Package 'landpred'

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Type Package

Title Landmark Prediction of a Survival Outcome

Version 2.0

Description Nonparametric models for landmark prediction of long-term survival outcomes, incorporating covariate and short-term event information. The package supports the construction of flexible varying-coefficient models that use discrete covariates, as well as multiple continuous covariates. The goal is to improve prediction accuracy when censored short-term events are available as predictors, using robust nonparametric procedures that do not require correct model specification and avoid restrictive parametric assumptions found in alternative methods. More information on these models can be found in Parast et al. (2012, Journal of the American Statistical Association, <doi:10.1080/01621459.2012.721281>, and Parast et al. (2011, Biometrical Journal, <doi:10.1002/bimj.201000150>). More information and examples can also be found at <https://baolong281.github.io/landpred/>.

License GPL

Imports survival, stats, quantreg, splines, sm, quantreg

NeedsCompilation no

Suggests testthat (>= 3.0.0)

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Contents

`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)
```

Arguments

`t0`	The landmark time.
`tau`	The prediction window.
`data`	Matrix: 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

References

Parast, Layla, Su-Chun Cheng, and Tianxi Cai. Incorporating short-term outcome information to predict long-term survival with discrete markers. Biometrical Journal 53.2 (2011): 294-307.

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.

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

References

Parast, Layla, Su-Chun Cheng, and Tianxi Cai. Incorporating short-term outcome information to predict long-term survival with discrete markers. Biometrical Journal 53.2 (2011): 294-307.

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)
```

`coef.landpred_model_continuous` *Extract Coefficients from Landpred Continuous Model*

Description

Extracts coefficients. If `t_s` is provided, it fits the short-term GLM and returns its coefficients.

Usage

```
## S3 method for class 'landpred_model_continuous'
coef(object, t_s = NULL, ...)
```

Arguments

`object`	A landpred_model_continuous object.
`t_s`	Optional short-term covariate time.
`...`	Additional arguments.

Value

A named vector of coefficients.

`coefficient_se` *Calculate Standard Errors for Coefficients*

Description

Calculates standard errors for the coefficients of the landpred model. If `t_s` is provided, it uses the perturbation resampling method. Otherwise, it returns the standard errors from the GLM.

Usage

```
coefficient_se(model, t_s = NULL, samples = 200)
```

Arguments

model	A landpred_model_continuous object.
t_s	The time of the short-term covariate measurement.
samples	The number of resampling iterations.

Value

A named vector of standard errors.

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cumsum2 *Cumulative Sum Helper*

Description

Cumulative Sum Helper

Usage

```
cumsum2(mydat)
```

Arguments

mydat	Data matrix.

---

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)
```

fit_glm_normal *Fit GLM with Normal Weights (No Short Covariate Info)*

Description

Fits a GLM for the probability of the event occurring before `t0 + tau`, given survival up to `t0`, using only baseline covariates.

Usage

```
fit_glm_normal(landpred_obj, t0, tau)
```

Arguments

`landpred_obj`	A landpred object containing the data.
`t0`	The landmark time.
`tau`	The prediction window.

Value

A fitted glm object.

fit_short_glm *Fit GLM with Kernel Weights (Short Covariate Info)*

Description

Fits a GLM for the probability of the event occurring before `t0 + tau`, given survival up to `t0` and information on a short-term covariate. Uses kernel weighting based on the short-term covariate value.

Usage

```
fit_short_glm(landpred_obj, t0, tau, t_s, bw, transform, indices = NULL)
```

Arguments

`landpred_obj`	A landpred object containing the data.
`t0`	The landmark time.
`tau`	The prediction window.
`t_s`	The time of the short-term covariate measurement.
`bw`	The bandwidth for kernel weighting.
`transform`	A transformation function for the time variable (e.g., log).
`indices`	Optional indices to subset the data.

Value

A fitted glm object.

get_model *Get Landpred Model*

Description

Fits the base GLM (no short covariate info) and creates a landpred model object.

Creates a landpred model object for a specific landmark time and prediction window. Dispatches to continuous or discrete model creation based on the landpred object type.

Usage

```
get_model(landpred_obj, t0, tau, bw = NULL, transform = identity)
```

Arguments

landpred_obj	A landpred object.
t0	The landmark time.
tau	The prediction window.
bw	The bandwidth (for continuous models).
transform	Transformation function (for continuous models).

Value

A landpred_model_continuous object.

A landpred_model object (continuous or discrete).

Ghat.FUN *Estimate Survival Function*

Description

Estimate Survival Function

Usage

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

Arguments

tt	Time points.
data	Data frame.
type	Type of estimator.
weight.given	Optional weights.

helper.si *Helper Function for AUC*

Description

Helper Function for AUC

Usage

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

Arguments

yy	Vector 1.
FUN	Comparison operator.
Yi	Vector 2.
Vi	Optional weights.

Kern.FUN *Kernel Function*

Description

Kernel Function

Usage

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

Arguments

zz	Target points.
zi	Data points.
bw	Bandwidth.

`landpred` *Create a Landpred Object*

Description

Parses the formula and data to create a landpred object used for landmark prediction. Call '?landpred.pacakge' for more information on the legacy API.

Usage

```
landpred(formula, data, discrete = FALSE)
```

Arguments

`formula`	A formula object with a Surv object on the LHS and covariates on the RHS.
`data`	The data frame.
`discrete`	Logical, whether to use the discrete method (legacy).

Value

A landpred_object.

Examples

```
library(landpred)
library(survival)

# Load example data
data(data_example_landpred)

# Define landmark time and prediction window
t0 <- 2
tau <- 8

# Create a landpred object using the formula interface
# The formula specifies: Long-term survival ~ Short-term survival + Covariates
# Note: The short-term covariate must be a Surv object
obj <- landpred(
  Surv(XL, DL) ~ Surv(XS, DS) + Z,
  data = data_example_landpred,
  discrete = FALSE
)

# 1. Optimize bandwidth (Optional but recommended)
# This uses cross-validation to find the optimal bandwidth for the short-term covariate
# We use log transformation for the time variable as it's often more appropriate
bw <- optimize_bandwidth(
  landpred_obj = obj,
  t0 = t0,
  tau = tau,
  lower = 0.5,
  upper = 5,
  transform = log
```

```
)

print(paste("Optimal bandwidth:", bw))

# 2. Fit the model
# We pass the optimized bandwidth and the transformation used
model <- get_model(
  landpred_obj = obj,
  t0 = t0,
  tau = tau,
  bw = bw,
  transform = log
)

print(model)

# 3. Predict on new data
# For demonstration, we use the first 10 rows of the original data as "new data"
new_data <- data_example_landpred[1:10, ]

# The predict function expects a data frame with the same column names as used in the formula
probs <- predict(model, newdata = new_data)

print("Predicted probabilities:")
print(probs)
```

`mse_cv` *Calculate MSE for Bandwidth Selection using Cross-Validation*

Description

Calculate MSE for Bandwidth Selection using Cross-Validation

Usage

```
mse_cv(
  bw,
  landpred_obj,
  t0,
  tau,
  transform = identity,
  reps = 50,
  train_prop = 0.66
)
```

Arguments

`bw`	The bandwidth to test.
`landpred_obj`	The landpred object.
`t0`	The landmark time.
`tau`	The prediction window.

transform	Transformation function for short-term covariate.
reps	Number of repetitions.
train_prop	Proportion of data to use for training.

Value

The Mean Squared Error.

`optimize_bandwidth` *Optimize Bandwidth for Continuous Landpred Models*

Description

Selects the optimal bandwidth by minimizing the Mean Squared Error (MSE) using cross-validation.

Usage

```
optimize_bandwidth(
  landpred_obj,
  t0,
  tau,
  lower = 0.05,
  upper = 5,
  transform = identity,
  reps = 50,
  train_prop = 0.66
)
```

Arguments

landpred_obj	A landpred object.
t0	The landmark time.
tau	The prediction window.
lower	Lower bound for bandwidth search.
upper	Upper bound for bandwidth search.
transform	Transformation function for the short-term covariate (e.g., log). Default is identity.
reps	Number of cross-validation repetitions. Default is 50.
train_prop	Proportion of data used for training in each fold. Default is 0.66.

Value

The optimal bandwidth.

predict.landpred_model_continuous
Predict Method for Landpred Continuous Model

Description

Predicts the probability of the event occurring given new data.

Usage

```
## S3 method for class 'landpred_model_continuous'
predict(object, newdata = NULL, type = "response", ...)
```

Arguments

object	A landpred_model_continuous object.
newdata	New data frame containing covariates and short-term event info.
type	Type of prediction (default "response").
...	Additional arguments

Value

A vector of predicted probabilities.

predict.landpred_model_discrete
Predict Method for Discrete Landpred Model

Description

Predicts probabilities using the discrete landpred model.

Usage

```
## S3 method for class 'landpred_model_discrete'
predict(object, newdata = NULL, ...)
```

Arguments

object	A landpred_model_discrete object.
newdata	Optional new data.
...	Additional arguments.

Value

Predicted probabilities.

print.landpred_model_continuous *Print Method for Landpred Continuous Model*

Description

Prints the continuous landpred model results.

Usage

```
## S3 method for class 'landpred_model_continuous'
print(x, ...)
```

Arguments

x	A landpred_model_continuous object.
...	Additional arguments.

print.landpred_model_discrete *Print Method for Discrete Landpred Model*

Description

Prints the discrete landpred model results.

Usage

```
## S3 method for class 'landpred_model_discrete'
print(x, ...)
```

Arguments

x	A landpred_model_discrete object.
...	Additional arguments.

print.landpred_object *Print Method for Landpred Object*

Description

Prints a summary of the landpred object.

Usage

```
## S3 method for class 'landpred_object'
print(x, ...)
```

Arguments

x	A landpred_object.
...	Additional arguments.

Prob.Covariate *Calculate Probability with Covariate Information*

Description

Calculates the probability of the event occurring before t0 + tau, given survival up to t0, using a single covariate.

Usage

```
Prob.Covariate(t0, tau, data, weight = NULL, short = TRUE, newdata = NULL)
```

Arguments

t0	The landmark time.
tau	The prediction window.
data	The data frame for training.
weight	Optional weights.
short	Logical, whether the covariate is short-term.
newdata	Dataframe of new data for prediction.

Value

A landpred_result object.

Prob.Covariate.ShortEvent *Calculate Probability with Short Event Information*

Description

Calculates the probability of the event occurring before `t0 + tau`, given survival up to `t0`, using information on a short-term event.

Usage

```
Prob.Covariate.ShortEvent(
  t0,
  tau,
  data,
  weight = NULL,
  bandwidth = NULL,
  newdata = NULL
)
```

Arguments

`t0`	The landmark time.
`tau`	The prediction window.
`data`	The data frame.
`weight`	Optional weights.
`bandwidth`	Bandwidth for kernel smoothing.
`newdata`	Optional new data for prediction.

Value

A landpred_result object.

Prob.Null *Calculate Probability with No Information*

Description

Calculates the probability of the event occurring before `t0 + tau`, given survival up to `t0`, without using any covariate information.

Usage

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

Arguments

t0	The landmark time.
tau	The prediction window.
data	The data frame.
weight	Optional weights.
newdata	Optional new data for prediction.

Value

A landpred_result object.

Prob2 *Calculate Probability Component (No Kernel)*

Description

Calculate Probability Component (No Kernel)

Usage

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

Arguments

t0	Landmark time.
tau	Prediction window.
data	Data frame.
covariate.value	Covariate value.
weight	Optional weights.

Prob2.k.t *Calculate Probability Component with Kernel Smoothing*

Description

Calculate Probability Component with Kernel Smoothing

Usage

```
Prob2.k.t(t, t0, tau, data.use, bandwidth, covariate.value, weight = NULL)
```

Arguments

t	Time points.
t0	Landmark time.
tau	Prediction window.
data.use	Data frame.
bandwidth	Bandwidth.
covariate.value	Covariate value.
weight	Optional weights.

---

prob2.single *Calculate Single Probability Component*

Description

Calculate Single Probability Component

Usage

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

Arguments

K	Kernel weights.
W2i	IPCW weights.
Xi.long	Long term event times.
tau	Prediction window.
Di.short	Short term event indicators.
Xi.short	Short term event times.
Zi	Covariates.
t0	Landmark time.
covariate.value	Covariate value.

summary.landpred_model_continuous

Summary Method for Landpred Continuous Model

Description

Prints a summary of the model, including coefficients and standard errors.

Usage

```
## S3 method for class 'landpred_model_continuous'
summary(object, t_s = NULL, ...)
```

Arguments

object	A landpred_model_continuous object.
t_s	Optional short-term covariate time.
...	Additional arguments.

summary.landpred_object

Summary Method for Landpred Object

Description

Prints a detailed summary of the landpred object.

Usage

```
## S3 method for class 'landpred_object'
summary(object, ...)
```

Arguments

object	A landpred_object.
...	Additional arguments.

var.fun *Estimate Variance of Coefficients*

Description

Estimates the variance of the coefficients for the short-term GLM using a perturbation resampling method.

Usage

```
var.fun(t, data.v, tau, s, h, vmat, Ainv, weight = NULL, transform = identity)
```

Arguments

t	The target time for the short-term covariate (usually t_s).
data.v	The data frame used for estimation.
tau	The landmark time.
s	The prediction window.
h	The bandwidth.
vmat	A matrix of perturbation weights.
Ainv	The inverse information matrix from the model fit.
weight	Optional weights.
transform	Transformation function.

Value

A list containing the estimated standard errors for the intercept and slopes.

VTM *Vector to Matrix*

Description

Vector to Matrix

Usage

```
VTM(vc, dm)
```

Arguments

vc	Vector.
dm	Number of rows.

`Wi.FUN` *Calculate Inverse Probability of Censoring Weights*

Description

Calculate Inverse Probability of Censoring Weights

Usage

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

Arguments

`data`	Data frame.
`t0`	Landmark time.
`tau`	Prediction window.
`weight.given`	Optional weights.

Index