Package 'MIICD'

May 27, 2017

Type Package

Title Multiple Imputation for Interval Censored Data

Version 2.4

Depends R (>= 2.13.0)

Date 2017-05-27

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Description Implements multiple imputation for proportional hazards regression with interval censored data or proportional sub-distribution hazards regression for interval censored competing risks data. The main functions allow to estimate survival function, cumulative incidence function, Cox and Fine & Gray regression coefficients and associated variance-covariance matrix. 'MIICD' functions call 'Surv', 'survfit' and 'coxph' from the 'survival' package, 'crprep' from the 'mstate' package, and 'mvrnorm' from the 'MASS' package.

LazyData true

License GPL-3

Imports survival, MASS, mstate

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NeedsCompilation no

Repository CRAN

Date/Publication 2017-05-27 16:20:01 UTC

R topics documented:

`bcos` *bcos : breast cosmesis data*

Description

A data frame with 94 observations on the following 3 variables :

- left
- right
- treatment

The data comes from the `Interval` library by Michael P. Fay.

Author(s)

Michael P. Fay

References

Finkelstein, D.M., and Wolfe, R.A. (1985). A semiparametric model for regression analysis of interval-censored failure time data. Biometrics 41: 731-740.

Examples

```
head(bcos)
```

`ICCRD` *ICCRD : interval censored competing risks data*

Description

Interval censored competing risks data. A data frame with 150 observations. the columns are :

- left -> lower bound of the interval
- right -> upper bound of the interval
- status -> cause of failure (1 or 2)
- treatment -> treatment (1 or 2)
- cov2 -> another covariate (continuous)

Details

This dataset is given for demonstration purpose. 2 causes of failure are given, only cause 1 is interval censored. Right censored observations are indicated by `0` in the `status` column.

Examples

```
head(ICCRD)
```

`MI.ci` *Cumulative incidence estimation for interval censored competing risks data using multiple imputation*

Description

Uses multiple imputation to compute the cumulative incidence function for interval censored competing risks data

Usage

```
MI.ci(k, m, data, status, trans, cens.code, conf.int = F, alpha = 0.05)
```

Arguments

`k`	An integer, indicates the number of iteration to perform
`m`	An integer, indicates the number of imputation to perform at each iteration
`status`	The name of the column where status are to be found
`trans`	Denomination of the event of interest in the status column
`data`	The input data (see details)
`conf.int`	Logical, computes the confidence interval
`cens.code`	Censor indicator in the status column of the data
`alpha`	Parametrize the confidence interval width

Details

This function uses a multiple imputation approach to estimate a cumulative incidence function for interval censored competing risks data. Estimates are computed using Rubin's rules (Rubin (1987)). The cumulative incidence is computed as the mean of cumulative incidences over imputations. The variance is computed at each point by combining the within imputation variance and the between imputation variance augmented by an inflation factor to take into account the finite number of imputations. At each iteration, the cumulative incidence is updated and multiple imputation is performed using the updated estimate. If `conf.int` is required, the log-log transformation is used to compute the lower confidence interval.

Print and plot methods are available to handle results.

The `data` must contain at last three columns: `left`, `right` and `status`. For interval censored data, the `left` and `right` columns indicates lower and upper bounds of intervals, respectively. `Inf` in

the `right` column stands for right censored observations. When an observation is right censored, the `status` column must contain the censor indicator specified by `cens.code`. The transition of interest must be specified by the `trans` parameter.

Value

`est` A data frame with estimates

`...` Other objects

Author(s)

Marc Delord <<mdelord@gmail.com>>

References

Delord, M. & Genin, E. Multiple Imputation for Competing Risks Regression with Interval Censored Data Journal of Statistical Computation and Simulation, 2015

PAN, Wei. A Multiple Imputation Approach to Cox Regression with Interval-Censored Data. Biometrics, 2000, vol. 56, no 1, p. 199-203.

Rubin, D. B. (1987). Multiple imputation for nonresponse in surveys.

Schenker, N. and Welsh, A. (1988). Asymptotic results for multiple imputation. The Annals of Statistics pages 1550-1566.

Tanner, M. A. and Wong, W. H. (1987). An application of imputation to an estimation problem in grouped lifetime analysis. Technometrics 29, 23-32.

Wei, G. C., & Tanner, M. A. (1991). Applications of multiple imputation to the analysis of censored regression data. Biometrics, 47(4), 1297-1309.

See Also

Surv, survfit

Examples

```
res <- MI.ci(k = 5,  m = 5, status = 'status',  trans = 1 , data = ICCRD,
 conf.int = TRUE, cens.code = 0 , alpha = 0.05)
 res
 print(res)
 plot(res)
```

`MI.surv` *Survival estimation for interval censored data using multiple imputation*

Description

Uses multiple imputation schemes to compute the survival function when data are interval censored

Usage

```
MI.surv(k, m, data, conf.int = FALSE, alpha = 0.05)
```

Arguments

`k`	An integer, indicates the number of iteration to perform
`m`	An integer, indicates the number of imputation to perform at each iteration
`data`	The input data (see details)
`conf.int`	Logical, computes the confidence interval
`alpha`	Parametrize the confidence interval width

Details

This function uses multiple imputation aproach to estimate the survival function when data are interval censored. Estimates are #' computed using Rubin's rules (Rubin (1987)). The survival is computed as the mean of survival over imputations. The variance is computed at each point by combining the within imputation variance and the between imputation variance augmented by an inflation factor to take into account the finite number of imputation. At each iteration, the survival function is updated and multiple imputation is performed using the updated estimate. If `conf.inf` is required, the log-log transformation is used to compute the lower confidence interval.

Print and plot methods are available to handle results.

The `data` must contain at last two columns: `left` and `right`. For interval censored data, the `left` and `right` columns indicate lower and upper bounds of intervals, respectively. `Inf` in the right column stands for right censored observations

Value

`est` A data frame with estimates

Author(s)

Marc Delord <<mdelord@gmail.com>>

References

Delord, M. & Genin, E. Multiple Imputation for Competing Risks Regression with Interval Censored Data Journal of Statistical Computation and Simulation, 2015

PAN, Wei. A Multiple Imputation Approach to Cox Regression with Interval-Censored Data. Biometrics, 2000, vol. 56, no 1, p. 199-203.

Rubin, D. B. (1987). Multiple imputation for nonresponse in surveys.

Schenker, N. and Welsh, A. (1988). Asymptotic results for multiple imputation. The Annals of Statistics pages 1550-1566.

Tanner, M. A. and Wong, W. H. (1987). An application of imputation to an estimation problem in grouped lifetime analysis. Technometrics 29, 23-32.

Wei, G. C., & Tanner, M. A. (1991). Applications of multiple imputation to the analysis of censored regression data. Biometrics, 47(4), 1297-1309.

See Also

Surv, survfit

Examples

```
res<-MI.surv(k = 5 , m = 5 , data = ICCRD , conf.int = TRUE , alpha = 0.05 )
 res
 plot(res)
```

`MIICD.coxph` *Cox regression for interval censored data using multiple imputation*

Description

Uses the multiple imputation approach to compute the regression coefficient and its associated variance-covariance matrix, and the baseline survival estimates of a Cox proportional hazards regression for interval censorded data

Usage

```
MIICD.coxph(formula, k, m, data, method = c("PMDA", "ANDA"),
  verbose = FALSE)
```

Arguments

`formula`	A formula. The right hand side indicates names of covariables to be found in `data`
`method`	Which data augmentation scheme shall be used ? Two algorithms are implemented : *The Poor man's Data Augmentation scheme* and the *Asymptotic Normal Data Augmentation scheme* (the later may be preferred).
`verbose`	Logical, display the results ?

k	An integer, indicates the number of iteration to perform
m	An integer, indicates the number of imputation to perform at each iteration
data	The input data (see details)

Details

This function uses multiple imputation approach to estimate regression coefficient, its variance-covvariance matrix, and baseline survival estimates for a Cox proportional hazards regression for interval censorded data.

Estimates are computed using Rubin's rules (Rubin (1987)). Estimate of coefficient is computed as the mean of estimates over imputation. #' The variance-covariance matrix is computed as the within imputation variance and the between imputation variance augmented by an inflation factor to take into account the finite number of imputation. At each iteration, the baseline survival function is updated and multiple imputation is performed using updated estimates.

Print and plot methods are available to handle results.

The `data` must contain at last two columns: `left` and `right`. For interval censored data, the `left` and the `right` columns indicates lower and upper bounds of intervals respectively. `Inf` in the right column stands for right censored observations.

Value

`est` A data frame with estimates

Author(s)

Marc Delord

References

Delord, M. & Genin, E. Multiple Imputation for Competing Risks Regression with Interval Censored Data Journal of Statistical Computation and Simulation, 2015

PAN, Wei. A Multiple Imputation Approach to Cox Regression with Interval-Censored Data. Biometrics, 2000, vol. 56, no 1, p. 199-203.

Rubin, D. B. (1987). Multiple imputation for nonresponse in surveys.

Schenker, N. and Welsh, A. (1988). Asymptotic results for multiple imputation. The Annals of Statistics pages 1550-1566.

Tanner, M. A. and Wong, W. H. (1987). An application of imputation to an estimation problem in grouped lifetime analysis. Technometrics 29, 23-32.

Wei, G. C., & Tanner, M. A. (1991). Applications of multiple imputation to the analysis of censored regression data. Biometrics, 47(4), 1297-1309.

See Also

Surv, survfit, coxph, mvrnorm

Examples

```
res <- MIICD.coxph(formula = ~ treatment, k = 5, m = 5, data = bcos, verbose = FALSE)
 plot(res)
 #diagnostic plot for coefficients end associated standard error
 plot(res , type = 'coef' , coef = 1)
 plot(res , type = 'sigma' , coef = 1)
```

`MIICD.crreg` *Fine & Gray regression for interval censored competing risks data using multiple imputation*

Description

Uses the multiple imputation approach to compute regression coefficient and its associated variance-covariance matrix, and baseline cumulative incidence estimates for interval censorded competing risks data

Usage

```
MIICD.crreg(formula, k, m, status, trans, cens.code, data, method = c("PMDA",
  "ANDA"), verbose = FALSE)
```

Arguments

`formula`	A formula. The right hand side indicates names of covariables to be found in `data`
`verbose`	Logical, display the results ?
`method`	Which data augmentation scheme shall be used ? Two algorithms are implemented : *The Poor man's Data Augmentation scheme* and the *Asymptotic Normal Data Augmentation scheme* (the later may be preferred).
`k`	An integer, indicates the number of iteration to perform
`m`	An integer, indicates the number of imputation to perform at each iteration
`status`	The name of the column where status are to be found
`trans`	Denomination of the event of interest in the status column
`cens.code`	Censor indicator in the status column of the data
`data`	The input data (see details)

Details

This function uses data augmentation and multiple imputation aproach to estimate regression coefficient, variance-covariance matrix and baseline cumulative incidence estimates in a competing risks proportional hazards regression model for interval censorded competing risks data.

Estimates are computed using Rubin's rules (Rubin (1987)). Estimate of coefficient is computed as the mean of estimates over imputation. The variance-covariance matrix is computed as the within

imputation variance and the between imputation variance augmented byan inflation factor to take into account the finite number of imputation. At each iteration, the baseline cumulative incidence function is updated and multiple imputation is performed using the updated estimates. Print and plot methods are available to handle results.

`Print` and `plot` methods are available to handle results.

The `data` must contain at last four columns. One named `left`, one named `right`, the name of the 3^rd is indicated by the `status` parameter and one for the covariate to be tested. For interval censored data, the left and right columns indicates the lower and the upper bounds of the intervals respectively. `Inf` in the right column stands for right censored observations. When an observation is right censored, the `status` column must contain the censor indicator specified by `cens.code`. The transition of interest must be precised by the `trans` parameter.

Value

`Coef.` Final estimate of the coefficient

`vcov` Final estimate of the variance-covariance matrix

`Coef_seq` Sequence of the coefficient estimate over iterations

`Sigma_seq` Sequence of the coefficient standard deviation over iterations

`df` data frame containing the main results

`...` Other returned values

Author(s)

Marc Delord <<mdelord@gmail.com>>

References

Delord, M. & Genin, E. Multiple Imputation for Competing Risks Regression with Interval Censored Data Journal of Statistical Computation and Simulation, 2015

Fine JP and Gray RJ (1999) A proportional hazards model for the subdistribution of a competing risk. JASA 94:496-509.

PAN, Wei. A Multiple Imputation Approach to Cox Regression with Interval-Censored Data. Biometrics, 2000, vol. 56, no 1, p. 199-203.

Rubin, D. B. (1987). Multiple imputation for nonresponse in surveys.

Schenker, N. and Welsh, A. (1988). Asymptotic results for multiple imputation. The Annals of Statistics pages 1550-1566.

Tanner, M. A. and Wong, W. H. (1987). An application of imputation to an estimation problem in grouped lifetime analysis. Technometrics 29, 23-32.

Wei, G. C., & Tanner, M. A. (1991). Applications of multiple imputation to the analysis of censored regression data. Biometrics, 47(4), 1297-1309.

See Also

Surv, survfit, FGR, mvrnorm

Examples

```
res <- MIICD.crreg(formula = ~ treatment, k = 5, m = 5, status = 'status',
 trans = 1, data = ICCRD,  cens.code = 0, method = 'ANDA', verbose = FALSE )
 res
 plot(res)
 #diagnostic plot for coefficients end associated standard error
 plot(res , type = 'coef' , coef = 1)
 plot(res , type = 'sigma' , coef = 1)
```

---

plot.MIICD_coxph *plot method for MIICD_coxph objects*

Description

plot method for MIICD_coxph objects

Usage

```
## S3 method for class 'MIICD_coxph'
plot(x, type = c("baseline", "coef", "sigma"),
  coef = 1, ylab = "Survival", xlab = "Time", ...)
```

Arguments

x	a MIICD_coxph object
type	type of diagnoctic plot to display
coef	An integer: the no of the coefficient to display
ylab	Label for y axix
xlab	Label for x axis
...	other arguments

---

plot.MIICD_crreg *plot method for MIICD_crreg objects*

Description

plot method for MIICD_crreg objects

Usage

```
## S3 method for class 'MIICD_crreg'
plot(x, type = c("baseline", "coef", "sigma"),
  coef = 1, ylab = "Cumulative incidence", xlab = "Time", ...)
```

Arguments

x	a MIICD_crreg object
type	type of diagnoctic plot to display
coef	An integer: the no of the coefficient to display
ylab	Label for y axix
xlab	Label for x axis
...	other arguments

---

plot.MI_ci *plot method for MI_ci objects*

Description

plot method for MI_ci objects

Usage

```
## S3 method for class 'MI_ci'
plot(x, xlab = "Time", ylab = "Cumulative incidence", ...)
```

Arguments

x	A MI_ci object
xlab	Label for x axis
ylab	Label for y axix
...	other arguments

---

plot.MI_surv *plot method for MI_surv objects*

Description

plot method for MI_surv objects

Usage

```
## S3 method for class 'MI_surv'
plot(x, xlab = "Time", ylab = "Survival",
  fun = c("surv", "event"), ...)
```

Arguments

x	a MI_surv object
xlab	Label for x axis
ylab	Label for y axix
fun	If fun = event, 1 - the surv is drown
...	other arguments

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