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USING GIS TO IMPROVE DISASTER RESPONSE FOLLOWINGAN ASTEROID IMPACT

Monica I. Maynard (1) (2)
(1) The Aerospace Corporation,2310 E. El Segundo, CA 90245, (2) California State University-Los Angeles, 5151 State University Dr., Los Angeles, CA 90032

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Extended Abstract—

Natural disasters have plagued humanity for thousands of years. Civilizations have learned to adapt to a changing world and create ways to cope with these catastrophes. With the onset of newer technology, Geographical Information Systems (GIS) has been used to help communities in mitigation and preparedness prior to the occurrence of a natural disaster. More recently, GIS has been improved and implemented in the response and recovery efforts after a natural disaster. Although mitigation and preparedness are important to lessen the effects of a disaster, the response, and subsequent recovery, to such disasters is paramount to decreasing its effects on the population. This project seeks to bring light to the immediate outcomes following an asteroid impact and how communities can use GIS to guide recovery endeavors. Using GIS in tandem with remote sensing, in real-time, can be used by agencies to collaborate and respond to locations with the greatest need. GIS cannot only be used at the community level by local agencies, but also at a global level to bring resources and collaborative efforts to the most impacted areas. GIS can also be used to identify available resources such as nearest hospitals, shelters, open roads or areas to avoid.

Introduction

Geographic information systems (GIS) are a compilation of computer-based tools that help scientists, governments, and other organizations visualize, analyze and store data for interpretation and further communication of findings with the respective stakeholders. The use of geospatial data, such as GIS, is used in almost any sector to incorporate statistical analysis with mapping capability to offer explanations to patterns that arise, plan strategies to solve a problem, and predict outcomes to better prepare. For the purpose of this presentation, the focus will be on using GIS data and techniques to aid in the response process after a natural disaster such as an asteroid impact. According to Rumpf et al., 2017, the minimum asteroid size to cause fatalities is 18 meters. GIS technology has previously been used in emergency management for natural disasters such as floods, wildfires, earthquakes, tsunamis, hurricanes and tornadoes, to name a few. Most of the work using GIS for disaster emergency management has been in the planning, mitigation, and preparedness phases. The response and recovery phases include activities following a disaster that provide emergency assistance to the public and aim to reduce the effects of secondary damage or to stabilize the situation. Recovery can include short-term activities that identify damage and immediate need for services. Long-term recovery activities may include location suitable sites for refugee relocation (Younes et al., 2022). When GIS is used in tandem with remote sensing techniques using satellite -based imagery (pre and post disaster) can help identify broad zones of damage (Eguchi et al., 2001). Furthermore, these studies highlight the change in the land surface as it did after the 2004 Indian Ocean Tsunami which caused massive destruction of villages and infrastructure (Fig. 1). After the tsunami hit the Andaman Sea coast of Thailand satellite imagery helped create damage maps to better understand the impact and disseminate basic information (Roemer et al., 2010).

Use of GIS and Remote Sensing

GIS has been widely used to assess damage in areas hit by natural disasters such as earthquakes, tsunamis, tornadoes, and hurricanes. Knowing the location of areas most affected can help response teams allocate personnel and resources to begin the response and recovery phases. In the case of an asteroid impact, it is more difficult to know where these areas of need will be as there are many variables to account for including size, composition, trajectory, and velocity of the asteroid. Nonetheless, using prior disasters as an analog, similar techniques can be identified and applied to asteroid impacts. In the case of the 2004 Indian Ocean tsunami, before and after satellite imagery was used to assess the extent of the destruction of the coastline in Thailand. Change detection techniques using Normalized

Difference Vegetation Index (NDVI) can show changes in vegetation distribution in an area. Similarly, Normalized Burn Ratio (NBR) can be used to assess health of vegetation and thus detecting changes. Data modeling techniques can be used to plan emergency operations such as distribution of supplies, evacuation and transportation of citizens. In the case of forest fires, integration of slope, land use, and other parameters can help simulate a shortest route for evacuation or acquisition of resources. The fire simulation model uses spatial data analysis using real-time sensor information to map out affected areas and allow emergency responders to adapt to changes as they happen (Wang et al. 2014).

Techniques

Normalized Burn Ratio (NBR) in fire areas can detect burnt areas by using near infrared (NIR) and shortwave infrared (SWIR) as follows:

$$NBR = NIR – SWIR / NIR + SWIR$$

NBR Burnt areas or areas with vegetation damage have low reflectance in the NIR and high reflectance in the SWIR. Difference, or change NBR is the change between pre fire and post fire:

$$dNBR = PrefireNBR – PostfireNBR$$

dNBR assesses the severity of the burn and the change is shown as a value ranging between -1 and 1. The most severe burn damage occurs in values above 0.66 and healthy unaffected vegetation occurs in the negative values. In the case of an asteroid impact, NBR could be used instead of NDVI as it can show the severity of the impact based on vegetation burned. Using pre-fire imagery (Fig. 3) and post-fire imagery of the same area (Fig. 4) the dNBR can be used to map out areas of damage.

Least cost path is a distance GIS technique used to find the optimal route between two points. In this analysis more than one variable are used in the algorithm to select the best path that minimizes cost. In the case of a disaster, surface, distance, and other variables such as access to emergency resources are used to model the terrain. Figure 6a shows least cost path using type of land and depicts the shortest path. Figure 6b shows least cost path determined by elevation. This technique is helpful when used with post disaster satellite imagery and current terrain limitations to determine best routes for emergency responders.

Conclusions and Further Research

The uncertain location of an asteroid impact makes response plans more difficult to implement. The knowledge of an approaching asteroid toward earth, with months to years in advance, can help in the planning and preparation for impact. However, even small changes in trajectory or size of the object can mean that any given location can be at risk of impact, and teams on the ground will have less time to prepare. For this reason, it is imperative that governments and organizations have agreements in place ahead of an asteroid impact to implement response plans that focus on loss reduction and potential relocation of populations in the affected area. Further research is necessary to explore the use of GIS and remote sensing, in real-time, to analyze potential and feasible response plans after an asteroid impact. There are limitations to the use of GIS in disaster response as the suitability and scale of spatial data may not be available in real-time (Zenger and Smith 2003). Disaster response can include search and rescue efforts, locating available resources including shelter or emergency services, and assessment of further threats. One key criterion to accomplish this work is identifying funding, not only for disaster response but also for public education. Human fear can hinder response efforts, so it is crucial there is constant communication and education of the public. Generally, asteroid impacts are not viewed as a real threat by the public despite the earth's long history of impact events.

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