Disaster Evacuation Support System Considering User's Situation

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Abstract: In case of a disaster, it is important to notify information on disasters and evacuation to residents quickly and accurately to encourage evacuation. In this paper, we propose a disaster evacuation support system considering user's situation based on open data. When a disaster occurs, the system detects whether the user's location is in a dangerous area or not, the user is approaching the dangerous area or not. Then the system notifies and provides evacuation direction to the user. Moreover, the system also supports a rescue function to share rescue information to neighborhood people automatically. We conducted a verification experiment, and the results of the experiment verify the usefulness of the proposed system.

Key-Words: - Location information service, smartphone application, open data, disaster support system, evacuation support, social network service, A* algorithm.

1 Introduction

Various kinds of large-scale natural disasters occurred every year in Japan, and they caused serious damage. For examples, earthquakes, tsunamis, torrential rains and floods. Before and after the disaster, it is very important to evacuate quickly to reduce the damage of disasters.

Nowadays, when the disaster occurs, the emergency bulletin mail [1], the disaster prevention flash application [2], and so on is used to notify disaster and evacuation-related information to residents. However, there are many issues. For example, many of information on disasters and evacuation is text-based, and then it is difficult for residents to understand a critical situation of disasters. Also, information on disasters and evacuation are not sent to affected areas but sent to the entire area (such as city, town, village), there is also a problem from the viewpoint of reliability of information. For example, when the floods occur or an occurrence is foreseen, residents need to evacuate immediately depends on the geography and elevation of the location point and the distance from the river. Moreover, if many residents concentrate on one evacuation shelter, the road leading to the evacuation center and the evacuation center entrance will be crowded, and there is also the possibility that it cannot accommodate all evacuees.

Based on the background stated above, in this paper, we use various open data to build a disaster evacuation support system which detects whether the user is staying in a dangerous area (an area expected to suffer from a disaster) or intending to intrude into such an area. The system provides suitable evacuation directions and encourages evacuation. By using this system, the user can appropriately recognize the degree of danger, and we think that it is possible to reduce human injury due to disasters.

2 Related works

Hamamura et al. [3][4] developed an evacuation support system called "AkariMap" based on evacuation support information such as shelters and AEDs which is provided by the cities and local governments. Yoshino et al. [5] used AkariMap to make disaster-prevention maps and discussed its applicability.

Amano [6] developed an application to display flood hazard map on a smartphone by using open data which is provided by National Land Numeral Information. In this study, in addition to the display of inundation supposed areas and evacuation facilities, functions necessary for a disaster such as searching for information and searching for shelter are examined and implemented.

Suyama et al. [7] developed a disaster evacuation support system that enables provision of disaster-

related information in situations where information for evacuation is needed.

3 Proposed method

3.1 Overview

In this study, to provide appropriate information to each individual, we suppose that user's terminal is a smartphone. Figure 1 shows the outline of the proposed system. Figure 2 shows the flow of the proposed method on the user side (smartphone application).

When a disaster occurs, user's location and user's direction of movement are acquired. After that, the dangerous area and disaster prevention related facilities are gotten from the server and saved on the user's smartphone. If the user is staying in or approaching to the dangerous area the smartphone application notifies the user that he/she are staying in or approaching to dangerous area. At the same time, the application provides the suitable evacuation direction and encourages him/her to evacuate.

The evacuation direction is selected according to as the occurred disaster, the situation of disaster prevention related facilities or the user's condition. Specifically, the following three ways are considered:

- In case of an earthquake or a landslide disaster, the system guides users to shelters. On the other hand, in case of a tsunami, heavy rain, or flood, the system induces users to evacuate to high places.
- The system carries out evacuation guidance that all evacuees can accommodate by taking into consideration the circumstances of shelters.
- In consideration of the health condition of the user, the system determines the evacuation direction and carries out the supportive action. For example, when evacuation is impossible, information is provided by SNS and applications to request neighboring people to rescue.

As described above, if it becomes possible to provide necessary and appropriate information to users, it is possible to prompt evacuation. And from there to reduce the damage caused by disasters. Then, we believe that it is possible to reduce the damage caused by disasters.

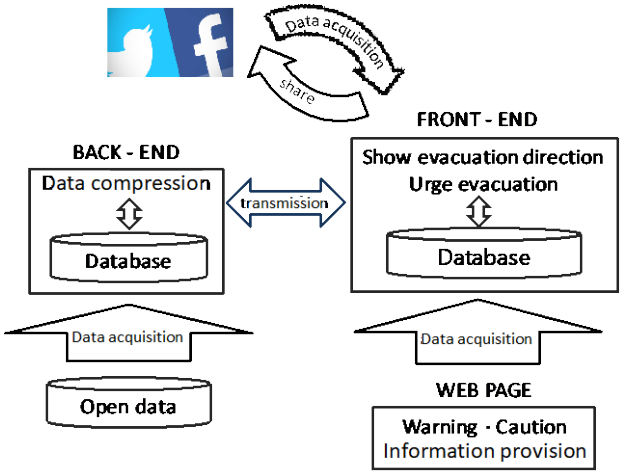

Fig. 1 Outline of the proposed system

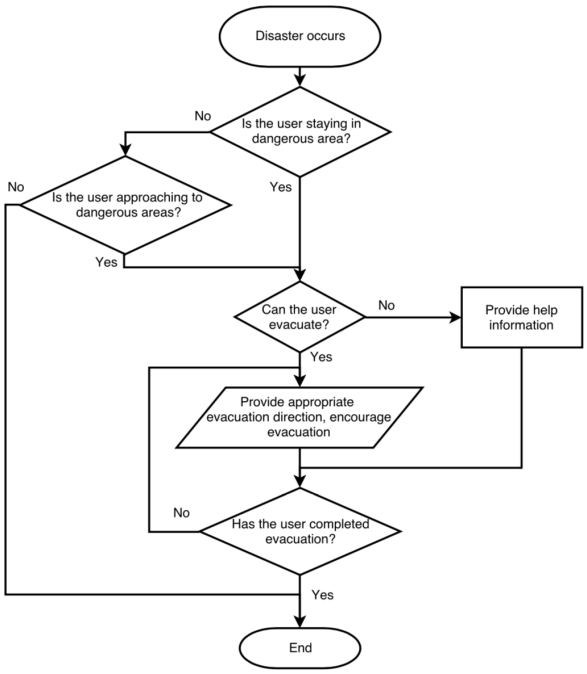

Fig. 2 Flow of the proposed method

3.2 Digital data compression

We use National Land Numerical Information which is provided by Land Information Section, National Land Policy Bureau, MLIT, Japan as open data. In this study, we especially use river data [8], inundation supposed area data [9], evacuation facility data [10]. The inundation supposed area data is polygon type, and each flood depth is created by prefectures.

Table 1 Comparison of original and encoded data

	Original data	Encoded data
Amount of data	1.7 GB	266.7 MB

Because the digital data is big and may affect processing and transmission between server and front-end, it is necessary to compress the data. Therefore, polygon type data is compressed by Polyline Encoding Algorithm [11]. An example is shown below.

- Original points: (38.500000, -120.200000), (40.700000, -120.950000), (43.252000, -126.453000)
- Encoded: _p~iF~ps|U_ulLnnqC_mqNvxq`@

By applying this algorithm, the data is compressed sufficiently. Table 1 shows the comparison between original data and encoded data.

3.3 Detection of whether the user is in a danger area

We detect whether the user is in a danger area by the following two condition:

- The user's location is inside a polygon (danger area).
- When user's location is changing and approaching a polygon (danger area), we calculate distances from the user's location to all polygon and find a minimum of distances. If the distance is smaller than the threshold, it is determined that the user is approaching a polygon (danger area). An example is shown in Fig. 3.

3.4 Evacuation direction

To prompt evacuation from a dangerous area, using the A * algorithm [12] and the RAY - LINE SEGMENT INTERSECTION algorithm [13], a point which is the shortest path from the position of the user to the point on the polygon. If there is a route from that point to the evacuation shelter, the route is connected. Examples are shown in Figs. 4 and 5.

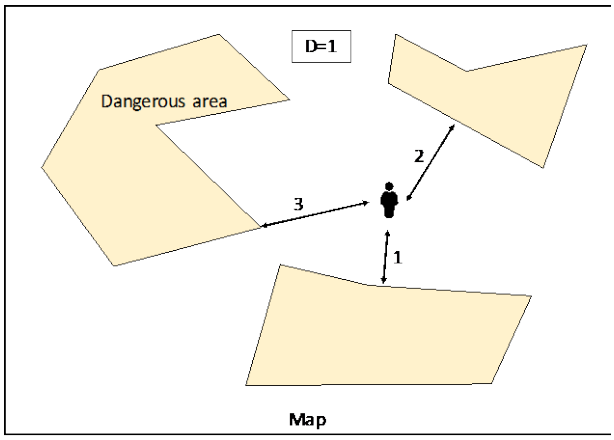

Fig. 3 Detection of approaching danger area

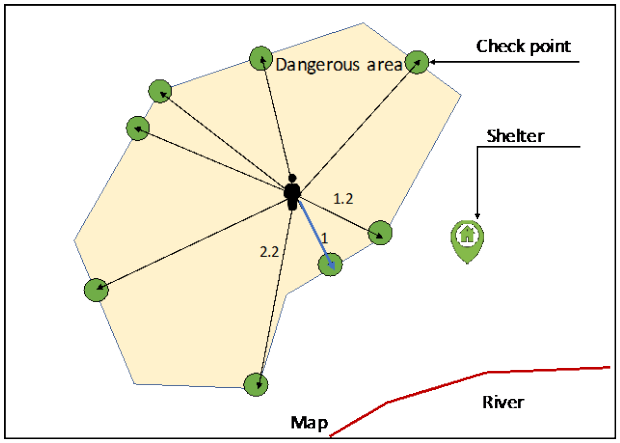

Fig. 4 Examples of selected checkpoints

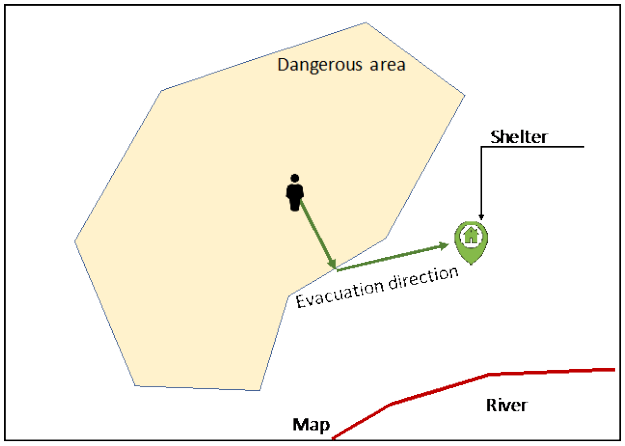

Fig. 5 An example of evacuation direction selection

4 Development environment

In this study, for the front-end side, we developed an application for Android smartphone using Android studio tool. For the back-end side, we use Apache web server with MySQL database. For the transmission between front-end and back-end, we use SOAP web service technology. Table 2 shows deployment environment.

Table 2 Development environment

Front-end	Android
Back-end	Apache web server
Database	MySQL (Back-end), SQL Lite (Front-end)
Web service	SOAP

5 Disaster evacuation support system

5.1 Front-end interface

In the front-end side, to build an intuitive and easy-to-use interface, we propose following two screens:

- Login (Fig. 6): In login function, we need user's information to provide rescue information when users can not evacuate and to avoid the duplication of information when providing rescue information.
- Main screen (Fig. 7): In the main interface of front-end, we use map view with the dangerous area, people who need help, shelters, and evacuation direction.

Beside main screens, we add two sub-screens:

- Detailed information screen (Figs. 8 and 9): This is embedded at the bottom of the main screen, it will be displayed when users click on each object on the map (shelter, people who need help). In the shelter's detail screen, google street view is used to provides a visual view to the user.
- Profile screen: In this screen, users can edit their information.

5.2 Rescue function

In case the user cannot evacuate to a safe area (by touch the button), rescue information is sent to others automatically. This information is saved in the server by posted ID, and neighborhood users can see this recuse information via SNS and the application's map view. By the way, rescue information will be sent to not only neighborhood users but also people who do not use the application. In this study, we focus on Twitter because it is widely used in Japan. Rescue information contains the user's current geo-location information (address), name, number of people who need to be rescued, and the hashtag of the form "#救助" (that means #(Rescue)). This simple but effective function is shown in Fig. 10.

5.3 Providing evacuation direction

By the proposed method considered in section 3.4, we built the providing evacuation direction function shown in Fig. 11. The red marker indicates the user's location, the red polygon areas mean dangerous area, and the big blue arrow is the evacuation direction provided by the system.

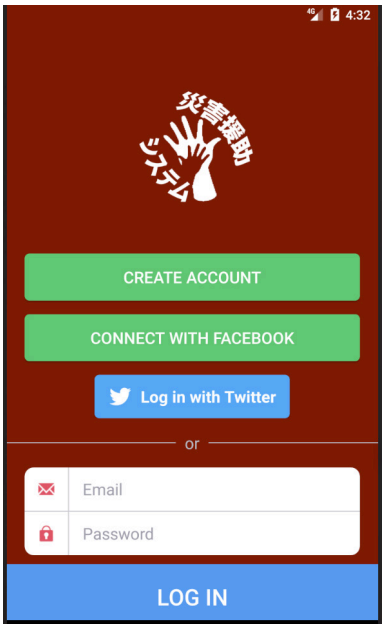

Fig. 6 Login screen

Fig. 7 Main screen

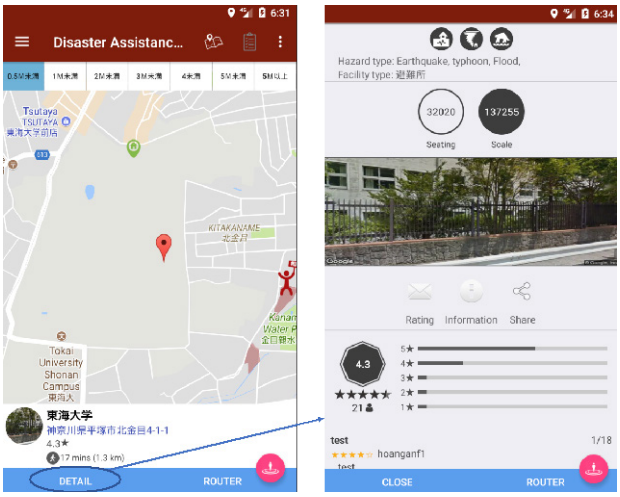

Fig. 8 Details of shelter

Fig. 9 Information on people who need help

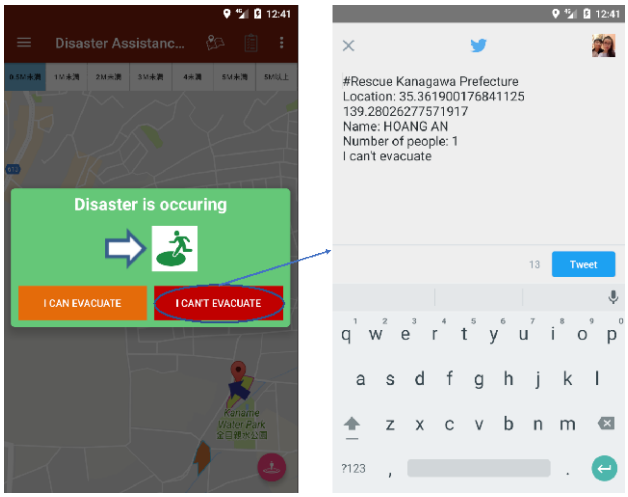

Fig. 10 Rescue function

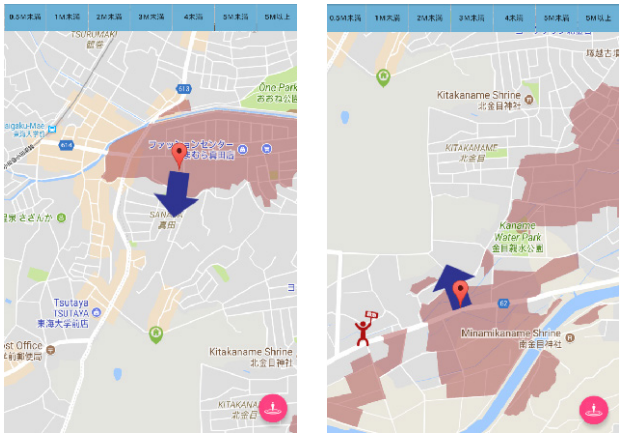

Fig. 11 Providing evacuation direction

6 Conclusion

In this study, we implemented a disaster evacuation support system considering user's situation based on open data with following functions:

- detection whether a user location is in a dangerous area or not, approaching the dangerous area or not,
- notification and provision of evacuation direction to users,
- sharing rescue information with neighborhood people automatically.

Since the proposed system is a user-friendly one, we believe that it will be widely accepted by many people. However, considering the practical use, there are still a lot of challenges left. Therefore, we will consider solutions to these issues in the future.

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