Package ‘rcbayes’

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Title Estimate Rogers-Castro Migration Age Schedules with Bayesian Models

Version 0.1.0

Description A collection of functions to estimate Rogers-Castro migration age schedules using ‘Stan’. This model which describes the fundamental relationship between migration and age in the form of a flexible multi-exponential migration model was most notably proposed in Rogers and Castro (1978) <doi:10.1068/a100475>.

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Biarch true

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LinkingTo BH (>= 1.66.0), Rcpp (>= 0.12.0), RcppEigen (>= 0.3.3.3.0), RcppParallel (>= 5.0.1), rstan (>= 2.18.1), StanHeaders (>= 2.18.0)

Suggests knitr, rmarkdown, ggplot2

SystemRequirements GNU make

VignetteBuilder knitr

RdMacros Rdpack

NeedsCompilation yes

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rcbayes-package  The 'rcbayes' package.

Description
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References

init_rc Set initial values for Rogers-Castro migration model

Description
Choose initial values for parameters in the Rogers-Castro model in a strategic way based on your data. Provide these initial values to improve convergence of model. Intended to be used with rcbayes::mig_estimate_rc as an additional input into 'Stan'.

Usage

init_rc(  
ages,  
net_mig,  
pop,  
pre_working_age,  
working_age,  
retirement,  
post_retirement,  
nchains = 4  
)
Arguments

- **ages** numeric. A vector of integers for ages.
- **net_mig** numeric. A vector of integers for observed age-specific net migrants.
- **pop** numeric. A vector of integers for age-specific population.
- **pre_working_age** logical (TRUE/FALSE). Whether or not you are including pre working age component.
- **working_age** logical (TRUE/FALSE). Whether or not you are including working age component.
- **retirement** logical (TRUE/FALSE). Whether or not you are including retirement age component.
- **post_retirement** logical (TRUE/FALSE). Whether or not you are including post retirement age component.
- **nchains** numeric. A positive integer specifying the number of Markov chains. Should be 4 unless changed otherwise.

Value

A list of length nchains. Each element of the list is a list of numeric values. Within the inner lists, there is one element for every model parameter.

Examples

```r
# define ages, net migrants, and population
ages <- 0:80
net_mig <- c(202,215,167,188,206,189,164,
203,237,249,274,319,345,487,
491,521,505,529,527,521,529,
507,484,467,439,399,399,380,
368,310,324,289,292,278,269,
285,254,245,265,257,258,263,
253,346,293,332,346,349,355,
386,346,344,352,351,320,307,
320,310,258,254,243,256,263,
183,169,172,160,166,113,132,
111,130,110,113)
pop <- c(105505,105505,105505,105505,105505,
106126,106126,106126,106126,106126,
100104,100104,100104,100104,100104,
114880,114880,114880,114880,114880,
136845,136845,136845,136845,136845,
136582,136582,136582,136582,136582,
141935,141935,141935,141935,141935,
134097,134097,134097,134097,134097,
130769,130769,130769,130769,130769,
133718,133718,133718,133718,133718,
154178,154178,154178,154178,154178,
```

# compute initial values
iv <- init_rc(ages, net_mig, pop, pre_working_age=TRUE, 
working_age=TRUE, retirement=TRUE, post_retirement=TRUE)

---

### interact_rc

**Run Interactive Rogers-Castro App**

**Description**

Run an interactive Rogers-Castro app. Use interactive sliders to see how parameters affect the Rogers-Castro age schedules.

**Usage**

interact_rc()

**Value**

No return value, called for interactive widget

**Examples**

```r
## Not run:
interact_rc()
## End(Not run)
```

---

### mig_calculate_rc

**Calculate Rogers-Castro migration age schedule**

**Description**

Given a set of ages and parameters, calculate the migration age schedule based on the Rogers and Castro formula. Choose between a 7, 9, 11 or 13 parameter model.

**Usage**

mig_calculate_rc(ages, pars)
**mig_calculate_rc**

### Arguments

- **ages** numeric. A vector of ages for migration rates to be calculated.
- **pars** numeric. A named list of parameters. See below for details.

### Details

In the full 13 parameter model, the migration rate at age $x$, $m(x)$ is defined as

$$m(x) = a_1 \exp(-1*alpha_1*x) + a_2 \exp(-1*alpha_2*(x-mu_2)) \exp(-1*lambda_2*(x-mu_2)) + a_3 \exp(-1*alpha_3*(x-mu_3)) \exp(-1*lambda_3*(x-mu_3)) + a_4 \exp(lambda_4*x) + c$$

The first, second, third and fourth pieces of the equation represent pre-working age, working age, retirement and post-retirement age patterns, respectively. Models with less parameters gradually remove terms at the older ages. Parameters in each family are:

- pre-working age: $a_1$, $alpha_1$
- working age: $a_2$, $alpha_2$, $mu_2$, $lambda_2$
- retirement: $a_3$, $alpha_3$, $mu_3$, $lambda_3$
- post retirement: $a_4$, $lambda_4$

For a specific family to be included, values for all parameters in that family must be specified.

### Value

A vector the same length as `ages`. Values represent migration rate for each age in `ages`.

### References


### Examples

```r
pars <- c(a1= 0.09, alpha1= 0.1, a2= 0.2, alpha2= 0.1, mu2= 21, lambda2= 0.39, a3= 0.001, alpha3= 1, mu3= 67, lambda3= 0.6, c= 0.01)
ages <- 0:75
mx <- mig_calculate_rc(ages = ages, pars = pars)
plot(ages, mx, type = 'l')
```
Estimate Rogers-Castro migration age schedule

Description

Given a set of ages and observed age-specific net migrants, estimate the parameters of a Rogers-Castro model migration schedule. Choose between a 7, 9, 11 or 13 parameter model.

Usage

```r
mig_estimate_rc(
  ages,
  net_mig,
  pop,
  pre_working_age,
  working_age,
  retirement,
  post_retirement,
  ...
)
```

Arguments

- `ages` numeric. A vector of integers for ages.
- `net_mig` numeric. A vector of integers for observed age-specific net migrants.
- `pop` numeric. A vector of integers for age-specific population.
- `pre_working_age` logical (TRUE/FALSE). Whether or not to include pre working age component.
- `working_age` logical (TRUE/FALSE). Whether or not to include working age component.
- `retirement` logical (TRUE/FALSE). Whether or not to include retirement age component.
- `post_retirement` logical (TRUE/FALSE). Whether or not to include post retirement age component.
- `...` additional inputs to stan, see `?rstan::stan` for details.

Value

A list of length 3. The first element, `pars_df`, is a data frame that provides parameter estimates with 95% credible intervals. The second element, `fit_df`, is a data frame that shows the data and estimated migration rates at each age. The third element, `check_converge`, is a data frame that provides the R-hat values and effective sample sizes.
Examples

```r
# define ages, net migrants, and population
ages <- 0:80
net_mig <- c(202, 215, 167, 188, 206, 189, 164,
             158, 197, 185, 176, 173, 167, 198,
             203, 237, 249, 274, 319, 345, 487,
             491, 521, 505, 529, 527, 521, 529,
             507, 484, 467, 439, 399, 399, 380,
             368, 310, 324, 289, 292, 270, 269,
             285, 254, 245, 265, 257, 258, 263,
             253, 346, 293, 332, 346, 349, 355,
             386, 346, 344, 352, 331, 320, 307,
             320, 310, 258, 254, 243, 256, 263,
             183, 169, 172, 160, 166, 113, 132,
             111, 130, 110, 113)
pop <- c(105505, 105505, 105505, 105505, 105505,
         106126, 106126, 106126, 106126, 106126,
         100104, 100104, 100104, 100104, 100104,
         114880, 114880, 114880, 114880, 114880,
         136845, 136845, 136845, 136845, 136845,
         136582, 136582, 136582, 136582, 136582,
         141935, 141935, 141935, 141935, 141935,
         134097, 134097, 134097, 134097, 134097,
         130769, 130769, 130769, 130769, 130769,
         133718, 133718, 133718, 133718, 133718,
         154178, 154178, 154178, 154178, 154178,
         145386, 145386, 145386, 145386, 145386,
         126270, 126270, 126270, 126270, 126270,
         108314, 108314, 108314, 108314, 108314,
         79827, 79827, 79827, 79827, 79827, 59556,
         59556, 59556, 59556, 59556, 59556)

# fit the model
res <- mig_estimate_rc(ages, net_mig, pop,
                        pre_working_age = TRUE,
                        working_age = TRUE,
                        retirement = TRUE,
                        post_retirement = FALSE,
                        #optional inputs into stan
                        control = list(adapt_delta = 0.95, max_treedepth = 10),
                        iter = 10, chains = 1 #to speed up example)

# plot the results and data
plot(ages, net_mig/pop, ylab = "migration rate", xlab = "age")
lines(ages, res["fit_df"]$median, col = "red")
legend("topright", legend=c("data", "fit"), col=c("black", "red"), lty=1, pch = 1)
```
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