

# Package ‘cenROC’

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**Type** Package

**Title** Estimation of the Time-Dependent ROC Curve and AUC for Censored Survival Data

**Version** 1.0.0

**Author** Kassu Mehari Beyene and Anouar El Ghouch

**Maintainer** Kassu Mehari Beyene <kasu.beyene@uclouvain.be>

**Description** Contains functions to estimate a smoothed and a non-smoothed (empirical) time-dependent ROC curve (receiver operating characteristic curve) and the corresponding area under the ROC curve (AUC) for the right censored survival data, as described in Beyene and El Ghouch (2019) <<https://dial.uclouvain.be/pr/boreal/object/boreal:219643>>.

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**License** GPL (>= 2)

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**NeedsCompilation** no

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| cenROC | <i>Estimation of the time-dependent ROC curve for right censored survival data</i> |
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### Description

This function computes the time-dependent ROC curve (receiver operating characteristic curve) for right censored survival data using the cumulative sensitivity and dynamic specificity definitions. The ROC curves can be either empirical (non-smoothed) or smoothed with/without boundary correction. It also calculates the time-dependent area under the ROC curve (AUC).

### Usage

```
cenROC(Y, M, censor, t, U = NULL, h = NULL, bw = "NR", method = "tra",
       ktype = "normal", ktype1 = "normal", B = 0, alpha = 0.05, plot = TRUE)
```

### Arguments

|        |   |
|--------|---|
| Y      | The numeric vector of event-times or observed times.  |
| M      | The numeric vector of marker values for which the time-dependent ROC curves is computed.  |
| censor | The censoring indicator, 1 if event, 0 otherwise.   |
| t      | A scalar time point at which the time-dependent ROC curve is computed.  |
| U      | The vector of grid points where the ROC curve is estimated. The default is a sequence of 151 numbers between 0 and 1.   |
| h      | A scalar for the bandwidth of Beran's weight calculations. The default is the value obtained by using the method of Sheather and Jones (1991).  |
| bw     | A character string specifying the bandwidth estimation method for the ROC itself. The possible options are "NR" for the normal reference, the plug-in "PI" and the cross-validation "CV". The default is the "NR" normal reference method. The user can also introduce a numerical value. |
| method | The method of ROC curve estimation. The possible options are "emp" empirical method; "untra" smooth without boundary correction and "tra" is smooth ROC curve estimation with boundary correction. The default is the "tra" smooth ROC curve estimate with boundary correction.           |
| ktype  | A character string giving the type kernel distribution to be used for smoothing the ROC curve: "normal", "epanechnikov", "biweight", or "triweight". By default, the "normal" kernel is used.   |
| ktype1 | A character string specifying the desired kernel needed for Beran weight calculation. The possible options are "normal", "epanechnikov", "tricube", "boxcar", "triangular", or "quartic". The default is "normal" kernel density.   |
| B      | The number of bootstrap samples to be used for variance estimation. The default is 0, no variance estimation.   |
| alpha  | The significance level. The default is 0.05.  |
| plot   | The logical parameter to see the ROC curve plot. The default is TRUE.   |

## Details

The empirical (non-smoothed) ROC estimate and the smoothed ROC estimate with/without boundary correction can be obtained using this function. The smoothed ROC curve estimators require selecting two bandwidth parameters: one for Beran's weight calculation and one for smoothing the ROC curve. For the latter, three data-driven methods: the normal reference "NR", the plug-in "PI" and the cross-validation "CV" were implemented. To select the bandwidth parameter needed for Beran's weight calculation, by default, the plug-in method of Sheather and Jones (1991) is used but it is also possible to introduce a numeric value. See Beyene and El Ghouch (2019) for details.

## Value

Returns the following items:

ROC The vector of the estimated ROC at U for the given t. These will be numeric numbers between 0 and 1.

U The vector of grid points used.

AUC A data frame of dimension  $1 \times 4$ . The columns are: AUC, standard error of AUC, the lower and upper limits of bootstrap CI.

bw The computed value of bandwidth. For the empirical method this is always 1.

## Author(s)

Kassu Mehari Beyene, Catholic University of Louvain. <kasu.beyene@uclouvain.be>

Anouar El Ghouch, Catholic University of Louvain. <anouar.elghouch@uclouvain.be>

## References

Beyene, K. M. and El Ghouch A. (2019). Smoothed time-dependent ROC curves for right-censored survival data.<<https://dial.uclouvain.be/pr/boreal/object/boreal:219643>>.

Sheather, S. J. and Jones, M. C. (1991). A Reliable data-based bandwidth selection method for kernel density estimation. *Journal of the Royal Statistical Society. Series B (Methodological)* 53(3): 683–690.

## Examples

```
library(cenROC)
```

```
data(mayo)
```

```
cenROC(Y=mayo$time, M=mayo$mayoscore5, censor=mayo$censor, t=365*6)$AUC
```

## Description

This function computes the data-driven bandwidth for smoothing the ROC (or distribution) function using the CV method of Beyene and El Ghouch (2019). This is an extension of the classical (unweighted) cross-validation bandwidth selection method to the case of weighted data.

## Usage

```
CV(X, wt, ktype = "normal")
```

## Arguments

|       |  |
|-------|--|
| X     | The numeric data vector.   |
| wt    | The non-negative weight vector.  |
| ktype | A character string giving the type kernel to be used: "normal", "epanechnikov", "biweight", or "triweight". By default, the "normal" kernel is used. |

## Details

Bowman et al (1998) proposed the cross-validation bandwidth selection method for unweighted kernel smoothed distribution function. This method is implemented in the R package `kerdiest`. We adapted this for the case of weighted data by incorporating the weight variable into the cross-validation function of Bowman's method. See Beyene and El Ghouch (2019) for details.

## Value

Returns the computed value for the bandwidth parameter.

## Author(s)

Kassu Mehari Beyene, Catholic University of Louvain. <kasu.beyene@uclouvain.be>

Anouar El Ghouch, Catholic University of Louvain. <anouar.elghouch@uclouvain.be>

## References

Beyene, K. M. and El Ghouch A. (2019). Smoothed time-dependent ROC curves for right-censored survival data. <<https://dial.uclouvain.be/pr/boreal/object/boreal:219643>>.

Bowman A., Hall P. and Trvan T.(1998). Bandwidth selection for the smoothing of distribution functions. *Biometrika* 85:799-808.

Quintela-del-Rio, A. and Estevez-Perez, G. (2015). `kerdiest`: Nonparametric kernel estimation of the distribution function, bandwidth selection and estimation of related functions. R package version 1.2.

**Examples**

```
library(cenROC)

X <- rnorm(100) # random data vector
wt <- runif(100) # weight vector

## Cross-validation bandwidth selection
CV(X = X, wt = wt)$bw
```

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mayo

*Mayo Marker Data*

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**Description**

Two marker values with event time and censoring status for the subjects in Mayo PBC data.

**Usage**

```
data(mayo)
```

**Format**

A data frame with 312 observations and 4 variables: time (event time/censoring time), censor (censoring indicator), mayoscore4, mayoscore5. The two scores are derived from 4 and 5 covariates respectively.

**References**

Heagerty, P. J., and Zheng, Y. (2005). Survival model predictive accuracy and ROC curves. *Biometrics*, 61(1), 92-105.

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NR

*The normal reference bandwidth selection for weighted data*

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**Description**

This function computes the data-driven bandwidth for smoothing the ROC (or distribution) function using the NR method of Beyene and El Gouch (2019). This is an extension of the classical (unweighted) normal reference bandwidth selection method to the case of weighted data.

**Usage**

```
NR(X, wt, ktype = "normal")
```

**Arguments**

|       |  |
|-------|--|
| X     | The numeric data vector.   |
| wt    | The non-negative weight vector.  |
| ktype | A character string giving the type kernel to be used: "normal", "epanechnikov", "biweight", or "triweight". By default, the "normal" kernel is used. |

**Details**

See Beyene and El Ghouch (2019) for details.

**Value**

Returns the computed value for the bandwidth parameter.

**Author(s)**

Kassu Mehari Beyene, Catholic University of Louvain. <kasu.beyene@uclouvain.be>

Anouar El Ghouch, Catholic University of Louvain. <anouar.elghouch@uclouvain.be>

**References**

Beyene, K. M. and El Ghouch A. (2019). Smoothed time-dependent ROC curves for right-censored survival data. <<https://dial.uclouvain.be/pr/boreal/object/boreal:219643>>.

**Examples**

```
library(cenROC)

X <- rnorm(100) # random data vector
wt <- runif(100) # weight vector

## Normal reference bandwidth selection
NR(X = X, wt = wt)$bw
```

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PI

*The plug-in bandwidth selection for weighted data*

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**Description**

This function computes the data-driven bandwidth for smoothing the ROC (or distribution) function using the PI method of Beyene and El Ghouch (2019). This is an extension of the classical (unweighted) direct plug-in bandwidth selection method to the case of weighted data.

**Usage**

```
PI(X, wt, ktype = "normal")
```

**Arguments**

|       |  |
|-------|--|
| X     | The numeric vector of random variable.   |
| wt    | The non-negative weight vector.  |
| ktype | A character string giving the type kernel to be used: "normal", "epanechnikov", "biweight", or "triweight". By default, the "normal" kernel is used. |

**Details**

See Beyene and El Ghouch (2019) for details.

**Value**

Returns the computed value for the bandwidth parameter.

**Author(s)**

Kassu Mehari Beyene, Catholic University of Louvain. <kasu.beyene@uclouvain.be>

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**References**

Beyene, K. M. and El Ghouch A. (2019). Smoothed time-dependent ROC curves for right-censored survival data. <<https://dial.uclouvain.be/pr/boreal/object/boreal:219643>>.

**Examples**

```
library(cenROC)

X <- rnorm(100) # random data vector
wt <- runif(100) # weight vector

## Plug-in bandwidth selection
PI(X = X, wt = wt)$bw
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