CX4230 - Computer Simulation

Project 3B - Zika Virus Propagation - The Plan

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Literature Review:

One example of a model we found that is related to the work we want to accomplish for this project is found at this link: https://github.com/nicholasyager/airport-disease-modeling/. The aforementioned model is called Edge-based control of disease propagation through the world-wide airport network. The model simulated the spread of a pathogen through air routes and a directed network was made using current airports as vertices and their respective routes as edges. Airports were infected at random and then were set to recover. The model implemented multiple strategies to thwart the number of infected airports by canceling flights based on edge betweenness centrality and a clustering coefficient, which they have defined in their model. This model is close to what we want to accomplish with the model we are planning to make.

For our model, we are thinking about extending this model by first, removing all the airports and just having the airports in the US. Second, we are going to display a map of the US instead of a globe as the model has done. Third, include the major interstates that will act as additional pathways or routes to spread the Zika virus. Fourth, we are planning on adding agent-based modeling by having patches of mosquitoes infect humans (other agents) and see how it affects the spread of the Zika virus. We are planning on using this model found on GitHub and extending it to have a model that suits our creativity. Further details on the conceptual model are described in the conceptual model section with some simulation experiments that we are planning on running.

Another paper/model we found that could be usefule for our project is found here: https://ij-healthgeographics.biomedcentral.com/articles/10.1186/1476-072X-8-50. The paper is called an agent-based approach for modeling dynamics of contagious disease spread; it deals with how diseases are propagated through an agent-based model where the humans are the agents. The objective of the model was to use an agent-based modelling approach that integrates geographic information systems (GIS) to simulate the spread of the measles disease in an urban environment, as a result of individuals' interactions (which act as the agents) in a geospatial context (the urban area). Individuals in a closed population are explicitly represented by agents associated to places where they interact with other agents. The agents are given mobility through a transportation network that allows them to move freely giving the model some complexity in terms of the propagation of the disease. Due to its ability to depict the disease progression based on the agents' interactions, the results of the model provide insights into the application of the model to calculate ratios of susceptible and infected in specific time steps and urban environments. It is portrayed in the model that the spatial interactions within the population lead to high numbers of exposed individuals who perform stationary activities in areas after they have finished commuting. Thus, due to this, the sick agents are conglomerated in locations like schools and universities. This could apply to our model because most of the sick agents are probably going to be concentrated in major cities and not minor ones. Basically, this agent based model designed in this paper can be easily used/customized to study the disease spread dynamics of any other contagious disease by simply adjusting the modeled disease timeline and/or the infection model and modifying the transmission process, which is what were are planning on doing for our Zika virus propagation model. We will be modifying the transmission process, which will happen through two types of agents: humans and mosquitoes. We are also planning on adjusting the infection model by implementing a way to stop the propagation of the disease by possibly shutting down certain flights/routes.

A network-patch methodology for adapting agent-based models for directly transmitted disease to mosquito-borne disease

Conceptual Model:

Zika Propagation in the US Task:

The problem we are modeling and simulating is the potential propagation of the Zika virus through the US via network-based and agent-based modeling.

Model Customer:

The hypothetical "customer" would be the Center for Disease Control (CDC), which is based out of Atlanta. This model could be useful for the CDC to see where the Zika virus has the potential to spread and the CDC could also use this model to see what preventative methods they can take to help decrease the propagation of the Zika Virus.

Modeling Approach:

The network-based modeling portion will be via the road interstates and airline travel routes and the agent-based modeling portion will be via patches of mosquitos. The boundary of the model will be set based on area that the type of mosquito that can carry the Zika virus can live in. Examples from the literature review (above) and what is learned during class on network-based and agent-based models will be used as guides to the simulation study of the Zika virus propagation via network-based and agent-based modeling of mosquitos and humans.

Need detail on how to model from literature review

Software Implementation:

For this model, we are planning on using Python and NetworkX, which is a Python package for the creation, manipulation, and study of the structure, dynamics, and functions of complex networks. Since the simulation will be stochastic, i.e., use random numbers to model unpredictable elements of the system, we will be using an existing random number generator library. We will be using a network of all the major cities connected via their respective airplane and major interstate routes. We will also have a global dictionary noting what the current state of each city is i.e. how much of they city has been infected.

Simplifications:

Some simplifications are made for our model. Since It is both unnecessary and difficult to take some details into consideration in our model, we make the following simplifications:

- We are only having the major cities, airports, and interstates.
- A certain number of cities (cities with airports/interstates that are in high-degree/busier) will be started as infected in the simulation.
- The time to travel via plane/car is constant regardless of where the plane/car goes from its source. The time will be measured in days and since it is possible to get anywhere in the US by plane in a day and car, each time step will represent a day.
- Routes are directional. Based upon the degree of the source and destination airports, each edge is weighted to represent the probability of carrying infectious individuals.
- To properly model the flow of individuals around our cancellations, edge weights are recalculated after each cancellation strategy

Assumptions:

Some data about our simulation is hard to collect. So we need to make some assumptions to process our model.

- Airports/interstates are used as proxies for individuals harbored within the city. This assumption is held with the understanding that transient passengers are able to infect permanent residents of the city. These residents are then able to pass the infection on to other individuals in the city.

- There is no record for an infectious person's behavior. Thus, we treat all infectious persons as unaggressive/inhumane people, and then we induce no one will help propagate the disease faster by purposely infecting others.
- On the other hand, mosquitoes will be aggressive and will infect whomever randomly and at a quicker pace than humans.

Experiments:

The following are different scenarios we will experiment with:

1. Start infections at different hubs (airports, cities) and run simulation to determine worst cities that could be infected so that preventive measures could be started now
2. Change infection rates, movement rates, vaccination rates
3. Shutdown different hubs to minimize infection
4. Determine if infection could be stopped through all out preventative measures
5.

Implementation Plan:

- Implementation checkpoint C - Monday, April 11
    - Obtain updated airport dataset for major airports in the US
    - Obtain number of flights and passengers per route
    - Obtain interstate dataset for the US
    - Obtain interstate travel data
    - Obtain population data for all major cities in the US
    - Obtain seasonal boundaries for where mosquitos that can carry the Zika virus can live throughout the year
    - Figure out mosquito reproduction dynamics
    - 1 page summary complete
- Implementation checkpoint D - Monday, April 18
    - Draft network and agent-based model complete
    - 1 page summary complete
- Implementation checkpoint E - Monday, April 25
    - Final network and agent-based model complete
    - Final analysis complete

    - ➢ 1 page summary complete
    - ➢ Draft Poster complete
- ❖ Implementation checkpoint F - Wednesday, May 4, 8:00-10:50am
    - ➢ Final Poster complete
    - ➢ Print out poster by Monday, May 2

References:

https://github.com/nicholasyager/airport-disease-modeling/

https://ij-healthgeographics.biomedcentral.com/articles/10.1186/1476-072X-8-50

http://www.simondobson.org/complex-networks-complex-processes/epidemic-spreading.html

https://vax.herokuapp.com/faq

http://www.tandfonline.com/doi/pdf/10.1080/17513758.2015.1005698

http://arxiv.org/pdf/cond-mat/0205009.pdf

A literature review (or survey) is a short summary of work related to your project. This may include background papers or books about your topic, as well as any prior attempts, if any, to model or simulate your target phenomenon. You should *not* just list a bunch of papers and books related to the topic; you should try to synthesize this material by comparing and contrasting techniques or results, identifying gaps in prior work, or characterizing the work in an interesting and compelling way.

Your conceptual model should clearly state a) the problem you are modeling & simulating; b) who the (hypothetical) "customer" of your project is (besides us); and c) outline your modeling approach (a la Project 2-B). Since you will also have done a literature survey, you should relate your modeling approach to prior work — that is, are you replicating prior work? Adding a new twist? Taking a completely different approach?

Your implementation plan should outline the major goals for your implementation of parts C, D, and E. That is, what do you hope to accomplish at each of these checkpoints? You should also describe the simulation experiments you are planning, as well as what sources of data you would need (e.g., census reports and from where you expect to get it).