

Package ‘ICglm’

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Title Information Criteria for Generalized Linear Regression

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Maintainer Fatih Saglam <fatih.saglam@omu.edu.tr>

Description Calculate various information criteria in literature for ``lm" and ``glm" objects.

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Author Fatih Saglam [aut, cre] (ORCID:
<<https://orcid.org/0000-0002-2084-2008>>),
Emre Dunder [aut]

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AIC

Akaike Information Criterion

Description

Calculates Akaike Information Criterion (AIC) and its variants for "lm" and "glm" objects.

Usage

```
AIC(model)
```

```
AIC4(model)
```

Arguments

model a "lm" or "glm" object

Details

AIC (Akaike, 1973) is calculated as

$$-2LL(theta) + 2k$$

and AIC4 (Bozdogan, 1994) as

$$-2LL(theta) + 2k \log$$

Value

AIC or AIC4 measurement of the model

References

Akaike H., 1973. Maximum likelihood identification of Gaussian autoregressive moving average models. *Biometrika*, 60(2), 255-265.

Bozdogan, H. 1994. Mixture-model cluster analysis using model selection criteria and a new informational measure of complexity. In *Proceedings of the first US/Japan conference on the frontiers of statistical modeling: An informational approach*, 69–113. Dordrecht: Springer.

Examples

```

x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

AIC(m1)
AIC(m2)
AIC(m3)
AIC4(m1)
AIC4(m2)
AIC4(m3)

```

BIC

Bayesian Information Criterion

Description

Calculates Bayesian Information Criterion (BIC) and its variants (BICadj, BICQ) for "lm" and "glm" objects.

Usage

```
BIC(model)
```

```
BICadj(model)
```

```
BICQ(model, q = 0.25)
```

Arguments

model	a "lm" or "glm" object
q	adjustment parameter for BICQ. Default is 0.25.

Details

BIC (Schwarz, 1978) is calculated as

$$-2LL(\theta) + k\log(n)$$

Adjusted BIC (Dziak et al., 2020) as

$$-2LL(theta) + klog(n/2\pi)$$

and BICQ (Xu, 2010) as

$$-2LL(theta) + klog(n) - 2klog(q/(1 - q))$$

.

Value

BIC, BICadj or BICQ measurement of the model

References

Dziak, J. J., Coffman, D. L., Lanza, S. T., Li, R., & Jeremiin, L. S. (2020). Sensitivity and specificity of information criteria. *Briefings in bioinformatics*, 21(2), 553-565.

Xu, C. (2010). Model Selection with Information Criteria.

Schwarz, G. 1978. Estimating the dimension of a model *The Annals of Statistics* 6 (2), 461–464. <doi:10.1214/aos/1176344136>

Examples

```
x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

BIC(m1)
BIC(m2)
BIC(m3)
BICadj(m1)
BICadj(m2)
BICadj(m3)
```

CAIC	<i>Consistent Akaike's Information Criterion and Consistent Akaike's Information Criterion with Fisher Information</i>
------	--

Description

Consistent Akaike's Information Criterion (CAIC) and Consistent Akaike's Information Criterion with Fisher Information (CAICF) for "lm" and "glm" objects.

Usage

CAIC(model)

CAICF(model)

Arguments

model a "lm" or "glm" object.

Details

CAIC (Bozdogan, 1987) is calculated as

$$-2LL(theta) + k(log(n) + 1)$$

CAICF (Bozdogan, 1987) as

$$-2LL(theta) + 2k + k(log(n)) + log(|F|)$$

F is the Fisher information matrix.

Value

CAIC or CAICF measurement of the model.

References

Bozdogan, H. (1987). Model selection and Akaike's information criterion (AIC): The general theory and its analytical extensions. Psychometrika, 52(3), 345-370.

Examples

```

x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

CAIC(m1)
CAIC(m2)
CAIC(m3)
CAICF(m1)
CAICF(m2)
CAICF(m3)

```

FIC

Fisher Information Criterion

Description

Calculates Fisher Information Criterion (FIC) for "lm" and "glm" objects.

Usage

```
FIC(model)
```

Arguments

model a "lm" or "glm" object

Details

FIC (Wei, 1992) is calculated as

$$-2LL(theta) + \log(|X^T X|)$$

Value

FIC measurement of the model

References

Wei, C. Z. (1992). On predictive least squares principles. The Annals of Statistics, 20(1), 1-42.

Examples

```

x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

FIC(m1)
FIC(m2)
FIC(m3)

```

GCV

*Generalized Cross-Validation***Description**

Calculates Generalized Cross-Validation (GCV) for "lm" and "glm" objects.

Usage

```
GCV(model)
```

Arguments

model a "lm" or "glm" object

Details

GCV (Koc and Bozdogan, 2015) is calculated as

$$RSS/(n(1 - k/n))$$

RSS is the residual sum of squares.

Value

GCV measurement of the model

References

Koc, E. K., & Bozdogan, H. (2015). Model selection in multivariate adaptive regression splines (MARS) using information complexity as the fitness function. *Machine Learning*, 101(1), 35-58.

Examples

```

x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

GCV(m1)
GCV(m2)
GCV(m3)

```

HBIC

Haughton Bayesian information criterion

Description

Calculates Haughton Bayesian information criterion (HBIC) for "lm" and "glm" objects.

Usage

```
HBIC(model)
```

Arguments

model a "lm" or "glm" object

Details

HBIC (Bollen et al., 2014) is calculated as

$$-2LL(\theta) + k \log(n/(2\pi))$$

Value

HBIC measurement of the model

References

Bollen, K. A., Harden, J. J., Ray, S., & Zavisca, J. (2014). BIC and alternative Bayesian information criteria in the selection of structural equation models. *Structural equation modeling: a multidisciplinary journal*, 21(1), 1-19.

Examples

```
x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

HBIC(m1)
HBIC(m2)
HBIC(m3)
```

HQIC	<i>Hannan-Quinn Information Criterion</i>
------	---

Description

Calculates Hannan-Quinn Information Criterion (HQIC) for "lm" and "glm" objects.

Usage

```
HQIC(model)
```

Arguments

model a "lm" or "glm" object

Details

HQIC (Hannan and Quinn, 1979) is calculated as

$$-2LL(theta) + 2k\log(\log(n))$$

Value

HQIC measurement of the model

References

Hannan, E. J., & Quinn, B. G. (1979). The determination of the order of an autoregression. *Journal of the Royal Statistical Society: Series B (Methodological)*, 41(2), 190-195.

Examples

```

x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

HQIC(m1)
HQIC(m2)
HQIC(m3)

```

IBIC

*Information Matrix-Based Information Criterion***Description**

Calculates Information Matrix-Based Information Criterion (IBIC) for "lm" and "glm" objects.

Usage

```
IBIC(model)
```

Arguments

model a "lm" or "glm" object

Details

IBIC (Bollen et al., 2012) is calculated as

$$-2LL(theta) + k \log(n/(2\pi)) + \log(|F|)$$

F is the fisher information matrix.

While calculating the Fisher information matrix (F), we used the joint parameters ($beta, sigma^2$) of the models.

Value

IBIC measurement of the model

References

Bollen, K. A., Ray, S., Zavisca, J., & Harden, J. J. (2012). A comparison of Bayes factor approximation methods including two new methods. *Sociological Methods & Research*, 41(2), 294-324.

Examples

```
x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

IBIC(m1)
IBIC(m2)
IBIC(m3)
```

IC	<i>Information Criteria</i>
----	-----------------------------

Description

Calculates Various Information Criteria for "lm" and "glm" objects.

Usage

```
IC(
  model,
  criteria = c("AIC", "BIC", "CAIC", "KIC", "HQIC", "FIC", "ICOMP_IFIM_C1",
    "ICOMP_PEU_C1", "ICOMP_PEU_LN_C1", "CICOMP_C1"),
  ...
)
```

Arguments

model	a "lm" or "glm" object or object list
criteria	a vector of criteria names. Can be set to respective numbers. Possible criteria names at the moment are: 1 = "AIC" 2 = "AIC4" 3 = "BIC" 4 = "BICadj"

```

5 = "BICQ"
6 = "CAIC"
7 = "CAICF"
8 = "FIC"
9 = "GCV"
10 = "HBIV"
11 = "GQIC"
12 = "IBIC"
13 = "ICOMP_IFIM_CF"
14 = "ICOMP_IFIM_C1"
15 = "ICOMP_IFIM_C1F"
16 = "ICOMP_IFIM_C1R"
17 = "ICOMP_PEU_CF"
18 = "ICOMP_PEU_C1"
19 = "ICOMP_PEU_C1F"
20 = "ICOMP_PEU_C1R"
21 = "ICOMP_PEU_LN_CF"
22 = "ICOMP_PEU_LN_C1"
23 = "ICOMP_PEU_LN_C1F"
24 = "ICOMP_PEU_LN_C1R"
25 = "CICOMP_CF"
26 = "CICOMP_C1"
27 = "CICOMP_C1F"
28 = "CICOMP_C1R"
29 = "JIC"
30 = "KIC"
31 = "KICC"
32 = "SPBIC"

... additional parameters. Currently none.

```

Details

Calculates Various Information Criteria for "lm" and "glm" objects. `model` can be a list. If it is a list, function returns a matrix of selected information criteria for all models.

Value

Information criteria of the model(s) for selected criteria

Examples

```

x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)

```

```

m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

IC(model = m1, criteria = 1:32)
IC(model = list(lm = m1,
                glm = m2,
                glm_pois = m3), criteria = 1:32)

```

ICOMP

Informational Complexity

Description

These functions calculates Informational Complexity (ICOMP) variants for "lm" and "glm" objects.

Usage

```

ICOMP(model, type = "IFIM", C = "C1")

ICOMP_IFIM_CF(model)

ICOMP_IFIM_C1(model)

ICOMP_IFIM_C1F(model)

ICOMP_IFIM_C1R(model)

ICOMP_PEU_CF(model)

ICOMP_PEU_C1(model)

ICOMP_PEU_C1F(model)

ICOMP_PEU_C1R(model)

ICOMP_PEU_LN_CF(model)

ICOMP_PEU_LN_C1(model)

ICOMP_PEU_LN_C1F(model)

ICOMP_PEU_LN_C1R(model)

CICOMP_CF(model)

CICOMP_C1(model)

```

CICOMP_C1F(model)

CICOMP_C1R(model)

Arguments

model	a "lm" or "glm" object
type	type of ICOMP. Available types are "IFIM", "PEU", "PEU_LN" and "CICOMP". Default is "IFIM".
C	type of complexity. Available types are "CF", "C1", "C1F" and "C1R". Default is "C1".

Details

ICOMP(IFIM) (Bozdogan, 2003) is calculated as

$$-2LL(theta) + 2C(F^{-1})$$

ICOMP(IFIM-peu) (Koc and Bozdogan, 2015) as

$$-2LL(theta) + k + 2C(F^{-1})$$

ICOMP(IFIM-peuln) (Bozdogan, 2010) as

$$-2LL(theta) + k + 2\log(n)C(F^{-1})$$

and CICOMP (Pamukcu et al., 2015) as

$$-2LL(theta) + k(\log(n) + 1) + 2C(F^{-1})$$

F is the fisher information matrix. F^{-1} is the reverse Fisher information matrix. C is the complexity measure. Four variants are available:

C_1 (Bozdogan, 2010) is

$$C_1(F^{-1}) = s/2 * \log(\lambda_{a_g}/\lambda_{a_a})$$

C_F (Bozdogan, 2010) is

$$C_F(F^{-1}) = 1/s * \sum_i^s (\lambda_{a_i} - \lambda_{a_a})$$

C_1F (Bozdogan, 2010) is

$$C_1F(F^{-1}) = 1/(4\lambda_{a_a}^2) * \sum_i^s (\lambda_{a_i} - \lambda_{a_a})$$

C_1R (Bozdogan, 2000) is

$$C_1R(F^{-1}) = 1/2 * \log(|R|)$$

Here, R is the correlation matrix of the model, $\lambda_1, \dots, \lambda_s$ are eigenvalues of F , λ_a and λ_g are arithmetic and geometric mean of eigenvalues of F , respectively. s is the dimension of F . While calculating the Fisher information matrix (F), we used the joint parameters (β, σ^2) of the models. In $C1R(\cdot)$ function, we utilized the usual variance-covariance matrix $Cov(\beta)$ of the models. β is the vector of regression coefficients.

Value

Informational Complexity measurement of the model

References

- Bozdogan, H. (2003). Intelligent Statistical Data Mining with Information Complexity and Genetic Algorithms. Hampaşum Bozdogan University of Tennessee, Knoxville, USA. In Statistical data mining and knowledge discovery (pp. 47-88). Chapman and Hall/CRC.
- Koc, E. K., & Bozdogan, H. (2015). Model selection in multivariate adaptive regression splines (MARS) using information complexity as the fitness function. *Machine Learning*, 101(1), 35-58.
- Bozdogan, H. (2010). A new class of information complexity (ICOMP) criteria with an application to customer profiling and segmentation. *İstanbul Üniversitesi İşletme Fakültesi Dergisi*, 39(2), 370-398.
- Pamukçu, E., Bozdogan, H., & Çalık, S. (2015). A novel hybrid dimension reduction technique for undersized high dimensional gene expression data sets using information complexity criterion for cancer classification. *Computational and mathematical methods in medicine*, 2015.
- Bozdogan, H. (2000). Akaike's information criterion and recent developments in information complexity. *Journal of mathematical psychology*, 44(1), 62-91.

Examples

```
x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

ICOMP_IFIM_CF(m1)
ICOMP_IFIM_CF(m2)
ICOMP_IFIM_CF(m3)
CICOMP_C1(m1)
CICOMP_C1(m2)
CICOMP_C1(m3)
ICOMP(m1, type = "PEU", C = "C1R")
```

JIC

*Joint Information Criterion***Description**

Joint Information Criterion (JIC) for "lm" and "glm" objects.

Usage

```
JIC(model)
```

Arguments

model a "lm" or "glm" object

Details

JIC (Rahman and King, 1999) is calculated as

$$-2LL(\theta) + 1/2 * (k \log(n) - n \log(1 - k/n))$$

Value

JIC measurement of the model

References

Rahman, M. S., & King, M. L. (1999). Improved model selection criterion. Communications in Statistics-Simulation and Computation, 28(1), 51-71.

Examples

```
x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

JIC(m1)
JIC(m2)
JIC(m3)
```

KIC

*Kullback–Leibler Information Criterion***Description**

Calculates Kullback–Leibler Information Criterion (KIC) and its corrected form (KICC) for "lm" and "glm" objects.

Usage

```
KIC(model)
```

```
KICC(model)
```

Arguments

model a "lm" or "glm" object

Details

KIC (Seghouane, 2006) is calculated as

$$-2LL(theta) + 3k$$

and KICC (Seghouane, 2006) is calculated as

$$-2LL(theta) + ((k + 1)(3n - k - 2)) + (k/(n - k))$$

Value

KIC measurement of the model

References

Seghouane, A. K. (2006). A note on overfitting properties of KIC and KICC. *Signal Processing*, 86(10), 3055-3060.

Examples

```
x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
```

```

m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

KIC(m1)
KIC(m2)
KIC(m3)
KICC(m1)
KICC(m2)
KICC(m3)

```

SPBIC

Scaled Unit Information Prior Bayesian Information Criterion

Description

Calculates Scaled Unit Information Prior Bayesian Information Criterion (SPBIC) for "lm" and "glm" objects.

Usage

```
SPBIC(model)
```

Arguments

model a "lm" or "glm" object

Details

SPBIC (Bollen et al., 2012) is calculated as

$$-2LL(theta) + k(1 - \log(k/(beta^T(Sigma)^{-1}beta)))$$

beta and Sigma are vector and covariance matrix of regression coefficients.

Value

SPBIC measurement of the model

References

Bollen, K. A., Ray, S., Zavisca, J., & Harden, J. J. (2012). A comparison of Bayes factor approximation methods including two new methods. *Sociological Methods & Research*, 41(2), 294-324.

Examples

```
x1 <- rnorm(100, 3, 2)
x2 <- rnorm(100, 5, 3)
x3 <- rnorm(100, 67, 5)
err <- rnorm(100, 0, 4)

## round so we can use it for Poisson regression
y <- round(3 + 2*x1 - 5*x2 + 8*x3 + err)

m1 <- lm(y~x1 + x2 + x3)
m2 <- glm(y~x1 + x2 + x3, family = "gaussian")
m3 <- glm(y~x1 + x2 + x3, family = "poisson")

SPBIC(m1)
SPBIC(m2)
SPBIC(m3)
```

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