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Development of a Sustainable Community-based Hazard Map Creation Support System for Traditional Towns with Local Heritage

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ABSTRACT

This paper describes design and development of a system that supports continuous creation of hazard maps by local residents in their daily life. We made an interview survey to design our system in a model traditional town in Saga, Japan. The results show that in spite of continuous efforts, many practical problems remain and residents feel unsafe. Based on these results, we designed and developed a unique ICT-based support system which contributes to community-based disaster prevention/reduction. The continuous resident participation and posting design are core concept for our sustainable community-based approach. Our system continues to support making a hazard map by integrating the community-based hazard information. Local residents register information about the spot (disaster types, a risk level, a photograph, comments, positional information) that can be dangerous in case of disaster. We have evaluated the usefulness and possibilities of our prototype system implemented as an iOS application.

Key words*: Disaster Prevention, Hazard Map, Traditional Town, Sustainable, Community-Based, ICT-Based.*

1. INTRODUCTION

Japan has many natural disasters such as earthquakes and typhoons, or volcanic eruption. Therefore, studies on these disasters have been made widely [1]. After the Great East Japan Earthquake Disaster (March 11, 2011) [2], efforts of disaster prevention and reduction have been further strengthened. Not only a DIG (Disaster Imagination Game) which is a map exercise for disasters to enhance disaster prevention of communities [3], but also a variety of ICT-based approach including information collection by using cameras and sensors, notification of disaster information by using ICT or game-based training has been proceeded [1], [4], [5].

While cities better prepared to cope with future disasters due to the upgrade of infrastructure is advanced, the traditional local towns that exist in various parts of Japan [6] suffers the problems specific to them. The traditional local towns are characterized by preservation of traditional landscape and environment, depopulation and aging. They are vulnerable to disasters because these factors causes spatial and human constraints. Disaster prevention efforts adaptive for such local towns have attracted an attention and are studied recently [7]-[11].

One of prospective ICT-based disaster prevention approach for local heritage is large scale networks which utilize sensors [12]. This receives benefits of advanced ICT. However, it requires a large scale investment in equipment including initial installation costs and maintenance costs.

Our approach in this paper is small start scalable ICT-based disaster prevention, which rooted in the region and based on the characteristics of these towns as disaster prevention efforts in these constraints [13]-[15]. Distinctive features of our approach is sustainable community-based disaster prevention and reduction. To achieve safety and sustainability of livelihoods, our system encourages the local residents to be conscious of disaster risks and to participate disaster prevention/reduction activities. Furthermore, it enables the detailed hazard information collecting and recording by local residents themselves. This continuous resident participation and posting design can make a significant contribution to sustainable community-based disaster prevention and reduction across the ages.

This is an excellent paper selected from the papers presented at ICCC 2015.

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

We selected Hizen-Hamashuku in Kashima City of Saga Prefecture in Japan as a model areas of traditional local towns [16]. This region has remained old city from the Edo era and has been designated as nationally important traditional buildings preservation districts [17]. Fig. 1 shows snapshots of historic town scenery.

In this study, we have an interview survey on natural disasters to local residents of this model area so as to understand the needs and efforts in the field related to disaster prevention and reduction. Based on the results, we designed and implemented a hazard map creation support system for traditional towns. Our experiment of the prototype system demonstrates examples of ICT-based hazard map creation by local residents and future potential of the system.

In order to describe contributions of this paper, we first present our interview survey to design our system in Section 2. We present our hazard map creation support system in Section 3. In section 4, we evaluate our system by experiment in the model town. Finally we arrange concluding remarks of this study and some tips for future works.

2. INTERVIEW SURVEY

2.1 Methods

We had a survey by face-to-face interview at community center of Hizen-Hamashuku on August 18, 2014. Conditions of interview is shown in Fig.2. We got the answer from 18 participants, who are district welfare officers or chiefs of wards. They play a leadership role in this region. We asked the following three points. The first is existing efforts for disaster prevention and reduction. The second is anxiety and difficulty in the present efforts and the last is information sharing for disaster prevention and reduction.

Fig. 2. Face-to-face interview survey at the model area

2.2 Results

We found the following issues by analyzing the survey results.

2.2.1 Existing Efforts for Disaster Prevention and Reduction

There is voluntary disaster prevention organizations. It implemented firefighting training once or twice a year. This effort achieved a certain level of effect in firefighting. We also found that mutual assistance system was organized, in which district welfare officers and chiefs of wards played leading role in case of disasters.

Although the voluntary disaster prevention organizations and the mutual assistance system are organized, specific roles and their cooperation are not clear. To enhance the effectiveness of these organizations is the issue.

2.2.2 Anxiety and Difficulty in the Present Efforts

Participants have anxiety and feel difficulty in the present efforts in disaster prevention and reduction. The followings are example voice. "There is not much awareness of the disaster.", "Cross-district training is necessary." and "Detailed local information about requiring assistance people, for preventing the risk of damage and for escaping disasters safely.". Another voice is that they need customized disaster manuals for various disaster types which instructs them to action guideline.

2.2.3 Information Sharing for Disaster Prevention and Reduction

For sharing of information, the following voice was heard. "Detailed hazard map corresponding to the actual situations of each local community is necessary" and "While individual tradition includes past disasters, these information is not integrated and not fully shared".

To enable the mutual assistance to effectively work in case of disaster, sharing local community information such as information on persons in need of aids on occasions of disaster and hazardous location notification is necessary.

Based on this information, it is necessary to pre-determined concrete actions in cooperation with neighbors.

2.3 Findings

As we mentioned above, voluntary disaster prevention organizations and the mutual assistance system have already been organized and efforts for disaster prevention and reduction have been made. Also concrete actions on occasions of disaster are not fully examined and local residents have anxiety and feel difficulty about them if they have emergency faced with disaster. In addition, we found that the detailed local community information is required.

Against issues in disaster prevention and reduction efforts in the traditional local town found in this study, we are going to address the issues and help the anxiety reduction for the disaster of residents by taking advantage of the ICT.

The purpose of our system is to improve disaster resistance of the traditional local town by allowing local residents to design and implement concrete action guidelines. Our system supports to collect, integrate and sharing information about local community and hazardous location indispensable for customized disaster manuals.

3. SYSTEM DEVELOPMENT

3.1 System Outline

We have developed a hazard map creation support system with community participation type using the location information [13]-[15]. Disaster prevention awareness of residents can be improved by participation activities. Local residents can collect detailed information. Making hazard map with resident participation activities can improve sharing local community information. The exchanges of the conventional information based on conversations, telephones and letters.

Our system is implemented as an iOS application. We show development settings and execution environment in Table 1.

Table 1. Development 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

Fig. 3 shows system architecture and flow. Our system is composed of four screens and a database. They are a starting screen, a map screen, a positional information screen and an information registration screen. The starting screen presents a system name and type of a user. The map screen displays hazardous location stored in a database and the present location of the user. The positional information screen is used to indicate the location to be registered. The information registration screen receives information of disaster types, risk levels, comments and a photograph of the location. These data are stored in the internal database (SQLite [18]). The information is reflected by a map screen and makes a hazard map.

3.2 Information Presentation

The map screen displays all hazardous location around the user's current location. It displays hazardous location stored in a database and the present location of the user acquired by GPS (Fig. 4). The balloons point to the hazardous location, which includes a photograph of the spot. A user can see the detailed information (disaster types, a risk level, comments) of the spot by tapping the balloon (Fig. 5).

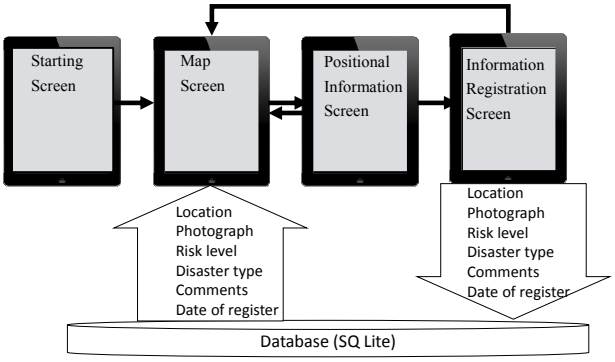

Fig. 3. System architecture and flow

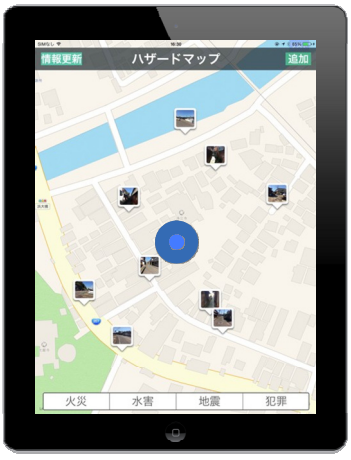

Fig. 4. Map screen (default)

Fig. 5. Map screen (focusing)

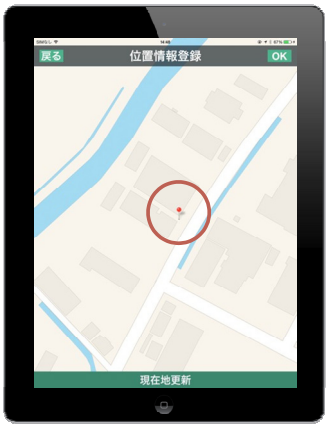

Fig. 6. Positional information screen

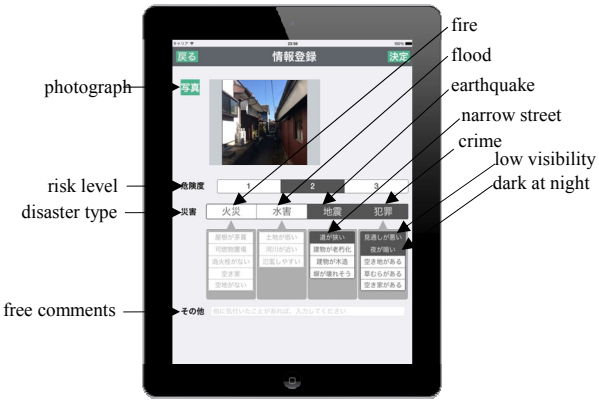

Fig. 7. Information registration screen

3.3 Information Registration

When a user registers information, at first he/she specifies the location of the spot. Using GPS, a red pin is placed automatically at the current location. It can be corrected by dragging the pin and appoint an intended hazardous location (Fig. 6). The position data that the pin points at is handed to the next information registration screen.

In this screen a user inputs disaster types, a risk level, comments and a photograph of the spot. Additional free description can be added (Fig. 7). These data are stored in the internal database. The information is reflected in a map screen. Integration of information forms a hazard map of the area.

4. EVALUATION EXPERIMENT

4.1 Experiment Outline

On October 17, 2015, we carried out an evaluation experiment in a total of ten people, five local people and five Saga University teachers and students. We prepared three iPad mini for the experiment. 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, which is stored in each iPad mini.

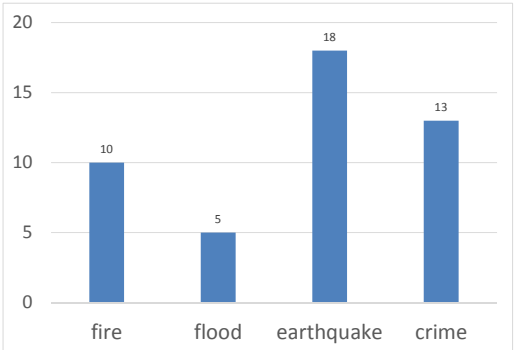

Fig. 8. Registered hazard for each disaster categories

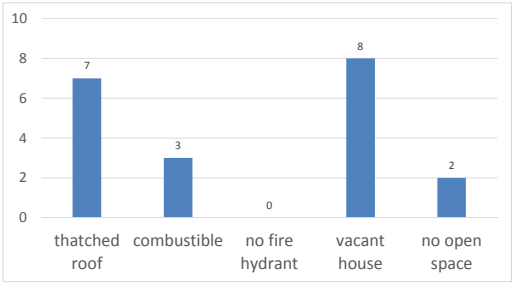

Fig. 9. Comments on fire

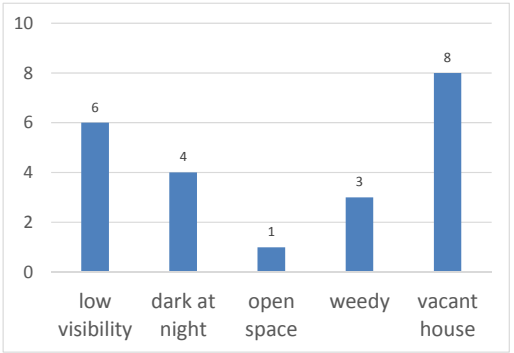

Fig. 10. Comments on crime

1. fire 2. flood 3. earthquake 4. crime

(a) Registered hazard data of Nakamachi-Hasshuku area (District A)

1. fire 2. flood 3. earthquake 4. crime

(b) Registered hazard data of MinamiFunatsu-Shokin area (District B)

Fig. 11. Comparison of each hazard information in two investigation areas

4.2 Results and Consideration

4.2.1 Collection of local hazard information

The Fig. 8 shows information collected by the experiment. A total of 27 locations, 46 information was registered in just less than one hour. The information associated with the hazard for flood was registered in the low land area. Also, the hazard information for the fire and earthquake was registered where the houses are clustered. This indicates that it was possible to collect information of hazardous location which local residents feel in their daily lives in a short time.

Our evaluation experiment shows that people of the region are the most concerned about the hazards due to earthquake.

The next is the risks from crime rather than other natural disasters. The reason why is that setting of fire hydrants and river improvement work would reduce the risk. Small fire hydrants which residents can use by themselves are equipped around the area of traditional wooden house clustering. Against the risk of fire, the anxiety of the fire hydrant equipment was zero (Fig. 9).

On the other hand, anxiety of crime is higher than the risk of fire and flood. This is because the existence of blind spot by clustering of old wooden houses or vacant houses (Fig. 10).

Although these houses can be a trigger of crimes, they cannot be removed easily with the objective of traditional landscape preservation.

Originally, the targets of hazard maps are natural disasters such as earthquake and flood. In this study, we consider crimes from the point view of the safety of local residents. Our experiment revealed potential anxieties for crimes in their own backyards.

Fig. 11 compares the data of selected two districts from three target areas. In the district A, there are small number of risks due to natural disasters, whereas larger number of risks for crimes are registered. In the district B, on the other hand, natural disasters are more concerned than crimes. This area is located in the downstream of the river and land is low. In addition, more old houses are clustered. These situation was reflected in the results.

In this way, it can be seen that there is a difference to the danger by the district even in a small area. Our system also allows visually-apparent comparison of the hazard information of each district. We believe that this can contribute to improve safety of local residents.

4.2.2 Operational Performances

Our system is designed for elderly person 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 the touch. In addition, a user

can input original comments by using a keyboard. There was an opinion from a user, "It was easy to use".

Actually, a user inputs smoothly, and input was completed in around one minute per one. These results demonstrate that our system has been developed as a user-friendly iOS application.

4.2.3 Possibility of Overlooking

We also revealed necessity of multiple viewpoints. Posting information by local residents make it possible to register local detailed information of residents unique. There are, however, dangers that people who lives there overlook, because these dangers are always around them without any trouble every day and they gradually do not mind them. This indicates that variety of viewpoints are necessary.

5. CONCLUDING REMARKS

We have designed and implemented a hazard map creation support system for traditional towns with local heritage based on an interview survey to local residents of the model area. Sustainable community-based disaster prevention/reduction is quite characteristic of our approach. We are focusing safety and sustainability of livelihoods. Our system encourages the participation of local residents and collects the detailed hazard information of the area by post of residents themselves. The continuous resident participation and posting design are core concept of our approach, which can make a significant contribution to sustainable community-based disaster prevention and reduction.

Our system makes a hazard map by displaying the posted hazard information on the map. Local residents register information about the spot (disaster types, a risk level, a photograph, comments, positional information) that can be hazardous in case of disaster. We have evaluated the usefulness and possibilities of our prototype system in the model area. As a result, we confirmed that our prototype system works well as expected. 46 information of 27 hazardous location was registered in less than one hour experiment. Easy-to-use interface contributed to the smooth registration of information. Our experiment of the prototype system demonstrates examples of ICT-based hazard map creation by local residents and future potential of our system. We evaluated our system in the model area. It, however, can be easily applied to any other towns because our system is a local iOS application, which requires only iOS devices with GPS.

The future works includes integration of the information inputted from other terminals and improvement of the quality of information by giving the authority of modification, mergence and deletion of information provided by the system.

After implementing these functions, we are going to apply our system continuously on a larger scale to demonstrate usability of our ICT-based modern approach of community-based disaster prevention and mitigation.

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