Jacob Englert Midterm Homework Part 3

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1. Our particular SIR is not discussed. What interesting twists (which we do not include in our SIR) do these authors discuss?

The main difference in between our SIR model and the authors’ SIR model that I first noticed was that there was an “end” in theirs. Because they were modelling measles, nobody from their recovered population re-entered the susceptible population, as immunity is gained after having the disease once. Hence the term “removed” population was used instead. This differs from our model because our disease does not have immunity, so we had flows connecting our recovered population to the susceptible population as well.

Another big difference I noticed was that the authors also chose to introduce birth and death rates. They did this because they noticed their model only included one epidemic, and that everyone became infected and then immune within this relatively short time period. They noted that newborns are constantly increasing the susceptible population, so introducing this term would allow for multiple epidemics. They assumed population size was constant, so newborns ended up being the only new term technically, but mortality rate was also factored into this model.

1. What do you learn about the **stability** of the asymptotic solutions of SIR models? Can we conclude what happens in the long run to our sleek SIR?

The authors proved their model was “globally asymptotically stable”, meaning all solutions would reach the equilibrium for S and I eventually given that positive initial values were provided for these terms. Basically, even with multiple outbreaks, the model of infectives will end up hovering around an asymptote at equilibrium eventually. They found a Lyapunov function for their basic SIR model and mentioned that the existence of such a model supports the concept of a globally asymptotically table equilibrium.

Our sleek SIR model is globally asymptotically stable as well. In the long run, all three of our populations S, I, and R will become stable around an asymptote (given reasonable initial values are entered). This is because the recovery and infectivity rate are most likely not equal. Whichever is greater will eventually overpower the other, and either the disease will win out or die out. This will happen regardless of our initial values for the sub-populations – changing these will only delay/accelerate the graph to equilibrium.

1. What are the authors' suggestions for introducing more realistic dynamics into an SIR model?

The authors make several suggestions to build upon the SIR model. Firstly, they suggest adding noise to the population. Even with a sufficiently large population, due to the underlying discreteness of the data (can’t really have half a person, and if you do there are probably bigger problems in the world than measles), each individual compartment can still be affected. Adding a little bit of stochastic noise to the model sustain the dampening oscillation in the SIR.

Another suggestion the authors make is to introduce seasonal forcing. They observed that diseases such as the measles require human contact, which is likely not constant throughout the year (i.e. kids have a lot more contact with one another when school is in session). With this in mind, they chose to fluctuate the transmission rate sinusoidally with a period of 1 year. This fix was able to stop dampening oscillations altogether.

One last suggestion the author made was to introduce long-term changes, such as birth rates and child vaccination rates. Because these values can change significantly over long periods of time (the author mentions the Great Depression vs. the Baby Boom), including these ideas helps to explain the different patterns in the time series that are more than just annual fluctuations.

1. What's your favorite story about a disease?

My favorite story about a disease is that of Dr. Ignaz Semmelweis. His story begins in Vienna General Hospital in the 1800s. Occurrences of “childbed fever” were very common during this time and often resulted in the death of the mother at childbirth.

There were two wards responsibly for delivering children at this hospital, the doctors’ (men’s’) ward and the midwives’ ward. In his research, he found that the mortality occurring due to this disease in the doctors’ ward was around three times that of the midwives’ ward! He also noted that the doctors would spend time working with cadavers, and then would go straight to delivering a baby. In other words, the conditions were not as nice in the doctors’ ward. He suggested washing hands would drastically decrease mortality in patients, however nobody believed him because he did not have scientific evidence to back it up, seeing as barely any research had been done on germs and disease.

Doctors took great offense to his suggestion, as he was in a way implying that the doctors had been killing these women. Semmelweis was ridiculed for his work and eventually was admitted to an asylum where he would be beaten to death at the age of 47. It wasn’t until years after his death when the research and medical communities began to take his work seriously.