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Development of Evacuee Support Using Heart Rate Variability

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ABSTRACT

Residents under hazard and disaster conditions should be evacuating to the pre-assigned nearest safety facilities, community hall, local schools, friend's houses, etc. in a safety zone, quickly as soon as possible. The small percentage of evacuees shows serious economy class syndrome after the quake, because those people are forced to a stressful dairy evacuee-life in scattered homes and/or in-vehicle, for instance. Then, we consider on supporting evacuees using heart rate variability, Geospatial Positioning System (GPS) and WiFi functions of a smartphone, and Web-server on the Internet to keep their health in good conditions.

Key words*: Caring Evacuees, Heart Rate Variability, Poincaré Plot, GPS, Web Service.*

1. INTRODUCTION

During the last decade not only in Japan and Korea, but also in countries around the world, huge devastating earthquakes, typhoons, hurricanes, flooding, etc., have been destroying the residents' lives and houses, infrastructures, and so on. Those disasters were resulting in the large numbers of citizens into evacuees who were staying at pre-assigned nearest safety facilities, community hall, and schools, friend's houses in a safety zone, for example. Some of the evacuees were staying at their vehicle for long period, causing the fatal economy class syndrome. In order to prevent evacuees from those circulatory

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system diseases, it is necessary for them, especially for elderly persons, to care themselves within moderate heart rate (HR) variability. Then we have been considering the usefulness of wearable sensor devices with a smartphone [1]-[5]. Then, in this paper, we describe the remote services for supporting evacuees using a wearable sensor of HR variations, current location using GPS (Geospatial Positioning System) and WiFi functions of a smartphone, and Web server on the Internet. A similar system for monitoring arrhythmia of the patient was reported in [6].

This paper is organized as follows. In Sec.2, the system architecture is described. In Sec.3, typical scenario that residents have to evacuate from lowland to highland area is considered based on HR variability with the current location of the evacuee. Sec. 4 concludes our considerations.

2. SYSTEM ARCHITECTURE

2.1 Overview

The system considered in this paper is composed of two main components: wrist-type wearable sensor device detecting the values of HR and the current location of an evacuee using smartphone connected via the Bluetooth link, and for sending those sensed data items to the dedicated Web server on the Internet via wireless WiFi equipped with a smartphone.

2.2 Wrist-type wearable HRV sensor

Nowadays, a lot of commercial wrist-type wearable HRV sensors are found in a market. We selected sensor device with capable of detecting HR values within at less than one-second interval, because those data items may be used for analyzing strengthen of fatigue and/or degree of stress of evacuee in time- and/or frequency-domain. The guidelines for analysing HR variability are described in [6]. Considering the convenience of evacuees, in this paper, we focus on the performance of HR variability and the characteristics of Poincaré plot.

2.3 How to get HR values and GPS location data-items using smartphone

The capturing software for a smartphone with GPS and the Bluetooth linking with the wearable HR-s(version >=4.4). The data items of each evacuee, *username*, *recorded date and time*, *the value of HR* and *longitude/latitude of the current location* in every around one-second interval, are getting from the sensor devices as the vital, and *altitude* and *moving speed* of evacuee are as optional. Those sensed data-items are stored not only in the main memory or secondary SD-memory of smartphone device but also send to the Web server on the Internet described in next subsection. Fig.1 shows the screen shot of the smartphone; on the top part of the screen showing HR variation and on the bottom showing the current location of an evacuee on the Open Street Map [9]. The numerical values of HR and GPS with other data-items are shown in the middle part of the screen.

2.4 Web (LAMP) server

The Web-server we are developing is composed of LAMP stands for Linux Operating System, Apache webserver, MySQL database, PHP and Javascript languages. The server parses and analyses the received data items of each evacuee from each smartphone using the transfer protocol, *httpclient.protocol* [7], and shows the analytic results to the corresponding evacuee (and their concerned persons) on the browser as shown in figures in Sec.3.

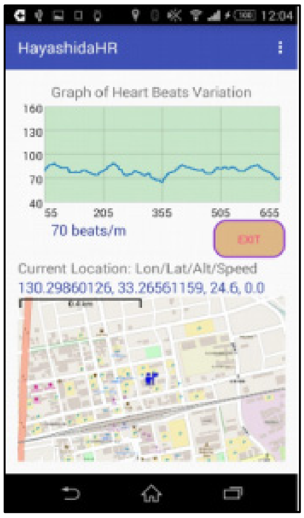

Fig.1. Screen shot of smartphone

3. SCENARIO OF SUPPORTING MOVING-EVACUEE

Hizen Hamashuku [10] in Saga Prefecture locates north-western part of Kyushu of Japan, as shown in Fig. 2, where is the part of alongside ARIAKE bay-area from Nagasaki, Saga, Kumamoto and Kagoshima prefecture, be a famous area as a beautiful natural lowland in the world. Hizen Hamashuku includes historical houses and streets established in Edo period between 1603 and 1868, specified as an Important Preservation Districts for Groups of Historic Buildings in 2006. Many visitors including foreigners are coming to this area every year. As shown in Fig. 3, the altitude Hama-river located near the national road No. 207 is about 4-meter-hight, so they call this area as low-land facing Ariake Sea causing vulnerability on sea level and flooding due to heavy torrential rain.

We select two typical evacuation routes: one starting location from Minami Funatsu to Hama Community Hall at the altitude of about 20 meter-height which has the capacity of 200 evacuees, other route is from Minami Funtsu to Kotohira-shrine at the altitude of about 30-meter-height via alongside Hama-river. On the way to the Kotohira-shrine, evacuees have to step up on the Stone steps with 109 steps as shown in Fig. 3.

Fig. 2. Hizen-Hamashuku, Kashima-city, Saga is a famous area as beautiful natural lowland

Fig. 3. Two evacuation routes: one from Minami Funatsu to Hama Community Hall, and second to Kotohira-shrine

Field experiments were performed on April 26, 2016, at Hizen Hamashuku with a residential person as a collaborator, called Mr. I, 68-year-old healthy gentleman. He took two routes; route 1 and route 2, having a short interval of rest. The typical results are shown in Fig.4 and 5. The Google map [11] is used in which the current location and values of HR variation of evacuee as a color marker. The Google map elevation service API [12] is used to find the values of altitude based on the current location of evacuee because inaccuracy of the value of altitude getting from GPS.

At the first trial of an evacuee was performed the route 1 of the total distance of about 400 meters. From the starting location to 300 meters the path is almost flat following the sharp climbing up to the community hall. When he met and talked his friend in a few minutes at the location of 140 meters on the path, the values of his HR decreased lower, meaning that he was in the relax state as shown in Fig 4. After meeting, he walked again on his own waking-pace, and then climbed final uphill slope to the community hall.

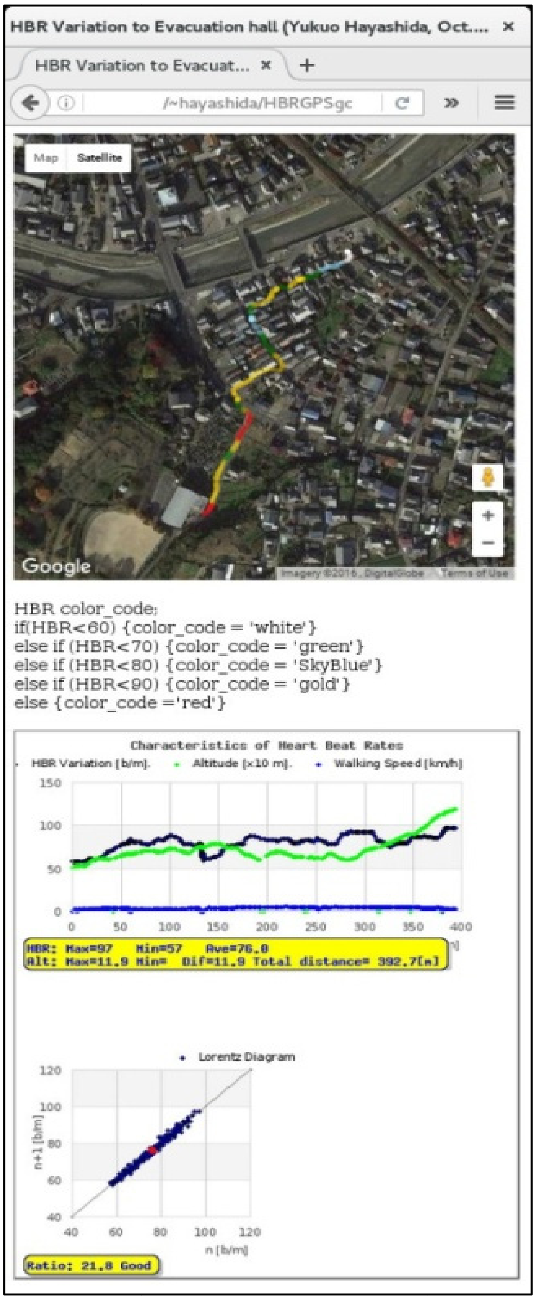

Fig. 4. Evacuation route, one from Minami Funatsu to Hama Community Hall

The second trial of the same person just after 30 minutes of the first trail was experimented on the alternate route 2 which is at the same starting point, but taking river-side of lower altitude of about 3 meters to the point of distance of 150 meters. The graph of Fig. 5 shows that the values of his HR between 75 and 90 [beat/s], meaning that he was walking to the community hall without having a break time. As depicted in the Poincaré plots (or Lorentz diagram) [8], the results of those two trials indicate us that the evacuation route 1 shown in Fig. 3 is a better choice than the alternate route 2 in Fig. 4 for the evacuees from the residential houses at lowland to the community hall at highland to prevent their lives from disasters.

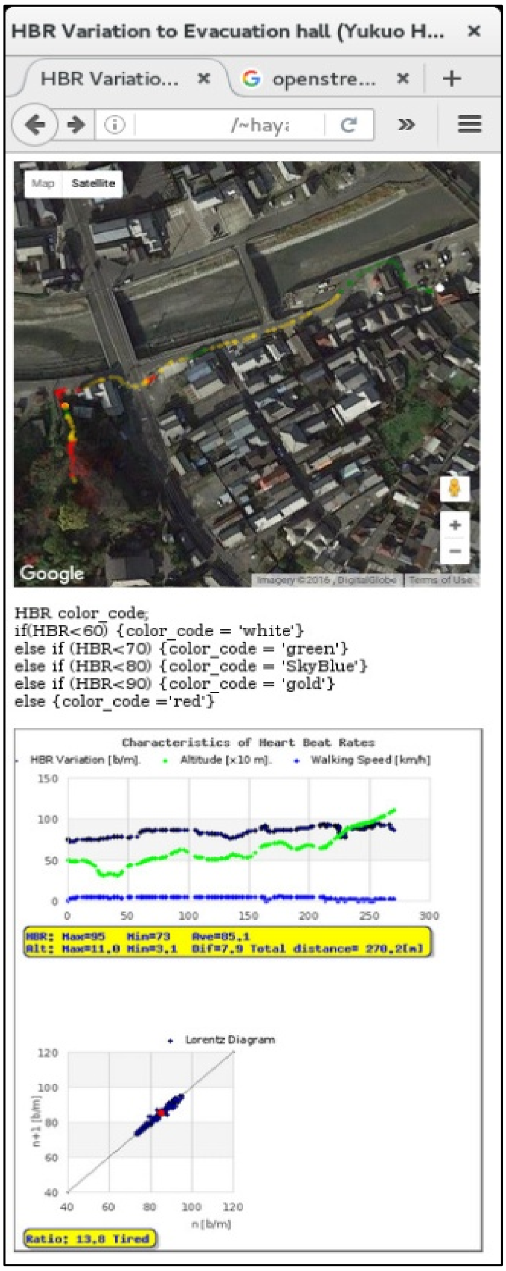

Fig. 5. Evacuation route, two, from Minami Funatsu to Kotohira-shrine

4. CONCLUSIONS

In this paper, the remote support system of evacuees is developed. The system is composed of a wearable HR sensor and smartphone of a consumer product that is widely used by people in the society of information and communication technology (ICT). Web server composed of LAMP collects the data items of evacuees via the Internet and feedback the analytical results to evacuees and their concerned persons if necessary.

How to select the evacuation routes to protect residents living in lowland from disaster is shown as one of a typical scenario as an application field. As a result, this system is useful for the one of design tool of disaster prevention and mitigation.

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