Development of a simultaneous safety conformation system for impaired persons at the time of earthquake occurrence

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SUMMARY:
During and after the occurrence of earthquake, handicapped persons such as visual-impaired persons, auditory-impaired persons, and others are extremely under serious situations. It is very important to check whether they are safe or under dangerous situations, and if they are injured or under dangerous situation, rescue activity should be taken as soon as possible. From this point of view, the author has developed a "simultaneous safety confirmation system" which checks the situation of the impaired persons, especially visual-impaired persons and auditory-impaired persons at the time of the occurrence of earthquake. This system consists of server computers and terminals. It is a kind of "server and client system". The server computers are placed at public agencies and the information in the server system is shared among them. Each impaired person, a client, has their own terminal.

Keywords: Information system, Impaired person, Safety society, Earthquake

1. INSTRUCTION

An earthquake occurs suddenly. During and after the occurrence of earthquake, handicapped persons such as visual-impaired persons, auditory-impaired persons, orthopedically impaired persons and others are extremely under serious situations. Actually, many problems are reported to keep these impaired persons safe at the great 1995 Hanshin-Awaji earthquake, at the recent 2011 Great East Japan earthquake and other severe earthquakes. It is very important to check that the impaired persons are safe or under dangerous situations, and if he/she is injured or under dangerous situation, rescue activity should be taken as soon as possible.

From this point of view, the author has developed a "simultaneous safety confirmation system" which checks the situation, i.e., safe or injured or necessary for help, of the impaired persons, especially visual-impaired persons and auditory-impaired persons at the time of the occurrence of earthquake. This system consists of server computers and terminals. It is a kind of "server and client system". The server computers are placed at public agencies, such as municipal offices, fire stations, social welfare agencies, etc., and the information in the server system which consists of several personal computers is shared among them. Each impaired person, a client, has their own terminal.

It is necessary to check the situations of large number of impaired persons at the same time when a severe earthquake occurs, therefore, the information exchanged between the server system and the terminals should be very simple, i.e., a few bits for each person. To realize this, all the messages which may be used are stored in the terminal and suitable messages are displayed in sound or characters according to the signal from the server system.

In this paper, the author describes the structure and function of the simultaneous safety conformation system and summarizes the problems to be solved for the future practical use.

2. OUTLINE OF THE SIMULTANEOUS SAFETY CONFORMATION SYSTEM

2.1. Flow of information in the system

Figure 1 shows the simple image of the simultaneous safety conformation system. The system consists of the server system of which personal computers are located at the public agencies such as municipal offices, fire stations, police offices, social welfare agencies, etc., and many terminals which impaired persons possess. The terminals are distributed to the impaired persons who registered at this system. Arrows in the figure designate the flow of information which is exchanged between the server and the terminals.

It is necessary to check the situations of large number of impaired persons at the same time, therefore, the information exchanged between the server system and the terminals should be very simple, i.e., a few bits for each person. To realize this, all the messages which may be used are stored in the terminal and suitable messages are displayed in sound or characters according to the signal from the server.

The process of the information exchange is as follows; first, the massage is given to all the terminals from the server system asking whether the owner of the terminal, i.e., a client, is safe or needs help. Then, the client answers whether help is needed or not by simple operation. When the server received the answer, the server send back massage to the client that the answer is accepted, and lifeguards will be dispatched if necessary.

These information exchanges are automatically performed. The information corresponding to the numbers attached to the arrows in the figure is as follows;

(1) When an earthquake occurs, safety conformation information is sent to all the terminals from the server system automatically from the municipal government, where the headquarter of the measures against the earth disasters is placed.
(2) Each impaired person, a client, will answer to the question from the headquarter whether he/she is safe or not, needs rescue or not depending on the situation.
(3) Receiving the answer from the terminal, the public agencies start the activities. For example, fire departments despatch the rescue team to the client who needs the help.

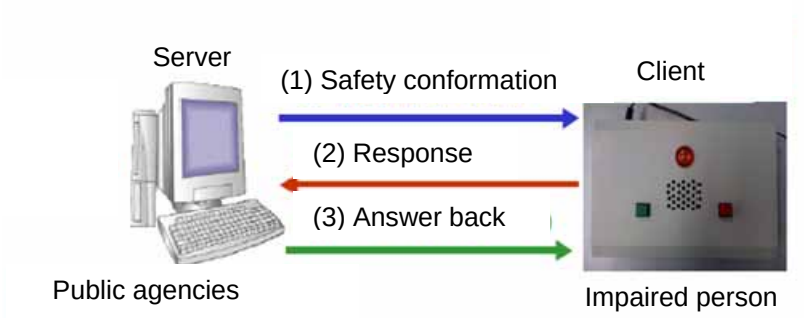


Figure 1. Outline of the system

2.2. Server system

The information in the server system is revised in real time and shared between the server computers placed at the public agencies. The system is , therefore, autonomous, distributed and cooperative system.

The server system has the following functions;

(1) It is always ready to respond, i.e., on standby mode.
(2) When an earthquake occurs, it sends massage to all the impaired persons inquiring the safety of them.

(3) It can grasp the conditions of the impaired persons from the answers and promotes the rescue action to the persons in charge.
(4) It can display the present location of the impaired person with the aid of GPS on the monitor.
(5) To make possible the above actions, it stores the database of the attributes of the impaired persons.

2.3. Terminal system for impaired persons

The terminal system has the following characteristics and functions;
(1) The communication line to the terminal should not depend on a specific carrier for the public use.
(2) The terminal can inform both of the visual-impaired persons and auditory-impaired persons of the signal from the server without fail although they have different abilities.
(3) To realize above, it has the function of vibration, sound, light and character display and so on.
(4) Even when a client can not answer, his/her situation should be recognized to the server.

2.4. Flowchart of the information

Figure 2 shows an example of the flow chart of the system at the time of occurrence of earthquake. First, when an earthquake occurs, the signal which informs the impaired persons of the occurrence of an earthquake and asks them safe or not, is sent to all the terminals from the headquarter of the municipal government. The signal (signal 1) is transformed to vibration, light, voice and characters in the terminal device. Each person will answer “safe” or “need help” by pushing the “safe” or “need help” button depending on his/her situation. After that the flow divides into three flows as follows including “no answer”.

(1) When the “safe” button is pushed, the information is transferred to the server and at the same time the “signal 2” is announced and displayed on the terminal to inform that the signal is correctly transferred. When the server system receives the “signal 2”, it sends back the answer “signal 3” to the person to inform that the server surely accepted the signal.

(2) When the “need help” button is pushed the information is transferred to the saver and at the same time the “signal 4” is announced and displayed on the terminal. When the server system receives the “signal 4”, it sends back the answer “signal 5” to the person to inform that the signal is surely accepted to the server. At the same time persons in charge of rescue will go to the person to help.

(3) When neither “safe” nor “need help” answer transferred to the server, in this situation, two cases are possible. One is that the person is not at home, and the other is that the person cannot access to the terminal due to serious situation for example, heavily injured or confined in a narrow space of the collapsed house. In these cases, the location of the person is examined and if he/she is in the house a rescue team is dispatched.

The signals are determined based on the condition of the persons. The followings are examples for “signal 1” to “signal 5”.
“signal 1”: “An earthquake occurred. Are you alright?”
“signal 2”: “I am safe”.
“signal 3”: “We accepted you answer. Be careful from now on, too.”
“signal 4”: “I need help”.
“signal 5”: “We accepted your help. Rescue is coming. Hold on”.

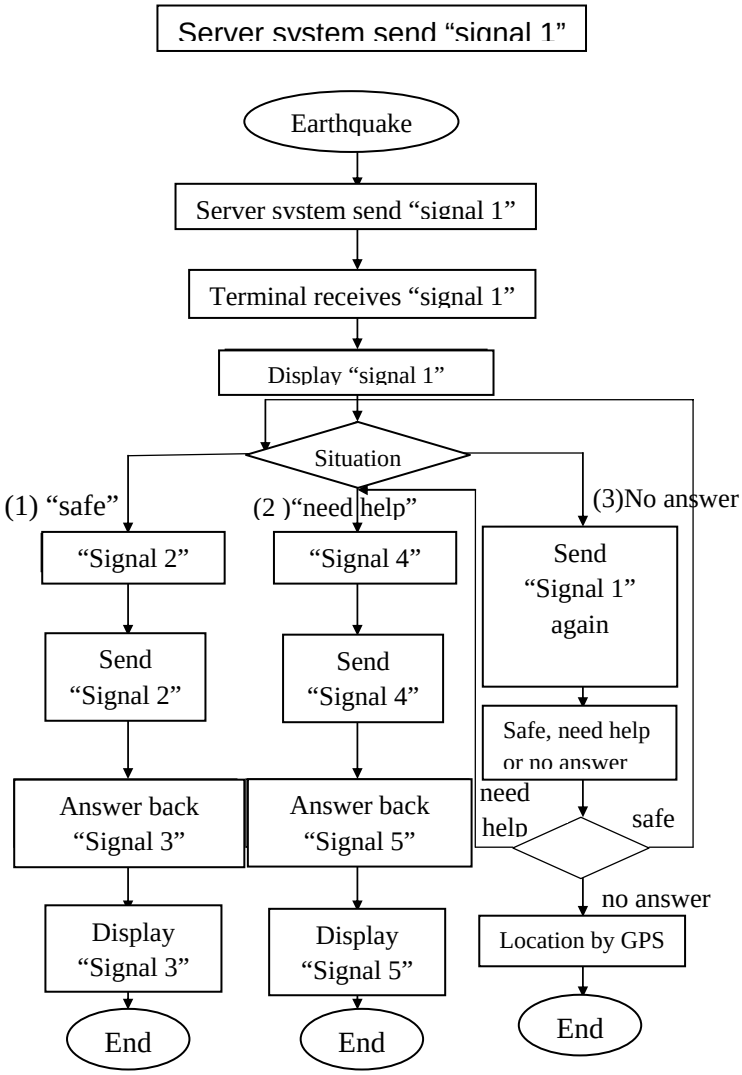


Figure 2. Flow of information and activity

3. SERVER SYSTEM

3.1. Database system

The server system has the functions mentioned in 2.2. To realize them, the clients’ various attributes are stored in advance as a database in the server. For example, the kind and degree of disability, living alone or with families, living in wooden house or concrete house, new or old, and the location of the house such as near the beach or on/under the steep slope, etc. as well as name, age, address and so on. Based on the attributes, suitable rescue action will be selected.

To grasp the conformation process is very important to perform the efficient rescue activity. Therefore, the real time process of the response from the clients is summarized in a table as shown in Figure 3. The table lists the number of total responses, “safe” answers, “need help” answers as well as the number of the clients for the areas. By cricking a area button, detailed information, i.e., individual information and present situation in the area is given on the screen. With this aid, personal rescue action is possible. By cricking the “No. of “need help”” button, the list of the person who wants rescue is displayed. By making use of these functions of this table, the efficient action is possible.

Figure 3. Conformation process screen

3.2. Decision making support system for the order of priority in rescue

Dangerous situation is different depending on the kind and degree of the disability, such as visual-impaired or auditory-impaired, on the kind of disasters, such as earthquake, heavy rain and typhoon, on the time of occurrence of the disaster, such as at night or day time, on the age of the person, on the location of person's house, and so on. The severity of the dangerous situation is very complicated in this way, however, it can be classified into some ranks, in other words, the order of priority of the rescue activity can be determined. For example, old houses are more dangerous than new ones, houses on the soft ground are more dangerous than on hard ground, houses on the coast are danger to tsunami and tidal wave, houses at the foot/top of steep and high slope are danger to slope failure. Houses on the river and law land are danger to flood and so on.

By taking account these factors above, and giving scores (1~5) for each factor determined by experts, the order of the priority of rescue activity is determined by using AHP (Analytic Hierarchy Process) method. Examples of the score are listed in Table 1.

Table 1. Example of scores for AHP method

Score	Handicap		Age	Living style
	visual-impaired	auditory-impaired		
1	Rank 5		65~75	Impaired person with young family
2	Rank 4	Rank 4	76~85	Young impaired persons
3	Rank 3	Rank 3	86~	Old family and young impaired
4	Rank 2	Rank 2		Old and impaired
5	Rank 1	Rank 1		Impaired, old and alone

Figure 4 shows an example of the application of the AHP method for the rescue action. Red color bar represents the persons who are in the group of the highest priority, then vermilion, orange, and yellow bars. Dark gray bar means "waiting" the response, light gray means "no response" and Green means "safe". By using this screen rescue action will be performed effectively with the limited manpower.

In the actual usage of the system, the process is as follows. The user is a person in charge of this system, generally the expert in the disaster mitigation section in the city office.

Step 1: Choose the kind of disaster, the occurrence time of the disaster etc. from the input screen.
Step 2: The order of the priority is automatically determined from the input data above and attributions of the impaired persons in the database, and listed as priority table.

Step 3: By comparing the response from the clients, i.e., the conformation process shown in Fig.3 and the priority table, determine the order of the actual rescue action.
Step 4: As the response from the clients increases, the order is renewed.

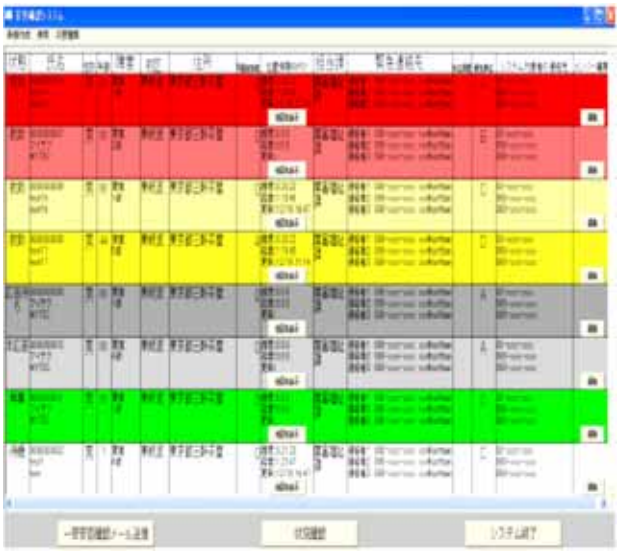


Figure 4. Output of the decision making support system

4. TERMINAL SYSTEM FOR IMPAIRED PERSONS

4.1 Communication system of the terminal

Generally speaking, the communication system should not depend on a carrier such as a specific mobile phone company in the public use, “e-mobile” is employed in the communication system and “Armadillo-500” is employed as for a CPU board in this study. Almadillo-500 is a small size, high performance CPU module, and can be used as a main processer of the multimedia equipments. The control program is developed using C language. Photograph 1 shows the structure of the terminal, i.e., “e-mobile” and “Armadillo-500.

Photograph 1. Structure of the terminal

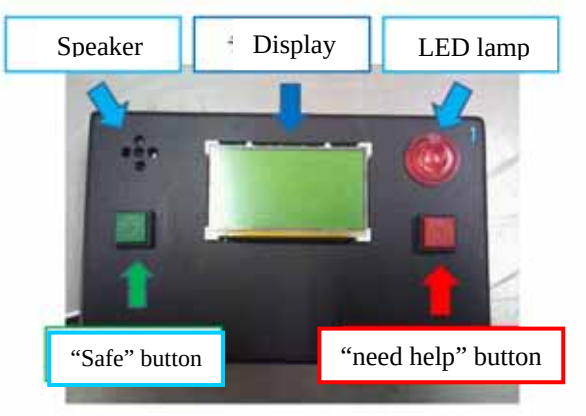
4.2. Function of the terminal

The terminal has to have several functions to communicate with impaired persons. Photograph 2 show the terminal. This model is a prototype which just realized the functions, and in the actual use, this must be smaller easy to carry. The functions are as follows.

(1) Communication: HTTP request.
(2) Vibration: When the first “signal 1” reaches, the terminal starts to vibrate to notice that there is a

massage from the server system, the municipal government, to both visual-impaired and auditory-impaired persons.

(3) LED lamp: Same purpose as above.
(4) Sound: Sentences are recorded in advance and the proper sentence is selected and uttered based on the signal explained in 2.4(3). This is for visual-impaired persons.
(5) Character display: As same as in the Sound, the proper sentence is shown on the display. This is for auditory-impaired persons.
(6) GPS: Detect the position where the person is. If he/she is in his/her house but no response, the situation should be dangerous. If he/she is not in his/her house and moves, he/she is safe.
(7) Power supply: After the occurrence of earthquake, breakdown likely occurs. The UPS (Uninterrupted Power Supply) function is needed. Charging dry battery, "eneloop", is installed.
(8) Response buttons: "safe" and "need help". They should be carefully designed for the usage of impaired parsons.



Photograph 2. Terminal

5. EVALUATION TEST

The performance evaluation test of the system was conducted on Feb. 14 in 2011. The purpose of the test is to confirm that the communication between the server system and the terminals is possible as designed and to get opinions from users of the system. In the test, four visual-impaired persons and four auditory-impaired persons attended. A scene during the test is shown in Photo.3. The server computer is set in the author's laboratory in the Faculty of engineering of Yamaguchi University and four terminals were used in Ube social welfare agency. The distance between the two is about 3km. The communication was completed.

Photograph 3. A scene of the performance evaluation test

Main opinions from the users are summarized in Table 2.

Table 2. Main opinioins

About the function of the terminal
・should be more small, i.e., handy size ・combine the functions with the mobile phone, i.g., possible of talking ・make the characters in the display larger ・make different shape for “safe” button and “need help” button, and use Braille, the point system ・make the light stronger, and use stroboscopic lamp ・make the vibration stronger.
About the system
・access to the server should be possible even after the situation changed ・possible to access from the terminal in the emergency situation (even not in the case of earthquake) ・want to know when the rescue team arrive after the response

6. CONCLUSION

In this study, a prototype “simultaneous safety confirmation system” is explained. The system is for the use of visual-impaired persons and auditory-impaired persons. The system is a server and client system. The server system is installed in public agencies and is a kind of autonomous, distributed and cooperative system, therefore, information is always shared and renewed automatically. The client terminal for impaired persons is multifunctional. It enable the communication between impaired persons and public persons during and after the occurrence of earthquake. From the evaluation test for the prototype system, it was revealed that the system has great possibility to help them and at the same time, there still exist problems to be solved, for example, the terminal should be more handy size, combine the functions with the mobile phone, make the characters in the display larger, separate the functions for visual-impaired persons and auditory-impaired persons and so on.

AKCNOWLEDGEMENT

With the aid of many participants who are considered to be future users of the system in the local agencies and impaired persons, the author could developed a prototype system and could performance verification tests in Ube city as a model city. This study is not completed yet but almost done. During the long time of the study, many students worked with me. The author expresses deepest thanks to all of them.

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