Package ‘rcbayes’

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Title Estimate Rogers-Castro Migration Age Schedules with Bayesian Models

Version 0.2.0

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

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**Description**

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**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**

```r
going init_rc(  
  ages,  
  migrants,  
  pop,  
  mx,  
  pre_working_age,  
  working_age,  
  retirement,  
  post_retirement,  
  nchains = 4,  
  net_mig  
)
```
**Arguments**

ages   numeric. A vector of integers for ages.
migrants numeric. A vector of integers for observed age-specific migrants.
pop   numeric. A vector of integers for age-specific population or sample sizes, of which "migrants" experienced a migration event.
mx   numeric. A vector of age-specific migration rates.
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.
net_mig   numeric. Deprecated argument, use migrants instead.

**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
# Ex. 1: Using ages, migrants, and population
ages <- 0:80
migrants <- 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, 464, 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, 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, 105505, 105505,
        106126, 106126, 106126, 106126, 106126, 106126,
        100104, 100104, 100104, 100104, 100104,
        114880, 114880, 114880, 114880, 114880, 114880,
        136845, 136845, 136845, 136845, 136845, 136845,
        136582, 136582, 136582, 136582, 136582,
        141935, 141935, 141935, 141935, 141935,
```

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

# Ex 2: Using ages and mx
ages <- 0:80
mx <- c(0.001914601, 0.002037818, 0.001582863, 0.001781906,
        0.001952514, 0.001780902, 0.001545333, 0.001488796,
        0.001856284, 0.001743211, 0.001758172, 0.00128203,
        0.001668265, 0.001977943, 0.002027891, 0.002063022,
        0.002167479, 0.002385097, 0.002776811, 0.003003134,
        0.003558771, 0.003588001, 0.003807227, 0.003690307,
        0.003865687, 0.003858488, 0.003814558, 0.003873131,
        0.003712056, 0.003543659, 0.003290238, 0.003092965,
        0.002871146, 0.002811146, 0.002677282, 0.002744282,
        0.002311759, 0.002416161, 0.002155156, 0.002177528,
        0.002064710, 0.002057062, 0.002179416, 0.001942356,
        0.001875333, 0.001981783, 0.001921955, 0.001929434,
        0.001966826, 0.001892041, 0.002244159, 0.001908401,
        0.002153355, 0.002244159, 0.002263617, 0.002441776,
        0.002655001, 0.002379872, 0.002366115, 0.002421141,
        0.002621367, 0.002534252, 0.002431298, 0.002534252,
        0.002450507, 0.002381964, 0.002345034, 0.002243477,
        0.002363499, 0.002428126, 0.002292457, 0.002117078,
        0.002154659, 0.002004334, 0.002079497, 0.001897374,
        0.002216401, 0.001863792, 0.002182820, 0.001847001,
        0.001897374)

# compute initial values
iv <- init_rc(ages=ages, mx=mx,
pre_working_age=TRUE,
working_age=TRUE,
retirement=TRUE,
post_retirement=TRUE)
**mig_calculate_rc**

**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)`

**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

$$m(x) = a_1 \exp(-1*\alpha_1*x) + a_2 \exp(-1*\alpha_2*(x-\mu_2)) - \exp(-1*\lambda_2*(x-\mu_2)) + a_3 \exp(-1*\alpha_3*(x-3)) - \exp(-1*\lambda_3*(x-\mu_3)) + a_4 \exp(\lambda_4*x) + c$$

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: $a_2, \alpha_2, \mu_2, \lambda_2$
mig_estimate_rc

- retirement: a3, alpha3, mu3, lambda3
- post retirement: a4, lambda4

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')
```

---

**mig_estimate_rc**

*Estimate Rogers-Castro migration age schedule*

**Description**

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

**Usage**

```r
mig_estimate_rc(
  ages,
  migrants,
  pop,
  mx,
  sigma,
  pre_working_age,
  working_age,
  retirement,
  post_retirement,
  net_mig,
  ...
)
```
Arguments

- **ages** numeric. A vector of integers for ages.
- **migrants** numeric. A vector of integers for observed age-specific migrants.
- **pop** numeric. A vector of integers for age-specific population or sample sizes, of which "migrants" experienced a migration event.
- **mx** numeric. A vector of age-specific migration rates.
- **sigma** numeric. Standard deviation of migration rates for Normal model. Argument is option, standard deviation is estimated if Normal model is run without being specified.
- **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.
- **net_mig** numeric. Deprecated argument, use migrants instead.
- **...** 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
# Ex 1: Run poisson model using ages, migrants, and population
ages <- 0:80
migrants <- 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,
```
# fit the model
res <- mig_estimate_rc(ages = ages, migrants = migrants, pop = 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, migrants/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)

# Ex 2: Run normal model using ages and mx
ages <- 0:80
mx <- c(0.001914601, 0.002037818, 0.001582863, 0.001781906, 0.001952514, 0.001780902, 0.001545333, 0.001488796, 0.001856284, 0.001743211, 0.001547817, 0.001488796, 0.001977943, 0.002027891, 0.002063022, 0.002167479, 0.002385097, 0.002776811, 0.003003134, 0.003558771, 0.003588001, 0.003807227, 0.003690307, 0.003865687, 0.003854888, 0.003814558, 0.003873131, 0.003712056, 0.003543659, 0.003290238, 0.003290238, 0.002811146, 0.002811146, 0.002677282, 0.002744282, 0.002311759, 0.002416161, 0.002155156, 0.002177528, 0.002067100, 0.002057062, 0.002179416, 0.001942356, 0.001873533, 0.001981783, 0.001921955, 0.001929434, 0.001966826, 0.001928041, 0.002244159, 0.00190401, 0.002153355, 0.002244159, 0.002263617, 0.002441776, 0.002655001, 0.002379872, 0.002366115, 0.002421141, 0.002621367, 0.002534252, 0.002431298, 0.002534252, 0.002455057, 0.002381964, 0.002345034, 0.002243477, 0.002363499, 0.002482126, 0.002292457, 0.002117078, 0.002154659, 0.00204334, 0.002079497, 0.001897374, 0.002216401, 0.001863792, 0.002182820, 0.001847001, 0.001897374)

# fit the model
res <- mig_estimate_rc(ages = ages, mx = mx,
  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
)
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