Homework 1

Spencer Matthews

10/11/2021

Problem 1

Complete the following programming exercises in any language of your choice.

(a) Discrete time individual-based modeling

(i) Write a function that simulates a fixed number of generations of a discrete time individual-based SIR model. Your function should have the following user specified arguments: initial vector of individual labels, infection probability p, and number of generations r

(ii) Assuming that initially the population of interest has 9 susceptible individuals, 1 infectious individual, and 0 removed individuals, print 5 realizations of label vectors at each generation using $p = 0.3$ and $r = 5$.

(b) Continuous time individual-based modeling

(i) Write a function that simulates a fixed number of time units of a continuous tim individual-based SIR model. Your function should have the following user specified arguments: initial vector of individual labels, infection rate β, removal rate γ, and the number of time units t.

(ii) Assuming that initially the population of interest has 9 susceptible individuals, 1 infectious individual, and 0 removed individuals, print 5 realizations of label vectors, using $\beta = 0.8$, $\gamma = 1.5$, and $t = 2$. Print times of events and new label vectors at the event times.

(c) Continuous time compartmental modeling

(i) Write a function that simulates a fixed number of time units of a continuous time compartmental SIR model. Your function should have the following user specified arguments: initial ector of S, I, and R counts, infection rate β, removal rate γ, and the number of time units t.

(ii) Assuming that initially the population of interest has 990 susceptible individuals, 10 infectious individuals, and 0 removed individuals, plot 5 realizations of SIR trajectories using $\beta = 0.008$, $\gamma = 3.5$, and $t = 4$.

Problem 2

Formulate an extension of an SIR ODE model with vaccinated and unvaccinated compartments. Vaccinated individuals should be able to get infected and to transmit the disease.

(a) Write down the differential equations

(b) Provide interpretations of all parameters

(c) What parameters would allow you to measure vaccine efficacy against infection and transmission if you were able to estimate them from the data?