Package ‘landpred’

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Landmark Prediction of a Survival Outcome

Description


Details

Package: landpred
Type: Package
Version: 1.0
License: GPL

Author(s)

Layla Parast

References


Examples

data(data_example_landpred)
t0=2
tau = 8

## Landmark prediction with no covariate or short term information
Prob.Null(t0=t0,tau=tau,data=data_example_landpred)
out = Prob.Null(t0=t0,tau=tau,data=data_example_landpred)
out$Prob
out$data
newdata = matrix(c(1,1,3,0,4,1,10,1,11,0), ncol = 2, byrow=TRUE)
out = Prob.Null(t0=t0,tau=tau,data=data_example_landpred,newdata=newdata)
out$Prob
out$newdata

#Landmark prediction with covariate information only
Prob.Covariate(t0=t0,tau=tau,data=data_example_landpred)
out = Prob.Covariate(t0=t0,tau=tau,data=data_example_landpred)
out$Prob
out$data

newdata = matrix(c(1,1,1,3,0,1,4,1,1,10,1,0,11,0,1), ncol = 3, byrow=TRUE)
out = Prob.Covariate(t0=t0,tau=tau,data=data_example_landpred,newdata=newdata)
out$Prob
out$newdata

#Landmark prediction with covariate information and short term event information
#note: computationally intensive commands below
#Prob.Covariate.ShortEvent(t0=t0,tau=tau,data=data_example_landpred)
#out = Prob.Covariate.ShortEvent(t0=t0,tau=tau,data=data_example_landpred)
#out$data
#data.plot = out$data
#plot(data.plot$XS[data.plot$Z ==1], data.plot$Probability[data.plot$Z ==1],
#pch = 20, xlim = c(0,t0))
#points(data.plot$XS[data.plot$Z ==0], data.plot$Probability[data.plot$Z ==0],
#pch = 20, col = 2)

newdata = matrix(c(1,1,0.5,1,0,3,0,1,1,4,1,1,5,1,0,10,1,5,1,0,11,0,11,0,1), ncol = 5, byrow=TRUE)
#note: computationally intensive command below
#out=Prob.Covariate.ShortEvent(t0=t0,tau=tau,data=data_example_landpred,newdata=newdata)
#out$newdata

---

**AUC.landmark**

*Estimates the area under the ROC curve (AUC).*

**Description**

This function calculates the AUC given the data (truth) and corresponding estimated probabilities; uses a continuity correction.

**Usage**

AUC.landmark(t0, tau, data, short = TRUE, weight=NULL)
BS.landmark

Arguments

- `t0`  
  the landmark time.

- `tau`  
  the residual survival time of interest.

- `data`  
  n by k matrix, where k = 4 or 6. A data matrix where the first column is XL = min(TL, C) where TL is the time of the long term event, C is the censoring time, and the second column is DL =1*(TL<C), the second to last column is the covariate vector (can be NULL) and the last column is the estimated probability P(TL<t0+tau | TL>t0).

- `short`  
  logical value indicating whether data includes short term event information. Should be TRUE if short term XS and DS are includes as third and fourth columns of data matrix, FALSE if not. Default is TRUE.

- `weight`  
  an optional weight to be incorporated in all estimation.

Value

- `AUC.est`  
  Estimated AUC

Author(s)

Layla Parast

References


Examples

data(data_example_landpred)
t0=2
tau = 8
Prob.Null(t0=t0,tau=tau,data=data_example_landpred)

out = Prob.Null(t0=t0,tau=tau,data=data_example_landpred)
out$Prob
out$data

AUC.landmark(t0=t0,tau=tau, data = out$data)

BS.landmark  

Estimates the Brier score.

Description

This function calculates the Brier score given the data (truth) and corresponding estimated probabilities.
BS.landmark

Usage

BS.landmark(t0, tau, data, short = TRUE, weight=NULL)

Arguments

t0 the landmark time.

tau the residual survival time of interest.

data n by k matrix, where k = 4 or 6. A data matrix where the first column is XL = min(TL, C) where TL is the time of the long term event, C is the censoring time, and the second column is DL =1*(TL<C), the second to last column is the covariate vector (can be NULL) and the last column is the estimated probability P(TL<t0+tau | TL>t0).

short logical value indicating whether data includes short term event information. Should be TRUE if short term XS and DS are includes as third and fourth columns of data matrix, FALSE if not. Default is TRUE.

weight an optional weight to be incorporated in all estimation.

Value

Brier.score Estimated Brier score

Author(s)

Layla Parast

References


Examples

data(data_example_landpred)
t0=2
tau = 8
Prob.Null(t0=t0,tau=tau,data=data_example_landpred)

out = Prob.Null(t0=t0,tau=tau,data=data_example_landpred)
out$Prob
out$data

BS.landmark(t0=t0,tau=tau, data = out$data)
Data Example Landpred

Helper function

cumsum2

Description
Helper function; should not be called directly by user.

Usage

cumsum2(mydat)

Arguments

mydat

Value

out

Author(s)

Layla Parast

Data Example Landpred
Hypothetical data to be used in examples.

Description
Hypothetical data to be used in examples.

Usage

data(data_example_landpred)

Format
A data frame with 4868 observations on the following 5 variables.

XL a numeric vector. XL = min(TL, C) where TL is the time of the long term event, C is the censoring time.

DL a 0/1 vector. DL =1*(TL<C) where TL is the time of the long term event, C is the censoring time.

XS a numeric vector. XS = min(TS, C) where TS is the time of the long term event, C is the censoring time.

DS a 0/1 vector. DS =1*(TS<C) where TS is the time of the long term event, C is the censoring time.

Z a 0/1 vector of discrete covariate values.
Examples

data(data_example_landpred)

Description

Calculates the survival probability for censoring i.e. P(C > tt) where C is censoring; used in inverse probability of censoring weights (IPCW). This function is called by Wi.FUN; this function should not be called on its own.

Usage

Ghat.FUN(tt, data, type = "fl", weight.given)

Arguments

tt the time (or vector of times) at which the survival probability should be estimated.
data n by k matrix, where k>=2. A data matrix where the first column is XL = min(TL, C) where TL is the time of the long term event, C is the censoring time, and the second column is DL =1*(TL<C)
type type sent to survfit function, default is "fl".weight.given a weight to be used in estimation.

Value

survival probability for censoring at time tt

Author(s)

Layla Parast
### helper.si

**Helper function for AUC.landmark**

#### Description

Helper function for AUC.landmark; should not be called directly by user.

#### Usage

```r
helper.si(yy, FUN, Yi, Vi=NULL)
```

#### Arguments

- `yy`: yy
- `FUN`: FUN
- `Yi`: Yi
- `Vi`: Vi

#### Value

- `out`: matrix

#### Author(s)

Layla Parast

---

### Kern.FUN

** Calculates kernel matrix**

#### Description

This calculates the kernel matrix needed for estimating the probability incorporating short term event information

#### Usage

```r
Kern.FUN(zz, zi, bw)
```

#### Arguments

- `zz`: zz
- `zi`: zi
- `bw`: bandwidth
Value
the kernel matrix

Author(s)
Layla Parast

Description
Helper function for optimize.mse.BW.

Usage
mse.BW(data, t0, tau, h, folds = 3, reps = 2)

Arguments
- `data` n by 5 matrix. A data matrix where the first column is \( XL = \min(TL, C) \) where \( TL \) is the time of the long term event, \( C \) is the censoring time, and the second column is \( DL = 1*(TL<C) \), the third column is \( XS = \min(TS, C) \) where \( TS \) is the time of the short term event, \( C \) is the censoring time, the fourth column is \( DS = 1*(TS<C) \), and the fifth column is the covariate. These are the data used to calculate the estimated probability.
- `t0` the landmark time.
- `tau` the residual survival time of interest.
- `h` bandwidth
- `folds` Number of folds wanted for K-fold cross-validation. Default is 3.
- `reps` Number of repitions wanted of K-fold cross-validation. Default is 2.

Value
mean of MSE

Author(s)
Layla Parast

References
optimize.mse.BW

Calculates initial optimal bandwidth.

**Description**

Calculates initial optimal bandwidth with respect to mean squared error using K-fold cross-validation.

**Usage**

```r
optimize.mse.BW(data, t0, tau, h.grid=seq(.01,2,length=50), folds=3, reps=2)
```

**Arguments**

- `data` n by 5 matrix. A data matrix where the first column is \( XL = \min(TL, C) \) where \( TL \) is the time of the long term event, \( C \) is the censoring time, and the second column is \( DL = 1*(TL<C) \), the third column is \( XS = \min(TS, C) \) where \( TS \) is the time of the short term event, \( C \) is the censoring time, the fourth column is \( DS = 1*(TS<C) \), and the fifth column is the covariate. These are the data used to calculate the estimated probability.

- `t0` the landmark time.

- `tau` the residual survival time of interest.

- `h.grid` The grid of possible bandwidths that the user would like the function to search through. Default is \( h.grid = \text{seq(.01,2,length=50)} \).

- `folds` Number of folds wanted for K-fold cross-validation. Default is 3.

- `reps` Number of repitions wanted of K-fold cross-validation. Default is 2.

**Value**

- `h` Selected bandwidth.

**Author(s)**

Layla Parast

**References**

Prob.Covariate

Estimates \( P(TL < t_0 + \tau \mid TL > t_0, Z) \), i.e. given discrete covariate.

Description

This function calculates the probability that the an individual has the event of interest before \( t_0 + \tau \) given the discrete covariate and given the event has not yet occurred and the individual is still at risk at time \( t_0 \); this estimated probability does not incorporate any information about the short term event information.

Usage

\[
\text{Prob.Covariate}(t_0, \tau, \text{data}, \text{weight} = \text{NULL}, \text{short} = \text{TRUE}, \text{newdata} = \text{NULL})
\]

Arguments

- **t0**: the landmark time.
- **tau**: the residual survival time for which probabilities are calculated. Specifically, this function estimates the probability that the an individual has the event of interest before \( t_0 + \tau \) given the event has not yet occurred and the individual is still at risk at time \( t_0 \).
- **data**: \( n \times k \) matrix, where \( k = 3 \) or \( k = 5 \). A data matrix where the first column is \( XL = \min(TL, C) \) where \( TL \) is the time of the long term event, \( C \) is the censoring time, and the second column is \( DL = 1*(TL < C) \). If short term event information is included in this dataset then the third column is \( XS = \min(TS, C) \) where \( TS \) is the time of the short term event, \( C \) is the censoring time, and the fourth column is \( DS = 1*(TS < C) \), and the fifth column is the covariate. If short term event information is not included then the third column is the covariates (see "short" parameter). These are the data used to calculate the estimated probabilities.
- **weight**: an optional weight to be incorporated in all estimation.
- **short**: logical value indicating whether data includes short term event information. Should be \text{TRUE} \ if short term \( XS \) and \( DS \) are includes as third and fourth columns of data matrix meaning that the covariates is in the fifth column, \text{FALSE} \ if not meaning that the covariate is in the third column. Default is \text{TRUE} \.
- **newdata**: \( n \times k \) matrix, where \( k = 3 \) or \( k = 5 \). A data matrix where the first column is \( XL = \min(TL, C) \) where \( TL \) is the time of the long term event, \( C \) is the censoring time, and the second column is \( DL = 1*(TL < C) \), and the last column (either 3rd or 5th) contains covariate values. Predicted probabilities are estimated for these data.

Value

- **Prob**: matrix of estimated probability for each value of the covariate; first column shows all covariate values and second column contains predicted probability at that covariate value.
Prob.Covariate.ShortEvent

\texttt{data} \hspace{1cm} the data matrix with an additional column with the estimated individual probabilities; note that the predicted probability is NA if TL < t_0 since it is only defined for individuals with TL > t_0.

\texttt{newdata} \hspace{1cm} the newdata matrix with an additional column with the estimated individual probabilities; note that the predicted probability is NA if TL < t_0 since it is only defined for individuals with TL > t_0; if newdata is not supplied then this returns NULL.

\textbf{Author(s)}

Layla Parast

\textbf{References}


\textbf{Examples}

data(data_example_landpred)
t0 = 2
tau = 8
Prob.Covariate(t0 = t0, tau = tau, data = data_example_landpred)

out = Prob.Covariate(t0 = t0, tau = tau, data = data_example_landpred)
out$Prob
out$data

newdata = matrix(c(1,1,1, 3,0,1, 4,1,1, 10,1,0, 11,0,1), ncol = 3, byrow = TRUE)
out = Prob.Covariate(t0 = t0, tau = tau, data = data_example_landpred, newdata = newdata)
out$Prob
out$newdata

---

\textbf{Prob.Covariate.ShortEvent}

\textit{Estimates P(TL < t_0 + \tau \mid TL > t_0, Z, \text{min(TS, t_0)}, I(TS <= t_0)), i.e. given discrete covariate and TS information.}

\textbf{Description}

This function calculates the probability that the an individual has the event of interest before t_0 + tau given the discrete covariate, given short term event information, and given the event has not yet occurred and the individual is still at risk at time t_0.

\textbf{Usage}

\texttt{Prob.Covariate.ShortEvent(t0, tau, data, weight = NULL, bandwidth = NULL, newdata=NULL)}
Arguments

t0
the landmark time.

tau
the residual survival time for which probabilities are calculated. Specifically, this function estimates the probability that the an individual has the event of interest before t0 + tau given the event has not yet occurred and the individual is still at risk at time t0.

data
n by 5 matrix. A data matrix where the first column is XL = min(TL, C) where TL is the time of the long term event, C is the censoring time, and the second column is DL =1*(TL<C), the third column is XS = min(TS, C) where TS is the time of the short term event, C is the censoring time, the fourth column is DS =1*(TS<C), and the fifth column is the covariate. These are the data used to calculate the estimated probability.

weight
a weight to be incorporated in all estimation.

bandwidth
an optional bandwidth to be used in kernel smoothing; is not provided then function calculates an appropriate bandwidth using bw.nrd and then undersmoothing with c = .10 (See reference)

newdata
an optional n by 5 matrix where the first column is XL = min(TL, C) where TL is the time of the long term event, C is the censoring time, and the second column is DL =1*(TL<C), the third column is XS = min(TS, C) where TS is the time of the short term event, C is the censoring time, the fourth column is DS =1*(TS<C), and the fifth column is the covariate. Predicted probabilities are estimated for these data.

Value

data
the data matrix with an additional column with the estimated individual probabilities; note that the predicted probability is NA if TL <t0 since it is only defined for individuals with TL> t0

newdata
the newdata matrix with an additional column with the estimated individual probabilities; note that the predicted probability is NA if TL <t0 since it is only defined for individuals with TL> t0; if newdata is not supplied then this returns NULL

Author(s)
Layla Parast

References

Examples

data(data_example_landpred)
t0=2
tau = 8
#note: computationally intensive command below
#Prob.Covariate.ShortEvent(t0=t0,tau=tau,data=data_example_landpred)

#out = Prob.Covariate.ShortEvent(t0=t0,tau=tau,data=data_example_landpred)
#out$data
#data.plot = out$data
#plot(data.plot$XS[data.plot$Z ==1], data.plot$Probability[data.plot$Z ==1],
#pch = 20, xlim = c(0,t0))
#points(data.plot$XS[data.plot$Z ==0], data.plot$Probability[data.plot$Z ==0],
#pch = 20, col = 2)

newdata = matrix(c(1,1,0.5,1,0,
                   3,0,1,1,1,
                   4,1,1.5,1,0,
                   10,1,5,1,0,
                   11,0,11,0,1), ncol = 5, byrow = TRUE)

#note: computationally intensive command below
#out = Prob.Covariate.ShortEvent(t0=t0,tau=tau,data=data_example_landpred,newdata=newdata)
#out$newdata

---

Prob.Null

Estimates \( P(TL < t_0 + \tau \mid TL > t_0) \).

**Description**

This function calculates the probability that an individual has the event of interest before \( t_0 + \tau \) given the event has not yet occurred and the individual is still at risk at time \( t_0 \); this estimated probability does not incorporate any information about the covariate or short term event information.

**Usage**

Prob.Null(t0, tau, data, weight = NULL, newdata=NULL)

**Arguments**

t0
  the landmark time.

tau
  the residual survival time for which probabilities are calculated. Specifically, this function estimates the probability that the an individual has the event of interest before \( t_0 + \tau \) given the event has not yet occurred and the individual is still at risk at time \( t_0 \).

data
  n by k matrix, where k >=2. A data matrix where the first column is XL = min(TL, C) where TL is the time of the long term event, C is the censoring time, and the second column is DL =1*(TL<C). These are the data used to calculate the estimated probability.

weight
  an optional weight to be incorporated in all estimation.
newdata an optional n by k matrix, where k >= 2. A data matrix where the first column is \( XL = \min(TL, C) \) where TL is the time of the long term event, C is the censoring time, and the second column is \( DL = 1*(TL < C) \). Predicted probabilities are estimated for these data.

**Value**

- **Prob** Estimated probability that the an individual has the event of interest before \( t_0 + \tau \) given the event has not yet occurred and the individual is still at risk at time \( t_0 \); this estimated probability does not incorporate any information about the covariate or short term event information.

- **data** the data matrix with an additional column with the estimated individual probabilities; note that the predicted probability is NA if TL < \( t_0 \) since it is only defined for individuals with TL > \( t_0 \)

- **newdata** the newdata matrix with an additional column with the estimated individual probabilities; note that the predicted probability is NA if TL < \( t_0 \) since it is only defined for individuals with TL > \( t_0 \); if newdata is not supplied then this returns NULL

**Author(s)**

Layla Parast

**References**


**Examples**

data(data_example_landpred)
t0=2
tau = 8
Prob.Null(t0=t0,tau=tau,data=data_example_landpred)

out = Prob.Null(t0=t0,tau=tau,data=data_example_landpred)
out$Prob
out$data

newdata = matrix(c(1,1,3,0,4,1,10,1,11,0), ncol = 2, byrow=TRUE)
out = Prob.Null(t0=t0,tau=tau,data=data_example_landpred,newdata=newdata)
out$Prob
out$newdata
Prob2

Estimates $P(TL < t_0 + \tau | TL > t_0, Z, TS > t_0)$.

Description

This function calculates the probability that the an individual has the event of interest before $t_0 + \tau$ given the discrete covariate, given the short term event has not yet occurred by $t_0$, and given the long term event has not yet occurred and the individual is still at risk at time $t_0$. This function is called by Prob.Covariate.ShortEvent; this function should not be called on its own.

Usage

Prob2(t0, tau, data, covariate.value, weight = NULL)

Arguments

t0
the landmark time.

tau
the residual survival time for which probabilities are calculated. Specifically, this function estimates the probability that the an individual has the event of interest before $t_0 + \tau$ given the event has not yet occurred and the individual is still at risk at time $t_0$.

data
n by 5 matrix. A data matrix where the first column is $XL = \min(TL, C)$ where TL is the time of the long term event, C is the censoring time, and the second column is $DL = 1*(TL < C)$, the third column is $\log(XS) = \log(\min(TS, C))$ where TS is the time of the short term event, C is the censoring time, the fourth column is $DS = 1*(TS < C)$, and the fifth column is the covariate. These are the data used to calculate the estimated probability.

covariate.value
the discrete covariate value at which to calculate the estimated probability.

weight
an optional weight to be incorporated in all estimation.

Value

Estimated probability = $P(TL < t_0 + \tau | TL > t_0, Z, TS > t_0)$.

Author(s)

Layla Parast

References

Description

This function calculates the probability that the an individual has the event of interest before \( t_0 + \tau \) given the discrete covariate, given the short term event occurred before \( t_0 \) and occurred at time \( t_s \), and given the long term event has not yet occurred and the individual is still at risk at time \( t_0 \). This function is called by Prob.Covariate.ShortEvent; this function should not be called on its own.

Usage

\[
\text{Prob2.k.t}(t, t_0, \tau, \text{data.use}, \text{bandwidth}, \text{covariate.value}, \text{weight} = \text{NULL})
\]

Arguments

- \( t \): time of the short term event, \( t_s \), on the log scale.
- \( t_0 \): the landmark time.
- \( \tau \): the residual survival time for which probabilities are calculated. Specifically, this function estimates the probability that the an individual has the event of interest before \( t_0 + \tau \) given the event has not yet occurred and the individual is still at risk at time \( t_0 \).
- \( \text{data.use} \): \( n \) by \( 5 \) matrix. A data matrix where the first column is \( X_L = \min(T_L, C) \) where \( T_L \) is the time of the long term event, \( C \) is the censoring time, and the second column is \( D_L = 1*(T_L < C) \), the third column is \( \log(X_S) = \log(\min(T_S, C)) \) where \( T_S \) is the time of the short term event, \( C \) is the censoring time, the fourth column is \( D_S = 1*(T_S < C) \), and the fifth column is the covariate.
- \( \text{bandwidth} \): bandwidth to be used.
- \( \text{covariate.value} \): covariate value at which to calculate probability.
- \( \text{weight} \): an optional weight to be incorporated in all estimation.

Value

returns estimated probabilities for each \( t_s \) value (parameter \( t \)) at the specified covariate value; returns NA if \( t_s > t_0 \).

Author(s)

Layla Parast

References

prob2.single  Estimates $P(TL < t0+\tau \mid TL > t0, Z, TS=ts)$ for a single $t$.

**Description**

Helper function for Prob2.k.t; should not be called directly.

**Usage**

```r
prob2.single(K, W2i, Xi.long, tau, Di.short, Xi.short, Zi, t0, covariate.value)
```

**Arguments**

- **K**: Kernel matrix.
- **W2i**: inverse probability of censoring weights.
- **Xi.long**: $XL = \min(TL, C)$ where $TL$ is the time of the long term event, $C$ is the censoring time.
- **tau**: the residual survival time for which probabilities are calculated. Specifically, this function estimates the probability that the individual has the event of interest before $t0 + \tau$ given the event has not yet occurred and the individual is still at risk at time $t0$.
- **Di.short**: $DS = 1*(TS<C)$, where $TS$ is the time of the short term event, $C$ is the censoring time.
- **Xi.short**: $\log(XS) = \log(\min(TS, C))$ where $TS$ is the time of the short term event, $C$ is the censoring time.
- **Zi**: covariate vector.
- **t0**: landmark time.
- **covariate.value**: specific covariate at which to estimate the conditional probability.

**Value**

returns estimated probability for values corresponding to the kernel matrix at the specified covariate value;

**Author(s)**

Layla Parast
VTM

Helper function, repeats a row.

Description
This function creates a matrix that repeats vc, dm times where each row is equal to the vc vector.

Usage
`VTM(vc, dm)`

Arguments
- `vc`: the vector to repeat.
- `dm`: number of rows.

Value
a matrix that repeats vc, dm times where each row is equal to the vc vector

Wi.FUN

Computes the inverse probability of censoring weights for a specific t0 and tau

Description
Computes the inverse probability of censoring weights for a specific t0 and tau i.e. this computes $I(t0 < XL < t0+tau) * DL / G(XL) + I(XL>t0+tau) / G(t0+tau)$ where $XL = \min(TL, C)$, TL is the time of the long term event, C is the censoring time, $DL = 1*(TL<C)$ and $G()$ is the estimate survival probability for censoring estimated using the Kaplan Meier estimator (see Ghat.FUN)

Usage
`Wi.FUN(data, t0, tau, weight.given = NULL)`

Arguments
- `data`: n by k matrix, where k>= 2. A data matrix where the first column is $XL = \min(TL, C)$ where TL is the time of the long term event, C is the censoring time, and the second column is $DL = 1*(TL<C)$
- `t0`: the landmark time..
- `tau`: the residual survival time for which probabilities are calculated.
- `weight.given`: an optional weight to be incorporated in estimation of this weight
Value
Inverse probability of censoring weight.

Author(s)
Layla Parast

Examples
```r
data(data_example_landpred)
t0 = 2
tau = 8

W2i <- Wi.FUN(data_example_landpred[,1], data = data_example_landpred[,c(1:2)], t0 = t0, tau = tau)
```
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