Package ‘eSIR’

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Type Package

Title extended state-space SIR models

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Description A inplementation of various extended state-
space SIR models developed recently by the study group of Song lab.

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Encoding UTF-8

Depends rjags, scales, ggplot2, chron, gtools

Suggests nCov2019

RoxygenNote 6.1.1

R topics documented:

`qh.eSIR` *SIR model with Fixed and known change in transmission rate*

Description

SIR model with fixed and known change in the transmission rate, either stepwise or continuous.

Usage

```
qh.eSIR(Y, R, phi = NULL, change_time = NULL,
  begin_str = "01/23/2020", T_fin = 200, nchain = 4,
  nadapt = 10000, M = 5000, thn = 10, nburnin = 2000,
  dic = FALSE, file_add = character(0), save_files = FALSE,
  death_in_R = 0.02, casename = "q.SIR", beta0 = 0.2586,
  gamma0 = 0.0821, R0 = beta0/gamma0, gamma0_sd = 0.1, R0_sd = 1)
```

Arguments

`Y`	the observed infected proportions by time.
`R`	the observed removed proportions by time, including death and recovered.
`phi`	a vector of values of the dirac delta function $\phi(t)$. Each entry denotes the proportion that will be qurantined at each change time point. Note that all the entries lie between 0 and 1, its default is `NULL`.
`change_time`	the change time points corresponding to `phi`, defalt value is `NULL`.
`begin_str`	the character of the starting time, the default is "01/23/2020", which is the starting date that the local government blocked Wuhan City.
`T_fin`	the maximum follow-up date after the beginning `begin_str`, the default is 200.
`nchain`	the number of MCMC chains called in rjags, the default is 4.
`nadapt`	the number of iterations for adaptation in the MCMC. The default is 1e4, which is what we suggest to use 1e4 instead.
`M`	number of draws from each chain, without considering thinning. The default is M=5e3 but we suggest using 5e5 instead.
`thn`	thinning interval for monitors. Thus, the total number of draws would be `round(M/thn)*nchain` . The default is 10.
`nburnin`	the burn-in period. The default is nburnin=2e3 but we suggest using nburin=2e5.
`dic`	logical, whether compute the DIC or deviance information criterion.
`file_add`	the string to denote the location to save the output files and tables.
`save_files`	logical, whether save (`TRUE`) the results or not (`FALSE`). This will enable saving the summary table, trace plots, the plot of the posterior mean of the first derivative of the infection proportion θ_t^I, and the proportion of quarantine.
`death_in_R`	numeric value of average ratio between deaths and cumulative removed subjects. It is 0.4 within Hubei and 0.02 outsite Hubei according to the reported data by Feb 11, 2020.
`casename`	string of the job's name. The default is "q.SIR".
`beta0`	the hyperparameter of the mean transmission rate, the default is the one estimated from SARS (0.2586) first-month outbreak.
`gamma0`	the hyperparameter of the mean recovery rate (including death), the default is estimated from SARS (0.0821) first-month outbreak.
`R0`	the hyperparameter of the mean R0 value. The default is `beta0/gamma0`, which can be overwritten by discarding the value set in `beta0`.
`gamma0_sd`	the standard deviance for the prior of the recovery/remove rate, the default is 0.1.
`R0_sd`	the standard deviance for the prior of R0, the default is 1.

Details

In this function we introduce a time-dependent multiplier (boundared between 0 and 1) of the transmisison rate, $\pi_{qbar}(t)$. In this way, we can edow the transmission some time-depdent changes. Note that the time-dependent change can be either a step function or a smooth exponetial function ($\exp(\lambda_0 t)$). The parameters of the function and change points, if any, need to be predefined.

Value

`casename` casename defined before

`incidence_mean` mean incidence

`incidence_ci` 2.5%, 50%, and 97.5% quantiles of the incidence

`out_table` summary table with varibles including the posterior mean of the proportions of the 3 states at their last observation date, and their respective credible inctervals (ci) including the median; the mean and ci of the reporduction number (R0), removed/recovery rate (gamma), transmission rate (beta)

`forecast_infection`
plot to forecast the infection with following lines: the vertial blue line denotes the last observation date; vertial purple line denotes the change point indicating a decrease in infection proportion or the date with 0 value of the posterior mean first-derivative infection proportion $\theta_t'^I$; the vertial darkgreen line denotes the deacceleration point of the increasing infection proportion or the date with maximum value of the posterior mean first-derivative infection proportion $\theta_t'^I$; the darkgray line denotes the posterior mean of the infection proportion; the red line denotes the posterior median of the infection proportion

`forecast_removed`
plot to forecast the removed lines described in `forecast_infection`. The meaning of the vertical lines were identical, but the horizontal mean and median were corresponding to the posterior mean and median of the removed state. Moreover, we introduce an additional line for the estimated death proportion, which is based on the input `death_in_R`

`first_stat_mean`
the mean first stationary date, which is the change point that we observe decline in the infection proportion (θ_t^I), or its stationary point; it is calculated using the average of the 0-points of all the repeats of posterior draws of the first derivative proportion or $\theta_t'^I$; this value may be slightly different from the one labeled by the "purple" lines in the `forecast_infection` and `forecast_removed` two plots, as the latter indicate the 0-value point of the first-derivative the posterior mean of θ_t^I.

`first_stat_ci` following the definition of `first_stat_mean`, but is the corresponding credible interval.

`second_stat_mean`
the mean second stationary date, which is the change point that we observe the decline in the increasing spead of the infection proportion (θ_t^I) or its derivative's stationary point;it is calculated using the average of the stationary values of all the repeats of posterior draws of the first-derivative porportion of infection or $\theta_t'^I$; this value may be slightly different from the one labeled by the "darkgreen" lines in the `forecast_infection` and `forecast_removed` two plots, as the latter indicate the stationary point of the first-derivative the posterior mean of θ_t^I.

`dic_val` the output of `dic.sample()` in `rjags`, computing deviance information criterion for model comparison.

Examples

```
NI_complete <- c( 41,41,41,45,62,131,200,270,375,444,549, 729,1052,1423,2714,3554,4903,5806,7153,9074,1117
RI_complete <- c(1,1,7,10,14,20,25,31,34,45,55,71,94,121,152,213,252,345,417,561,650,811,1017,1261,1485,19
 N=58.5e6
 R <- RI_complete/N
```

```
Y <- NI_complete/N- R #Jan13->Feb 11
change_time <- c("01/23/2020","02/04/2020","02/08/2020")
phi <- c(0.1,0.4,0.4)
res.q <- q.SIR (Y,R,begin_str="01/13/2020",T_fin=200,phi=phi,change_time=change_time,casename="Hubei_q",sa
res.q$forecast_infection
res.noq <- q.SIR (Y,R,begin_str="01/13/2020",T_fin=200,casename="Hubei_noq")
res.noq$forecast_infection
```

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tvt.eSIR *SIR model with a time-varying transmission rate*

Description

SIR model with fixed and known changes in the transmission rate, either stepwise or continuous.

Usage

```
tvt.eSIR(Y, R, pi_qbar0 = NULL, change_time = NULL,
  exponential = FALSE, lambda0 = NULL, begin_str = "01/23/2020",
  T_fin = 200, nchain = 4, nadapt = 10000, M = 5000, thn = 10,
  nburnin = 2000, dic = FALSE, file_add = character(0),
  save_files = FALSE, death_in_R = 0.02, casename = "pi.SIR",
  beta0 = 0.2586, gamma0 = 0.0821, R0 = beta0/gamma0,
  gamma0_sd = 0.1, R0_sd = 1)
```

Arguments

Y	the observed infected proportions by time.
R	the observed removed proportions by time, including death and recovered.
pi_qbar0	the time dependent function $\pi_b arq(t)$ between 0 and 1.
change_time	the change time points for step function pi, defalt value is NULL.
exponential	logical, whether $\pi_b arq(t)$ is exponential $\exp(-\lambda_0 t)$ or not; the default is FALSE.
lambda0	the rate of decline in the exponential function in $\exp(-\lambda_0 t)$.
begin_str	the character of the starting time, the default is "01/23/2020", which is the starting date that the local government blocked Wuhan City.
T_fin	the maximum follow-up date after the beginning begin_str, the default is 200.
nchain	the number of MCMC chains called in rjags, the default is 4.
nadapt	the number of iterations for adaptation in the MCMC. The default is 1e4, which is what we suggest to use 1e4 instead.
M	number of draws from each chain, without considering thinning. The default is M=5e3 but we suggest using 5e5 instead.
thn	thinning interval for monitors. Thus, the total number of draws would be round(M/thn)*nchain . The default is 10.
nburnin	the burn-in period. The default is nburnin=2e3 but we suggest using nburin=2e5.
dic	logical, whether compute the DIC or deviance information criterion.

file_add	the string to denote the location to save the output files and tables.
save_files	logical, whether save (TRUE) the results or not (FALSE). This will enable saving the summary table, trace plots, and the plot of the posterior mean of the first derivative of the infection proportion θ_t^I.
death_in_R	numeric value of average ratio between deaths and cumulative removed subjects. The default is 0.4 within Hubei, and 0.02 outsite Hubei according to the reported data by Feb 11, 2020.
casename	string of the job's name. The default is "pi.SIR".
beta0	the hyperparameter of the mean transmission rate, the default is the one estimated from SARS (0.2586) first-month outbreak.
gamma0	the hyperparameter of the mean recovery rate (including death), the default is estimated from SARS (0.0821) first-month outbreak.
R0	the hyperparameter of the mean R0 value. The default is `beta0/gamma0`, which can be overwritten by discarding the value set in `beta0`.
gamma0_sd	the standard deviance for the prior of the recovery/remove rate, the default is 0.1.
R0_sd	the standard deviance for the prior of R0, the default is 1.

Details

In this function we introduce a time-dependent multiplier (boundared between 0 and 1) of the transmisison rate, $pi_{qbar}(t)$. In this way, we can edow the transmission some time-dependent changes, either following a step-function or a smooth exponetial function ($\exp(\lambda_0 t)$). The parameters of the function and change points, if any, need to be predefined.

Value

casename	casename defined before
incidence_mean	mean incidence
incidence_ci	2.5%, 50%, and 97.5% quantiles of the incidences
out_table	summary table with varibles including the posterior mean of the proportions of the 3 states at their last observation date, and their respective credible inctervals (ci) including the median; the mean and ci of the reporduction number (R0), removed/recovery rate (gamma), transmission rate (beta)
forecast_infection	plot to forecast the infection with following lines: the vertial blue line denotes the last observation date; vertial purple line denotes the change point indicating a decrease in infection proportion or the date with 0 value of the posterior mean first-derivative infection proportion $\theta_t'^I$; the vertial darkgreen line denotes the deacceleration point of the increasing infection proportion or the date with maximum value of the posterior mean first-derivative infection proportion $\theta_t'^I$; the darkgray line denotes the posterior mean of the infection proportion; the red line denotes the posterior median of the infection proportion
forecast_removed	plot to forecast the removed lines described in `forecast_infection`. The meaning of the vertical lines were identical, but the horizontal mean and median were corresponding to the posterior mean and median of the removed state. Moreover, we introduce an additional line for the estimated death proportion, which is based on the input `death_in_R`

first_stat_mean
: the mean first stationary date, which is the change point that we observe decline in the infection proportion (θ_t^I), or its stationary point; it is calculated using the average of the 0-points of all the repeats of posterior draws of the first derivative proportion or $\theta_t\prime I$; this value may be slightly different from the one labeled by the "purple" lines in the `forecast_infection` and `forecast_removed` two plots, as the latter indicate the 0-value point of the first-derivative the posterior mean of θ_t^I.

first_stat_ci
: following the definition of `first_stat_mean`, but is the corresponding credible interval.

second_stat_mean
: the mean second stationary date, which is the change point that we observe the decline in the increasing spead of the infection proportion (θ_t^I) or its derivative's stationary point;it is calculated using the average of the stationary values of all the repeats of posterior draws of the first-derivative porportion of infection or $\theta_t'^I$; this value may be slightly different from the one labeled by the "darkgreen" lines in the `forecast_infection` and `forecast_removed` two plots, as the latter indicate the stationary point of the first-derivative the posterior mean of θ_t^I.

dic_val
: the output of `dic.sample()` in `rjags`, computing deviance information criterion for model comparison.

Examples

```
NI_complete <- c( 41,41,41,45,62,131,200,270,375,444,549, 729,1052,1423,2714,3554,4903,5806,7153,9074,11177,
RI_complete <- c(1,1,7,10,14,20,25,31,34,45,55,71,94,121,152,213,252,345,417,561,650,811,1017,1261,1485,191
N=58.5e6
R <- RI_complete/N
Y <- NI_complete/N- R #Jan13->Feb 11
### Step function of pi_qbar(t)
change_time <- c("01/23/2020","02/04/2020","02/08/2020")
pi_qbar0 <- c(1.0,0.9,0.5,0.1)
res.step <-pi.SIR(Y,R,begin_str="01/13/2020",T_fin=200,pi_qbar0=pi_qbar0,change_time=change_time,casename="
res.step$forecast_infection
### continuous exponential function of pi_qbar(t)
res.exp <- pi.SIR(Y,R,begin_str="01/13/2020",T_fin=200,pi_qbar0=pi_qbar0,change_time=change_time,exponentia
res.exp$forecast_infection
### without pi_qbar(t)
res.nopi <- pi.SIR(Y,R,begin_str="01/13/2020",T_fin=200,casename="Hubei_nopi")
res.nopi$forecast_infection
```

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