer, 2014 <https://doi.org/10.1002/cem.2555>).

Usage

```
bias.plot(x, abline = TRUE, ...)
```

Arguments

x	An object of class "lmridge".
abline	Horizontal and vertical lines show the minimum value of the ridge MSE at certain value of biasing parameter K.
...	Not presently used in this implementation.

Details

The effect of multicollinearity on the coefficient estimates can be identified using different graphical display. One of them is plot of bias, variance and MSE. A little addition of bias lead to a substantial decrease in variance, and MSE. Therefore, a trade-off is made between bias and variance to have acceptable MSE. The `bias.plot` can be helpful for selection of optimal value of biasing parameter K.

Value

Nothing returned

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

Kalivas, J. H., and Palmer, J. (2014). Characterizing multivariate calibration tradeoffs (bias, variance, selectivity, and sensitivity) to select model tuning parameters. *Journal of Chemometrics*, **28**(5), 347–357. Kalivas and Palmer, 2014.

See Also

The ridge model fitting `lmridge`, ridge CV and GCV plots `cv.plot`, ridge AIC and BIC plots `info.plot`, m-scale and isrm plots `isrm.plot`, ridge and VIF trace `plot.lmridge`, miscellaneous ridge plots `rplots.plot`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, 0.3, 0.002))
## for indication vertical line (biasing parameter k) and
## horizontal line (minimum minimum ridge MSE values corresponding to vertical line)
bias.plot(mod)

## without Horizontal and vertical line as set \code{abline = FALSE}
bias.plot(mod, abline=FALSE)
```

`cv.plot` *Ridge CV and GCV Plot*

Description

Plot of ridge CV and GCV against scalar or vector values of biasing parameter K (see Golub et al., 1979 <http://doi.org/10.2307/1268518>).

Usage

```
cv.plot(x, abline = TRUE, ...)
```

Arguments

`x`	An object of class "lmridge".
`abline`	Horizontal and vertical lines to show minimum value of ridge GCV and CV at certain value of biasing parameter K.
`...`	Not presently used in this implementation.

Details

Function `cv.plot` can be used to plot the values of ridge CV and GCV against scalar or vector value of biasing parameter K. The `cv.plot` can be helpful for selection of optimal value of ridge biasing parameter K. If no argument is used then horizontal line will indicate minimum GCV and Cv at certain value of biasing parameter K.

Value

Nothing returned

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Delaney, N. J. and Chatterjee, S. (1986). Use of the Bootstrap and Cross-Validation in Ridge Regression. *Journal of Business & Economic Statistics*. **4**(2), 255–262. Delaney and Chatterjee, 1986.

Golub, G., Wahba, G. and Heat, C. (1979). Generalized Cross Validation as a Method for Choosing a Good Ridge Parameter. *Technometrics*. **21**, 215–223. Golub et al., 1979.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

See Also

The ridge model fitting `lmridge`, bias variance trade-off plot `bias.plot`, ridge AIC and BIC plots `info.plot`, m-scale and isrm plots `isrm.plot`, ridge and VIF trace `plot.lmridge`, miscellaneous ridge plots `rplots.plot`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, 0.2, 0.002))
## for indication vertical line (biasing parameter k) and
## horizontal line (minimum respective CV and GCV values corresponding to vertical line)
cv.plot(mod)

## without Horizontal and vertical line set \code{abline = FALSE}
cv.plot(mod, abline = FALSE)
```

Hald *Portland Cement benchmark of Hald(1952)*

Description

Heat evolved during setting of 13 cement mixtures of four basic ingredients. Each ingredient percentage appears to be rounded down to a full integer. The sum of the four mixture percentages varies from a maximum of 99% to a minimum of 95%. If all four regressor X-variables always summed to 100%, the centered X-matrix would then be of rank only 3. Thus, the regression of heat on four X-percentages is ill-conditioned, with an approximate rank deficiency of MCAL = 1.

Usage

```
data(Hald)
```

Format

A data frame with 13 observations on the following 5 variables.

`X1` p3ca: Integer percentage of 3CaO.Al2O3 in the mixture.

`X2` p3cs: Integer percentage of 3CaO.SiO2 in the mixture.

`X3` p4caf: Integer percentage of 4CaO.Al2O3.Fe2O3 in the mixture.

`X4` p2cs: Integer percentage of 2CaO.SiO2 in the mixture.

`y` hear: Heat (cals/gm) evolved in setting, recorded to nearest tenth.

Details

The (lmridge) Hald data are identical to the (MASS) cement data except for variable names.

Source

Woods, H., Steinour, H.H. and Starke, H.R. (1932). Effect of Composition of Portland Cement on Heat Evolved During Hardening. *Industrial Engineering and Chemistry* **24**: 1207–1214.

References

Hald, A. (1952). *Statistical Theory with Engineering Applications*.(page 647.) New York; Wiley.

`hatr.lmridge` *Ridge Regression: Hat Matrix*

Description

The `hatr` function computes hat matrix (see Hastie and Tibshirani, 1990).

Usage

```
hatr(x, ...)
## S3 method for class 'lmridge'
hatr(x, ...)
```

Arguments

`x`	An object of class "lmridge".
`...`	Not presently used in this implementation.

Details

Hat matrix for scalar or vector values of biasing parameter provided as argument to `lmridge`. It is used to compute degrees of freedom for given K, and error degree of freedom etc. The hat matrix can be computed using formula $X(X'X + kI)^{-1}X'$ equivalently $\sum \frac{\lambda_j}{(\lambda_j+k)}$.

Value

returns a list of matrix for each biasing parameter K:

`hatr`	A list of hat matrix for each biasing parameter K

.

Author(s)

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References

Cule, E. and De lorio, M. (2012). A semi-Automatic method to guide the choice of ridge parameter in ridge regression. *arXiv:1205.0686v1 [stat.AP]*. Cule and De lorio, 2012.

Hastie, T. and Tibshirani, R. (1990). *Generalized Additive Models*. Chapman \& Hall.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

See Also

The ridge model fitting `lmridge`, ridge Var-Cov matrix `vcov.lmridge`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = c(0, 0.1, 0.2, 0.3))
## Hat matrix for each biasing parameter
hatr(mod)

## Hat matrix for first biasing parameter i.e. K = 0.1
hatr(mod)[[2]]
```

`info.plot` *Model Selection Criteria Plots*

Description

Plot of ridge AIC and BIC model selection criteria against ridge degrees of freedom (see Akaike, 1974 <https://doi.org/10.1109/TAC.1974.1100705>; Imdad, 2017 and Schwarz, 1978 <https://doi.org/10.1214/aos/1176344136>).

Usage

```
info.plot(x, abline = TRUE, ...)
```

Arguments

`x`	An object of class "lmridge".
`abline`	Vertical line to show minimum value of ridge MSE at certain value of ridge degrees of freedom.
`...`	Not presently used in this implementation.

Details

Plot of ridge AIC and BIC against ridge degress of freedom $\sum_{j=1}^{p} \frac{\lambda_j}{\lambda_j+k}$. A vertical line represents the minimum ridge MSE at certain value of ridge df.

Value

Nothing returned

Author(s)

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References

Akaike, H. (1974). A new look at the Statistical Model Identification. *IEEE Transaction on Automatic Control*, **9**(6), 716–723. Akaike, 1974.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

Schwarz, G. (1978). Estimating the Dimension of a Model. *Annals of Statistics*, **6**(2), 461–464. Schwarz, 1978.

See Also

The ridge model fitting `lmridge`, ridge CV and GCV plot`cv.plot`, variance biase trade-off plot `bias.plot`, m-scale and isrm plots `isrm.plot`, ridge and VIF trace `plot.lmridge`, miscellaneous ridge plots `rplots.plot`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, 0.15, 0.002))
## for indication vertical line (df ridge)
info.plot(mod)

## without vertical line set \code{abline = FALSE}
info.plot(mod, abline = FALSE)
```

`infocr.lmridge` *Model Selection Criteria for Ridge Regression*

Description

The `infocr.lmridge` function computes model information selection criteria (AIC and BIC), see Akaike, 1974 <https://doi.org/10.1109/TAC.1974.1100705>; Imdad, 2017 and Schwarz, 1978 <https://doi.org/10.1214/aos/1176344136>).

Usage

```
infocr(object, ...)
## S3 method for class 'lmridge'
infocr(object, ...)
```

Arguments

`object`	An object of class "lmridge".
`...`	Not presently used in this implementation.

Details

Model information selection criteria are common way of selecting among model while balancing the competing goals of fit and parsimony. The model selection criteria AIC and BIC are computed by quantifying `df` in the ridge regression model, using formula ($df = trace[X(X'X + kI)^{-1}X']$). It can be helpful for selecting optimal value of biasing parameter K.

Value

It returns a matrix of information criteria, AIC and BIC for each biasing parameter K. Column of matrix indicates model selection criteria AIC and BIC, respectively, while rows indicate value of biasing parameter K for which model selection criteria are computed.

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Akaike, H. (1974). A new look at the Statistical Model Identification. *IEEE Transaction on Automatic Control*, **9**(6), 716-723. Akaike, 1974.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

Schwarz, G. (1978). Estimating the Dimension of a Model. *Annals of Statistics*, **6**(2), 461–464. Schwarz, 1978.

See Also

the ridge model fitting `lmridge`, ridge AIC and BIC plot `info.plot`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, .2, 0.001))
infocr(mod)

## Vector of AIC values
infocr(mod)[,1]
```

```
## vector of BIC values
infocr(mod)[,2]
```

`isrm.plot` *ISRM and m-scale Plot*

Description

Plot of m-scale and ISRM against scalar or vector values of biasing parameter K (Vinod, 1976 <http://doi.org/10.2307/2286847>).

Usage

```
isrm.plot(x, ...)
```

Arguments

`x`	An object of class "lmridge".
`...`	Not presently used in this implementation.

Details

The `isrm.plot` function can be used to plot the values of m-scale and ISRM against given list (scalar or vector values) of biasing parameter K as argument to `lmridge`. It can be helpful for the optimal selection of the biasing parameter K.

Value

Nothing returned

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

Vinod, H. (1976). Application of New Ridge Regression Methods to a Study of Bell System Scale Economics. *Journal of the American Statistical Association*, **71**, 835–841. Vinod, 1976.

See Also

The ridge model fitting `lmridge`, ridge CV and GCV plots `cv.plot`, ridge AIC and BIC plots `info.plot`, variance bias trade-off plot `bias.plot`, ridge and VIF trace `plot.lmridge`, miscellaneous ridge plots`rplots.plot`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, 0.2, 0.002))

isrm.plot(mod)
isrm.plot(mod, abline=FALSE)
```

`kest.lmridge` *Computation of Ridge Biasing Parameter K*

Description

The `kest` function computes different biasing parameters available in the literature proposed by different researchers.

Usage

```
kest(object, ...)
## S3 method for class 'lmridge'
kest(object, ...)
## S3 method for class 'klmridge'
print(x, ...)
```

Arguments

`object`	An object of class "lmridge" for the `kest`.
`x`	An object of class "klmridge" for the `print.kest.klmridge`.
`...`	Not presently used in this implementation.

Details

The `kest` function computes different biasing parameter for the ordinary linear ridge regression. All these methods are already available in the literature and proposed by various authors. See reference section.

Value

The function returns the list of following biasing parameter methods proposed by various researchers.

`mHKB`	By Thisted (1976), $\frac{((p-2)*\hat{\sigma}^2)}{\sum(\beta^2)}$
`LW`	As in `lm.ridge` of `MASS` $\frac{((p-2)*\hat{\sigma}^2*n)}{\sum(\hat{y}^2)}$
`LW76`	By Lawless and Wang (1976), $\frac{p*\hat{\sigma}^2 2}{\sum(\lambda_j*\hat{\alpha}_j^2)}$
`CV`	Value of Cross Validation (CV) for each biasing parameter K, $CV_k = \frac{1}{n}\sum_{j=1}^{n}(y_i - X_j\hat{\beta}_{j_K})^2$.

kCV	Value of biasing parameter at which CV is small.
HKB	By Hoerl and Kennard (1970), $\frac{p*\hat{\sigma}^2}{\hat{\beta}'\hat{\beta}}$
kibAM	By Kibria (2003), $\frac{1}{p} * \sum(\frac{\hat{\sigma}^2}{\hat{\beta}_j^2)}$
GCV	Value of Generalized Cross Validation (GCV) for each biasing parameter K, $\frac{(y_i - X_j \hat{\beta}_{J_K})^2}{[n-(1+Trace(H_{R,k}))]^2}$.
kcGCV	Value of biasing parameter at which GCV is small.
DSK	By Dwividi and Shrivastava, (1978), $\frac{\hat{\sigma}^2}{\hat{\beta}'\hat{\beta}}$
kibGM	By Kibria (2003), $\frac{\hat{\sigma}^2}{(\prod(\hat{\alpha}_j^2))^{(1/p)}}$
kibMEd	By Kibria (2003), $median(\frac{\hat{\sigma}^2}{\hat{\alpha}_j^2})$
KM2	By Muniz and Kibria (2009), $max[\frac{1}{\sqrt{\frac{\hat{\sigma}^2}{\hat{\alpha}_j^2}}}]$
KM3	By Muniz and Kibria (2009), $max[\sqrt{\frac{\hat{\sigma}^2}{\hat{\alpha}_j^2}}]$
KM4	By Muniz and Kibria (2009), $[\prod \frac{1}{\sqrt{\frac{\hat{\sigma}^2}{\hat{\alpha}_j^2}}}]^{\frac{1}{p}}$
KM5	By Muniz and Kibria (2009), $[\prod \sqrt{\frac{\hat{\sigma}^2}{\hat{\alpha}_j^2}}]^{\frac{1}{p}}$
KM6	By Muniz and Kibria (2009), $Median[\frac{1}{\sqrt{\frac{\hat{\sigma}^2}{\hat{\alpha}_j^2}}}]$
KM8	By Muniz *et al.* (2012), $max(\frac{1}{\sqrt{\frac{\lambda_{max}\hat{\sigma}^2}{(n-p)\hat{\sigma}^2+\lambda_{max}\hat{\alpha}_j^2}}})$
KM9	By Muniz *et al.* (2012), $max[\sqrt{\frac{\lambda_{max}\hat{\sigma}^2}{(n-p)\hat{\sigma}^2} + \lambda_{max}\hat{\alpha}_j^2}]$
KM10	By Muniz *et al.* (2012), $[\prod(\frac{1}{\sqrt{\frac{\lambda_{max}\hat{\sigma}^2}{(n-p)\hat{\sigma}^2+\lambda_{max}\hat{\alpha}_j^2}}})]^{\frac{1}{p}}$
KM11	By Muniz *et al.* (2012), $[\prod(\sqrt{\frac{\lambda_{max}\hat{\sigma}^2}{(n-p)\hat{\sigma}^2+\lambda_{max}\hat{\alpha}_j^2}})^{\frac{1}{p}}$
KM12	By Muniz *et al.*, $Median[\frac{1}{\sqrt{\frac{\lambda_{max}\hat{\sigma}^2}{(n-p)\hat{\sigma}^2+\lambda_{max}\hat{\alpha}_j^2}}}]$
KD	By Dorugade and Kashid (2012), $0, \frac{p\hat{\sigma}^2}{\hat{\alpha}'\hat{\alpha}} - \frac{1}{n(VIF_j)_{max}}$
KAD4	By Dorugade and Kashid (2012), $HM[\frac{2p}{\lambda_{max}} \sum(\frac{\hat{\sigma}^2}{\hat{\alpha}_j^2})]$
alphahat	The OLS estimator in canonical form, i.e., $\hat{\alpha} = (P'X'XP)^{-1}X'^{*}y$, where $X^* = XP$ P is eigenvector of $X'X$.

Author(s)

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References

Dorugade, A. and Kashid, D. (2010). Alternative Method for Choosing Ridge Parameter for Regression. *Applied Mathematical Sciences*, **4**(9), 447-456.

Dorugade, A. (2014). New Ridge Parameters for Ridge Regression. *Journal of the Association of Arab Universities for Basic and Applied Sciences*, **15**, 94-99. Dorugade, 2014.

Hoerl, A. E., Kennard, R. W., and Baldwin, K. F. (1975). Ridge Regression: Some Simulation. *Communication in Statistics*, **4**, 105-123. Hoer et al., 1975.

Hoerl, A. E. and Kennard, R. W., (1970). Ridge Regression: Biased Estimation of Nonorthogonal Problems. *Technometrics*, **12**, 55-67. Hoerl and Kennard, 1970.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

Kibria, B. (2003). Performance of Some New Ridge Regression Estimators. *Communications in Statistics-Simulation and Computation*, **32**(2), 491-435. Kibria, 2003.

Lawless, J., and Wang, P. (1976). A Simulation Study of Ridge and Other Regression Estimators. *Communications in Statistics-Theory and Methods*, **5**(4), 307-323. Lawless and Wang, 1976.

Muniz, G., and Kibria, B. (2009). On Some Ridge Regression Estimators: An Empirical Comparisons. *Communications in Statistics-Simulation and Computation*, **38**(3), 621-630. Muniz and Kibria, 2009.

Muniz, G., Kibria, B., Mansson, K., and Shukur, G. (2012). On developing Ridge Regression Parameters: A Graphical Investigation. *SORT-Statistics and Operations Research Transactions*, **36**(2), 115–138.

Thisted, R. A. (1976). Ridge Regression, Minimax Estimation and Empirical Bayes Methods. *Technical Report 28, Division of Biostatistics*, Stanford University, California.

Venables, W. N. and Ripley, B. D. (2002). *Modern Applied Statistics with S*. Springer New York, 4th edition, ISBN 0-387-95457-0.

See Also

The ridge model fitting `lmridge`, Ridge Var-Cov matrix `vcov`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, 0.2, 0.001))
kest(mod)

## GCV values
kest(mod)$GCV

## minimum GCV value
kest(mod)$kGCV

## Hoerl and Kennard (1970)
kest(mod)$HKB
```

`lmridge` *Linear Ridge Regression*

Description

Fits a linear ridge regression model after scaling regressors and returns an object of class "lmridge" (by calling `lmridgeEst` function) designed to be used in plotting method, testing of ridge coefficients and for computation of different ridge related statistics. The ridge biasing parameter K can be a scalar or a vector. See Hoerl et al., 1975 <https://doi.org/10.1080/03610927508827232>, Horel and Kennard, 1970 <http://doi.org/10.2307/1267351>.

Usage

```
lmridge(formula, data, K = 0, scaling=c("sc", "scaled", "centered"), ...)
lmridgeEst(formula, data, K=0, scaling=c("sc", "scaled", "centered"), ...)
## Default S3 method:
lmridge(formula, data, K = 0, scaling=c("sc", "scaled", "centered"), ...)
## S3 method for class 'lmridge'
coef(object, ...)
## S3 method for class 'lmridge'
print(x, digits = max(5,getOption("digits") - 5), ...)
## S3 method for class 'lmridge'
fitted(object, ...)
```

Arguments

`formula`	Standard R formula expression, that is, a symbolic representation of the model to be fitted and has form `response~predictors`. For further details, see `formula`.
`data`	An optional 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 `lmridge` or `lmridgeEst` is called.
`K`	Ridge biasing parameter (may be a vector).
`scaling`	The method to be used to scale the predictors. The scaling option `"sc"` scales the predictors to correlation form, such that the correlation matrix has unit diagonal elements. `"scaled"` option standardizes the predictors to have zero mean and unit variance. `"centered"` option centers the predictors.
`object`	A lmridge object, typically generated by a call to `lmridge` for `fitted.lmridge`, `predict.lmridge`, `vcov.lmridge`, `residuals.lmridge`, `infocr.lmridge`, `coef.lmridge`, `summary.lmridge` and `press.lmridge` functions.
`x`	An object of class `lmridge` (for the `hatr.lmridge`, `rstats1.lmridge`, `rstats2.lmridge`, `vif.lmridge`, `kest.lmridge`, `summary.lmride`, `print.lmridge`, `print.summary.lmridge`, `print.klmridge`, `print.rstats1`, `print.rstats2`, and `plot.lmridge`, `bias.plot`, `cv.plot`, `info.plot`, `isrm.plot`, and `rplots.plot` functions).
`digits`	Minimum number of significant digits to be used.
`...`	Additional arguments to be passed to or from other methods.

Details

lmridge or lmridgeEst function fits in linear ridge regression after scaling the regressors and centering the response. The lmridge is default a function that calls lmridgeEst for computation of ridge coefficients and returns an object of class "lmridge" designed to be used in plotting method, testing of ridge coefficients and for computation of different ridge related statistics. If intercept is present in the model, its coefficient is not penalized. However, intercept is estimated from the relation $y = \overline{y} - \beta\overline{X}$. print.lmridge tries to be smart about formatting of ridge coefficients.

Value

lmridge function returns an object of class "lmridge" after calling list of named objects from lmridgeEst function:

coef	A named vector of fitted coefficients.
call	The matched call.
Inter	Was an intercept included?
scaling	The scaling method used.
mf	Actual data used.
y	The response variable.
xs	The scaled matrix of predictors.
xm	The vector of means of the predictors.
terms	The terms object used.
xscale	Square root of sum of squared deviation from mean regarding the scaling option used in lmridge or lmridgeEst function as argument.
rfit	The fitted value of ridge regression for given biasing parameter K.
K	The ridge regression biasing parameter K which can be scalar or a vector.
d	A vector of singular values of scaled X matrix.
div	Eigenvalues of scaled regressors.
Z	A list of matrix $(X'X + KI)^{-1}X'$ for further computations.

Note

The function at the current form cannot handle missing values. The user has to take prior action with missing values before using this function.

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Hoerl, A. E., Kennard, R. W., and Baldwin, K. F. (1975). Ridge Regression: Some Simulation. *Communication in Statistics*, **4**, 105-123. Hoer et al., 1975.

Hoerl, A. E. and Kennard, R. W., (1970). Ridge Regression: Biased Estimation of Nonorthogonal Problems. *Technometrics*, **12**, 55-67. Hoerl and Kennard, 1970.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

See Also

Testing of ridge coefficient `summary.lmridge`

Examples

```
data(Hald)
mod <- lmridge(y~., data = as.data.frame(Hald), K = seq(0, 0.1, 0.01), scaling = "sc")
## Scaled Coefficients
mod$coef

## Re-Scaled Coefficients
coef(mod)

## ridge predicted values
predict(mod)

## ridge residuals
residuals(mod)

##ridge and VIF trace
plot(mod)

## ridge VIF values
vif(mod)

## ridge Var-Cov matrix
vcov(mod)

## ridge biasing parameter by researchers
kest(mod)

## ridge fitted values
fitted(mod)

## ridge statistics 1
rstats1(mod)

## ridge statistics 2
rstats2(mod)

## list of objects from lmridgeEst function
```

```
lmridgeEst(y~., data = as.data.frame(Hald), K = seq(0, 0.1, 0.01), scaling = "sc")
```

`plot.lmridge` *VIF and Ridge Trace Plot*

Description

Plot of VIF values (VIF trace) and ridge coefficients (ridge trace) for scalar or vector values of biasing parameter K.

Usage

```
## S3 method for class 'lmridge'
plot(x, type = c("ridge", "vif"), abline = TRUE, ...)
```

Arguments

`x`	An object of class "lmridge".
`type`	Either VIF trace or ridge trace.
`abline`	Horizontal and vertical line to show minimum value of MSE and GCV value at certain value of biasing parameter K on ridge and VIF trace respectively.
`...`	Not presently used in this implementation.

Details

Graphical way of selecting optimal value of biasing parameter K. The biasing parameter is selected when coefficients becomes stable in case of ridge trace. In cae of VIF trace K (ridge biasing parameter) can be selected for which VIF of each regressor near to one or value of K at which GCV is minimum. If no argument is used then all traces of ridge coefficients will be displayed. A vertical and horizontal line will also be displayed on *ridge trace* graph to indicate minimum ridge MSE (among the all computed ridge MSE based on provided vector of K) along with the value of respective biasing parameter K. For VIF trace, vetical line shows minmum GCV value at certain value of biasing parameter K.

Value

Nothing

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Hoerl, A. E., Kennard, R. W., and Baldwin, K. F. (1975). Ridge Regression: Some Simulation. *Communication in Statistics*, **4**, 105-123. Hoer et al., 1975.

Hoerl, A. E. and Kennard, R. W., (1970). Ridge Regression: Biased Estimation of Nonorthogonal Problems. *Technometrics*, **12**, 55-67. Hoerl and Kennard, 1970.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

See Also

The ridge model fitting `lmridge`, ridge CV and GCV plots `cv.plot`, variance bias trade-off plot `bias.plot`, m-scale and isrm plots `isrm.plot`, ridge AIC and BIC plots `info.plot`, miscellaneous ridge plots `rplots.plot`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, 0.15, 0.002))
## Ridge trace
plot(mod)
plot(mod, type = "ridge")

## VIF trace
plot(mod, type = "vif")
## Ridge trace without abline
plot(mod, type = "ridge", abline = FALSE)
```

`predict.lmridge` *Predict method for Linear Ridge Model Fits*

Description

Predicted values based on linear ridge regression model for scalar or vector values of biasing parameter K.

Usage

```
## S3 method for class 'lmridge'
predict(object, newdata, na.action=na.pass, ...)
```

Arguments

`object`	An object of class "lmridge".
`newdata`	An optional data frame in which to look for variables with which to predict.
`na.action`	Function determine what should be done with missing values in `newdata`. The default is to predict `NA`.
`...`	Not presently used in this implementation.

Details

The `predict.lmridge` function produces predicted values, obtained by evaluating the regression function in the frame `newdata` which defaults to model.frame (`object`). If `newdata` is omitted the predictions are based on the data used for the fit. In that case how cases with missing values in the original fit are handled is determined by the `na.action` argument of that fit. If `na.action = na.omit` omitted cases will not appear in the predictions, whereas if `na.action = na.exclude` they will appear (in predictions), with value NA.

Value

`predict.lmridge` produces a vector of predictions or a matrix of predictions for scalar or vector values of biasing parameter.

Note

Variables are first looked for in `newdata` and then are searched for in the usual way (which will include the environment of the formula used in the fit). A warning will be given if the variables found are not of the same length as those in the `newdata` if it was supplied.

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Cule, E. and De lorio, M. (2012). A semi-Automatic method to guide the choice of ridge parameter in ridge regression. *arXiv:1205.0686v1 [stat.AP]*. Cule and De lorio, 2012.

Hoerl, A. E., Kennard, R. W., and Baldwin, K. F. (1975). Ridge Regression: Some Simulation. *Communication in Statistics*, **4**, 105-123. Hoer et al., 1975.

Hoerl, A. E. and Kennard, R. W., (1970). Ridge Regression: Biased Estimation of Nonorthogonal Problems. *Technometrics*, **12**, 55-67. Hoerl and Kennard, 1970.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

See Also

The ridge model fitting `lmridge`, ridge residuals `residuals`, ridge PRESS `press.lmridge`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, 0.2, 0.05))
predict(mod)
predict(mod, newdata = as.data.frame(Hald[1:5, -1]))
```

`press.lmridge` *Predicted Residual Sum of Squares*

Description

The `press.lmridge` function computes predicted residual sum of squares (PRESS) (see Allen, 1971).

Usage

```
press(object, ...)
## S3 method for class 'lmridge'
press(object, ...)
```

Arguments

`object`	An object of class "lmridge".
`...`	Not presently used in this implementation.

Details

All of the `n` leave-one-out predicted residual sum of squares is calculated by fitting full regression model by using, $\sum \frac{\hat{e}_{i,k}}{1-\frac{1}{n}-H_{ii_{R,k}}}$, where $H_{ii_{R,k}}$ is hat matrix from ridge model fit, $\hat{e_{i,k}}$ is the ith residual at specific value of K.

Value

The `press.lmridge` produces a vector of PRESS or a matrix of PRESS for scalar or vector values of biasing parameter.

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Allen, D. M. (1971). Mean Square Error of Prediction as a Criterion for Selecting Variables. *Technometrics*, **13**, 469-475. Allen, 1971.

Allen, D. M. (1974). The Relationship between Variable Selection and Data Augmentation and Method for Prediction. *Technometrics*, **16**, 125-127. Allen, 1974.

Hoerl, A. E., Kennard, R. W., and Baldwin, K. F. (1975). Ridge Regression: Some Simulation. *Communication in Statistics*, **4**, 105-123. Hoer et al., 1975.

Hoerl, A. E. and Kennard, R. W., (1970). Ridge Regression: Biased Estimation of Nonorthogonal Problems. *Technometrics*, **12**, 55-67. Hoerl and Kennard, 1970.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

See Also

The ridge model fitting `lmridge`, ridge residual `residuals`, ridge predicted value `predict`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, 0.5, 0.04))
press(mod)
```

`residuals.lmridge` *Ridge Regression Residuals*

Description

The `residuals` function computes the ridge residuals for scalar or vector value of biasing parameter K.

Usage

```
## S3 method for class 'lmridge'
residuals(object, ...)
```

Arguments

`object`	An object of class "lmridge".
`...`	Not presently used in this implementation.

Details

The generic functions `residuals` can be used to compute residuals object of linear ridge regression from `lmridge` function.

Value

Returns a vector or a matrix of ridge residuals for scalar or vector value biasing parameter K provided as argument to `lmridge` function.

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Berk, R. (2008). *Statistical Learning from a Regression Perspective.* Springer.

Hoerl, A. E., Kennard, R. W., and Baldwin, K. F. (1975). Ridge Regression: Some Simulation. *Communication in Statistics*, **4**, 105-123. Hoer et al., 1975.

Hoerl, A. E. and Kennard, R. W., (1970). Ridge Regression: Biased Estimation of Nonorthogonal Problems. *Technometrics*, **12**, 55-67. Hoerl and Kennard, 1970.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

Lee, W. F. (1979). Model Estimation Using Ridge Regression with the Variance Normalization Criterion. *Master thesis, Department of Educational Foundation, Memorial University of Newfoundland.*

See Also

The ridge mode fitting `lmridge`, ridge prediction `predict`, ridge PRESS values `press`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, 1, 0.2))
residuals(mod)
```

`rplots.plot` *Miscellaneous Ridge Plots*

Description

Panel of three ridge related plots, df trace vs K, RSS vs K and PRESS vs K for graphical judgement of optimal value of K.

Usage

```
rplots.plot(x, abline = TRUE, ...)
```

Arguments

`x`	An object of class "lmridge"
`abline`	Vertical line to show minimum value of ridge PRESS at cartain value of biasing parameter K on PRESS vs K plot.
`...`	Not presently used in this implementation.

Details

Function `rplots.plot` can be used to plot the values of df vs K, RSS vs K and PRESS vs K for scalar or vector values of biasing parameter K. If no argument is used then a vertical line will be drawn on ridge PRESS plot to show the minimum value of PRESS at certain K. The panel of these three plots can be helful in selecting the optimal value of biasing parameter K.

Value

nothing

Author(s)

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References

Allen, D. M. (1971). Mean Square Error of Prediction as a Criterion for Selecting Variables. *Technometrics*, **13**, 469-475. Allen, 1971.

Allen, D. M. (1974). The Relationship between Variable Selection and Data Augmentation and Method for Prediction. *Technometrics*, **16**, 125-127. Allen, 1974.

Berk, R. (2008). *Statistical Learning from a Regression Perspective.* Springer.

Hoerl, A. E., Kennard, R. W., and Baldwin, K. F. (1975). Ridge Regression: Some Simulation. *Communication in Statistics*, **4**, 105-123. Hoer et al., 1975.

Hoerl, A. E. and Kennard, R. W., (1970). Ridge Regression: Biased Estimation of Nonorthogonal Problems. *Technometrics*, **12**, 55-67. Hoerl and Kennard, 1970.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

See Also

The ridge model fitting `lmridge`, ridge CV and GCV plots `cv.plot`, variance bias trade-off plot `bias.plot`, m-scale and isrm plots `isrm.plot`, ridge AIC and BIC plots `info.plot`, ridge and VIF trace `plot.lmridge`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = seq(0, 0.2, 0.005))
rplots.plot(mod)
rplots.plot(mod, abline = FALSE)
```

`rstats1.lmridge` *Ordinary Ridge Regression Statistics 1*

Description

The `rstats1` function computes the ordinary ridge related statistics such as variance, squared bias, MSE, R-squared and condition number (CN), etc. (see Lee, 1979; Kalivas and Palmer, 2014 <https://doi.org/10.1002/cem.2555>)

Usage

```
    rstats1(x, ...)
    ## S3 method for class 'lmridge'
rstats1(x, ...)
    ## S3 method for class 'rstats1'
print(x, digits = max(5,getOption("digits") - 5), ...)
```

Arguments

`x`	An object of class "lmridge" (for the `rstats1` or `print.rstats1.lmridge`)
`digits`	Minimum number of significant digits to be used for most numbers.
`...`	Not presently used in this implementation.

Details

The `rstats1` function computes the ordinary ridge regression related statistics which may help in selecting optimal value of biasing parameter K. If value of K is zero then these statistics are equivalent to the relevant OLS statistics.

Value

Following are the ridge related statistics computed for given scalar or vector value of biasing parameter K provided as argument to `lmridge` or `lmridgeEst` function.

`var`	Variance of ridge regression for given biasing parameter K.
`bias2`	Squared bias of ridge regression for given biasing parameter K.
`mse`	Total MSE value for given biasing parameter K.
`Fv`	F-statistics value for testing of the significance of the ordinary ridge regression estimator computed for given biasing parameter K.
`rfact`	Shrinkage factor $\frac{\lambda_j}{\lambda_j+K}$ for given biasing parameter K.
`R2`	R-squared for given biasing parameter K.
`adjR2`	Adjusted R-squared for given biasing parameter K.
`eigval`	Eigenvalue of $X'X$ matrix for $K = 0$.
`CN`	Condition number after addition of biasing parameter in $X'X$ matrix.

Author(s)

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References

Cule, E. and De lorio, M. (2012). A semi-Automatic method to guide the choice of ridge parameter in ridge regression. *arXiv:1205.0686v1 [stat.AP]*. Cule and De lorio, 2012.

Hoerl, A. E., Kennard, R. W., and Baldwin, K. F. (1975). Ridge Regression: Some Simulation. *Communication in Statistics*, **4**, 105-123. Hoer et al., 1975.

Hoerl, A. E. and Kennard, R. W., (1970). Ridge Regression: Biased Estimation of Nonorthogonal Problems. *Technometrics*, **12**, 55-67. Hoerl and Kennard, 1970.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

Kalivas, J. H., and Palmer, J. (2014). Characterizing multivariate calibration tradeoffs (bias, variance, selectivity, and sensitivity) to select model tuning parameters. *Journal of Chemometrics*, **28**(5), 347–357. Kalivas and Palmer, 2014.

See Also

Ridge related statistics `rstats2`, the ridge model fitting `lmridge`, ridge var-cov matrix `vcov`

Examples

```
data(Hald)
mod <- lmridge(y~., data = as.data.frame(Hald), K = seq(0,0.2, 0.005) )
rstats1(mod)
```

`rstats2.lmridge` *Ordinary Ridge Regression Statistics 2*

Description

The `rstats2` function computes the ordinary ridge related statistics such as Ck, σ^2, ridge degrees of freedom, effective degrees of freedom (EDF), and prediction residual error sum of squares PRESS statistics for scalar or vector value of biasing parameter K (See Allen, 1974 <http://doi.org/10.2307/1267500>; Lee, 1979; Hoerl and Kennard, 1970 <http://doi.org/10.2307/1267351>).

Usage

```
   rstats2(x, ...)
   ## S3 method for class 'lmridge'
rstats2(x, ...)
   ## S3 method for class 'rstats2'
print(x, digits = max(5,getOption("digits") - 5), ...)
```

Arguments

`x`	For the `rstats2` method, an object of class "lmridge", i.e., a fitted model.
`digits`	Minimum number of significant digits to be used.
`...`	Not presently used in this implementation.

Details

The `rstats2` function computes the ridge regression related different statistics which may help in selecting the optimal value of biasing parameter K. If value of K is zero then these statistics are equivalent to the relevant OLS statistics.

Value

Following are ridge related statistics computed for given scalar or vector value of biasing parameter K provided as argument to `lmridge` or `lmridgeEst` function.

- `CK` — Ck similar to Mallows Cp statistics for given biasing parameter K.
- `dfridge` — DF of ridge for given biasing parameter K, i.e., $Trace[Hat_{R,k}]$.
- `EP` — Effective number of Parameters for given biasing parameter K, i.e., $Trace[2Hat_{R,k} - Hat_{R,k}t(Hat_{R,k})]$.
- `redf` — Residual effective degrees of freedom for given biasing parameter K from Hastie and Tibshirani, (1990), i.e., $n - Trace[2Hat_{R,k} - Hat_{R,k}t(Hat_{R,k})]$.
- `EF` — Effectiveness index for given biasing parameter K, also called the ratio of reduction in total variance in the total squared bias by the ridge regression, i.e., $EF = \frac{\sigma^2 trace(X'X)^{-1} - \sigma^2 trace(VIF_R)}{Bias^2(\hat{\beta}_R)}$.
- `ISRM` — Quantification of concept of stable region proposed by Vinod and Ullah, 1981, i.e., $ISRM_k = \sum_{j=1}^{p}(\frac{p(\frac{\lambda_j}{\lambda_j+k})^2}{\sum_{j=1}^{p}\frac{\lambda_j}{(\lambda_j+k)^2}\lambda_j} - 1)^2$.
- `m` — m-scale for given value of biasing parameter proposed by Vinod (1976) alternative to plotting of the ridge coefficients, i.e., $p - \sum_{j-1}^{p}\frac{\lambda_j}{\lambda_j+k}$.
- `PRESS` — PRESS statistics for ridge regression introduced by Allen, 1971, 1974, i.e., $PRESS_k = \sum_{i=1}^{n} e_{i,-i}^2$ for scalar or vector value of biasing parameter K.

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Allen, D. M. (1971). Mean Square Error of Prediction as a Criterion for Selecting Variables. *Technometrics*, **13**, 469-475. Allen, 1971.

Allen, D. M. (1974). The Relationship between Variable Selection and Data Augmentation and Method for Prediction. *Technometrics*, **16**, 125-127. Allen, 1974.

Cule, E. and De lorio, M. (2012). A semi-Automatic method to guide the choice of ridge parameter in ridge regression. *arXiv:1205.0686v1 [stat.AP]*. Cule and De lorio, 2012.

Hastie, T. and Tibshirani, R. (1990). *Generalized Additive Models*. Chapman & Hall.

Hoerl, A. E., Kennard, R. W., and Baldwin, K. F. (1975). Ridge Regression: Some Simulation. *Communication in Statistics*, **4**, 105-123. Hoer et al., 1975.

Hoerl, A. E. and Kennard, R. W., (1970). Ridge Regression: Biased Estimation of Nonorthogonal Problems. *Technometrics*, **12**, 55-67. Hoerl and Kennard, 1970.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

Kalivas, J. H., and Palmer, J. (2014). Characterizing Multivariate Calibration Tradeoffs (Bias, Variance, Selectivity, and Sensitivity) to Select Model Tuning Parameters. *Journal of Chemometrics*, **28**(5), 347–357. Kalivas and Palmer, 2014.

Lee, W. F. (1979). Model Estimation Using Ridge Regression with the Variane Normalization Criterion. *Master thesis, Department of Educational Foundation Memorial University of Newfoundland.*

See Also

Ridge related statistics `rstats1`, ridge model fitting `lmridge`

Examples

```
data(Hald)
mod <- lmridge(y~., data=as.data.frame(Hald), K = seq(0,0.2, 0.001) )
rstats2(mod)
```

`summary.lmridge` *Summarizing Linear Ridge Regression Fits*

Description

The summary method for class "lmridge" for scalar or vector biasing parameter K (Cule and De Iorio, 2012 <https://arxiv.org/abs/1205.0686v1>).

Usage

```
## S3 method for class 'lmridge'
summary(object, ...)
## S3 method for class 'summary.lmridge'
print(x, digits = max(3, getOption("digits") - 3),
           signif.stars = getOption("show.signif.stars"), ...)
```

Arguments

`object`	An "lmridge" object, typically generated by a call to `lmridge`.
`x`	An object of class `summary.lmridge` for the `print.summary.lmridge`.
`signif.stars`	logical: if `TRUE`, p-values are additionally encoded visually as `significance starts` in order to help scanning of long coefficient tables. It default to the `show.signif.stars` slot of `options`.
`digits`	The number of significant digits to use when printing.
`...`	Not presently used in this implementation.

Details

`print.summary.lmridge` tries to be smart about formatting the coefficients, standard errors etc. and additionally gives 'significance stars' if `signif.stars` is `TRUE`.

Value

The function `summary` computes and returns a list of summary statistics of the fitted linear ridge regression model for scalar or vector value biasing parameter K given as argument in `lmridge` function. All summary information can be called using list object `summaries`.

- `coefficients` A $p \times 5$ matrix with columns for the scaled estimated, descaled estimated coefficients, scaled standard error, scaled *t*-statistics, and corresponding *p*-value (two-tailed). The Intercept term is computed by the relation $\hat{\beta}_{R_{0K}} = \overline{y} - \sum_{j=1}^{p} \overline{X}_j \hat{\beta}_{R_{0K}}$. The standard error of intercept term is computed as, $SE(\hat{\beta}_{R_{0K}}) = \sqrt{Var(\overline{y}) + \overline{X}_j^2 diag[Cov(\hat{\beta}_{R_{0K}})]}$.
- `stats` Ridge related statistics of *R*-squared, adjusted *R*-squared, *F*-statistics for testing of coefficients, AIC and BIC values for given biasing parameter K.
- `rmse1` Minimum MSE value for given biasing parameter K.
- `rmse2` Value of K at which MSE is minimum.
- `K` Value of given biasing parameter.
- `df1` Numerator degrees of freedom for p-value of F-statistics.
- `df2` Denominator degrees of freedom for p-value of F-statistics.
- `fpvalue` p-value for each F-statistics.

Author(s)

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References

Cule, E. and De lorio, M. (2012). A semi-Automatic method to guide the choice of ridge parameter in ridge regression. *arXiv:1205.0686v1 [stat.AP]*. Cule and De lorio, 2012

Hoerl, A. E., Kennard, R. W., and Baldwin, K. F. (1975). Ridge Regression: Some Simulation. *Communication in Statistics*, **4**, 105-123. Hoer et al., 1975.

Hoerl, A. E. and Kennard, R. W., (1970). Ridge Regression: Biased Estimation of Nonorthogonal Problems. *Technometrics*, **12**, 55-67. Hoerl and Kennard, 1970.

Imdad, M. U. *Addressing Linear Regression Models with Correlated Regressors: Some Package Development in R* (Doctoral Thesis, Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan), 2017.

See Also

The ridge model fitting `lmridge`

Examples

```
mod <- lmridge(y~., as.data.frame(Hald), K = c(0, 0.0132, 0.1))
summary(mod)

## coefficients for first biasing parameter
summary(mod)$summaries[[1]]$coefficients
```

```
summary(mod)$summaries[[1]][[1]]

## ridge related statistics from summary function
summary(mod)$summaries[[1]]$stats

## Ridge F-test's p-value
summary(mod)$summaries[[1]]$fpvalue
```

`vcov.lmridge` *Variance-Covariance Matrix for Fitted Ridge Model*

Description

The `vcov` function computes the variance-covariance matrix for the estimates of linear ridge regression model.

Usage

```
## S3 method for class 'lmridge'
vcov(object, ...)
```

Arguments

`object`	For `VCOV` method, an object of class "lmridge", i.e., a fitted model.
`...`	Not presently used in this implementation.

Details

The `vcov` function computes variance-covariance matrix for scalar or vector value of biasing parameter K provided as argument to `lmridge` function.

Value

A list of matrix of estimated covariances in the linear ridge regression model for scalar or vector biasing parameter `KK` is produced. Each list element has row and column names corresponding to the parameter names given by the `coef(mod)`. List items are named correspond to values of biasing parameter K.

Note

Covariance will be without intercept term, as intercept term is not penalized in ridge regression.

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Brown, G.W. and Beattie, B.R. (1975). Improving Estimates of Economic Parameters by use of Ridge Regression with Production Function Applications. *American Journal of Agricultural Economics*, 57(1), 21-32. Brown, Beattie, 1975.

See Also

The ridge model fitting `lmridge`, ridge VIF values `vif`

Examples

```
data(Hald)
mod<- lmridge(y~., data=as.data.frame(Hald), scaling="sc", K=seq(0,1,.2) )

vcov.lmridge(mod)
vcov(mod)
```

`vif.lmridge` *Variance Inflation Fator for Linear Ridge Regression*

Description

Computes VIF values for each scalar or vector value of biasing parameter K (Marquardt, 1970 <http://doi.org/10.2307/1267205>).

Usage

```
vif(x, ...)
## S3 method for class 'lmridge'
vif(x, ...)
```

Arguments

`x`	For VIF method, an object of class "lmridge", i.e., a fitted model.
`...`	Not presently used in this implementation.

Details

The `vif.lmridge` function computes VIF value for each regressor in data set after addition of biasing parameter as argument to `lmridge` function. The VIF is computed using $(X'X+kI)^{-1}X'X(X'X+kI)^{-1}$, given by Marquardt, (1970).

Value

The `vif` function returns a matrix of VIF values for each regressor after adding scalar or vector biasing parameter K to $X'X$ matrix. The column of returned matrix indicates regressors name and row indicates value of each biasing parameter K provided as argument to `lmridge` function.

Author(s)

Muhammad Imdad Ullah, Muhammad Aslam

References

Fox, J. and Monette, G. (1992). Generalized Collinearity Diagnostics. *JASA*, **87**, 178–183. Fox, Monette, 1992.

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Marquardt, D. (1970). Generalized Inverses, Ridge Regression, Biased Linear Estimation, and Nonlinear Estimation. *Technometrics*, **12**(3), 591–612. Marquardt, 1970.

See Also

The ridge model fitting `lmridge`, ridge Var-Cov matrix `vcov`

Examples

```
data(Hald)
mod <- lmridge(y~., data = as.data.frame(Hald), scaling = "sc", K = seq(0,1,.2) )
vif(mod)
```

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