Delineo Disease Modeling: Small-town Interactive Disease Simulation

Mentors: Dr. Anton Dahbura, Dr. Kimia Ghobadi

Mahmoud Said, Lixing Wu, Alisa Yang, Allen Gong, Iason Mihalopoulos, Jeffrey Yao, Jin Hong Moon, Keeyan Mukherjee, Matthew Yu, Michelle Wang, Neil Patel, Ryan Lu, Scott Klosen, Siva Indukuri, Zoe Xie, Shayan Hossain

Johns Hopkins Whiting School of Engineering

Project Overview

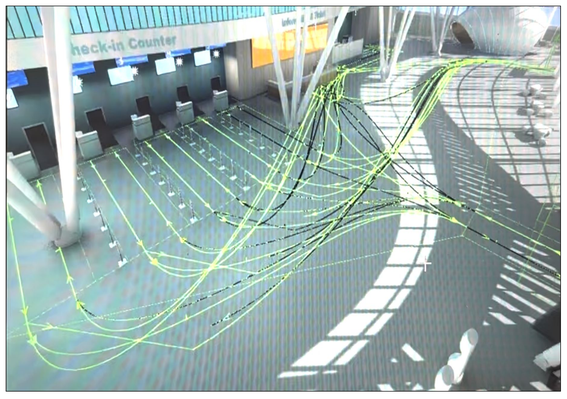
The Delineo project is a disease simulator that focuses on realistic infection modeling on a much smaller scale than traditional disease models. Rather than focusing on modeling the entire country, or entire states, Delineo instead focuses on modeling small geographic “convenience zones,” where the movement within each zone is maximized and the movement in/out of each zone is minimized. This allows for much faster modeling on select communities. From our website, users are able to customize disease and population parameters to their own specification and run realistic small-scale simulations, all within their browser.

The Delineo Project has three main aims: modularity, customization, and optimization. Each aspect of the simulator is developed as separate “modules” that are meant to be easily replaceable for more advanced users.The simulator is also highly customizable, especially with regards to disease parameters such as infectivity and severity. With our focus on optimization, a lot of the heavily lifting is dead ahead of time, as a “pre-computational” step, which includes the small “convenience zones”, population and household demographics, and movement patterns for our synthetic population to follow. All that the simulator needs to do in real-time is manage disease infectivity and how the disease spreads within a specific population.

External Collaborations

Amazon Web Services (AWS)

This joint project between AWS and Delineo combines Delineo's infectious model and simulation expertise with the spatial simulation specialization of AWS SimSpace Weaver. The study focuses on the spread of infection within an airport scenario, using Unreal Engine to create a realistic visualization.

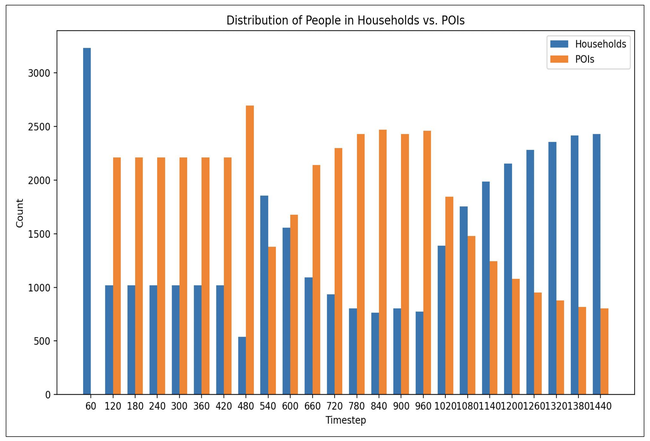


University of Tsukuba

The Delineo team also keeps close contact with several students and faculty at the University of Tsukuba in Japan. Our foc iuss on collaboration on simulator aspects such as realism and explainability.

Algorithms - Movement Patterns

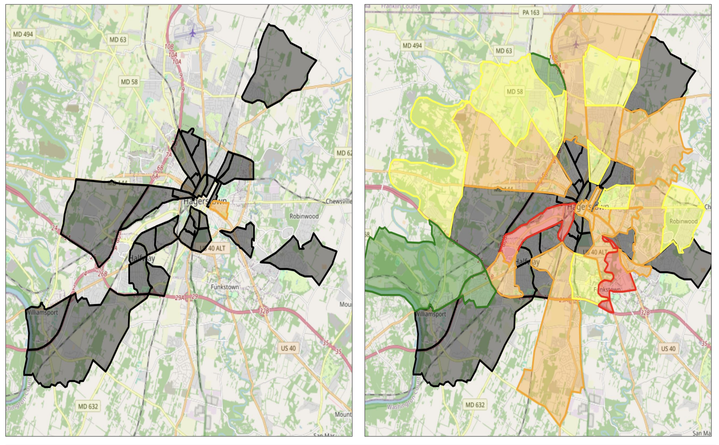
In our simulation, we create synthetic populations of simulated people that mimic realistic movement patterns we get from our real-world SafeGraph geolocation dataset.



First, we manage data structures for households, which represent small population units, while keeping track of individuals' details. Then, we handle interactions at various facilities such as workplaces while and managing durations of visits. Simulating interactions between different households to improve model's ability to track spread of disease, and integrating household and facility interactions alongside dynamics events like job-related movement and day-to-day activities. Our movement simulation algorithms are flexible enough to handle simulation of any convenience zone of a set population generated by our clustering algorithm.

Algorithms - Clustering

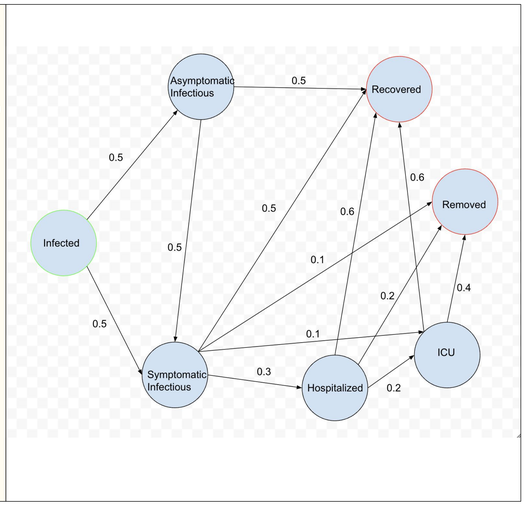
Taking U.S. Census population data and SafeGraph movement data, our clustering algorithm analyzes how people move between different CBGs (census block groups, the smallest geographic area used in the census) in the area of interest, and in the end produces a full visualization on a map that shows how people move between different CBGs over time, providing insights into how interconnected a sample population may be. This visualization can be created for any input city and population.



An example cluster of population zones for Barnsdall, Oklahoma. The left is our starting point (orange) and the right is the final cluster output.

Disease Model Platform (DMP)

When a person is marked as “infected” by the simulator’s infection model, their information is passed over to our DMP to determine the “timeline” of the individual as they progress through disease states. The DMP is designed to simulate a dynamic system, featuring multiple states and transitions based on user provided data. It aims to model the progression of people through different states over time using transition matrices.



Simulator

Taking all of our precomputed algorithms for clustering, population data, households, and movement patterns, our simulator is then able to model the spread of disease throughout a given population. Each part of the simulator (DMP, infection model, user set parameters) are developed with customizability in mind, and are all modularized to be easily swapped out for more advanced users of the simulator.

Fullstack

Scan this QR code to come try out the Delineo Disease Simulator on our website! Feel free to explore to learn more about Delineo or jump straight to the simulator and customize population and disease parameters and see how it can change the spread of disease within a small community.