Disaster Information Sharing System using Pictograms: Representation of Multidimensional Information

Kakeru Kusano, Tomoko Izumi and Yoshio Nakatani

Abstract— **This work aims to support the actions of disaster victims, including tourists and persons who do not understand local language, via information sharing when disasters occur. Existing disaster support systems are often targeted at local residents, and understanding the local language is a prerequisite for use. In consideration of this situation, our system converts linguistic information to a nonlinguistic approach including maps, pictograms and multidimensional information. We propose a system that can express information visually, and operate information collection and provision intuitively. In this paper, we describe the prototype system, and an examination of future evaluation experiments to verify the system's effectiveness.**

***Index Terms*—Disaster Prevention, Information Sharing, Nonlinguistic, Pictogram and Multidimensional Information**

I. Introduction

A. Background

AT the present time, various measures are in place for disaster mitigation and disaster reduction in Japan, due to the influence of estimations of damage by a Nankai Trough Quake [1]. Moreover, during the Great East Japan Earthquake of 2011, social media played an important role in sharing disaster information among victims. Such utilization of social media during disasters, exemplified by Twitter, is gaining attention. A "Wisdom of Crowds" was constructed from multiple users' contributions (Tweets), and the effectiveness of this as an information infrastructure to ascertain the damage situation was recognized [2]. Interest in disaster mitigation and disaster reduction that utilizes such information infrastructure is increasing, due to the influence of anticipated major earthquakes and the disasters that have caused serious damage in recent years.

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However, the present information systems to support victims when disasters occur target only local residents, who are geographically familiar with the local area. That is, they require understanding of the local language. Tourists, who are likely to be geographically unfamiliar with the area, and non-local language speakers, tend to have difficulty in sharing and understanding information about the disaster, and to have greater damage than residents [3]. Therefore, a framework is required that can support all disaster victims, including persons predisposed to difficulty such as those described above.

B. Importance of Universal Disaster Mitigation

Methods to support disaster victims, including persons who cannot understand the local language and persons geographically unfamiliar with the area, by transmitting information visually and intuitively have been considered. Although multilingual system is one of the solutions to support foreigner disaster victims, there is no standard of the languages which should be handled in the system, and information provision sides have a high load if they provide a large amount of information in the various languages with expedition during the occurrence of disasters.

The Japanese FDMA (Fire and Disaster Management Agency) is creating a universal design for disaster mitigation pictograms using such a method. Pictograms are diagrams that express meaning using color and shape, which can transmit the meaning of information without using language [4]. These pictograms are created in accordance with the principles of graphic symbols stipulated by JIS (Japanese Industrial Standards), and are registered by the ISO (International Organization for Standardization). In this way, universal methods to support disaster victims are starting to be considered in Japan.

In this research, we propose a disaster information sharing system that is able to collect and provide information visually and intuitively using GIS (Geographic Information System) and pictograms. We constructed a system that does not only make use of zero-dimensional information that expresses information dealing with points, but also single dimensional information and two-dimensional information that express zones and areas using lines and plane figures. There are currently no existing systems in which the user not only collects multidimensional information about disasters, but can also post such information themselves. We aim to construct a disaster information sharing system that supports disaster victims' decision-making, as well as their grasp of the situation in the surrounding area, by

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implementing an interface that enables disaster victims to post information easily when disasters occur.

II. Related Works

A. Disaster Information Sharing Support System

Aoyama et al. proposed an information sharing system using WebGIS. Their system is a communication tool that is targeted at sightseeing spots [5]. Outside of disasters occurrence, businesses engaged in the tourism industry can use the system to provide tourism promotional information; during disasters, each of these businesses becomes a disaster shelter for tourists and local residents and transmits information. Their system assumes a wide range of users, including staff of local governments, residents, business personnel and tourists. A key feature of the system is the capability for users to mutually transmit information, whether during a disaster or in normal periods.

Transmission of information can be executed using the following four steps.

1) A registered user (including business personnel and residents) select either category of "sightseeing information" and "disaster prevention information".
2) The user confirms the geographical location for their information update or registration .
3) The user inputs detailed information.
4) The information is registered/updated on the GIS screen.

By dealing with information that is appropriate to the situation, Aoyama et al.'s system is grasped to play a role in ascertaining the local damage situation during the occurrence of a disaster. On the other hand, since it is necessary for users to input the location and details of the registered information in order to send such information, we can assume that the operation of the registration may be complicated for the victims because they must operate the information provision in times of emergency - i.e. the occurrence of a disaster - even if a wide range of users is assumed. Furthermore, understanding of the local language is a prerequisite of using Aoyama et al.'s system, so people who cannot understand the local language will have difficulty not only when contributing information, but also when understanding the contributed information. Accordingly, in our research we aim to resolve such problems by simplifying the system and providing information that have high visibility by using an intuitive interface.

B. Information Collection Support System for Disaster-affected Areas using Mini-blogs

Yokobe and Nakatani proposed an information collection system using social media and mini-blogs to collect information when disasters occur [6]. Social media and mini-blogs have high real-time applicability, and are capable of responding to the fluid situations that arise when disasters occur. In this system, unnecessary and unreliable information is deleted in accordance with the following two assumptions.

1) Useful information for victims is sent from disaster-affected areas.
2) The reliability of information is evaluated by people in the area where the information is sent.

Based on these assumptions, Yokobe and Nakatani's system deletes information which is sent from areas geographically separated from the disaster affected area. Specifically, they assume that information with exact location data has high reliability, and the reliability of each Tweet and Twitter user is evaluated based on the location data and responses from people living around the location where the Tweet is sent. From the results of their evaluation, it was demonstrated that Tweets that included geographical names had a strong relationship with the disaster-affected area. This fact implies that geographical names are important in deciding the reliability of Tweets.

However, most Tweets do not contain location data, and there is no such service in Twitter itself. Thus, the ascertainment of reliability based on location data is not available in many cases. Moreover, a problem inherent in Twitter is that when Tweets are sent by a huge number of users in a short time, all these Tweets are displayed on the Time Line, making it difficult for the user to comprehend all the information. As a vast amount of the latest information is displayed during the time taken by a user to read a single Tweet, there is a risk that information valuable to the user may be missed.

In October 2012, disaster prevention training utilizing social media was conducted in Japan [7]. In this training, disaster victims identified evacuation shelters that were posted on social media, and traveled to those evacuation shelters in reality. During the training, there was a major information gap in proportion to the level of comprehension when using an information system, due to problems such as users who were not familiar with dealing with social media being unable to understand where the evacuation shelter information was posted on social media, and users who could not understand how to use social media itself. In this way, the difficulty of using social media effectively during disaster situations was confirmed. It is thus necessary to make innovations such as providing an easily understandable interface to users in which large amounts of information are condensed before displaying. To resolve such problems, we attempt to utilize pictograms and GIS for input and output of information in this research.

III. Outline Of Proposed System

A. Basic Policy

In this research, we aim to construct a system that performs both information collection and information provision when disasters occur, with all disaster victims as a target. This system will enable sharing of disaster information among disaster victims via implementation of an interface that allows information to be collected and provided visually and intuitively, even if users do not know how to operate the system.

B. Preliminary System Outline and Evaluation Experiment

As a preliminary study, we constructed a system for sharing disaster information that converts linguistic information to GIS and pictograms, as a nonlinguistic approach [8]. By allocating pictograms on GIS, the system expresses information visually about the disaster situation at specific locations. Additionally, this system enables the user to execute information provision intuitively by incorporating pictograms and gesture operation using a touchscreen display when users operate the system. Furthermore, the following functions are constructed utilizing network and GPS (Global Positioning System).

- The screen on GIS is displayed. In the screen, the current position of disaster victim getting from network and GPS is the center.
- Disaster information to be contributed by users is collected in the server.

By providing the above functions, we constructed a system for showing information surrounding the user and sharing disaster information among disaster victims.

In the evaluation experiment, we conducted two separate trials: for disaster mitigation experts and for normal users. The expert group consisted of three persons from the Disaster Management Office of Kyoto City and twelve persons from Konan Regional Fire Administrative Organization, Shiga Prefecture. The results of the evaluation experiment conducted with these subjects are summarized below.

- It is highly beneficial for disaster victims to obtain information during their evacuation or going back their home.
- Victims are able to obtain information immediately, because information is simply expressed by using Pictograms and GIS.
- Because victims are able to know the situation the surrounding area, they psychologically calm down.

On the other hand, subjects gave the following suggestions for improving disaster information using the system.

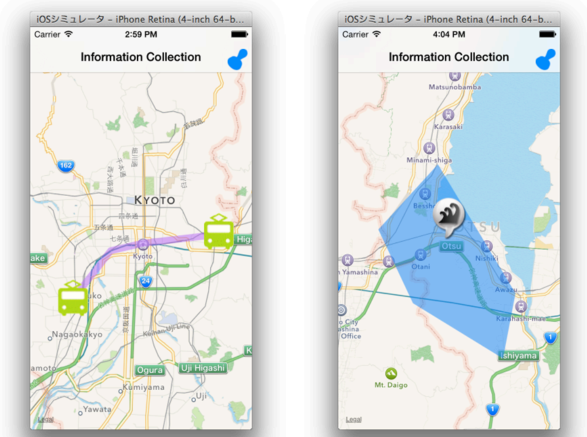
- The system should provide not only facilities which are not available, but also available ones.
- In the case of providing transportation information, the traffic section needs for disaster victims, not limited to travelling condition.

Moreover, we conducted an evaluation experiment with a group of normal users, consisting of two Chinese exchange students and six Japanese students. The method of this experiment was to use the system without any explanation of the method of operation. As a result, the normal users were able to use this system.

From the results of the evaluation experiment using this system, we were able to confirm the effectiveness of this nonlinguistic approach using pictograms and GIS to simplify information tranmission and collection related to disaster information sharing. On the other hand, to make disaster victims understand the disaster situation, the subjects pointed out the problems about the variation of provided information and the display format of them.

C. Multidimensional Information Sharing

In the system that we implemented during the preliminary research, information was shared as zero-dimensional information on GIS. This zero-dimensional information showed single-point information that corresponded only to one specific coordinate. However, among the information required by disaster victims during a disaster, there exists some information that is difficult to express as zero-dimensional information. One typical case is the zones of available public transportation operation. Although this information is important for disaster victims in order to evacuate or return home, it is desirable to handle this information as single-dimensional information, as a line connecting the transport route from the starting station to the terminal station. Similarly, when describing areas of damage such as flooding on GIS, this information is expressed as a plane - in other words, two-dimensional information. Specifically, this can be expressed by colorizing the corresponding area, as shown in Fig. 1.



Single Dimensional Information | Two-dimensional Information

Fig. 1 Input / Output of Multidimensional Information

In this research, we propose a multidimensional disaster information sharing system that not only provides single-dimensional information and two-dimensional information to show route and area, but also collects multidimensional information from disaster victims.

IV. System Architecture And Functions

A. Development Environment

This system uses a client-server model and is constructed as an iOS application and a Web application consisting of PHP programs and a database, similarly to our preliminary research. The reasons for utilizing an iOS device application on the client side are as follows.

1. iOS devices are portable devices that can be carried easily when disasters occur.
2. Intuitive operation is possible using the touchscreen display.
3. It is possible to save information such as image of pictograms in the devices before disasters occur, and thus, the load on communication channels is small.

We used the Objective-C language for the client application, and PHP and MySQL as the development environment for the server application, to construct a client-server model using an iOS application.

B. System Architecture

The system is consists of a client device that the user provides/collects information, and a server that responds to the client's requests. The database of the server application contains two tables as shown in TABLE I and TABLE II. The first is used for saving zero-dimensional information, and the second for saving single-dimensional information and two-dimensional information. The zero-dimensional information represents single-point information, that is, it corresponds only to one specific coordinate. The single dimensional and two-dimensional information represent a route and a range respectively, that is, they must have multiple coordinates to represent the route or range. Thus these multidimensional information are saved in the another table of database.

TABLE I
DATABASE TABLE OF ZERO-DIMENTIONAL INFORMATION

Name of Data
Name of Pictograms
Date and Time
Name of Contribution
Latitude (Coordinates of Information)
Longitude (Coordinates of Information)

TABLE II
DATABASE TABLE OF MULTIDIMENTIONAL INFORMATION

Name of Data
Name of Pictograms
Date and Time
Name of Contribution
Latitude of Starting Point (Coordinates of Information)
Longitude of Starting Point (Coordinates of Information)
Latitudes of Middle Points (Coordinates of Information)
Longitudes of Middle Points (Coordinates of Information)
Latitude of End Point (Coordinates of Information)
Longitude of End Point (Coordinates of Information)

The access to the database is executed by that PHP programs receiving HTTP requests of clients. The client device transmits server requests, and thereafter the server processes data in accordance with the client's request, information is registered in the database, and users are provided with information from a server side system throughout client application's interface, as shown in Fig. 2.

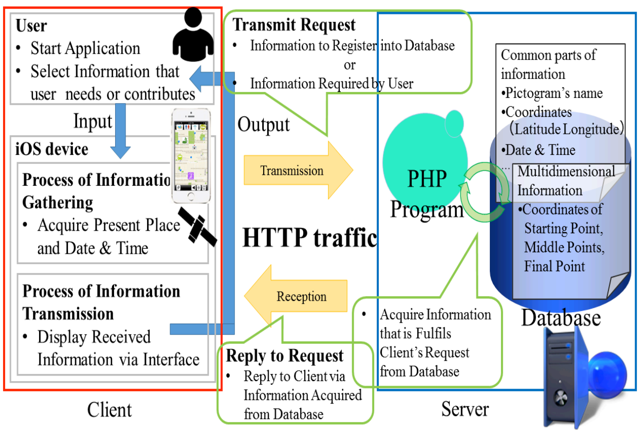


Fig. 2 System Structure Chart

C. System Functions

The functions of the prototype system are to collect information and to provide information. These functions are explained below.

➢ Disaster information collection function

The following describes the flow of the client application's processing when disaster victims collect information, as shown in Fig. 3.

1. The client application acquires the current location including latitude and longitude from GPS.
2. The client application acquires surrounding area information provided by other users from the server.
3. The information acquired from the server is displayed on GIS.

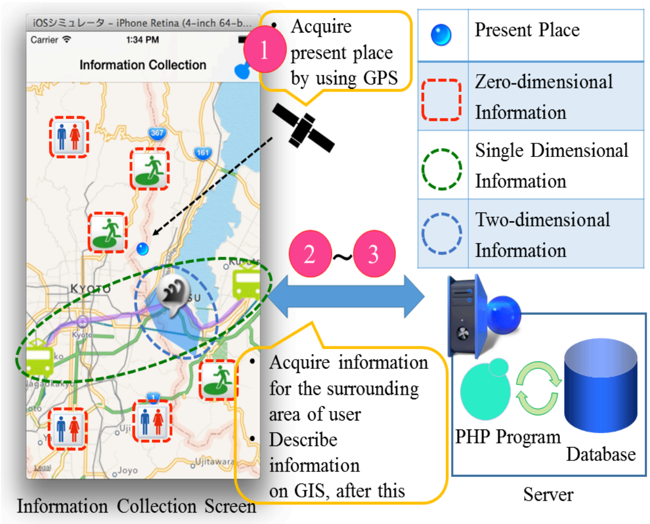


Fig. 3 System Processing Flow for the Information Collection

➢ Disaster information provision function

The following describes the flow of the client application's processing when disaster victims provide information, as shown in Fig. 4.

1. The system transitions from the information collection screen to the information provision screen.
2. The user selects a pictogram that corresponds to the information to be sent.
3. In the case of single dimensional information and two-dimensional information, the user input the routes or ranges of transmission information. (Fig. 5)
4. The user checks the output image, and confirms the information transmission.

When a user input single dimensional information, the user taps the positions of the start, middle and end points on the display, as shown in Fig. 5. When a user input two-dimensional information, the user taps the points of the boundary of the area in the same way, and then, taps the button to color the corresponding area. In these ways, the user are able to input multidimensional information visually.

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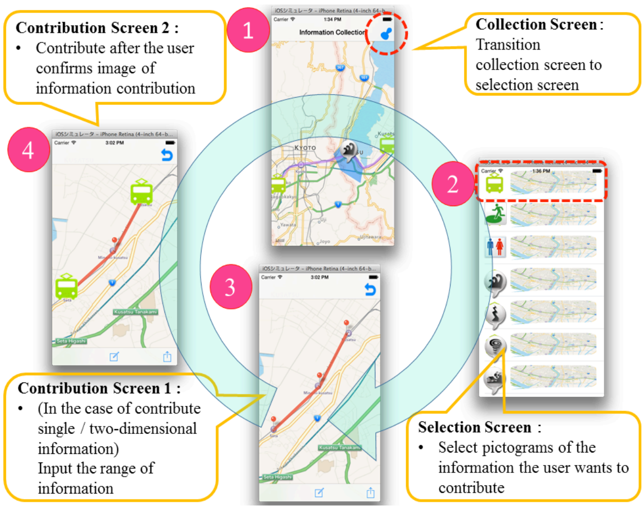

Fig. 4 System Processing Flow for the Information Contribution

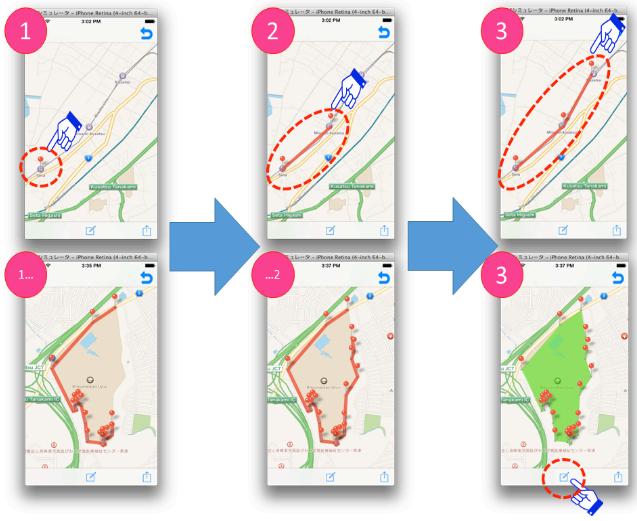
Fig. 5 Input Flow of Single / Two-dimensional Information

The server receives the data, including the type of selected pictogram and the corresponding location, the date and time, and the information is inserted or updated by operating the database with PHP programs.

V. System Evaluation

To verify the effectiveness of this system, we will conduct two types of evaluation experiment to examine the operability of the system and the visibility of information, respectively. Thus, we will evaluate the effectiveness of converting disaster information into nonlinguistic information from both of these aspects. In this section, we describe the evaluation experiments currently under consideration.

A. System Operability Test

The operability of this system will be verified using only the prototype system. We will measure the time of operating information provision, evaluate the accuracy of information quantitatively, and conduct a questionnaire survey on subjects. In this experiment, subjects will perform operation tasks (for example, providing information stating that "the trains are running from Station A to Station B"), and we will measure the time taken to transmit information, and also measure the ratio of correct answers. Furthermore, the experiment will be repeated a second time with similar task contents. The first experiment will be executed without explaining about system functions and the method of operation, whereas the second experiment will be executed after showing the subjects how to operate the system, although the contents of the second experiment will be the same as the first. However, the explanation of how to operate this system in the second experiment will be conducted using only pictures and images, not language.

The operability will be verified based on the changes in correct answer ratio and amount of time taken to provide information between the results of the two experiments. If the displacement is smaller and the correct answer ratio of subjects is higher in the second experiment, we consider that it will be possible to verify that the system has an intuitive user interface that can be used without an explanation of how to operate the system. Additionally, even if the amount time is long and/or the correct answer ratio is low in the first experiment, if the second experiment yields higher evaluation results, implementing a function that explains how to operate the system will enable us to evaluate the system as being easy to use.

B. Information Visibility Test

Visibility of information will be verified via a comparison between the proposed system and a version of the system that has been augmented with language-based information. The following describes the contents of such an evaluation experiment.

Experiment subjects will be shown information and asked to fill in disaster information obtained from each system within a time limit. By establishing a time limit for system operation and recording disaster information, the effectiveness of our nonlinguistic approach will be verified by measuring the information collected from these two systems within the time limit, both in terms of accuracy and volume of information. As a result of the comparison in this evaluation experiment, if the difference is minimal in the amount of collected information or the visibility of the systems, or the nonlinguistic system is superior, it will be possible to verfiy the effectiveness of the nonlinguistic approach. We consider that higher results for information visibility may be measured for the system with added language-based information. However, we also anticipate that the system with added language-based information will obtain lower evaluation results for the volume of collected information, as the attention of the subjects will be concentrated on the language-based information.

Thus, by conducted two types of evaluation experiment, we will verify the effectiveness of sharing information during a disaster using a nonlinguistic approach.

VI. Conclusion

In this research, we proposed a system that can be utilized by a wide range of disaster victims during the occurrence of a disaster, including tourists and persons who do not understand the local language, by constructing a system for disaster information collection and provision using a nonlinguistic approach. Moreover, in order to share information that contains zone and area information, which is vital when disasters occur, we proposed a system that enables disaster victims to collect and provide multidimensional information. Furthermore, in this research, collection of information from a large number of disaster

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victims is a means to achieve the objective of creating a "Wisdom of Crowds" during disasters. Accordingly, a future task will be to consider the safety and reliability of information that is shared when disasters occur. In future, we are considering methods such as peer-evaluation of user-provided information, or to verify the reliability of information based on the location of the information provider, as in Yokobe and Nakatani's research. In addition, as stated in Section 5, we will verify the effectiveness of this nonlinguistic system by conducting evaluation experiments with subjects including persons who are geographically unfamiliar with the area, persons who cannot communicate in a local language, and experts on disaster mitigation such as local government officials and fire fighting personnel.

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