Epidemics and `odeint` Assignment

Scientific Computing

Target Due Date: Friday, January 26, 2018

College of the Atlantic

Please upload your code to your google drive and submit short answers (either electronically or in writing) to these questions.

1. The mean infection time for Ebola,[1] is around 4 days. Estimates of the basic reproduction rate vary; we'll use $R_0 = 1.8$.[2]

   (a) Suppose you are studying a community of 1000 people and initially 10 people are infected. Make a plot of $S(t)$, $I(t)$, and $R(t)$. How many people will get sick? At what time (in days) is the outbreak the worst—i.e., when are the largest number of people sick?

   (b) An outbreak of Ebola occurs in a community of 2000, starting with a single infected person. Over the course of the epidemic, a total of 1000 people get sick. Use this information to estimate R_0 for Ebola in this community, assuming that the mean infection time remains 4 days.

2. In this series of exercises we'll extend the basic SIR model in a way that might make it more applicable to measles. Let's use an R_0 of 15 and assume a mean infection time of 6 days.[3]

   (a) Add a birth rate term to the basic SIR model. Choose a semi-realistic value, thinking carefully about units. Use ν for the birthrate. We'll assume that the birth rate is constant, independent of the total population size. Let's assume that the each person in the model has a 10% change of acquiring a sibling each year.

   (b) Outbreaks of measles are periodic—or at least they were before vaccines. One possible explanation for this is that the contact rate β changes. When school is in session, β is large. When school is out of session, β is small. Incorporate this into your model. To do so, let's assume that the contact rate is $\beta_{\text{lo}} = 3$ for six months of the year and has a value of $\beta_{\text{hi}} = 15$ for the other six months of the year. Show the result of your code, using a total population of 1000 and with 10 initially infected people.

[1] Ebola is usually modeled with equations that are a bit more complex than the basic SIR model.

[2] See, e.g., Fisman D, Khoo E, Tuite A. Early Epidemic Dynamics of the West African 2014 Ebola Outbreak: Estimates Derived with a Simple Two-Parameter Model. *PLOS Currents Outbreaks.* 2014 Sept. 8. `http:goo.gl/m20MGE`.

[3] The value of R_0 varies widely from country to country. Guerra, Fiona M., et al. "The basic reproduction number (R0) of measles: a systematic review." *The Lancet Infectious Diseases* (2017). I'm not sure if 6 is a realistic mean infection time, but it's probably close.