Endeavor to adopt GIS data on evacuation decision making model

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Abstract

By Multi Agent Simulation MAS, we focused on contagion of evacuation decision making on real map assuming that not all people evacuate at the time of disaster. Then, we found that for contagion of evacuation decision making, local neighborhood is needed and connection of sub network is needed. But, there we faced on difficulty of obtaining realistic population data on map, because Census Bureau data consists of not position data but numbers and properties. In this paper, we attempt to use geographic information system GIS data and population data, then we will simulate population with heterogeneous agents and their decision making.

Keywords: Multi agent simulation, Evacuation, GIS data, Population data.

1. Introduction

The Great East Japan Earthquake was a 9.0 magnitude undersea mega thrust earthquake that occurred on Friday, March 11, 2011. After the earthquake, since there were many people who were unable to effectively evacuate, damage was considered to have spread. In fact, the ratio of victims to the residents in the Great East Japan Earthquake was lower than that in the Meiji Sanriku Earthquake, which was an 8.2 magnitude undersea mega thrust earthquake that occurred off the Pacific coast of Japan on June 15, 1896. It is believed that various disaster prevention methods take effect[1]. Although according to a questionnaire and interview, about 30% of the people evacuate in Japan[2].

In our former study[3], we adopted a multi-agent simulation that focused on psychological conditions at time of disaster. We supposed that all agents evacuate. We confirm that it takes more time to complete evacuations if psychological conditions exist at the time of disaster. There, similar to other evacuation simulations, we set that all people decide to evacuate. In another study[4], to deal with the condition that not all people decide to evacuate and we deal with contagion of evacuation decision making by cascade model. We found that for contagion of evacuation decision making, local neighborhood is needed and connection of sub network is needed. In these studies, we faced on difficulty of obtaining realistic population data on map, because Census Bureau data consists of not position data but numbers and properties. By Wise[5], acquiring good data is frequently a challenge in research efforts, and many techniques have been devised in order to address this need. MAS incorporate theoretically boundless

heterogeneity, and consequently can be designed to take extremely rich data. For extension to many cities, it is important to obtain realistic population data on map. In this paper, we attempt to use geographic information system GIS data and population data, then we will simulate of population with heterogeneous agents and their decision making.

2. Population Synthesis and arrangement

People are arranged in houses and workers or students are arranged in their workplaces or schools. In this paper, we focus on population arranged in houses. Almost Census data include population and the number of homes in Census tract, but it is difficult to find the data including geographic locations of houses in the town.

2.1. *Our method*

In our former this study, we adopted 10 towns in Kure city where my academy located and 30 shelters, as shown in Fig. 1. We follow the Ohata's moddel[6] , which simulate of evacuation from Tsunami in Hokkaido area, and reproduced on Multi agent simulator Artisoc[7]. The area is 2.28km by 1.88km. According to the Census data of March 31, 2013, the residents per household averaged 1.937. We set an agent as two people, which is the average population of a household. It is reported that many people evacuated by family unit[8]. And we set many roads and intersections on Bing map by manual as shown in Fig. 1. And we set agents on an intersection node for each town at the first time step. Number of agents are 10,088 and number of intersection nodes and links are 213 and 384.

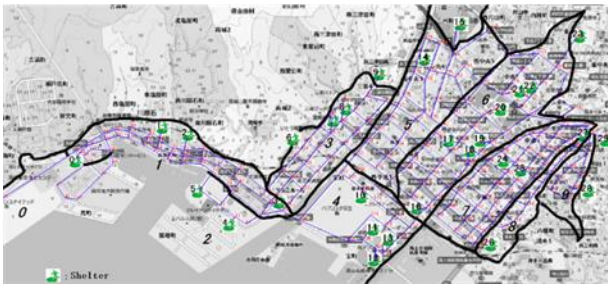

Fig. 1. Town, shelters and network of roads in Kure city.

2.2. *Wise[5] Method*

Wise used method discussed the statistical quality of the generated population by Barthelemy and Toint[9]. It proceeds in three main successive steps: generation of individuals, generation of household type's joint distributions, and generation of households by gathering individuals. The main idea in these generation steps is to use data at the most disaggregated level possible to define joint distributions, from which individuals and households are randomly drawn. The method also makes explicit use of both continuous and discrete optimization and uses the $\chi 2$ metric to estimate distances between estimated and generated distributions. The new generator is applied for constructing a synthetic population of 10,300,000 individuals and 4,350,000 households localized in the 589 municipalities of Belgium.

To automatically generate reasonable housing distributions, the set of all roads labeled "residential" by OpenStreetMap are extracted, and roads are assigned to Census tracts if both of their end points are located within the tract. Going tract by tract, the number of homes in the tract from the Census data is determined and the implied density of housing is calculated through the relative cumulative length of residential roads and number of housing units associated with the specific tract. The process then generates houses at the given density along all of the residential roads. After they have been assembled, households are assigned to these generated houses.

2.3. *Crooks[10] Method*

The model combines and utilizes both raster and vector data structures into a single simulation, utilizing both ESRI grid and shapefiles with a range of different resolutions. These data capture information about the target location, an 8 by 6 km area around Haiti's capital and most densely populated city, Port-au-Prince. To initialize the population of agents in a way that realistically parallels the distribution of individuals throughout the city, to estimate of population distribution over the study area, they use population counts from the 2009 LandScan[11] (2011). LandScan data divides the

Table 1. The planning and control components.

			Our method	Wise method	Crooks method
Population synthesis	Data	Population	Census data	Census data	LandScan data
		Households	Population/2	Barthelemy methodology	---
Arrangement of population	Data	Homes	Bing Map	OpenStreetMap	---
		Roads	Bing Map	OpenStreetMap	OpenStreetMap
	Position	Roads	Manual	Automatic	Automatic
		Nodes	Manual	Automatic	Automatic
		Homes	Manual	Along residential roads	Evenly distribute on grid

world into roughly 1 km by 1 km squares and assigns a population count to each cell. Such a data source is useful for estimating baseline populations where census data is missing. When using this data to initialize our agents, they assume that the agents are evenly distributed throughout the 1 km by 1 km area, excluding the parts of the environment that are determined from other GIS data to contain water or similar obstacles. Based on this information and methodology, the simulation is initialized with approximately 1.3 million agents.

3. Discussion

Almost towns have distorted boundary, but, computer simulation well-acquainted grid or cell data. So, to consider arrange of population, it is easy to use LandScan data for population synthesis. But, definition of agent depends on the case of simulation. For evacuation of disaster, it is reasonable to set agent as households.

As for arrangement of population, for extension to many cities, it is easy to use GIS data, such as OpenStreetMap. For behavior of agents, it is good to set agents on node not on over cell at first step, to easily walk on the road.

4. Example

For population synthesis, we will adapt LandScan data, which divides the 1 km by 1 km squares and assigns a population count to each cell. Fig. 2 is example of model of 8 km by 6 in Port-au-Prince, Haiti[12]. A cell means 1 km by 1 km square and large population area is deep in color. We export layer file (lyr) of population to text file by ArcGIS[13] and convert to comma separated values file (csv), then we import to Multi agent simulator Artisoc[7].

For arrangement of population, we will adapt shapefile of road (shp), which is GIS data. Because, there are so many nodes, we thin down the data by GIS Data Converter[14]. Nodes are shown in Fig.2, too. In fact, the nodes have links. We arrange agents on the nodes at first based on population of the 1 km by 1 km cell.

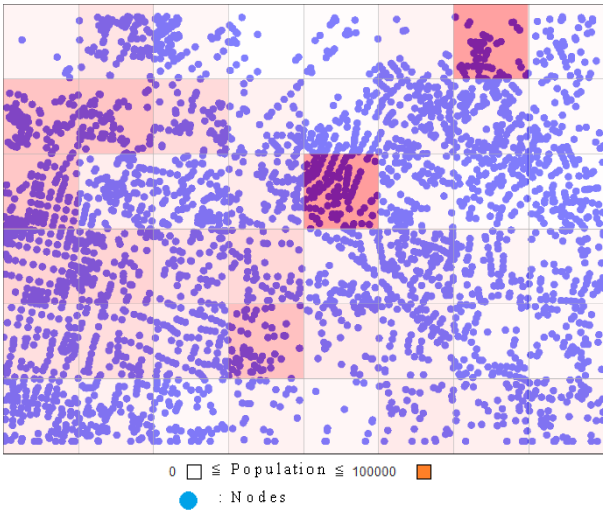

Fig. 2. Population and nodes in Port-au-Prince, Haiti.

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