Nonlinguistic Disaster Information Sharing System Using Visual Marks

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. We propose a system that can express disaster information visually, and operate information collection and provision intuitively without using languages. In this paper, we describe the prototype system, and show evaluation results to verify the effectiveness of our system. Moreover, we propose a solution for the problems which are indicated in the evaluation results. Specifically, an interface to collect ant provide multidimensional information is proposed in this paper.

Keywords Disaster information · Disaster prevention · Information sharing system · Mobile devices · Nonlinguistic · Pictograms

1 Introduction

Disaster prevention is one of the critical issues worldwide. In this section, we describe the present situation in Japan, and present the overview of our contributions.

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1.1 Background

Japan is affected by many disasters; in fact, the country is an area that suffers a concentration of disasters. Although this area is only 0.25 % of global landmass, it is the site of 20.5 % of all earthquakes of magnitude over 6.0, 7.1 % of all active volcanoes, and 16.0 % of disaster-related damage costs worldwide [1]. At the present time, various measures are in place for disaster mitigation and disaster reduction in, 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.

Meanwhile, Japan is aiming to make the country a global travel destination, which is being treated as important policy in the 21st century [3]. As an example, Kyoto city is visited by one million foreign tourists every year, and foreign visitors across Japan are expected to increase in the future. Paris is a famous model of an internationally competitive sightseeing city, visited by 45 million tourists every year, 60 % of whom are from overseas [4]. When a disaster strikes such sightseeing cities, many tourists will suffer from heavy damage. They are unfamiliar with the area, local language, culture and disasters. The safety of foreign tourists is critically important, and actions to protect them are the responsibility of the region and the nation.

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 [5]. Therefore, a framework is required that can support all disaster victims, including persons predisposed to difficulty such as those described above.

1.2 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.

These problems have been noticed by the Japanese FDMA (Fire and Disaster Management Agency). They are 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 [6]. 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.

The biggest advantage of this approach is to enable communication of information without the restraints of language. For example, signs such as 'emergency exit' and 'disabled access' are well known. In Japan, pictograms are adopted in places that are heavily used by the general public. Kunoki et al. of Ritsumeikan University considered the provision of unified design of disaster prevention pictograms at tourist sites [7]. They conducted an investigation into signs and guide plates at Kiyomizu Temple, a famous tourist attraction, as a target and suggested a method for improvement. The summary of their results is as follows:

1. Guide plates that display foreign languages or use pictograms are only about one quarter of the total.
2. Methods to express color, shape and content are different depending on the place. There is no sense of unity and this hinders understanding.

From the summary of results, Kunoki et al. advocated the necessity of offering information utilizing universal design to provide efficient evacuation guidance.

1.3 Our Contribution

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 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 implementing an interface that enables disaster victims to post information easily when disasters occur. First, we constructed a system that makes use of zero-dimensional information that expresses information dealing with points. This paper shows the evaluation results to verify the effectiveness of our system. In the results, one problem is indicated, that is, we need to treat with multidimensional information in order to express target zones and area. Then, we propose an extended system which makes also use single dimensional information and two-dimensional information 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.

In the next section, related work is described. We present outline of our first system and its evaluation results in Sect. 3, and in Sect. 4, we show our second system which makes use multidimensional information. Then evaluation experiment that we examining is presented in Sect. 5. Finally, a conclusion and future work are described.

2 Related Works

2.1 Analysis During the 2011 Tohoku Earthquake

In the 2011 Tohoku Earthquake, the Tokyo metropolitan area suffered from disaster for the first time after being developed as a modern city, and there were many people who had difficulty returning home. This is relevant to this study, as it is useful to design our system through analysis related to information media.

From the summary of a Cabinet Office survey conducted via the Internet, there were 5.15 million persons who had difficulty returning home in the metropolitan area, which includes Tokyo, Kanagawa, Chiba, Saitama and Ibaraki [5]. From the results of the survey into how people returned home, it was shown that the most common method of returning home was on foot, accounting for 37.0 % of the total victims, and the second most common method was by car. The reason for these being the most common is that trains ceased operation immediately after the earthquake. Disaster victims felt that certain information was necessary while returning home. In descending order, information on their families' safety, investigation of the damage, and time until the trains and subway would resume operation, were the most cited. If we exclude family safety information, we can see that victims need information about items required to return home.

The results of a survey conducted about future methods of obtaining information hoped for by disaster victims are also shown. Results are grouped for three conditions related to whether victims were capable of returning home. In particular, the provision of information by TV is strongly hoped for. This reason is considered to be that TV is capable of providing information visually, and that people watching TV can know an overview of the disaster in various places. The number of people who wish to be provided information by cell phone is high, because it is easy to use while on the move. In particular, there is a tendency for this to be desired by people who tried to return home but were prevented. This may be estimated as due to the necessity for information to decide a new course of action after being prevented from returning home.

2.2 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 [8]. 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.

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 providing information, but also when understanding the provided 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.

2.3 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 [9]. 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 [10]. 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.

3 Outline of Our Proposed First System

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.

3.1 System Functions

We constructed a system for sharing disaster information that converts linguistic information to GIS and pictograms, as a nonlinguistic approach [11]. 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.

This system uses a client-sever model in which the client is a smart phone application and the server is a web application utilizing a database and PHP programs. The database stores the pictogram type, location (latitude and longitude), provided time, provider and pictogram ID inputted by the user.

The system initial screen is showed in Fig. 1. The user can collect information on their current surroundings via map information and icons on this screen. In the screen, the current position of disaster victim getting from network and GPS (Global Positioning System) is the center. For the surrounding area up to a 3 km radius, the pictograms are placed on the screen. By tapping an icon, the users can find out the provider and posted time, which can aid in judging the situation.

During disasters, the time and operations required to provide information should be minimal. In this system, users can provide with three steps, as shown in Fig. 1.

1. Change to “Information Provision” screen
2. Select the pictograms corresponding to the information the user wants to provide from the icons at the bottom of screen
3. Tap “Provide” Button

Via this operation, the client-system sends the server information that includes the current position, pictogram name, time of provision and pictogram ID. Disaster information to be provided by users is collected in the server.

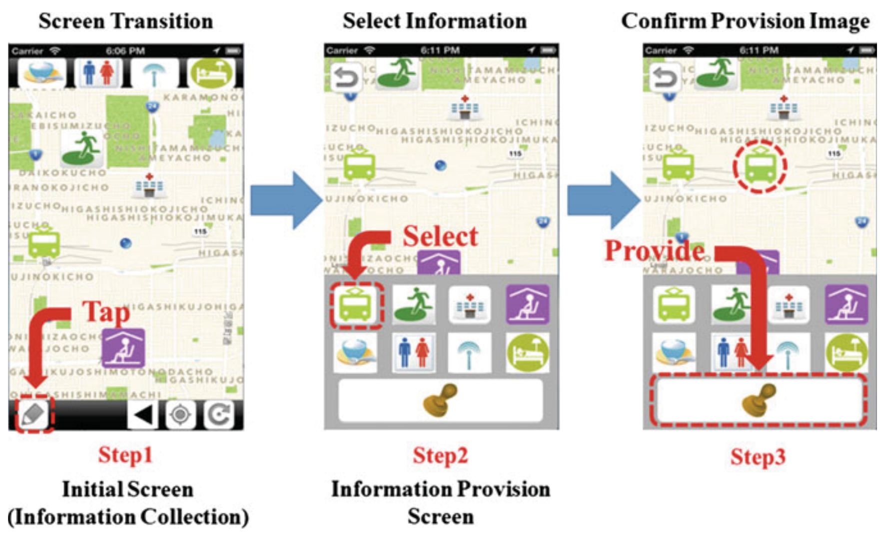

Fig. 1 The flow for providing information

4 System Evaluation Experiment

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 as experts, performed simulated operation of the system and answered a questionnaire survey after we explained about the system. Two students from China and six students from Japan participated in the experiment as normal users, and answered the same survey without hearing an explanation of how to use this system. Three of the students had not used social media or smartphones before. The list of questions in the questionnaire is shown in Table 1.

The following is a summary of the evaluation by the experts.

1. Response to Question 1
    - There are big advantages for evacuating to shelters and obtaining information for returning home.
    - Information is available quickly, as it is expressed using easy-to-understand pictograms.
    - Users can be psychologically reassured, as they can gather information on their surrounding area.
    - Comprehension of the situation can be increased, as information about the destination is easy to understand.
2. Response to Question 2
    - Pictograms were appropriate (13 out of 15 experts).
    - Users should be able to change the size of the pictograms (2 out of 15 experts).
3. Response to Question 3
    - If users already have smart phones, the system could be operated without problems.
    - Limiting the amount of provided information leads to ease of use.
    - Mental barriers to using this system are higher for elderly people.

Table 1 The list of the questionnaire survey

Question number	Question contents
1	Do you think comprehension of the situation during a disaster would increase by using this system?
2	Were the sizes and designs of pictogram appropriate?
3	Was the system sufficiently easy to use?
4	Are the types of information provided sufficient?
5	Do you have other points of feedback or improvement?

4. Response to Question 4
   - Information about unavailable facilities, not only available facilities, is necessary.
   - Information about means of transport (operation status and area) is necessary.
5. Response to Question 5
   - Need accurate and safe user-provided information.
   - Setting display periods for pictograms would improve management of information.
   - Wish to utilize Wi-Fi spots during disaster situations, for example bus stops.

The following is a summary of the evaluation by non-Japanese users (Chinese).

- The provided types of information and size of pictogram are appropriate.
- It is easy to ascertain the situation in the surrounding area via the combination of GIS and pictograms.
- If we have experience of this system as social media during non-disaster times, we can use it when a disaster occurs.
- We could not understand the difference between “Evacuation Site” and “Place for Rest” only from the pictogram.

The following is a summary of the evaluation by general users.

- The provided information types, size of pictograms and denotation are suitable on the whole.
- It is easy to use this system because it only uses pictograms.
- If we have operated this system once, we can use when a disaster occurs.
- Because the display is based on maps, we could ascertain both the geography and situation of our surroundings simultaneously.
- We could understand the meaning of the information quickly, as there was no need to read text.
- The pictograms for “Evacuation Site”, “Place for Rest” and “Available Accommodation” are too similar to distinguish. They should be revised or guidelines should be made.

Although some deficiencies in the provided information and comprehension problems for some of the pictograms were pointed out, we were able to confirm that this system can be used as an easy-to-operate disaster information sharing system through evaluation from experts, non-Japanese and general Japanese users. It is highly beneficial for disaster victims to obtain information during their evacuation or going back their home. By using our system, victims are able to obtain information immediately, because information is simply expressed by using pictograms and GIS. So, victims are able to know the situation the surrounding area.

On the other hand, subjects gave two suggestions for improving disaster information using the system: One is that the system should provide not only facilities which are not available, but also available ones. The other is that in the case of providing transportation information, the traffic section needs for disaster victims, not limited to traveling condition.

5 Multidimensional Information Sharing

In the first system, information is 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. 2.

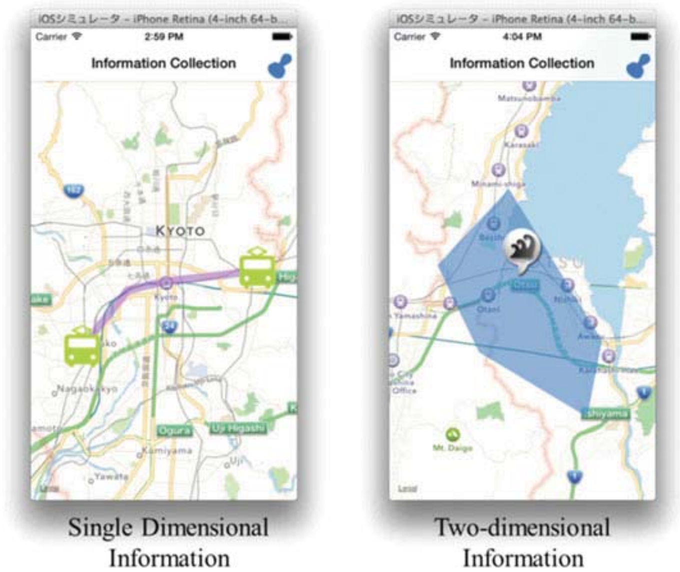

Fig. 2 Input/output of multidimensional information

In this section, 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 [12].

5.1 System Architecture

The system is consists of a client device, by which the user provides/collects information, and a server that responds to the client's requests. The database of the server application contains two tables. 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.

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. 3.

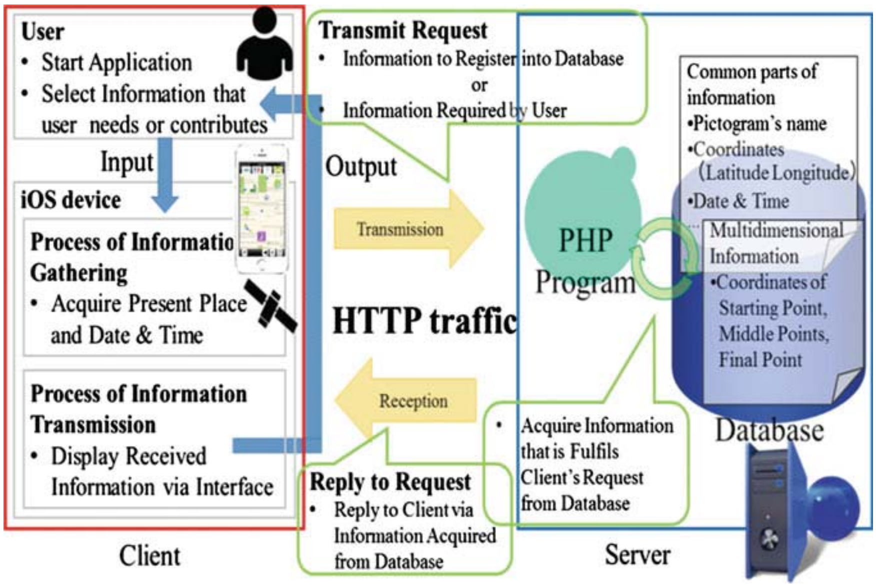

Fig. 3 System structure

5.2 System Functions

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

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

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.

The following describes the flow of the client application's processing when disaster victims provide information, as shown in Fig. 5.

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. 6).

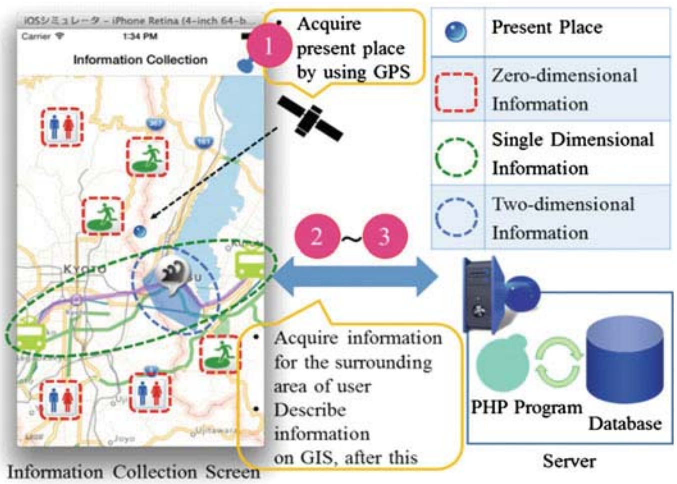

Fig. 4 System processing flow for the information collection

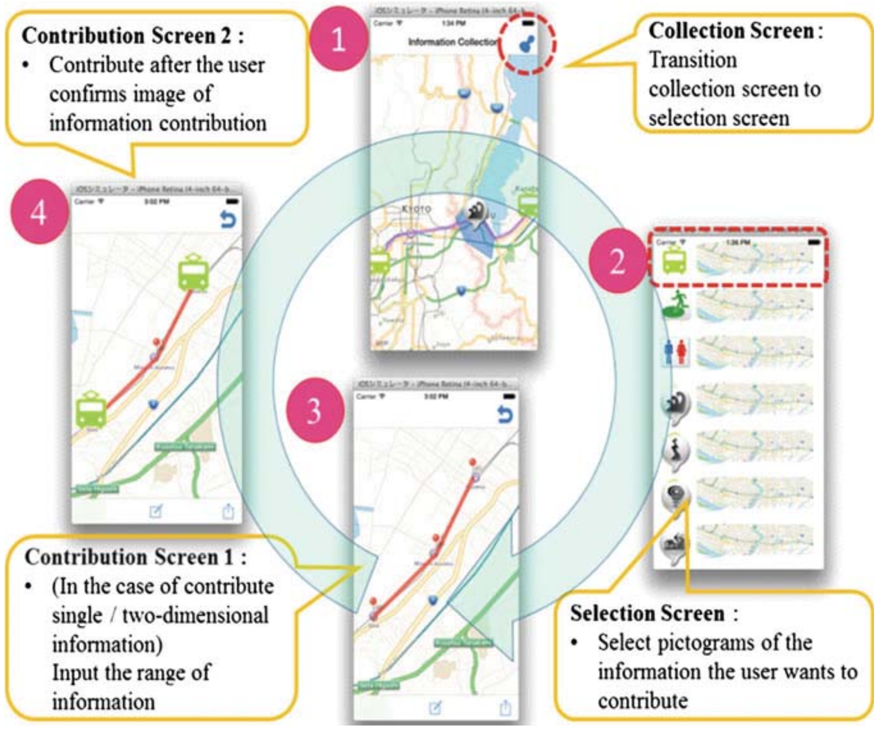

Fig. 5 System processing flow for the information provision

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. 6. 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.

6 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.

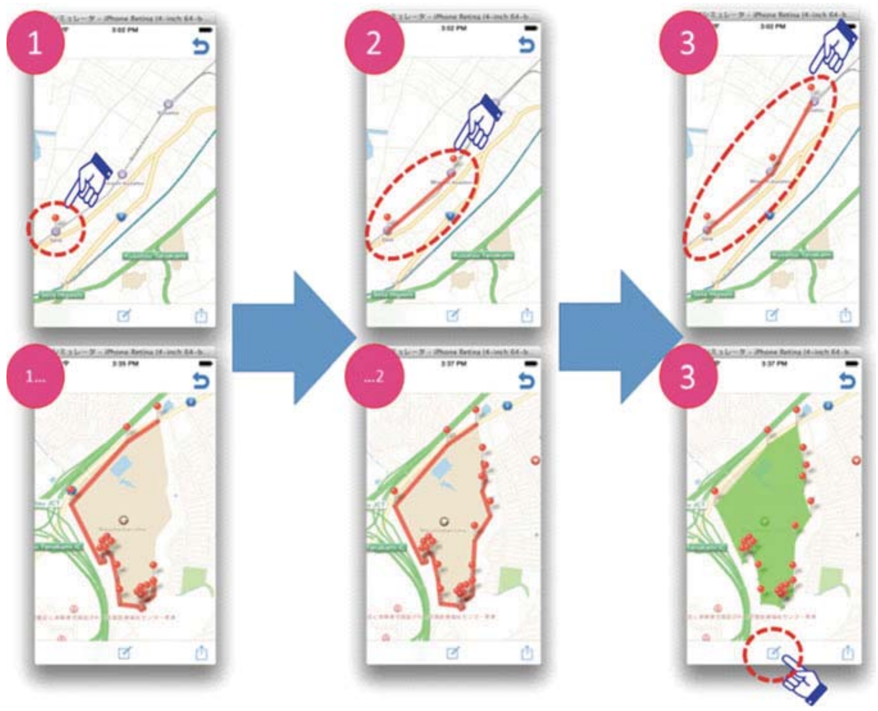

Fig. 6 System processing flow for the information collection

6.1 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.

6.2 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. 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 verify 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.

7 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.

In this research, collection of information from a large number of disaster 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 [9]. In addition, as stated in Sect. 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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