Mathematical Modeling of Diseases

Summer HSSP 2020

Introduction

Hey everyone, I'm Kenny, and I'm happy to offer Mathematical Modeling of Diseases for Summer HSSP 2020. The goal of this course is to introduce you to some fundamental principles of modeling infectious diseases, and to discuss how these models should or should not be used to inform policy during outbreaks.

There are no formal prerequisites for this course. However, you should have a background in algebra (understand what functions are, how graphing works, and how to solve equations).

How the Course is Structured

You can think of the course as having two main components. The first component is the math itself (we will be primarily discussing probability, differential calculus, and regression, and don't feel intimidated if you aren't familiar with these areas because we'll cover the basics together). The second component is how the math is applied to building disease models. I will try to spend as little time on the first component as possible – just long enough so you can understand how the disease models are constructed.

The course is lecture-based, but I will do my best to incorporate animations and videos. The emphasis is less about understanding all the math and theory, and more about understanding how the math is used to come up with the predictions we see in the news. Specifically, we will focus on the mathematical assumptions that underpin these predictions, and ask how accurately these assumptions capture what is really going on.

There are three units: probabilistic models, deterministic models, and regression models. Each unit is two weeks long, and the classes in each unit complement each other. There is a little bit of overlap between units, but in general, each unit focuses on a different area of math.

Simulation is the crucial step in disease modeling – the moment when the theory produces a prediction. Unfortunately, we won't have much time to discuss the algorithms and computer science topics associated with simulation in class (although I would be happy to provide extra resources if you're interested). But coding the simulations is pretty cool, and I wouldn't want to deprive you of that experience, so I will show you implementations of the models in Python.

Schedule

Date	Topic
Week 1: July 11th	Probability I: Basic Principles and Our First Model
Week 2: July 18th	Probability II: More Complicated Models
Week 3: July 25st	Determinism I: The SIR Model
Week 4: August 1st	Determinism II: Expanding the SIR Model
Week 5: August 8th	Regression I: Training
Week 6: August 15th	Regression II: Forecasting

Final Remarks

I recommend taking this course if you're interested in how math is useful in important real-world scenarios. You may also be interested in this course if you want to know more about COVID-19 models in particular, and how much we can trust them.

One of my central priorities is making sure you don't feel intimidated by the topics we will cover in the course. I know math is challenging, and it often doesn't make much sense. That's why this class will focus more on the application of the concepts and less on the theory behind them. If you do want to know more about the theory, just let me know and I can recommend some resources.

Above all, I recommend this course if you're interested in math or disease science. Maybe you'll find out it's not for you, but you'll never know unless you try, and the commitment is pretty low (no homework or projects). On the other hand, maybe you'll finally find some use to the math you've learned in school. I'm here as a teacher, but also as a resource. I've worked in biology labs for three years and I'm earning my degree in mathematics, so I can answer questions about both laboratory research and theoretical research. Please bring your questions and curiosity!