REAL TIME WEARABLE LOCATOR DEVICE FOR DISTRESS

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ABSTRACT

This paper presents a study in the development of a real time wearable locator device for distress which uses human pulse rate. A person who is in distress normally has delayed reaction. However, a good means of identifying distress is through pulse rate in which a notification can be done even before the person can make a distress call. An increase in pulse rate signal can be classified for illness, exercise, or a strong emotion. A comparative analysis of signals was conducted based on the instance of emotion shift by cinematic terror assumed to determine distress compared to that of a normal and in exercise condition. An inexpensive prototype was developed using wearable wrist band which is embedded with a pulse rate sensor, GPS and GSM modules for tracking location. In addition, notification to an emergency contact is sent via SMS and a locator map can be viewed through a smart phone or computer. The results show the distinct characteristics of the heartbeat of a person in distress with an increase of an average of 37 bpm in 10 seconds or 41±3% increase from the normal heart rate. The device is calibrated in a 1-minute initialization to register normal heart rate. The reaction rate of the wearable locator device is proven to be faster than the reaction time when a person picks up a phone, dial, and make a distress call. The reaction time for sending a distress notification varies depending on strength of the mobile network signals. A robust design can further be developed in the future through a more intelligent way of identifying distress with both pulse rate and brain activities.

KEYWORDS – pulse rate, wearable devices, distress locator

I. INTRODUCTION

A quick response for distress is one of the major needs of the people. The Philippine crime index as of 2016 is still large at 135.1 in a growing population[1]. The Philippine government has been trying a lot of solutions including the drug war, emergency response units being upgraded, as well as the 911 hotlines. For individual safety, there are devices from off the shelves in the market. Wearable devices serve as an advantage that will ease the risk for such unexpected events such as fear or any kind of distress, including physical dysfunction.

This study aims to develop a real-time wearable device that detects irregularities in heart rate to notify that a person is in distress. Experiments are conducted revealing the distinct behavior of a person in distress by evaluating it comparatively with that of a normal heart rate and in exercise. A pulse rate sensor integrated with an intelligent controller is useful for this application. A prototype has been developed in a pilot stage, that is, the bulky wearable device can still be improved.

The next sections present the following: Section II discusses some innovations on wearable devices as well as the validity of the use of pulse rate as means of detecting distress; Section III presents the hardware setup for the wearable device including the receiver side, the software setup, and the experiment model; and Section IV discusses the results of the experiments showing successful in sending distress; Section V the discussion of results as well as the advantages and pitfalls in the experiments; finally, Section VI the conclusion and recommendations for improvement.

II. LITERATURE REVIEW

A. Distinct characteristic of a heart rate of a person in distress

Fright affects cardiac changes. Doctors and nurses come in to examine these characteristics to those who are in perilous condition. A patient's pulse rate can change abruptly from 30 beats per minute (bpm) to 60 bpm during the pulse monitoring[2]. This is noticed in a 72-year-old patient terrified when a person enters in her room as shown in Fig. 1. Similar cardiac reactions were noticed during the physical and psychological distressing situations brought by contacts such as blood pressure measurement, and doctors and relatives' visit.

B. Heart beat change in emotion shift

To provide scientific evidences on how human interactions affect the heart, around 41% was observed to have increased when a person is terrified. Existing researches proved that violent or horror movies induce psychological fear and startle response to viewers. The average heart rate of the subjects increased from 77.6 bpm when they were watching calm scenes in a film to 110.1 bpm (41.9% increase) when they were watching scary scenes in the same film. There are also cases of different rhythmic patterns for abnormality of heart rate to signify that a person is in distress; whether in fear or in physical dysfunction[3], [4].

C. Wearable photoplethysmography (PPG) sensor, a great potential for distress detection

Several applications of PPG, a non-invasive method of measuring the variation in blood volume in tissue using a light source and detector, have been successful in detecting heart rate[5], [6]. The continuous pumping of blood through the body causes change in the blood volume inside the finger artery. Several devices use this principle in which the device is placed in a physical contact in areas where the artery is closest to the skin.

Unpleasant feelings and emotions are defined as mental or psychological distress. It can be measured directly, but various physiological parameters such as heart rate variability and blood pressure can interpret the level of mental distress. A design of a new wearable PPG sensor and its assessment for mental distress estimation was developed [7]. Forty-five volunteers participated to assess the proposal. A complete description of the device indicating its capability to acquire blood volume of an individual was introduced. This includes processing of signals, extraction of a series of features, and classification of calm and stress with remarkable accuracy.

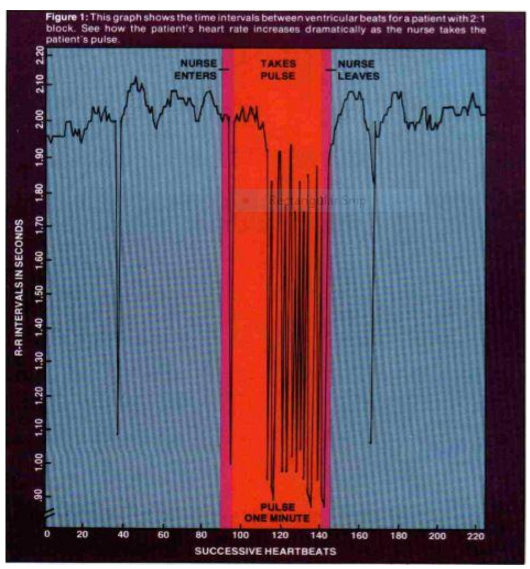

Figure 1. Dramatic increase in patient's heart rate.[2]

III. METHODOLOGY

A. Basic Hardware Setup

The basic hardware setup is composed of inexpensive devices (See Fig. 2). These devices are the pulse rate sensor (Pulse Sensor Amped), GSM modules, a GPS module, and microcontroller. The pulse rate sensor detects irregularities in heart rate when the user is in distress. The wearable intelligent microcontroller serves as the brain of the project. The GSM module communicates the signal from the wearable device and sends it to a smartphone or a computer. The GPS module provides the location of the user. All these are powered by 3.7V rechargeable Lithium Polymer (Li-Po) batteries. Furthermore, a personal computer for the windows application is required. This setup provides the user ease of access and comfort in using the wearable distress locator. The receiver will be able to receive the signal faster than making a phone call for distress signaling.

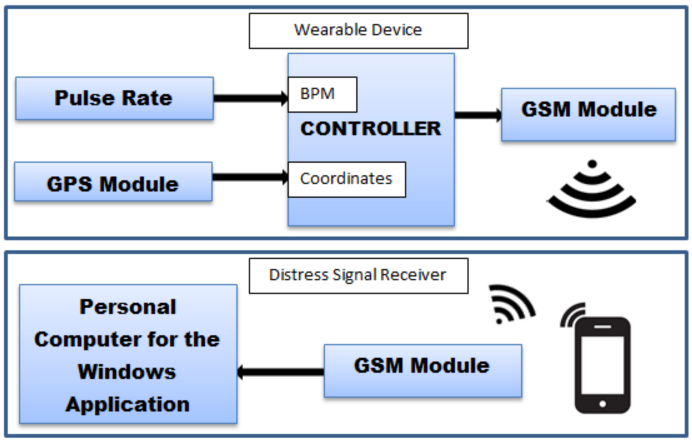

Figure 2. Prototype Block Diagram

B. Software Setup

The windows application displays the user's location in the event of distress. As an added value, companies aiding employees who spend most of the time working outside the office will be able to respond to distress. Figure 3 shows the gray pins which represent all previous points of location in which the device sent a signal, while the red pin represents the most recent location. These are some of the test results for detecting and sending the location of the distressed person. This was designed using Visual Studio 2017.

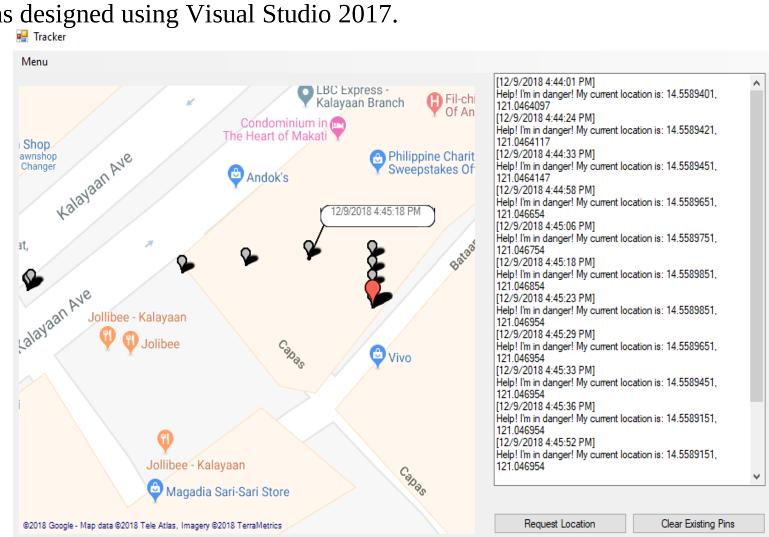

Figure 3. Windows Application

IV. RESULTS

Initialization is conducted prior to the computation of distress signal range to avoid bias or presets if another person uses the device. This initialization is conducted by acquiring data in a 1-minute interval so that the average heart rate is being recorded. From then, the 41±3% is set to be the working heart rate distress level. (See Fig. 4). The normal heart rate averages 90 bpm. The triggering value is computed by a 41±3%, with a ΔR=127 bpm. The average increase in bpm in this range is at 37 bpm.

A person's heart rate increases when in fear and during exercise. A noticeable distinct characteristic of heart rate when a person is in fear can be seen in Fig.5. The ranges variability is set at these levels, where and abrupt change in 10 seconds interval is detected. These signals when detected trigger the device to send a notification signal to the attending receiver. The heart rate increase can be distinguished from that of in an exercise since there is not much increase or even abrupt changes observed.

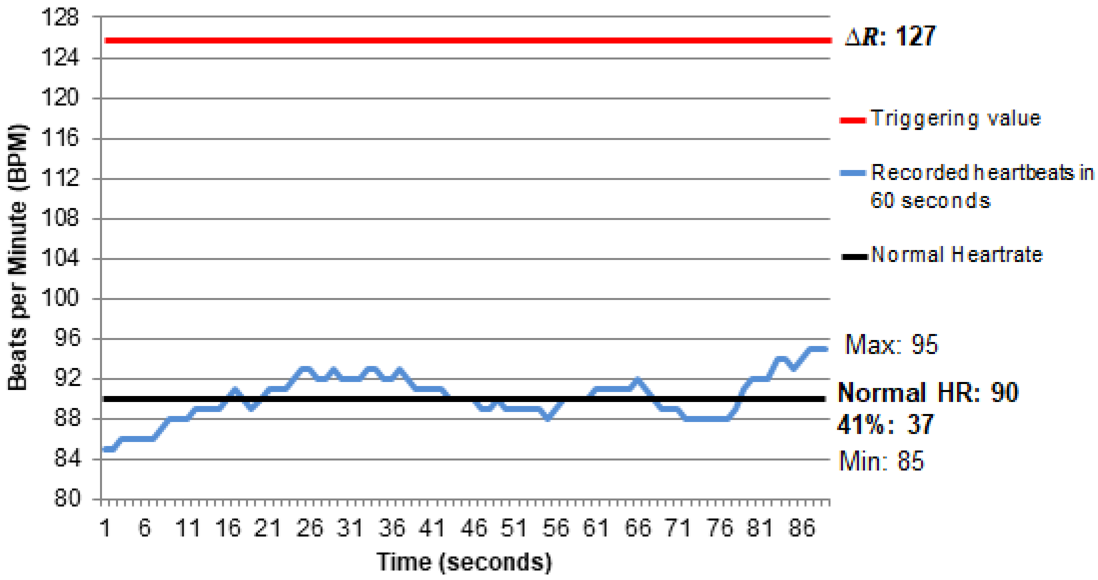

Figure 4. Heart rate initialization in one minute.

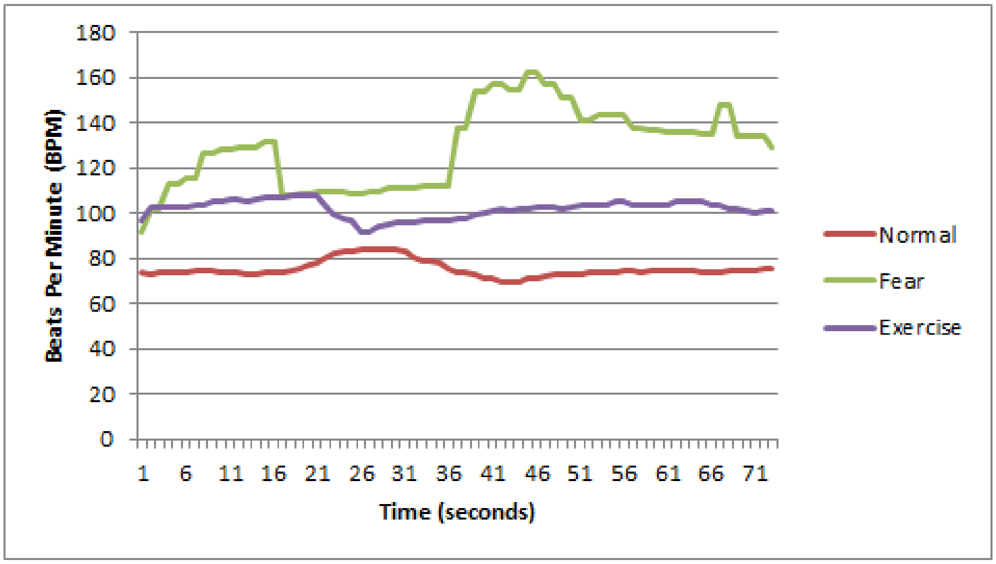

Figure 5. Comparative analysis for cinematic terror vs. normal and in exercise.

Monitoring of pulse rate is done by connecting the pulse rate sensor in a wrist band. For this pilot test, proper orientation is necessary. Erotic signals might be accumulated when the sensor is not in proper contact with the area where the artery is close. The data were gathered by connecting it to a microcontroller. Figures 6a and 6b show the pulse rate sensor connected to the wrist and controller, signal conditioning and conversion respectively. Results were displayed through the microcontroller's serial monitor.

To validate the detection and sending of distress signal, an SMS is programmed to be sent in a smartphone or a computer, indicating the location and a distress message. When the location is clicked, tab will be opened showing the map where the person in distress is located. (See Fig. 7). Several trials were done and as a result, all distress signal were received with the same cinematic setup.

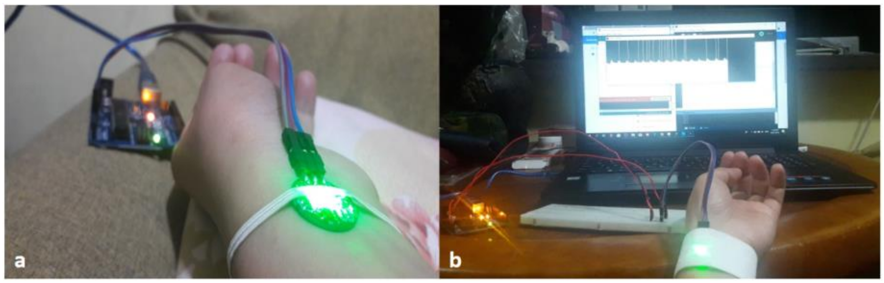

Figure 6. Prototype Testing: a) pulse rate sensor test b) signal conversion and conditioning

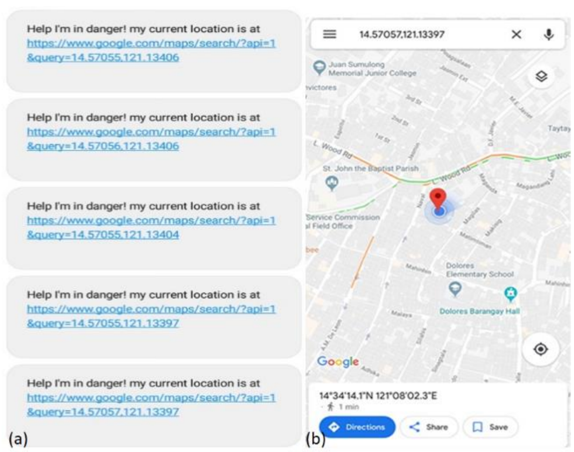

Figure 7. Distress signal received. a) SMS Notification b) Loation displayed in map on a smartphone.

V. DISCUSSION

The pulse rate sensor identified an irregularity in the user's heart rate. The GPS module was able to track the user's location by getting GPS coordinates. The GSM module attached to the wearable device was able to send SOS messages and GPS coordinates to predefined numbers, and to another GSM module connected to the computer. In application, this could be numbers of authorities or user's parents and close friends. Since the device is reprogrammable, it is the user's prerogative to change the number anytime they opt to.

User's location could also be viewed via Google Maps. The SOS message was designed to include Google Maps link in order for the receiver to easily locate the user with just one click on the link. This feature would make it easy for parents or authorities to locate the user who might be in danger the moment they received the message. Drawbacks were still experienced during some tests especially inside enclosed areas in which GPS locations could be inaccurate. In a real situation, it will be easier for authorities to trace the location of the user due to color indicators shown on the application (See Fig. 7). The gray pins represent previous locations, while the red pins represent the most recent one. It keeps updating every time the device sends a signal.

VI. CONCLUSIONS AND RECOMMENDATIONS

Real time wearable distress locator device can be achieved with inexpensive devices such as pulse sensor with GSM, GPS, and microcontroller modules. The distress signal and the location can be automatically sent when an irregularity in heart rate was sensed. This concept was verified by achieving a fast detection of distress. The device is calibrated to the user setting, so that the parameters are fit for the heart rate activities. As compared to making a distress phone call, this wearable device is an advantage to the responders and in the future will be able to help in saving lives.

This is a preliminary work done to test the capability of an inexpensive pulse sensor to detect a person in distress. In the future, the use of Artificial Neural Network will be done to have a more accurate and intelligent detection. A more robust wearable device for distress call can also be developed using this concept.

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