Efficient Evacuation of At-Risk Populations

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Recently, a multitude of natural disasters such as hurricanes, floods, and wildfires have been plaguing the United States. In light of these tragedies, if and how a population evacuates has become a pertinent question to address. During Hurricane Harvey, the city of Houston chose not to issue mandatory evacuation orders due to their experience with Hurricane Rita; however, in Florida and Puerto Rico such orders were given out, with the former employing an organized method. More recently, in southern California fire officials ordered evacuations in response to the Thomas Fire resulting in tens of thousands of residents fleeing their homes. In all of these cases, infrastructure was destroyed and lives were put at risk.

Our simulation aims to determine via observation of the time taken for complete egress which current method of evacuation should be utilized during these events. Over the course of this project, research will be conducted into real world evacuation plans; statistics from past evacuations, including accident rates; and route data from the location to be simulated in order to accurately model evacuation methods. The damage caused by disasters on infrastructure, specifically roads, will also be explored as this inevitably factors into the ease and direction of potential routes before and during such events.

Currently, our program consists of two distinct agents, nodes which represent intersections, and vehicles to represent the evacuating population. Additionally, in order to simulate the roadways, links between the various nodes have been created. Each of these links have several variables, including the speed limit and length of the respective road. These will be used to determine the approximate time it will take for the cars to travel.

The model does not yet include the implementation of real world evacuation methods, but rather has the agents evacuate in a chaotic fashion for preliminary testing purposes. The two routines that have been implemented and will be used to create the real world methods are *Evacuate From* and *Evacuate To*. In *Evacuate From*, an area is selected to represent an at risk area. Using a flood-fill algorithm, each node determines its distance from those in the danger area. Vehicles then progress node to node along the links away from the area of risk by selecting the node with the largest value (or distance). In *Evacuate To*, the reverse is true. In this routine, one or more nodes are selected as evacuation locations, representing shelters or exits from the city. As before, using a flood-fill algorithm, each node determines its distance from the selected points. Vehicles then travel node to node, always selecting that with the lowest value (or distance), enabling it to move towards the closest target area. An additional routine is under development, *Evacuate From To*, but has yet to be implemented.

In order to test these algorithms, a rudimentary layout generator has been created. This program generates a roadway system and enables us to select points as the evacuation area or destination and then run the various routines. This also enables us to select nodes and links, or

intersections and roads, to shut down, changing the evacuation route. This will eventually be replaced with a node layout representative of a portion of the city to be modeled.

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