Safety Confirmation System for Disaster Situations Using Wristwatch-type Terminals

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Abstract - *The Great East Japan Earthquake that occurred in March 2011 brought enormous damage to the entire East Japan area. For example, about 16,000 people died and 2,500 are still missing. One reason that a huge number of missing people and dead people occurred is that victims who became underlays of collapsed houses and lost consciousness could not show their own existence to the searcher. Then it is thought that ways for quickly and accurately discovering the victims underlying the houses are necessary. Therefore, in this study, we propose a safety confirmation system for disaster situations using wristwatch-type terminals and smart phones and implemented the prototype.*

Keywords: Safety confirmation system, Disaster, Wristwatch-type terminal

1 Introduction

The Great East Japan Earthquake that occurred in March 2011 brought enormous damage to the entire East Japan area. For example, about 16,000 people died and 2,500 are still missing [1] (Table 1). One reason that a huge number of missing people and dead people occurred is that victims who became underlays of collapsed houses and lost consciousness could not show their own existence to the searcher. In the area where many people are missing, not only the impact of the tsunami but also the number of destroyed houses is extremely large compared to other areas [2]. It is extremely difficult to search and rescue victims who are unconscious at the disaster relief site. Then it is thought that ways for quickly and accurately discovering the victims underlying the houses are necessary.

For the above reasons, disaster relief dogs that search for people who are buried alive at the time of a disaster has been drawing attention. In some cases, disaster relief dogs can enter the rescue site where humans cannot enter as quickly as possible and it is possible for disaster relief dogs to sniff out whether the victims who are being buried alive are surviving by the biological odor. However, at the time of disasters due to the earthquake, there were few achievements that the search by disaster relief dogs led to the discovery of survivors in Japan [3]. Table 2 shows activity records of rescue dogs dispatched by Rescue Dog Trainers' Association in Japan. Moreover, there are many problems for utilizing rescue dogs for disaster relief, for example, on rainy days it is difficult for them to search victims by following the smell, and their olfactory sense are paralyzed caused by stress due to putrefaction odor. Disaster relief dogs are sometimes dispatched from abroad. During the Great East Japan Earthquake, the number of dispatched disaster relief dogs was 68 from inside Japan and 29 from abroad. Considering the damage scale, it seems that the number of disaster relief dogs was insufficient. It is known that the survival rate drops sharply when it exceeds 72 hours since the occurrence of a disaster [4]. Therefore, waiting for disaster relief dog dispatch from a distant place such as overseas seems to be a problem.

Table 1 Number of death and missing due to the Grate East Japan Earthquake

Prefecture	Number of death	Number of missing
Miyagi	9540	1232
Iwate	4673	1123
Fukushima	1613	197
Ibaraki	24	1
Chiba	21	2
Tokyo	7	0

Table 2 Activity records of rescue dogs dispatched by Rescue Dog Trainers' Association in Japan

Date	Name of disaster	Number of dispatched rescue dog	Discovery of survivors
2016.4.14	Kumamoto Earthquake	About 25	No
2015.4.25	Nepal Earthquake	4	No
2014.8.20	Hiroshima Landslides	30	No
2011.3.11	The Great East Japan Earthquake	30-40	No
2009.9.30	Sumatra-Andaman Earthquake	5	No

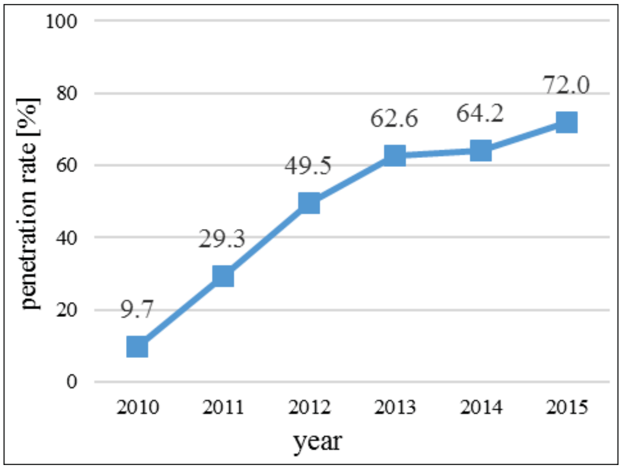

Fig. 1 Penetration rate of smartphone (in Japan)

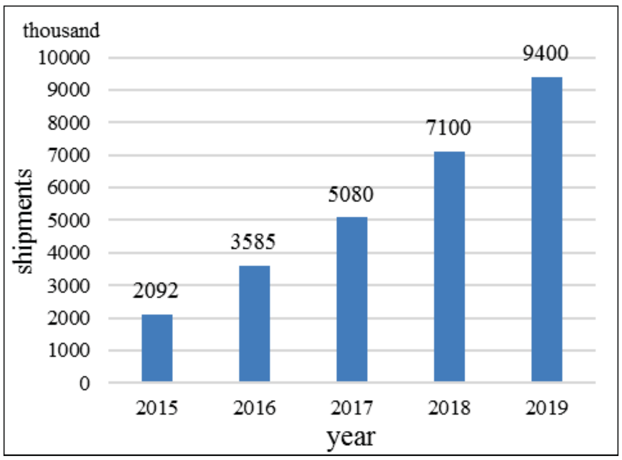

Fig. 2 Market size of wearable terminals (in Japan)

As mentioned above, there are many problems in utilizing disaster rescue dogs. Therefore, in this study, we try to construct a safety confirmation system for disaster situations using wristwatch-type terminals and smart phones. As shown in Figs. 1 and 2, the penetration rate of smartphones and the market size of wearable terminals in Japan has been increasing in recent years [5][6]. In recent years, due to the sale of smartphones for children and for the elderly people, the use of smartphones is increasing not only for young people but also for a wide range of age groups. By the way, at the time of the Kumamoto earthquake that occurred in April 2016, there were damage of up to 344 base stations of three major Japanese mobile phone carriers [7]. In such cases, the search operation using the mobile phone becomes very difficult. Therefore, in this study, we decided to construct a safety confirmation system using Bluetooth which is installed in many electronic terminals these days. By using this technique, it becomes possible to communicate between terminals without going through the base station of mobile phones. Moreover, in recent years, various types of wearable terminals have been developed and functions of them have been enhanced. Some

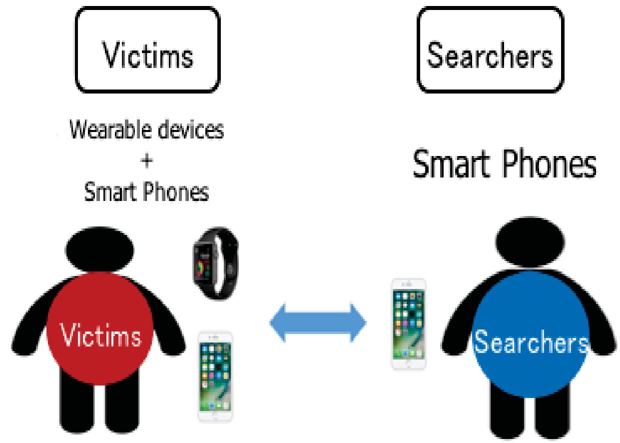

Fig. 3 Schematic of the proposed system

wearable terminals can acquire physical information such as heart rate and body temperature which could not be acquired with only smartphones. As described above, short range communication between smartphones and measurement of physical condition using wearable terminals are becoming common, and we think that these can be useful for searching for victims in disaster relief sites. Then, we propose a safety confirmation system for disaster situations using wristwatch-type terminals and smart phones in this study.

2 Proposed system

2.1 Brief overview

Figure 3 shows a schematic of the proposed system. As shown in Fig. 3, the system is composed of a wristwatch-type terminal possessed by the victim and a smartphone owned by both the victim and the searcher. When a disaster occurs, victims prepare to measure and transmit biological information using a wristwatch-type terminal and a smartphone. Then, when the searcher approaches the victim, the vital information of the victim is automatically sent to the searcher's smartphone. In addition, information on the victims is visualized on the map. In this study, we implemented a system as iOS applications. As a wristwatch-type terminal that measures biological information, it is assumed to use Apple Watch Series 2. The biometric information to be transmitted is the heart rate of the victim. By sending the vital information of the victims in real time, it will be possible to clarify the existence of inaccurate survivors and to conduct the search activities efficiently. Visualization of information on the map is aimed at making it possible for searchers to know the detailed positions of the victims easily. left.

2.2 Operation by victims

2.2.1 Overview

When a disaster occurs, the victim first activates an application that measures and transmits biological information on the smartphone. Then, measurement of the heart rate of the victim and acquisition of GPS information of the terminal are started. At the same time, the system enters readiness to communicate with the smartphone of the searcher. Therefore, when the searcher's smartphone approaches the victim, position information and heart rate of the victim is automatically transmitted to the searcher's smartphone.

2.2.2 Launch application

When a disaster occurs, the victim activates the information communication application on the smartphone. Then, both the measurement of the heart rate by the wristwatch-type terminal worn by the victim and the acquisition of the GPS information of the smartphone paired with his/her wristwatch-type terminal are started. By activating the application, the Bluetooth function is enabled in the smartphone of the victim and the communication preparation with the searcher's smartphone is started. In this study, we use CoreBluetooth framework to implement the application. By using this framework, it is possible to realize opportunistic communication between terminals. Since it is possible to communicate in the background, it is also an advantage that there is no need to always operate the system.

2.2.3 Preparing to transmit heart rate

It is currently impossible to directly transmit the heart rate of the victim measured by his/her wristwatch-type terminal to the searcher's smartphone. Therefore, the measured heart rate is transferred to the information communication application on the smartphone of the victim. By going through the information communication application using Bluetooth, it becomes possible to transmit and receive the heart rate between the victim and the searcher. When the paired smartphone completes receiving the heart rate, it is displayed on the screen of the smartphone. In this state, preparation for transmission of the heart rate is completed. Healthkit, which is one of iOS frameworks, is used to measure heart rate. Heart rate measured by Apple Watch is transmitted and stored to paired iPhone, then Healthkit framework is necessary to use this data.

2.2.4 Sending information to searcher’s terminal

The heart rate transferred to the application on the smartphone of the victim is transmitted to the application on the searcher's smartphone. Since this system realizes opportunistic communication, if smartphones with applications are introduced, information is transmitted and received only by approaching a certain distance. Therefore, when the searcher approaches the victim underlying the collapsed house, the heart rate of the victim and GPS information of his/her smartphone are transmitted to the searcher's smartphone. Thereafter, when the distance between the searcher and the victim is within a certain range, the heart rate of the victim and GPS information can be received.

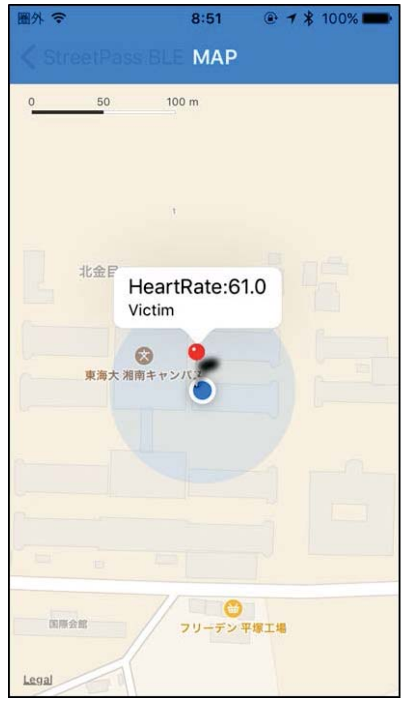

Fig. 4 Displaying the heart rate of the victim on the map

2.3 Operation by searcher side

First, the searcher activates the information communication application on the smartphone. With this operation, communication between the smartphone of the victim and the smartphone of the searcher is prepared. After receiving the information of the victim, the user can check the position of the victim on the map. When the pin displayed on the map is tapped, the heart rate of the victim is also displayed on the map (Fig. 4). Since this system communicates even in the background, even if the screen is off, information can be received if the victim's Bluetooth radio wave can be found.

2.4 Comparison with conventional rescue methods

By using the proposed system, it is expected that the time from the start of the search to the discovery of the victims can be shortened. We think that rescue activities can be carried out more efficiently by the approach from the victims to the searchers. Transmission of vital information from the victims' side also seems to facilitate correspondence at the time of search activities. Vital information transmitted from victim’s terminal help searchers to judge whether the target victim should be rescued immediately in a dangerous situation. Moreover, Information on the victims can be known at the time of rescue, which leads to ease of response after rescue. When the victim is buried beneath the fallen house, even if he/her is conscious, it may be difficult to inform the searcher of his/her own existence. In such cases, it can be expected that consumption of physical fitness can be reduced by using the proposed system rather than giving a loud voice for calling for rescue.

3 Verification experiment

3.1 Experimental method

Experiments were conducted to verify whether the proposed system operates normally. In this experiment, the communicable distance between the smartphone of the victim and the one of the searcher was measured. First, as an experimental device, we prepare two iOS terminals (iPhone 5s) on which information communication applications is installed and one Apple Watch. Next, as an assistant to the experiment, prepare one person for the role of victim and one person for the role of the searcher. The victim role player was handed one iOS terminal and one Apple Watch, and the searcher role player was handed one iOS terminal. Then, both were asked to start up the information communication application on their iOS terminals and to try to send and receive information. The above procedure was repeated five times from a closest distance to a long distance at a good-looking place without shielding objects, and the critical distance at which information transmission/reception was correctly performed was examined. In this time, we have experimented with the assumption that there are only two terminals using this system. We set the terminal to airplane mode so that communication other than Bluetooth communication is not performed and turned off Wi-Fi communication.

3.2 Experimental result

The experimental results are shown in Table 3. The average of the communicable distances was 202.4 m and the maximum was 260 m. From this result, it was confirmed that information is being transmitted and received at a sufficient distance for searching for victims. From this result, it was confirmed that information is being transmitted and received at a sufficient distance for searching for victims. Screen shots of the victim's terminal and searcher’s terminal are shown in Figs. 5 and 6, respectively. As shown in these figures, it was confirmed that the heart rate acquired by the terminal of the victim was displayed on his/her terminal, and the same numerical value was transmitted to the terminal of the searcher. However, even when terminals confirmed radio waves of Bluetooth, there were cases where transmission and reception of information was not performed correctly. In addition, cases occurred in which Bluetooth radio waves of other unrelated terminals were sensed.

Table 3 Communicable distance

Times	1	2	3	4	5	Ave.
Distance [m]	140	260	230	170	212	202.4

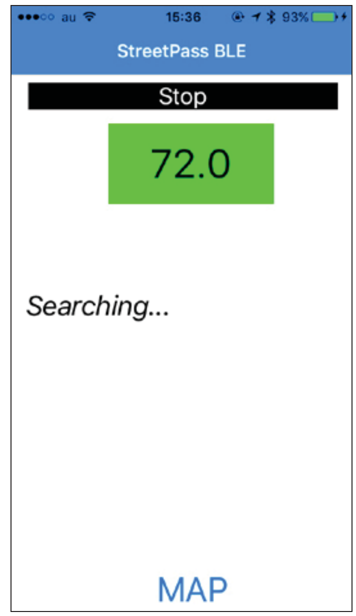

Fig. 5 Screen shots of the victim's terminal

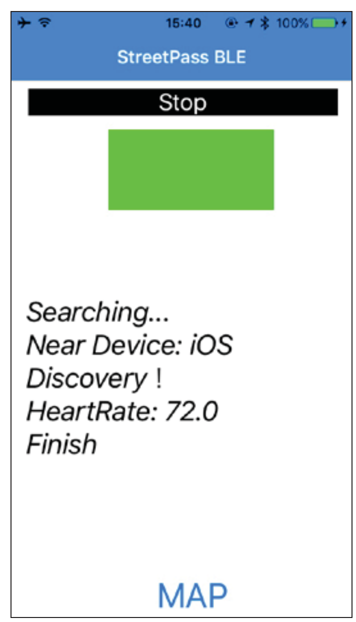

Fig. 6 Screen shots of the searcher’s terminal

4 Discussion

As described above, the average communication range of this system was 202.4 m. From this result, it is presumed that the communicable distance in the present system is sufficiently practical for searching for victims. Also, by acquiring the GPS information, it is possible to grasp the position information of the victim easily. On the other hand, there are variations in the communicable distances. As a reason of this variation, interference with the surrounding Bluetooth may be considered. This experiment was conducted in a good-looking environment without shields, but

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we did not consider the presence or absence of a passerby when carrying out the experiment. Therefore, it is considered that the number of passersby affected the communicable distance. By the way, though the communicable distance of Bluetooth used in the experiment is officially said to be around 100 m, the average communication range of this system was 202.4 m. If Bluetooth communication is possible at this distance, it will be difficult to identify the location of the victim. Therefore, transmission of GPS information is considered to be an essential function and mapping function is useful to easily know the location of the victims. The accuracy of GPS changes depending on the environment of the situation. If the condition is good, the precision is less than a few meters, but if the conditions are not good such as indoors, errors of several tens of meters or more may occur [8]. In the future, it is necessary to verify in detail whether the accuracy of GPS is in a practical range in the search for victims in actual disasters. In addition, it is expected that the accuracy of the GPS system will be improved by the launch of the quasi-zenith satellite in the future, and if the measurement accuracy becomes several centimeters, accurate position identification of the victim will be possible.

Although the system constructed in this study assumes a one-to-one situation, in fact it is assumed that many victims and searchers are mixed within a narrow area. It is necessary to verify that the proposed system works properly even under such circumstances. In addition, in the system constructed in this study, although only the heart rate is transmitted, the system will be a more practical system by sending body temperature of victims and environmental information such as temperature and pressure.

The proposed system is assumed to be used only in the event of a disaster, we think that it is important to revise a system that can be utilized even in peacetime. In this system, the victim him/herself must start up the application when a disaster occurs. Assuming unconscious victims buried under the rubble, the current method is undesirable. Therefore, we will consider how to launch applications that do not require user's own operation.

5 Conclusion and future works

In this study, we propose a safety confirmation system for disaster situations using wristwatch-type terminals and smart phones and implemented the prototype. For future work, it is necessary to conduct experiments in real environments. In this study, we conducted experiments at places where there are no obstacles and good prospects, but such an ideal environment is hard to think in actual disaster sites. In the real environment, it is conceivable that there are many obstacles such as rubble between victims and searchers. Assuming such shielding objects, it is considered that the communication distance with Bluetooth also changes greatly. It is necessary to verify the communicable distance assuming the situation of rubble at the actual disaster in the future.

We are also planning to consider the integrate the proposed system with other safety confirmation systems such as, for example, Twitter based Safety Confirmation System T-@npi proposed by Utsu et al [9][10].

Acknowledgement

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