Package 'SeasEpi'

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Title Spatiotemporal Modeling of Seasonal Infectious Disease

Version 0.0.1

Description Spatiotemporal individual-level model of seasonal infectious disease transmission within the Susceptible-Exposed-Infectious-Recovered-Susceptible (SEIRS) framework are applied to model seasonal infectious disease transmission. This package employs a likelihood based Monte Carlo Expectation Conditional Maximization (MCECM) algorithm for estimating model parameters. In addition to model fitting and parameter estimation, the package offers functions for calculating AIC using real pandemic data and conducting simulation studies customized to user-specified model configurations.

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Depends R (>= 3.5.0)

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Contents

`Datasets` *Hypothetical Datasets*

Description

The main function, `SeasEpi_Par_Est`, applies the Spatiotemporal Individual-Level SEIRS Model for Seasonal Infectious Disease Transmission to real-world data. It is compatible with any dataset that follows the required format, which includes two dataframes: `data` and `adjacency_matrix`, along with relevant parameter inputs. To demonstrate the expected input structure and the function's practical use, we provide two hypothetical examples of `data` and `adjacency_matrix`.

`data`

A data frame with 100 rows and 11 columns.

This sample dataset illustrates the required structure for the dataframe used with this package. While the number of rows can vary, each row must represent a single infected individual, and the column names and order must follow the specified format. The example includes individual-level attributes (e.g., age, infection status) as well as area-level information (e.g., socioeconomic status) for 100 individuals, each linked to a postal code. This dataset will serve as input in the example demonstrating the `SeasEpi_Par_Est` function.

Ave_Postal_Pop Average population of each postal code

AverageAge Average age of individuals within each postal code (individual-level data)

InfectedTime Time of infection for each individual, represented as a numerical value from 1 to the end of the pandemic period

LAT Latitude of the postal code

LONG Longitude of the postal code

Label_NC_shape The region number that the postal code belongs to, here assuming the study area is divided into five subregions

MaleRate Rate of males in the population of the postal code (individual-level data)

NInfected Number of infected individuals in the postal code

SES Socioeconomic status indicator of the region to which the postal code belongs (area-level data)

STI Sexually transmitted infection rate of the region that the postal code belongs to (area-level data)

SymptomRate Rate of disease symptoms in the postal code (individual-level data), indicating whether individuals are symptomatic or asymptomatic

`adjacency_matrix`

A 5x5 matrix.

This hypothetical adjacency matrix is provided to illustrate the structure required for use with this package. The matrix used with the package should follow a similar format, maintaining the same layout but allowing for any number of regions. The adjacency matrix defines the neighborhood relationships between subregions in a hypothetical study area. In this example, it represents a spatial structure with five subregions, where each cell indicates the presence or absence of a connection between the corresponding subregions. The example for the `GDILM_SEIRS_Par_Est` function will use this matrix as input.

V1 Subregion 1: Represents the first subregion in the region under study

V2 Subregion 2: Represents the second subregion in the region under study

V3 Subregion 3: Represents the third subregion in the region under study

V4 Subregion 4: Represents the fourth subregion in the region under study

V5 Subregion 5: Represents the fifth subregion in the region under study

Value Each cell in the matrix (e.g., between subregion 1 and subregion 2) represents the connection (typically 0 or 1) between the two subregions, where 1 indicates they are neighbors and 0 indicates they are not.

`SeasEpi_Par_Est` *SeasEpi for Real Data*

Description

This function applies the spatiotemporal individual-level model of seasonal infectious disease transmission within the Susceptible-Exposed-Infectious-Recovered-Susceptible (SEIRS) framework, to real data. It employs a likelihood based Monte Carlo Expectation Conditional Maximization (MCECM) algorithm for parameter estimation and AIC calculation. This function requires two dataframes, named `data` and `adjacency_matrix`, along with the necessary parameters. Detailed information on the structure of these two datasets is provided in the package.

Usage

```
SeasEpi_Par_Est(
  data,
  adjacency_matrix,
  DimCovInf,
  DimCovSus,
  tau0,
  lambda0,
  alphaS0,
  delta0,
  alphaT0,
  InfPrd,
  IncPrd,
```

```
  NIterMC,
  NIterMCECM,
  zeta10,
  zeta20,
  T_cycle
)
```

Arguments

data	Dataset. The dataset should exactly match the data file in the data folder, including all the columns with the same names.
adjacency_matrix	Adjacency matrix representing the regions in the study area (0 if no connection between regions)
DimCovInf	Dimensions of the individual infectivity covariate
DimCovSus	Dimensions of the area-level susceptibility to initial infection covariate
tau0	Initial value for spatial precision
lambda0	Initial value for spatial dependence
alphaS0	Initial value for the susceptibility intercept
delta0	Initial value for the spatial decay parameter
alphaT0	Initial value for the infectivity intercept
InfPrd	Infectious period that can be obtained either from the literature or by fitting an SEIRS model to the data
IncPrd	Incubation period that can be obtained either from the literature or by fitting an SEIRS model to the data
NIterMC	Number of MCMC iterations
NIterMCECM	Number of MCECM iterations
zeta10	Initial value for the amplitude of the seasonal oscillation parameter (sin part)
zeta20	Initial value for the phase of the seasonal oscillation parameter (cos part)
T_cycle	The duration of a complete seasonal cycle (e.g., 12 months for an annual cycle)

Value

alphaS Estimate of alpha S

BetaCovInf Estimate of beta vector for the individual level infection covariate

BetaCovSus Estimate of beta vector for the areal susceptibility to first infection covariate

alphaT Estimate of alpha T

delta Estimate of delta

zeta1 Estimate of zeta1

zeta2 Estimate of zeta2

tau1 Estimate of tau

lambda1 Estimate of lambda

AIC AIC of the fitted GDILM SEIRS

Examples

```
data(data)
data(adjacency_matrix)
SeasEpi_Par_Est(data,adjacency_matrix,2,2,0.5, 0.5, 1, 0.1, 1, 1, 1, 20, 2,0.2,0.2,5)
```

`SeasEpi_Sim_Par_Est` *SeasEpi for a Simulation Study*

Description

This function conducts a simulation study for spatiotemporal individual-level model of seasonal infectious disease transmission within the Susceptible-Exposed-Infectious-Recovered-Susceptible (SEIRS) framework, using a user-defined grid size. It applies a likelihood based Monte Carlo Expectation Conditional Maximization (MCECM) algorithm to estimate model parameters and compute the AIC.

Usage

```
SeasEpi_Sim_Par_Est(
  GridDim1,
  GridDim2,
  NPostPerGrid,
  MaxTimePand,
  tau0,
  lambda0,
  alphaS0,
  delta0,
  alphaT0,
  PopMin,
  PopMax,
  InfFraction,
  InfPrd,
  IncPrd,
  NIterMC,
  NIterMCECM,
  zeta10,
  zeta20,
  T_cycle
)
```

Arguments

`GridDim1`	First dimension of the grid
`GridDim2`	Second dimension of the grid

NPostPerGrid	Number of postal codes per grid cell
MaxTimePand	Last time point of the pandemic
tau0	Initial value for spatial precision
lambda0	Initial value for spatial dependence
alphaS0	Initial value for the susceptibility intercept
delta0	Initial value for the spatial decay parameter
alphaT0	Initial value for the infectivity intercept
PopMin	Minimum population per postal code
PopMax	Maximum population per postal code
InfFraction	Fraction of each grid cell's population to be infected
InfPrd	Infectious period that can be obtained either from the literature or by fitting an SEIRS model to the data
IncPrd	Incubation period that can be obtained either from the literature or by fitting an SEIRS model to the data
NIterMC	Number of MCMC iterations
NIterMCECM	Number of MCECM iterations
zeta10	Initial value for the amplitude of the seasonal oscillation parameter (sin part)
zeta20	Initial value for the phase of the seasonal oscillation parameter (cos part)
T_cycle	The duration of a complete seasonal cycle (e.g., 12 months for an annual cycle)

Value

alphaS Estimate of alpha S

BetaCovInf Estimate of beta vector for the individual level infection covariate

BetaCovSus Estimate of beta vector for the areal susceptibility to first infection covariate

alphaT Estimate of alpha T

delta Estimate of delta

zeta1 Estimate of zeta1

zeta2 Estimate of zeta2

tau1 Estimate of tau

lambda1 Estimate of lambda

AIC AIC of the fitted GDILM SEIRS

Examples

```
SeasEpi_Sim_Par_Est(5,5,10,30,0.7, 0.7, -1, 0.1, 0,40, 50,0.6, 5, 5, 10, 3,0.2,0.2,5)
```

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