Package 'elect'

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Type Package

Title Estimation of Life Expectancies Using Multi-State Models

Version 1.2

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Description Functions to compute state-specific and marginal life expectancies. The computation is based on a fitted continuous-time multi-state model that includes an absorbing death state; see Van den Hout (2017, ISBN:9781466568402). The fitted multi-state model model should be estimated using the 'msm' package using age as the time-scale.

Depends msm, nnet

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Contents

check.RestrAndConst *Checking the definition of* RestrAndConst *in* elect

Description

Function to check the definition of RestrAndConst in the elect call.

Usage

```
check.RestrAndConst(x, RestrAndConst, PRINT = FALSE)
```

Arguments

x	Fitted msm model
RestrAndConst	Vector which indexes the independent parameters in model\$opt\$par w.r.t. to the model parameters
PRINT	TRUE for printing the comparison

Details

Function to help defining the parameter constraints in the elect call\ when the constraint option is used in msm.

Value

TRUE when RestrAndConst is well-defined, FALSE otherwise.

Author(s)

Ardo van den Hout

See Also

elect

Examples

```
# Fit model with constraints:
Q     <- rbind(c(0,0.01,0.01), c(0,0,0.01), c(0,0,0))
model <- msm(state~age, subject = id, data = electData,
             center = FALSE, qmatrix = Q, deathexact = TRUE,
             fixedpars = c(7,8), covariates = ~age+x)
RestrAndConst <- c(1:6,0,0,7)
check.RestrAndConst(model, RestrAndConst, PRINT= TRUE)

# Usage: elect(x = model,..., RestrAndConst = RestrAndConst)
```

elect *State-specific and marginal life expectancies*

Description

Estimation of state-specific and marginal life expectancies given a multi-state survival model fitted using the msm-package

Usage

```
elect(x, b.covariates, statedistdata, time.scale.msm = "years",
        h, age.max, S = 0, setseed = NULL, RestrAndConst = NULL,
        statedist.covariates = "age", method = "step")
```

Arguments

x	Fitted msm model
b.covariates	List with specified covariates values (ignore intercept)
statedistdata	Data used to estimate prevalence distribution of living states
time.scale.msm	Time scale in multi-state model: "years", "months","weeks", or a value in (0,1]
h	Grid parameter for integration where scale is time.scale.msm
age.max	Assumed maximum age in same time scale as in fitted model
S	Number of replications for estimation of uncertainty (S=0 for no estimation)
setseed	Seed for the random number generation in the simulation
RestrAndConst	Vector which indexes the independent model parameters. Only needed when constraint is used in msm call
statedist.covariates	Names of covariates for model for prevalence distribution of living states
method	Approximation of integral: "step" for simple step function, "MiddleRiemann" or "Simpson"

Details

The elect-package is an add-on to the msm-package for models with one death state. In the msm call for fitting the model use center=FALSE, and names state and age. Do not use variables encoded as factor by R. Covariate age should be the first entry in b.covariates. The other covariates in b.covariates should follow the order in the msm call. The life expectancies are computed by approximating the integral numerically with a grid defined by h. The specification of statedist.covariates should be a subset of b.covariates.

Value

A list containing the following components:

pnt	Life expectancies derived from MLE of model parameters
sim	Simulated life expectancies using the MLE of model parameters
h	As specified in elect call
covars	Covariates as specified in elect call
S	S as specified in elect call
sd.model	Fitted model for the prevalence distribution of living states

Author(s)

Ardo van den Hout and Mei Sum Chan

References

Jackson, C.H. (2011). Multi-State Models for Panel Data: The msm Package for R., Journal of Statistical Software, 38(8), 1-29.

Van den Hout, A. (2017). Multi-State Survival Models for Interval-Censored Data. Boca Raton: CRC/Chapman & Hall.

See Also

summary.elect, plot.elect

Examples

```
# Fit msm model:
Q     <- rbind(c(0,0.01,0.01), c(0,0,0.01), c(0,0,0))
model <- msm(state~age, subject = id, data = electData,
             center = FALSE, qmatrix = Q, deathexact = TRUE,
             covariates = ~age+x)

# Estimate life expectancies:
sddata <- electData[electData$bsline == 1,]
LEs    <- elect(x = model, b.covariates = list(age = 0, x = 0),
                statedistdata = sddata, h = 0.5, age.max = 50, S = 25)
summary(LEs)
plot(LEs)     # For smoother graphs, increase S
```

electData *Three-state data for exploring* elect

Description

Simulated longitudinal data for a three-state illness-death process.

Usage

```
electData
```

Format

Data frame with 764 rows, grouped by 150 individuals. Simulated interval-censored transition times for living states 1 and 2, and exact times for death state 3. Variables: `id` = identification number, `state` = state, `age` = age in years on a shifted scale (current age minus 70), `x` = binary time-independent covariate (can be interpreted as 0/1 for women/men), `bsline` = baseline record indicator.

Author(s)

Ardo van den Hout

See Also

elect

Examples

```
# Sample size:
print(length(unique(electData$id)))
# Frequencies number of observation per individual:
print(table(table(electData$id)))
# State table
print(statetable.msm(state, id, data = electData))
```

explore *Data statistics for an age-dependent model*

Description

Data statistics that are important for fitting an age-dependent multi-state model. Basic summaries and additional information on the age distribution in the data

Usage

```
explore(data = NULL, id = NULL, state = NULL, age = NULL,
        digits = 3, HIST = TRUE, hist.col = c("green","red",
        "blue"), INFO = FALSE)
```

Arguments

data	Data frame with variables id, state, and age
id	Identifier. Specify if data is not provided
state	State variable. Specify if data is not provided
age	Age or transformed age. Specify if data is not provided
digits	Number of digits in the output
HIST	TRUE for histograms of the age distribution. FALSE otherwise
hist.col	Colours for the three histograms of the age distribution
INFO	TRUE for returning a list which links id with time intervals between the subsequent records. FALSE otherwise

Value

intervals	Data frame with variables interval.length and corresponding id (when INFO = TRUE)

Author(s)

Ardo van den Hout. With thanks to Ying Lou.

Examples

```
explore(electData)
```

---

hazards *Age-dependent hazards based on a 'msm' model*

Description

Graph with transition-specific hazard functions derived from an age-dependent model fitted using 'msm'

Usage

```
hazards(x, b.covariates, no.years, trans = NULL,
        max.haz = .5, min.haz = 0, CI = FALSE, col = NULL,
        lty = NULL, lwd = NULL, LEGEND = TRUE,
        location = "topleft", age.shift = 0)
```

Arguments

x	Fitted msm model with age as the Gompertz time scale
b.covariates	List with specified covariates values for the prediction (ignore intercept)
no.years	Number of years for the prediction
trans	Matrix with rows (r,s) for hazard of going from state r to state s. Default to all (r,s)-hazards that are modelled in x
max.haz	Upperbound hazard-axis
min.haz	Lowerbound hazard-axis
CI	TRUE for plotting 95% confidence bands. FALSE otherwise
col	Colour for each hazard curve. Example for two curves: col = c("red","green")
lty	Line type for each hazard curve. Example for two curves: lty = c(1,2)
lwd	Width of line for each hazard curve. Example for two curves: lwd = c(2,2)
LEGEND	TRUE for adding a legend. FALSE otherwise
location	Location for legend. Default to "topleft". See help file for legend for furhter details
age.shift	Value to shift the age scale in the graph. Useful when age in the model is on a shifted scale. Default to 0.

Details

This function is an add-on to the functionality in the 'msm' package. A Gompertz model with age as the time scale can be fitted in 'msm' piecewise-constantly by adding age as a covariate. The function qmatrix.msm is used by hazards repeatedly to take into account the age dependence when calculating the hazards.

Author(s)

Ardo van den Hout. With thanks to Ying Lou.

References

Jackson, C.H. (2011). Multi-State Models for Panel Data: The msm Package for R., Journal of Statistical Software, 38(8), 1-29.

Examples

```
# Fit msm model:
Q     <- rbind(c(0,0.01,0.01), c(0,0,0.01), c(0,0,0))
model <- msm(state~age, subject = id, data = electData,
             center = FALSE, qmatrix = Q, deathexact = TRUE,
             covariates = ~age+x)
# Plot hazards on original age scale:
hazards(model, b.covariates = list(age = 0, x = 0),
        no.years = 20, max.haz = 0.25,  age.shift = -70)
```

plot.elect *Plotting of life expectancies*

Description

Graphical representation by smoothed densities of the life expectancies as estimated by `elect`

Usage

```
## S3 method for class 'elect'
plot(x, which = NULL, kernel = "gaussian", col = "red", lwd = 2, cex.lab = 1,...)
```

Arguments

`x`	Life expectancies estimated by `elect`
`which`	Subselection for plotting (following the order in `summary`). Example: `which = c(1,3,5)`
`kernel`	Character string for smoothing kernel (`"gaussian"`, `"rectangular"`, `"triangular"`, `"epanechnikov"`, `"biweight"`, `"cosine"`, or `"optcosine"`)
`col`	Colour of curves
`lwd`	Line width of curves
`cex.lab`	Magnification to be used for axis-labels
`...`	Other arguments (not yet implemented)

Details

Presents distributions of the estimated life expectancies derived from the maximum likelihood estimate of the model parameters. The smoothing is undertaken using the `R` function `density`.

Author(s)

Ardo van den Hout

See Also

`elect`

plusmin *Computation of a function of life expectancies*

Description

Compute an additive function of a series of estimated life expectancies

Usage

```
plusmin(x, index = NA, func = "plus", probs = c(0.025, 0.5, 0.975), digits = 3)
```

Arguments

x	Life expectancies estimated by elect
index	Selection of the life expectancies in the function (following the order in summary)
func	Required series of "plus" and "minus". Example: func = c("plus","plus")
probs	Probabilities for the quantiles
digits	Number of digits in the output

Details

This function requires that uncertainty of LEs is estimated; that is, S is not 0.

Author(s)

Ardo van den Hout

See Also

elect

Examples

```
# Fit msm model:
Q     <- rbind(c(0,0.01,0.01), c(0,0,0.01), c(0,0,0))
model <- msm(state~age, subject = id, data = electData,
             center = FALSE, qmatrix = Q, deathexact = TRUE,
             covariates = ~age+x)

# Estimate function of life expectancies:
sddata <- electData[electData$bsline == 1,]
LEs    <- elect(x = model, b.covariates = list(age = 0, x = 1),
                statedistdata = sddata, h = 0.5, age.max = 50, S = 25)
plusmin(LEs, index = c(2,4), func = "plus")
```

summary.elect *Summarises the estimation of the life expectancies*

Description

Summary of estimated state-specific and marginal life expectancies

Usage

```
## S3 method for class 'elect'
summary(object, probs = c(0.025, 0.5, 0.975),
               digits = 3, StartStateTotals = FALSE,
               print = TRUE, sd.model = FALSE,...)
```

Arguments

object	Life expectancies estimated by elect
probs	Numeric vector of probabilities with values in [0,1] for quantiles
digits	Number of decimal places in output
StartStateTotals	TRUE for output on start-state totals e_r. (for S>0)
print	TRUE for printing output to screen, FALSE otherwise
sd.model	TRUE for printing a summary of the fitted model for the prevalence
...	Other arguments (not yet implemented)

Details

A summary for the state-specific and marginal life expectancies as derived in elect. Quantiles are derived from simulation based on the maximum likelihood estimation.

Author(s)

Ardo van den Hout

See Also

elect, plusmin, plot.elect

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