Modelling the Humanitarian Relief through Crowdsourcing, Volunteered Geographical Information and Agent-based modelling: A test Case - Haiti

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1. Introduction

Natural disasters such as earthquakes and tsunamis occur all around the world but the exact timing of such events are difficult to predict. A commonality of all natural disasters is that they alter the physical landscape and can cause severe disruption to peoples daily lives. To aid humanitarian efforts in such instance one needs spatial data but, more often than not, in less developed counties spatial data is lacking. Even in cases where spatial data is available, it often lags behind what has changed on the ground. Over recent years there has been a growth of *bottom-up* campaigns to crowdsource (Howe 2006) spatial data, using volunteers to map entire counties which some term volunteered geographic information (VGI, Goodchild, 2007). Recently attention has focused on using the crowd to help map the infrastructure and devastation caused by natural disasters, such as in Haiti and Pakistan (e.g. Biewald and Janah 2010).

While the use of GIS for emergency management is not new (see Cova 2005) applications often focus evacuation (e.g. Cova and Johnson 2003). Agent-based modellers have also attempted "agentize" such models (e.g. Thorp et al. 2006) thus adding more realistic behaviours but essentially such models are just evacuation models. There are few agent-based models that explore humanitarian assistance and those that do tend not to be overtly spatial (e.g. Salgado et al. 2010). There is a great potential for the use of agent-based modelling (ABM) and GIS to assist first responders and logistic support to understanding the complexities of people affected by such natural disasters (Fiedrich and Burghardt 2007).

This paper explores a prototype spatially explicit agent-based model where people search for food after an earthquake. The model is created from crowdsourced geographic information, coupled with other sources of publically available data, and explores how aid might be distributed to relieve the suffering of the people affected. We focus on the devastating magnitude 7.0 earthquake that struck Haiti on the 12th of January 2010 which is estimated to have killed 230,000 people and left more than 1.6 million people homeless (BBC 2010). Fig. 1, provides an idea of the population distribution of Haiti, with the greatest density in and around Port-au-Prince.

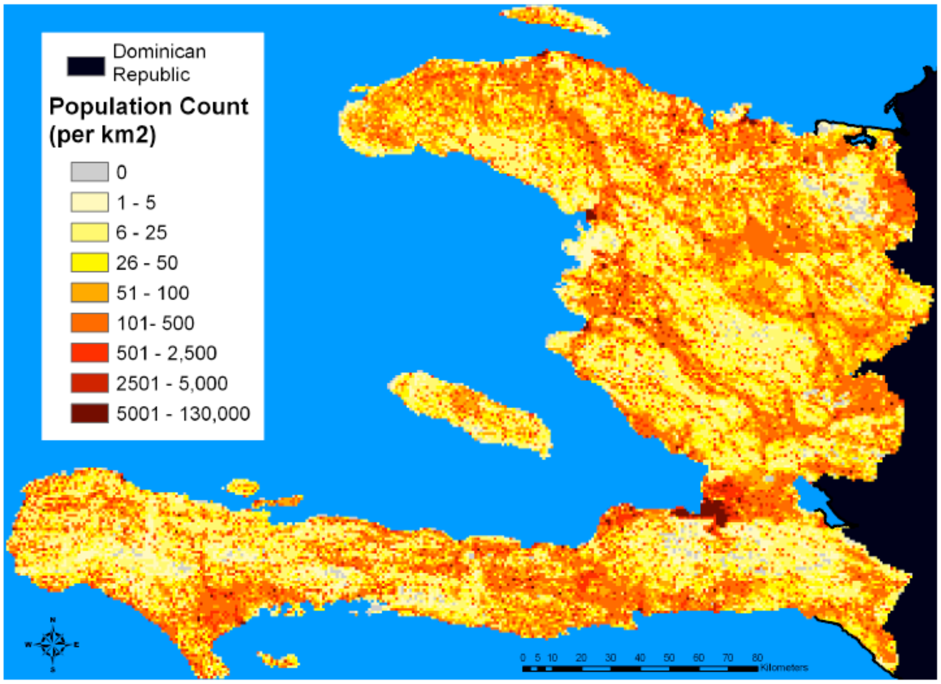
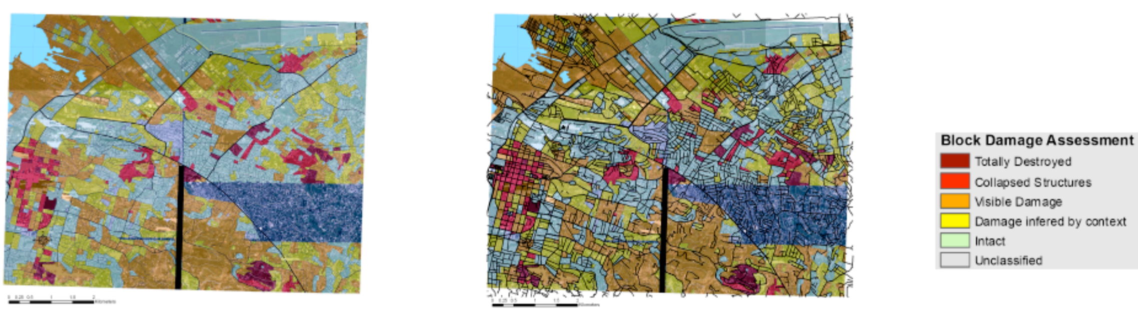


Figure 1. The Republic of Haiti and its population distribution in 2009.

2. Methodology

To demonstrate how such data can be utilized, we have created a basic agent-based model programmed in Java utilizing the MASON simulation toolkit (Luke et al. 2005) and its GIS extension, GeoMASON (Sullivan et al. 2010). One of the novelties of this model is that it combines both raster and vector data structures into a single simulation. The simulation area measures 8km by 6km around Haiti's capital, Port-au-Prince, as shown in Fig. 2.



A **B**

Figure 2. Data on the devastation focused on Port-au-Prince. A: original data, B: geo-referenced image with roads shown which where used to locate the map.

Raster data comes from several sources, Fig. 3, summarises the data used in the simulation. To initialize the agent population, we use population counts from the 2009 LandScan (2011) dataset. The agents need are based on information about the devastation from G-Mosaic (2010). This data assesses damage at a number of different levels from totally destroyed to intact structures. The assumption the model makes is that agents in the areas of greatest devastation have the greatest needs. The data was edited and geo-referenced using vector road lines sourced from Geocommons (2010). The road layer is also used for defining paths via an A* algorithm from the agents homes to the aid points. The spatial resolution of the model is set at $100m^2$ however, multiple agents can be in one cell and agents can move a maximum of 100m per iteration (tick) of the model.

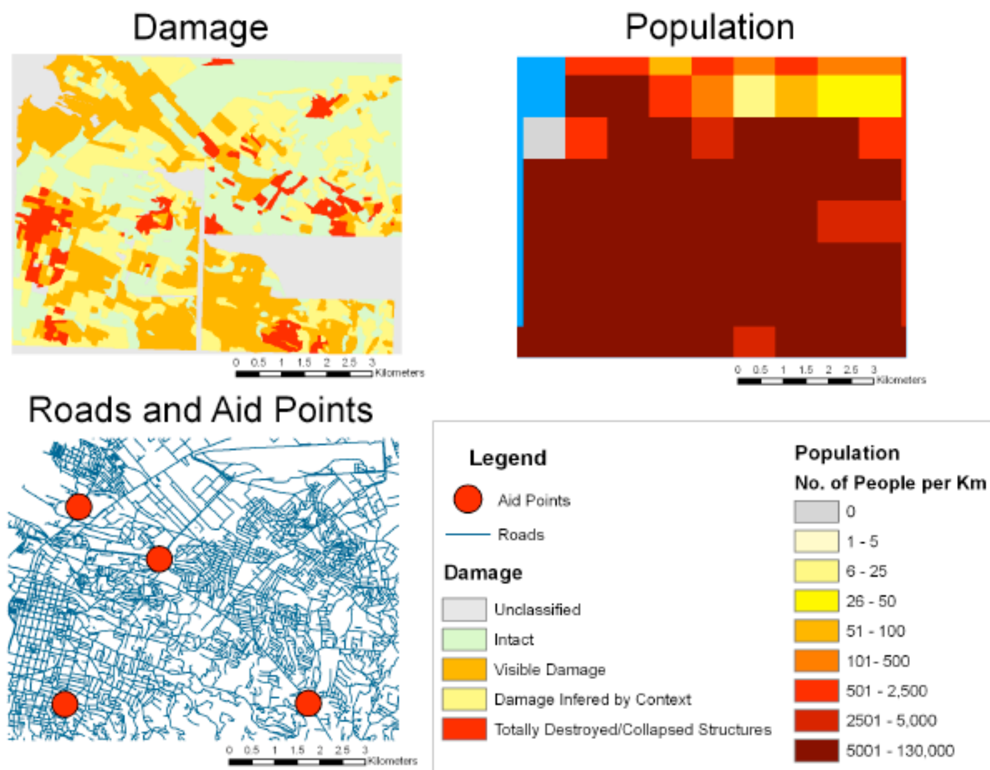


Figure 3. Model inputs.

2.1 Agent Decision Making Process

Data alone tells us little to how the people in such areas will react to the devastation or the supply of food. For this, we turn to ABM. The people (agents) within the simulation have a goal to maximize their energy, in the sense that no agent wants to starve as shown in Fig. 4. At model initialization agents around the food distribution points know of its location, agents then inform other agents about the distribution point via a diffusion mechanism. Over time more and more agents become aware of their nearest, but also other distribution points, as information is spread throughout the system. Agents then evaluate if it is worthwhile for them to go and get food. They do this by planning the shortest path to the food via the road network. Within the simulation agents have a certain amount of energy depending on the level of destruction of where they are initialised, when their energy level reaches 0 they die.

3. Simulation Results

Fig. 5, shows some simulation results. Initially, at *T=1*, few agents know about the food distribution points. Over time, such as at T=200, more agents become aware of the distribution points, as agents share information about the location of distribution points either by passing on the information to their neighbours (in the sense of a rumour model) or to agents they pass while moving towards the food source.

Currently we are in the stages of calibrating and validating the agents behaviours, along with exploring the optimal placement of distribution points, which we will report at the conference.

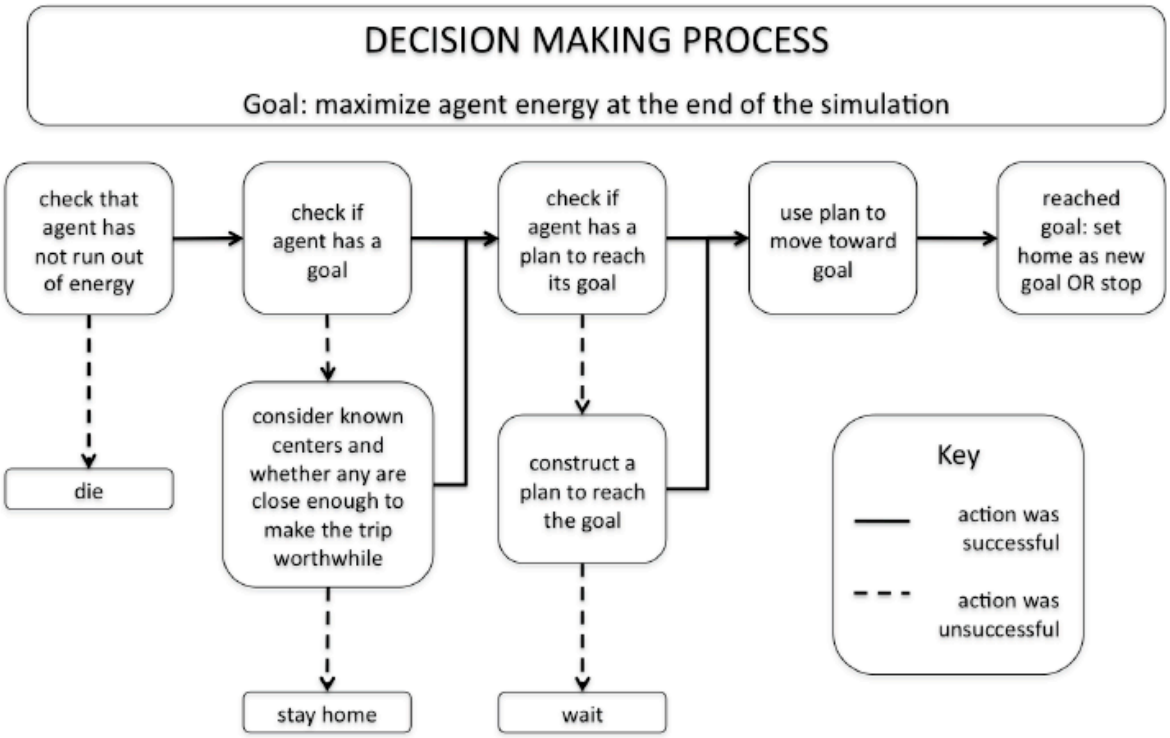
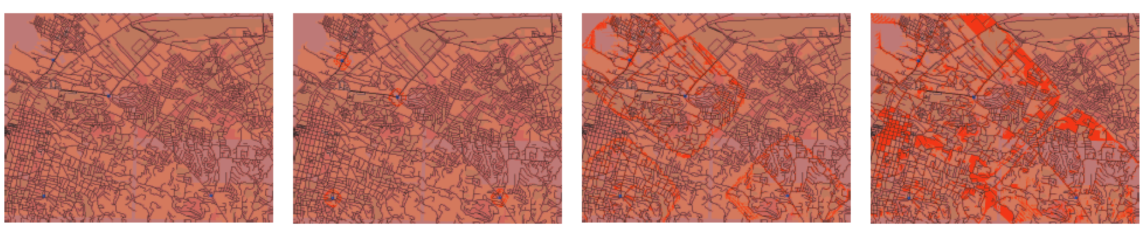


Figure 4. Agents decision making process.



Time(T)=1 T=25 T=100 T=200

Figure 5. The spread of information and movement of agents over time.

4. Summary

This paper attempts to demonstrate how GIS and ABM can be utilized to explore humanitarian relief after an earthquake. Such a model harnesses crowdsourced and other publicly accessible data. The model moves away from the more traditional disaster models that explore evacuation scenarios associated with catastrophic events, to map the consequences of such an event on the native population. It demonstrates how data can be used to initialize agents, their needs and their environments and how through a simple decision making process, people learn about and search for food. We consider this an important aspect for humanitarian relief as natural disasters are times of great uncertainty, and it is difficult to predict beforehand how people will react to such events. By using agent-based models we can explicitly explore potential agent behaviour. Such a model, once thoroughly developed could act as a decision support tool for humanitarian relief.

5. Acknowledgements

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