A Refuge Location Prediction System for Supporting Disaster Medicine

Akihiro Kawabe[1]and Tomoko Izumi[2] and Yoshio Nakatani[3]

[1] Graduate School of Science and Engineering, Ritsumeikan University, Kusatsu, Shiga, 525-8577 Japan, e.mail:is013087@ed.ritsumei.ac.jp

[2] College of Information Science and Engineering, Ritsumeikan University, Kusatsu, Shiga, 525-8577 Japan, e.mail:izumi-t@is.ritsumei.ac.jp

[3] College of Information Science and Engineering, Ritsumeikan University, Kusatsu city, Shiga, 525-8577 Japan, e.mail:nakatani@is.ritsumei.ac.jp

Abstract

During the 2011 Tohoku Earthquake and Tsunami, DMATs (Disaster Medical Assistance Teams) could not rescue victims efficiently with accurate location data, because the local governments had lost refuge location data and resident registers due to damage caused by the tsunami. In this paper, to support DMATs, a refuge prediction system based on the characteristics of disaster, landscape, and victims' psychology is proposed, which can function even if local governments lose information about victims and refuge locations. As an example, this system deals with tsunami. We demonstrate the effectiveness of this system by comparing the data of the 2011 Tohoku Earthquake and Tsunami and our prediction system.

1 Introduction

All over the world, suffering is caused by various kinds of natural disaster, including typhoons, floods, volcanic eruptions, and earthquakes. Japan is particularly affected by earthquakes, as the country is surrounded by four tectonic plates. According to recent statistics, magnitude 2.0 earthquakes occur in Japan about 10,000 times a year. For that reason, Japan is a country of frequent earthquakes and many earthquakes happen every year.

The 2011 Tohoku Earthquake and Tsunami occurred on March 11, 2011, killing more than 15 thousand people. This earthquake's magnitude was 9.0, which ranks fourth highest in global statistics of the past 100 years.

In this disaster, many hospitals and medical institutions were damaged by the tsunami, causing shortages of doctors. To solve this issue, DMATs (Disaster Medical Assistance Teams) supported the disaster area. In spite of the DMATs' early dispatch to the disaster area, they were not able to rescue with accurate location data, due to the fact that town office administration stopped because many coastal town offices suffered from the tsunami. There were no means of contacting victims, as the town offices had lost records of the sufferers' addresses. It is predicted that the probability of a Nankai or Tonankai Earthquake occurring in Japan within 30 years is over 60 percent. In future, when earthquakes occur, it is vital to know victims' addresses, conditions and ages in order to make full use of DMATs' abilities.

In this study, we propose a refuge prediction system for supporting disaster medicine from the viewpoint of disaster characteristics, regional characteristics and psychological characteristics, which can be used even when local governments are not able to acquire information on victims' addresses and conditions.

2 Related Work

During a disaster, it is important to exchange disaster information. In the 2011 Tohoku Earthquake and Tsunami, DMATs were not able to acquire sufferers' addresses or refuge location information, as the local governments that should have performed this task were too damaged by the tsunami. In order to solve these problems, DMATs must establish who is in need of rescue, where they are, and acquire refuge location data. If information cannot be obtained from sufferers, we need to predict refuge locations in some way. In this disaster, such support was not provided.

Over the past few decades, a considerable number of studies have been conducted on predicting refuge locations. We briefly introduce such research.

In 2009, Asakawa et al. proposed a system that shares the location information of the user by displaying it on a map. This system attaches these data to Google Maps using a mobile phone camera and GPS function. By sharing the data as map information, the system links between Google Maps and the physical world. Thus, Asakawa et al,'s system proposes an environment in which information can be exchanged as a reality.

In 2007, Tanida and Daito proposed a method for specifying victims' locations using IC tags when the telephone network fails in the damaged area, and demonstrated the system's effectiveness by simulation. In their system, a helicopter scatters active type IC tags on the ground, and the system specifies victims' locations by trilateration with three fixed IC tags and the location-unknown subject's IC tag.

In 2011, Google constructed the "Google Crisis Response System" in response to the Tohoku Earthquake and Tsunami. This system displays refuge locations with markers in Google Maps, and displays the number of evacuees by marker color. In addition, this system can output refuge location data for all forty-seven Japanese prefectures in CSV and KML formats.

In 2011, Iizuka et al. proposed a system that collects disaster situation information and shows it on a map when institutions such as universities are affected by disaster.

It is thus clear from the above research that it is effective to show disaster information on maps. However, sufferers were forced to take refuge in unexpected places by the Tohoku Earthquake's large tsunami, and rescue attempts by DMATs were hindered because the tsunami destroyed many designated refuge places. Therefore, a system is required that can predict refuge locations in advance, and give this data to DMATs, thus supporting disaster medicine

3 System Construction

The purpose of this research is to predict disaster victims' refuge locations, with the system's user envisaged as a disaster countermeasures office. Based on the system's results, DMATs can go to the forecast locations, and start rescuing.

Other disaster countermeasures offices can use this system even if the relevant office has suffered damage from flooding or earthquake. In such cases, the only necessary items are a database and a PC terminal. Therefore, external support is possible.

We used Google Maps to display refuge locations. The process of the system consists of the following web application tasks.

① The user clicks the area in which an earthquake occurred on Google Maps, and the system indicates the hypocenter with the mark '×', displaying latitude, longitude.

② The user inputs the expected maximum tsunami height, and the system predicts refuge locations using these data, in cooperation with the refuge location database.

③ Predicted refuge places are outputted as XML data, then, the system stores the XML data using JavaScript, and displays the refuge locations on Google Maps with markers.

④ Markers are not displayed if tsunami height is higher than the refuge location's altitude. This system also shows refuge location names and the number of evacuees if a marker is clicked, as shown in Figure 1.

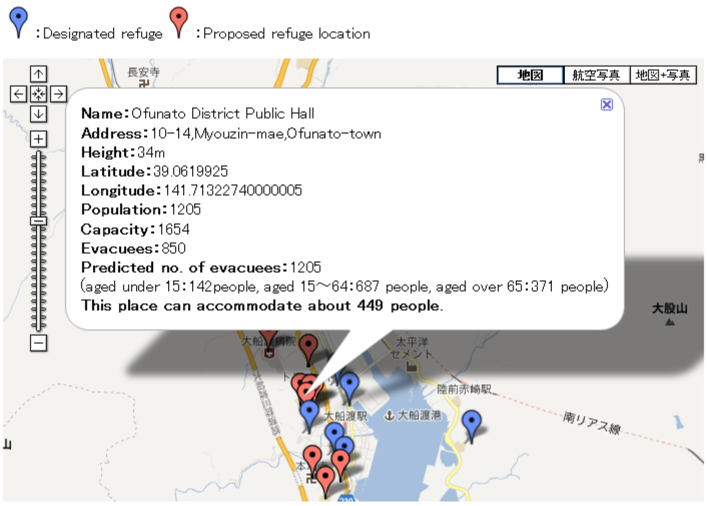

Figure 1: Output example: marker detail

The disaster countermeasures office can predict refuge locations using the above system functions. The system architecture is shown in Figure 2.

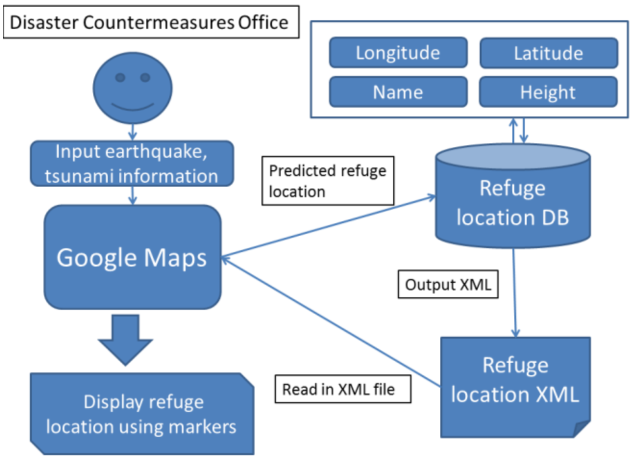

Figure 2: System architecture

4 System Evaluation

We conducted interviews with professionals in the field of fire department disaster prevention (Konan Fire Department, Kyoto City Fire Department), and we clarified issues by interviewing DMAT members about their problems and requirements.

4.1 System Efficacy

We obtained opinions regarding this system's usefulness, which are summarized below.

① After an earthquake, there is no way to acquire victims' information, thus this system is useful because we can obtain victims' location data, and refuge location information.

② If this system can get exact population data and refuge location information, we consider the system's population estimation algorithm to be effective.

③ There is some possibility of various applications (e.g. helping us to deliver relief goods to unknown places).

4.2 System Improvements

Areas in need of improvement were pointed out by fire department disaster prevention professionals, and are summarized below.

① This system needs to make predictions that consider alterations to the maximum tsunami height.

② DMATs may not understand victims' locations only by using a map of the disaster area, as extensive damage can cause changes to roads and townscape.

③ Refuge location prediction changes according to season, area and time of day, therefore this system needs to include these factors in prediction.

④ To achieve reliable rescue by DMATs, we must obtain accurate information of municipal population and accommodation capacity when the system constructs the refuge location database.

⑤ The system should display information regarding numbers and/or proportion of persons requiring rescue and those with injuries.

4.3 Future Work

According to the results of the system's evaluation by Konan Fire Department and Kyoto City Fire Department, it would be useful in future to predict the number of victims, their locations and ages when DMATs are dispatched for early rescue in disaster medicine. Also, this system needs to predict based on town office resident data. However, there are some problems: for example, there is a lack of a framework in which resident data is exchanged with neighboring town offices, and many town offices do not keep backups of resident data. This system must solve these problems in order to be ready for practice use.

Another issue of this system is that it needs real-time processing for disaster countermeasures offices to use the system. If DMATs visit refuge locations using this system, they can confirm the number of evacuees and their ages. However, it may occur that a DMAT may hear evacuees talk about a different refuge location which the system had not predicted. Consequently, this system needs to modify its data with real-world circumstances so that DMATs can get accurate information.

Also, the system needs to incorporate a comparison of pre-disaster and post-disaster photos and location referencing with GPS, because it is difficult for DMATs to understand their positions when team members are not familiar with the region. In future, we aim to build a platform in which local residents can mutually register the information. For example, local residents could register refuge locations and places where in the past ground liquefaction had occurred. Thus, when an earthquake occurs, disaster countermeasures offices could extract information from this platform.

5 Conclusion

In this paper, we proposed a system that predicts refuge locations in times of disaster so that DMATs can rescue effectively based on this information. In large-scale natural disasters such as the 2011 Tohoku Earthquake and Tsunami, DMATs were unable to obtain victims' locations and refuge location information because local governments that held such information had suffered extensive damage from the tsunami. The purpose of this research is to support disaster medicine. As confirmed by evaluation from professionals in fire department disaster prevention, it is important for us to predict refuge locations. However, there are many problems. In future, we will improve this system in order to achieve greater reliability of refuge location prediction. Furthermore, as the current system can only predict refuge locations in the case of tsunami, we aim to improve the system to predict refuge locations in the context of various disasters, including fire and floods.

References

References from Journals:

Kenta Asakawa, Kento Hirano, Tetsuya Tsukada, Yasuhiko Hayashi, Yusuke In, Yasuhiro Omiya, Tatsuaki Hamai, Hitomi Murakami: Collection and presentation of a system for safety information in disasters. ITE Technical Report Vol.33 No.11 (2009) pp.123-126

Kayo Iizuka, Yasuki Iizuka, Kyoko Yoshida.: A Real-time Disaster Situation Mapping System for University Campuses. HCII 2011, LNCS 6778, (2011) pp.40–49

References from Books:

Yoshimitsu Okada.: Japanese earthquake map. Tokyo Shoseki. (2004) pp.7-9

Yomiuri Shimbun Special compact edition one month after the Tohoku-Pacific Ocean Earthquake. Yomiuri Shimbun. (2011) pp.64-65.

References from Other Literature:

Tanida Noriyuki, Daito Masatora.: Agent Based Modeling for Finding Victims with IC tag.

References from websites:

The Headquarters for Earthquake Research Promotion.. www.jishin.go.jp/main/p_hyoka02L.htm (27 Augsut. 2012).

Google: Google Crisis Response: A Google.org project . http://shelter-info.appspot.com/maps (28 Augsut. 2012).