The etm Package

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Title Empirical Transition Matrix

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Description Matrix of transition probabilities for any time-inhomogeneous multistate model with finite state space

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Depends lattice

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R topics documented:

`etm` *Computation of the empirical transition matrix*

Description

This function computes the empirical transition matrix, also called Aalen-Johansen estimator, of the transition probability matrix of any multistate model. The covariance matrix is also computed.

Usage

```
etm(data, state.numbers, tra, cens.name, s, t = "last", covariance = TRUE)
```

Arguments

`data`	data.frame of the form data.frame(id,from,to,time) or (id,from,to,entry,exit) **id:** patient id **from:** the state from where the transition occurs **to:** the state to which a transition occurs **time:** time when a transition occurs **entry:** entry time in a state **exit:** exit time from a state This data.frame is transition-oriented, *i.e.* it contains one row per transition, and possibly several rows per patient. Specifying an entry and exit time permits to take into account left-truncation.
`state.numbers`	A vector of characters giving the states numbers.
`tra`	A quadratic matrix of logical values describing the possible transitions within the multistate model.
`cens.name`	A character giving the code for censored observations in the column 'to' of `data`. If there is no censored observations in your data, put 'NULL'.
`s`	Starting value for computing the transition probabilities.
`t`	Ending value. Default is "last", meaning that the transition probabilities are computed over $(s, t]$, t being the last event time in the data set.
`covariance`	Logical. Decide whether or not computing the covariance matrix. May be useful for, say, simulations, as the variance computation is a bit long. Default is TRUE.

Details

Data are considered to arise from a time-inhomogeneous Markovian multistate model with finite state space, and possibly subject to independent right-censoring and left-truncation.

The matrix of the transition probabilities is estimated by the Aalen-Johansen estimator / empirical transition matrix (Andersen et al., 1993), which is the product integral over the time period $(s, t]$ of I + the matrix of the increments of the Nelson-Aalen estimates of the cumulative transition hazards. The $(i, j) - th$ entry of the empirical transition matrix estimates the transition probability of being in state j at time t given that one has been in state j at time s.

The covariance matrix is computed using the recursion formula (4.4.19) in Anderson et al. (1993, p. 295). This estimator of the covariance matrix is an estimator of the Greenwood type.

If the multistate model is not Markov, but censorship is entirely random, the Aalen-Johansen estimator still consistently estimates the state occupation probabilities of being in state i at time t (Datta & Satten, 2001; Glidden, 2002)

Value

`est`	Transition probability estimates. This is a 3 dimension array with the first dimension being the state from where transitions occur, the second the state to which transitions occur, and the last one being the event times.

`cov`	Estimated covariance matrix. Each cell of the matrix gives the covariance between the transition probabilities given by the rownames and the colnames, respectively.
`time`	Event times at which the transition probabilities are computed. That is all the observed event times between $(s, t]$.
`s`	Start of the time interval.
`t`	End of the time interval.
`trans`	A `data.frame` giving the possible transitions.
`state.numbers`	A vector of character giving the state numbers.
`cens.name`	How the censored observation are coded in the data set.
`nrisk`	Matrix indicating the number of individuals at risk just before an event
`nev`	Array containing the number of transitions at each event times

Note

Transitions into a same state, mathematically superfluous, are not allowed. If transitions into the same state are detected in the data, the function will stop. Equally, `diag(tra)` must be set to FALSE, see the example below.

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References

Andersen, P.K., Borgan, O., Gill, R.D. and Keiding, N. (1993). *Statistical models based on counting processes*. Springer Series in Statistics. New York, NY: Springer.

Aalen, O. and Johansen, S. (1978). An empirical transition matrix for non-homogeneous Markov chains based on censored observations. *Scandinavian Journal of Statistics*, 5: 141-150.

Gill, R.D. and Johansen, S. (1990). A survey of product-integration with a view towards application in survival analysis. *Annals of statistics*, 18(4): 1501-1555.

Datta, S. and Satten G.A. (2001). Validity of the Aalen-Johansen estimators of stage occupation probabilities and Nelson-Aalen estimators of integrated transition hazards for non-Markov models. *Statistics and Probability Letters*, 55(4): 403-411.

Glidden, D. (2002). Robust inference for event probabilities with non-Markov data. *Biometrics*, 58: 361-368.

See Also

`print.etm`, `summary.etm`, `sir.cont`, `xyplot.etm`

Examples

```
data(sir.cont)

# Modification for patients entering and leaving a state
# at the same date
# Change on ventilation status is considered
# to happen before end of hospital stay
sir.cont <- sir.cont[order(sir.cont$id, sir.cont$time), ]
for (i in 2:nrow(sir.cont)) {
  if (sir.cont$id[i]==sir.cont$id[i-1]) {
    if (sir.cont$time[i]==sir.cont$time[i-1]) {
      sir.cont$time[i-1] <- sir.cont$time[i-1] - 0.5
    }
  }
}

### Computation of the transition probabilities
# Possible transitions.
tra <- matrix(ncol=3,nrow=3,FALSE)
tra[1, 2:3] <- TRUE
tra[2, c(1, 3)] <- TRUE

# etm
tr.prob <- etm(sir.cont, c("0", "1", "2"), tra, "cens", 1, 100)

tr.prob
summary(tr.prob)

# plotting
xyplot(tr.prob, tr.choice=c("0 0", "1 1", "0 1", "0 2", "1 0", "1 2"),
       layout=c(2, 3), strip=strip.custom(bg="white",
         factor.levels=c("0 to 0", "1 to 1", "0 to 1", "0 to 2", "1 to 0", "1 to 2")))
```

`plot.etm` *Plot method for an etm object*

Description

plot method for an object of class 'etm'. This function plots estimates of the transition probabilities in one panel.

Usage

```
## S3 method for class 'etm':
plot(x, tr.choice, xlab = "Time",
ylab = "Transition Probability",
legend = TRUE, curvlab, locator = FALSE,
coord, col, lty, xlim, ylim, ...)
```

Arguments

x	An object of class 'etm'
tr.choice	A character vector of the form 'c("from to","from to")' specifying which transitions should be plotted. Default, all the transition probabilities are plotted
xlab	x-axis label. Default is "Time"
ylab	y-axis label. Default is "Transition Probability"
legend	A logical specifying if a legend should be added
curvlab	If legeng=TRUE, a character or expression vector to appear in the legend. Default is the name of the transitions
locator	A logical indicating whether use `locator` to put the legend
coord	If locator=FALSE, a vector of length 2 indicating the coordinates of the legend
col	Vector of colour. Default is black
lty	Vector of line type. Default is 1:number of transitions
xlim	Limits of x-axis for the plot
ylim	Limits of y-axis for the plot
...	Additional arguments for plot

Details

This plot method permits to draw several transition probabilities on the same panel.

Value

No value returned.

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See Also

`etm`, `xyplot.etm`

Examples

```
data(sir.cont)

# Modification for patients entering and leaving a state
# at the same date
sir.cont <- sir.cont[order(sir.cont$id, sir.cont$time), ]
for (i in 2:nrow(sir.cont)) {
  if (sir.cont$id[i]==sir.cont$id[i-1]) {
    if (sir.cont$time[i]==sir.cont$time[i-1]) {
      sir.cont$time[i-1] <- sir.cont$time[i-1] - 0.5
    }
  }
```

```
}

tra <- matrix(ncol=3,nrow=3,FALSE)
tra[1, 2:3] <- TRUE
tra[2, c(1, 3)] <- TRUE

my.etm <- etm(sir.cont,c("0","1","2"),tra,"cens", s = 0)

plot(my.etm, tr.choice = c("0 0"))
```

`print-summary` *Print and summary methods for object of class 'etm'*

Description

Print and summary methods for objects of class `etm`.

Usage

```
## S3 method for class 'etm':
print(x, ...)
## S3 method for class 'etm':
summary(object, ...)
```

Arguments

`x`	An object of class `etm`.
`object`	An object of class `etm`.
`...`	Further arguments for print or summary.

Details

The print method displays the estimated matrix of transition probabilities for each event times in $(s, t]$.

The summary methods provides a description of the multistate model, along with the estimation of $P(s, t]$ and $\text{cov}(P(s, t])$.

Value

No value returned

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See Also

`etm`

`sir.cont` *Ventilation status in intensive care unit patients*

Description

Time-dependent ventilation status for intensive care unit (ICU) patients, a random sample from the SIR-3 study.

Usage

```
data(sir.cont)
```

Format

A data frame with 1161 rows and 4 columns:

id: Randomly generated patient id

from: State from which a transition occurs

to: State to which a transition occurs

time: Time when a transition occurs

The possible states are:

0: No ventilation

1: Ventilation

2: End of stay

And `cens` stands for censored observations.

Details

This data frame consists in a random sample of the SIR-3 cohort data. It focuses on the effect of ventilation on the length of stay (combined endpoint discharge/death). Ventilation status is considered as a transcient state in an illness-death model.

The data frame is directly formated to be used with the `mvna` function, i.e. it is transition-oriented with one row per transition.

References

Beyersmann, J., Gastmeier, P., Grundmann, H., Baerwolff, S., Geffers, C., Behnke, M., Rueden, H., and Schumacher, M. Use of multistate models to assess prolongation of intensive care unit stay due to nosocomial infection. *Infection Control and Hospital Epidemiology*, 27:493-499, 2006.

Examples

```
data(sir.cont)
```

`xyplot.etm` *xyplot method for object of class 'etm'*

Description

xyplot function for objects of class `etm`. Estimates of the transition probabilities are plotted as a function of time for all the transitions specified by the user.

Usage

```
## S3 method for class 'etm':
xyplot(x, data = NULL, tr.choice = "all", col = 1, lty = 1, xlab =
"Time", ylab = "Estimated Transition probability", ...)
```

Arguments

`x`	An object of class `etm`.
`data`	*Useless*.
`tr.choice`	A character vector of the form c("from to", "from to", ...) specifying the transition probabilities to be plotted. By default, all the transition probabilities are displayed.
`col`	Color of the curve.
`lty`	Type of the line.
`xlab`	x-axis label. Default is "Time".
`ylab`	y-axis label. Default is "Estimated transition probability".
`...`	Further arguments for `xyplot`.

Value

An object of class `trellis`.

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See Also

`etm`, `xyplot`

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