Creation of an Air Traffic Simulation Using Agent-Based Modeling and Embedded Statistical Analysis

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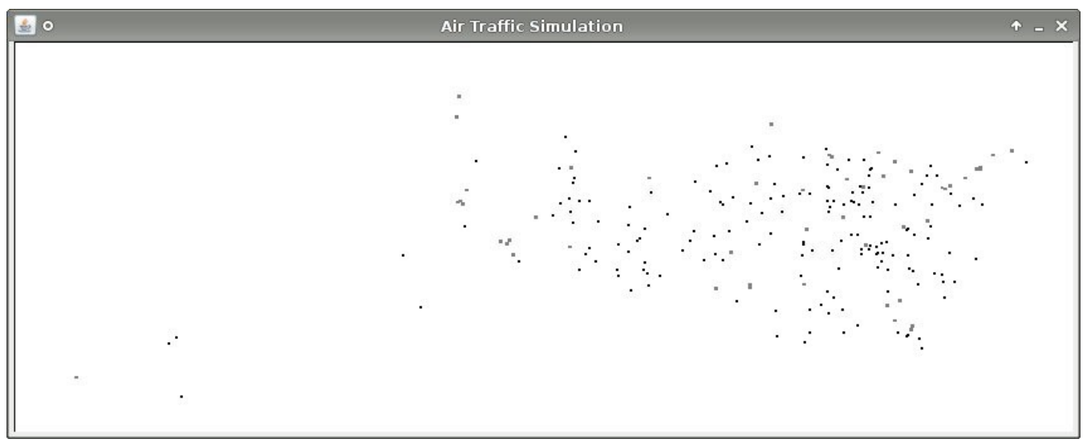
Abstract:

As the skies over the United States become increasingly crowded, airports in the United States are stressed to adapt to this increased demand. The goal of this project is to represent visually the strain on airports and passengers as a variety of problems generate record delays. By using agent based modeling, along with real air traffic information, this simulation may accurately predict the proliferation of delays through out airports in the United States.

Background:

The purpose of this project is to represent visually the proliferation of a delay throughout a system of airports. By using techniques such as agent based modeling, the simulation will predict actual delays with decent accuracy. Additionally by repeating the simulation multiple times, the simulation generates increasingly accurate results as the number of trials approached infinity. While a simulation such as this would take a human enormous amounts of time, a computer may be able to run a simulation of 24 hours in a matter of minutes. Due to the scale of the problem, efficiency will be key for the computer to run the simulation in a timely matter.



Screenshot of Simulation Interface

Results:

The final version of my project is a functional representation of air traffic over the United States. Unfortunately,due to time constraints, I was unable to implement a few features of the project. A glitch in the rendering process of the Java platform causes the planes to be rendered slightly off course. As a result, the path tracing and arc rendering were not included in the final build and the statistics were not displayed real-time.

However, the simulation is still functional and I am able to discern several patterns by simply watching the simulation run. The presence of clusters (as seen in the screenshot above) shows that the system is not yet at capacity and that any delays should be reduced as a whole. Also, the low concentration of planes which travel across the northwest shows that some planes may reach their destination faster by traveling across this relatively unused space.

Agent-Based Modeling:

In order to simulate such a large system, this project will use a technique known as agent based modeling. The development of a system using agent based modeling is key for the success of the project. Each agent must interact with other agents in the system in the most realistic way possible in order to generate the most accurate results. One benefit of the agent based modeling is that parameters for interaction between agents define the overall behavior of the system. This allows the programmer to work on much smaller problems with the agent in order to alter the overall system.

Embedded Statistical Analysis:

Embedded statistical analysis is a done when real time statistics are needed in a simulation. The program uses data at each time step to readjust statistical values for the desired population. These statistics are useful when determining if the system is able to handle the introduction of new agents or new constraints.

This simulation determines the mean, and standard deviation of delays from all of the agents under the control of an airport. Using properties of these statistics, an overall standard deviation and mean are determined without polling all agents a second time. Tracking the historical values for the mean and standard deviation then allow for regression modeling to determine the speed of propagation through the system. This analysis is particularly useful when changing how agents interact with one another because the statistics inform the user whether of not the change is positive.

Geocoding:

Geocoding is a process by which a formatted address such as 6560 Braddock Rd. Alexandria, VA 22312 is converted to a longitude and latitude. This process is important when dealing with map information that is displayed on a computer because the computer is unable to relate formatted addresses so longitudes and latitudes are used to generate accurate relationships about location.

I found that Google offered free geocoding with a maximum of 5000 requests per day, which was more than enough for the project. In order to interact with the Google geocoder, each airport was geocoded through an HTTP request sent to Google servers. These servers then interpret the parameters in the URL of the request and return the output specified by the user. The parameters in a request are as follows:

- q - The formatted address to be geocoded
- output - The desired output format (xml, kml, csv, or json)
- key - Google Maps API key

Sample Request (Key removed for privacy reasons):
http://maps.google.com/maps/geo?q=BWIairport&output=csv&key=API_KEY

Screnshot of Geocoding Results