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Prototyping of Community-based Hazard Mapping Support System for Traditional Towns with Local Heritage

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Abstract: This paper describes the design and trial development of a system that supports continuous hazard mapping by local residents in their daily life. We performed an interview survey to design our system in a model traditional town in Saga Prefecture, Japan. The results show that despite continued efforts, many practical problems remain and residents feel unsafe. Considering these results, we designed and developed a unique information and communication technology-based support system that contributes to community-based disaster prevention and reduction. The continuous resident participation and posting design are the core concept for our community-based approach. Our system continues to support making a hazard map by integrating the community-based hazard information. Local residents register information (disaster types, risk level, photographs, comments, positional information) about locations that could be dangerous in a disaster. In addition, our system enables information sharing through a Web server. We expect that this information sharing will allow local hazard information for each district to be used.

Keywords: Disaster Prevention, Hazard Map, Traditional Town, Community-Based, ICT-Based.

1. Introduction

Japan is a disaster-prone country because of its geographical, topographical, and meteorological conditions (Disaster Management, Cabinet Office, 2015). The country faces the threat of various natural disasters, such as earthquakes, typhoons, and volcanic eruptions. Disaster prevention and reduction measures have been strengthened following the Great East Japan Earthquake and subsequent disasters, including volcanic eruptions, and landslides and flooding caused by heavy rain.

Disaster imagination games (Komura, T. & Hirano, A., 1997), which are map exercises to improve disaster prevention in communities, and a variety of information and communication technology (ICT)-based approaches, including information collection by cameras and sensors, ICT disaster information notification, and game-based training, have been developed (Geospatial Information Authority of Japan (GSI),2017; Mitsuhara, H. et al., 2015).

Although cities are better prepared to cope with future disasters because of their advanced infrastructure, there are many traditional Japanese towns that suffer from specific risks (Japan Guide.com, 2012). These towns are characterized by the preservation of the traditional landscape and environment, depopulation, and aging. They are vulnerable to disasters because these factors cause spatial and human constraints. Disaster prevention measures adapted for these towns are now being studied (Mishima, N. et al., 2015; Nakai, F. et al., 2014; Nonomura, A. et al., 2016; Park, S. G. et al., 2015; Sakuma, A. et.al., 2015). A prospective ICT-based disaster prevention approach for local heritage is large-scale networks that use sensors and benefit from advanced ICT (Min, B. W. et al., 2015). However, this requires large investment in equipment, including initial installation costs and maintenance costs.

Our approach in this paper is small-start ICT-based disaster prevention, which is rooted in the region and based on the characteristics of these towns (Kozaki, S. et al., 2016; Mori, S. et al., 2015; Okazaki, Y., et al., 2015; Okazaki, Y., et al., 2016). In these traditional local towns, there is a characteristic that there is a strong connection between residents. Our approach is to utilize the power of these local communities in disaster prevention and reduction by ICT. To safeguard livelihoods, our system encourages local residents to be conscious of disaster risks and to participate in disaster prevention and reduction activities. Furthermore, the system allows local residents to collect and record detailed hazard information. This continuous resident participation and posting design can make a major contribution to community-based disaster prevention and reduction.

We selected Hizen-Hamashuku in Kashima City, Saga Prefecture, Japan as a model area of a traditional local town (Saga Trip Genius, 2014). This area has retained its Edo-era architecture and has been designated as a nationally important traditional building preservation district (Wikipedia, 2017.). Figure 1 shows its historic town scenery. We carried out an interview survey on natural disasters with local residents of Hizen-Hamashuku to understand their needs and measures related to disaster prevention and reduction. Based on the results, we designed and implemented a hazard-mapping support system for traditional towns. We expect that this system will provide residents with better knowledge of disasters and deeper awareness of disaster prevention. The organization of this paper is as follows. In Section 2, we describe our interview survey for designing our system. In Section 3, we present our prototype hazard-mapping support system. In Section 4, we give our concluding remarks and outline future work.

2. Interview Survey

1.1 Methods

We performed a survey by face-to-face interview at the Hizen-Hamashuku community center on August 18, 2014 with 18 participants, who are district welfare officers or ward chiefs who play a leadership role in this region. We asked about existing measures for disaster prevention and reduction, problems with the present measures, and information sharing for disaster prevention and reduction.

1.2 Results

We identified the following problems by analyzing the survey results.

1.2.1 Existing Disaster Prevention and Reduction Measures

There is a voluntary disaster prevention organization that implements firefighting training once or twice a year, which has achieved some success in firefighting. We also found that there is a mutual assistance system, in which district welfare officers and chiefs of wards play leading roles during disasters. Although the voluntary disaster prevention organizations and the mutual assistance system are organized, their specific roles and cooperation are unclear. The effectiveness of these organizations should be improved.

Figure. 1. Historic town scenery of model area (Hizen-Hama shuku in Kashima City of Saga Prefecture in Japan)

1.2.2 Problems with Present Measures

Participants feel anxious about problems with the present disaster prevention and reduction measures. The following quotes are examples of these opinions. “There is not much awareness of disasters”, “Cross-district training is necessary”, and “Detailed local information about people requiring assistance, for preventing the risk of damage, and for escaping disasters safely is needed”. They also felt that they need customized disaster manuals for various types of disaster to provide action guidelines.

1.2.3 Information Sharing for Disaster Prevention and Reduction

The following quotes about information sharing were gathered. “Detailed hazard maps corresponding to the actual situation of each local community are needed” and “While some individual traditions involve past disasters, the information is not integrated or fully shared”. To enable mutual assistance to work effectively in a disaster, sharing local community information, such as information on people needing aid in a disaster and hazardous location notification, is necessary. Based on this information, action should be predetermined in cooperation with neighbors.

1.3 Findings

Voluntary disaster prevention organizations and the mutual assistance system have already been organized and measures for disaster prevention and reduction have been put in place. Actions during a disaster have not been fully examined, and local residents are anxious about them. In addition, we found that detailed local community information is required.

We sought to address the current problems with disaster prevention and reduction measures in the traditional town in this study and to help to reduce anxiety among residents about disasters by using ICT. Our system is intended to improve the disaster resistance of traditional towns by allowing local residents to design and implement action guidelines. Our system collects, integrates, and shares information about local communities and hazardous locations that is vital for customized disaster manuals

2. System development

2.1 System Overview

We have developed a hazard-mapping support system with community participation using location information (Kozaki, S. et al., 2016; Mori, S. et al., 2015; Okazaki, Y., et al., 2015; Okazaki, Y., et al., 2016). The disaster prevention awareness of residents can be improved by participation and local residents can collect detailed information. Making a hazard map with resident participation can improve sharing of local community information. The exchange of conventional information is based on conversations, telephone calls, and letters. Our system is implemented as an iOS application. We show the development settings and execution environment in Table 1. Figure 2 shows the system architecture and flow. Our system consists of portable devices to present and post information, a database on the Web server, and a Web-based information management system.

Our software on portable devices has a starting screen, a map screen, a positional information screen, and an information registration screen. The starting screen presents the system name and type of user. The map screen displays hazardous locations stored in the database and the present location of the

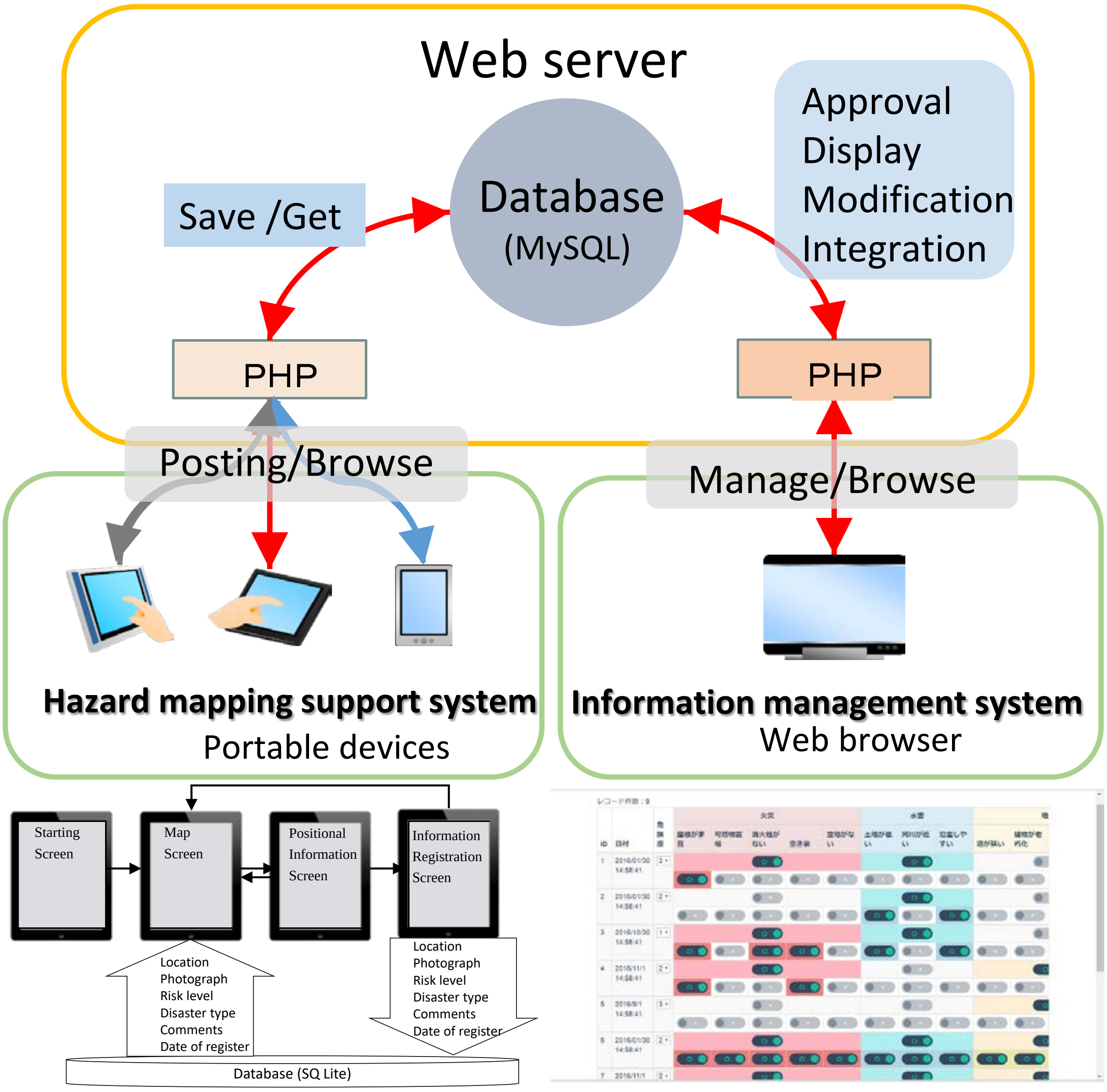

Figure 2 System architecture diagram

user. The positional information screen indicates the location to be registered. The information registration screen allows the disaster type, risk level, comments, and a photograph of the location to be input. These data are stored in the Web server database. The information is presented on the map screen as a hazard map.

Table 1Development settings and execution environment

Development environment	Xcode Version6.2 [19]
Programming language	Objective-C [20]
Operating system	OS X Version10.9.5
Execution environment	iPad Air 2, iPad mini3

2.2 Information Presentation

The map screen displays all hazardous locations stored in the database around the user's current location acquired by GPS (Figure 3). Balloons point to the hazardous locations and include a photograph of the spot. A user can see detailed information (disaster type, risk level, comments) about a location by tapping the balloon (Figure 4).

2.3 Information Posting

When a user posts information, first they specify the location. Using GPS, a red pin is placed automatically at the current location (Figure 5), which can be dragged to the intended location if required. The positional data for the pin is passed to the next information registration screen. In this

Figure 3. Map screen (default)

Figure 4. Map screen (focusing)

screen, the user inputs the disaster type, risk level, comments, and a photograph of the spot. Additional free descriptions can be added (Figure 6). These data are stored in the internal database. The information is reflected on the map screen. Integrating the information forms a hazard map of the area.

2.4 Information Sharing

An information-sharing function is accessed by tapping the information update button on the map screen. The information saved in SQLite on the tablet device is sent to a designated PHP program on the Web server. This information is combined with previously sent information and is saved in MySQL on the Web server. The photo data is sent to a directory on the Web server and the reference path for the photo data is saved in MySQL. Thus, information is collected from each tablet device and integrated on the Web server. The integrated information is output as a JSON file and each tablet device receives that file. The received information is overwritten before the information is saved in SQLite on the tablet device.

2.5 Information Management

Our system provides four information management functions: an approve function, a display function, a modify function, and an integrate function. The approve function ensures the reliability of information that has been posted by requiring system administrators to approve information. The display function provides only the information necessary for the residents by hiding old and irrelevant information. The modify function provides more reliable information by allowing the posted information to be modified on the Web server side. The integrate function improves the quality and ease of viewing of the information by organizing and integrating several pieces of information. The integrated information is directed to where there are several pieces of information posted at the same location. The integrated information is registered in the Web database. Because we can refer to the information prior to integration, the system keeps the integration history. The integrated information is stored in the database as new information.

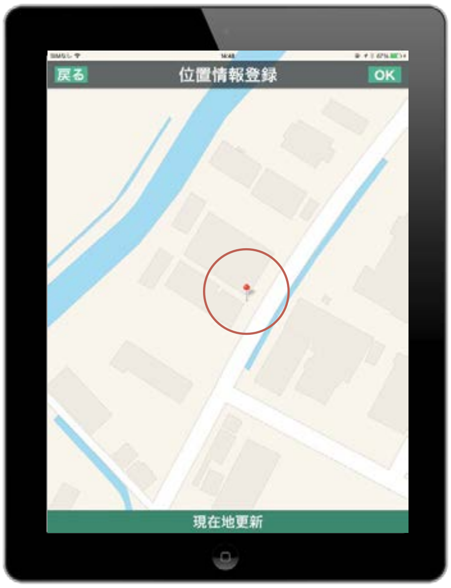

Figure 5. Positional information screen

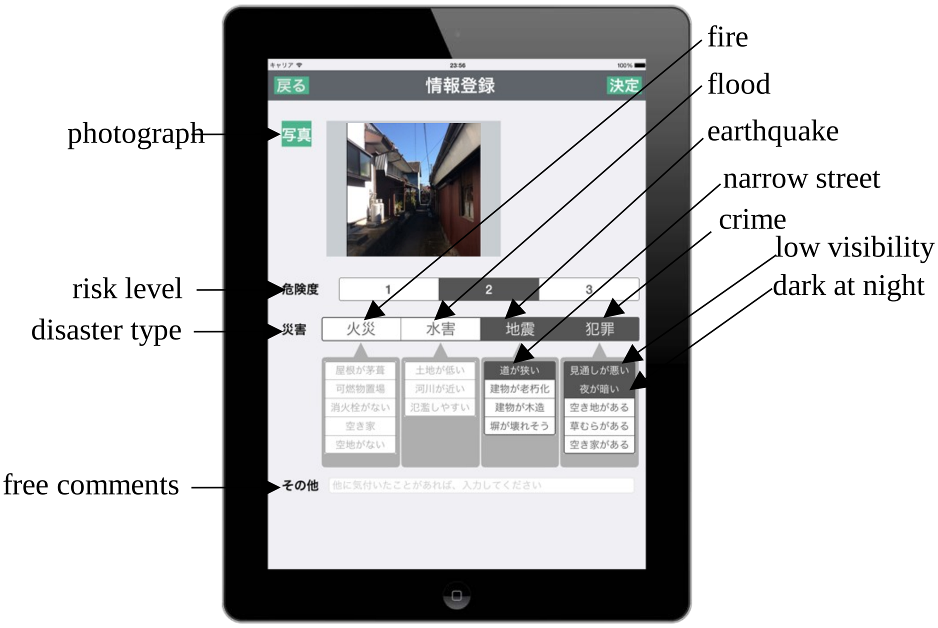

Figure 6. Information registration screen

3. Discussion

In this section, we discuss the basic performance of our prototype system based on our trial test in the field. A total of ten people, five local people and five Saga University teachers and students. We explained a function and how to use the system for around 15 minutes to participants. We divided all into three groups and assigned the area to investigate. We all went around the area for 40-50 minutes and input the data of hazardous location. A total of 27 locations, 46 information was registered in just less than one hour.

3.1 Collection of Local Hazard Information

Information associated with flood hazards was registered in low-lying areas, whereas hazard information for fires and earthquakes was registered where houses are clustered. This indicates that it was possible to collect information about hazardous locations from local residents in a short time.

Our trial experiment shows that people in the region are most concerned about earthquake hazards. The next greatest concern is the risk from crime rather than from other natural disasters. This is because fire hydrants and river improvement work have reduced the risk from fire and flooding.

Originally, the targets of the hazard maps were natural disasters, such as earthquakes and floods. In this study, we considered crime from the perspective of the safety of local residents. Our field test revealed potential anxiety about local crime.

3.2 Operational Performance

Our system is designed to allow elderly people who are not used to digital terminals to input information by touching presented choices. The comments for each hazard are also prepared and easily selected by touch. In addition, a user can input original comments by using a keyboard. One user expressed the opinion “It was easy to use”. The user input worked smoothly and input took about one minute per entry. These results demonstrate that our system is a user-friendly iOS application.

3.3 Overlooked Information

We also identified the necessity of multiple viewpoints. Posting information from local residents makes it possible to register unique local information. However, residents may overlook hazards because they become familiar with and complacent about risks.

4. Conclusion and Future Work

We have designed and implemented a hazard-mapping support system for traditional towns with local heritage based on an interview survey with local residents of the model area. Community-based disaster prevention and reduction is the main feature of our approach. Our system encourages the participation of local residents and allows residents to collect detailed hazard information about the area. The continuous resident participation and posting design are core concepts for our approach, which can make a major contribution to lasting community-based disaster prevention and reduction.

Our system creates a hazard map by displaying the posted hazard information on the map. Local residents register information (disaster type, risk level, photographs, comments, positional information) about locations that could be hazardous in a disaster. We have tested the usefulness and possibilities of our prototype system in the model area. The easy-to-use interface contributed to the smooth registration of information. Our prototype system demonstrates ICT-based hazard mapping by local residents and the potential of our system.

In future work, we will organize information management schemes in cooperation with local residents. We will use our system to make a practical hazard map and demonstrate our ICT-based approach to community-based disaster prevention and mitigation.

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