Development of Brady-Tachy heart automotive monitoring (*BT-Heartomotive*) device to prevent motor-vehicle accident

Mohd Azrul Hisham Mohd Adib[1,*], Muhamad Hazim Khalili[1], Nur Hazreen Mohd Hasni[2]

[1)] Medical Engineering & Health Intervention Team (MedEHiT), Human Engineering Group, Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia
[2)] Family Health Unit, Pahang State Health Department, Jalan IM 4, 25582 Bandar Indera Mahkota, Kuantan, Pahang, Malaysia

[*]Corresponding e-mail: azrul@ump.edu.my

Keywords: Brady-Tachy; heart rate; automotive; device; driving

ABSTRACT – The rate of car accidents is worrying nowadays. Other than problems in driving attitudes and skills, road accidents are also caused by uncontrollable factors such as medical conditions and drowsiness. These factors can be avoided by having early detection. *The BT-Heartomotive* device is a device that can detect early signs of drowsiness and health problems by measuring the heart rate of the drivers. Heart rate measurement can reveal a lot about the physical conditions of an individual. *BT-Heartomotive* device consists of three main components: the sensor, microcontroller, and heart rate monitor.

1. INTRODUCTION

The causes of road accidents vary between two groups of drivers: young and old drivers. Young drivers tend to be involved in road accidents due to the lack of experiences, risk-taking behaviors, over-speeding as well as alcohol and drug influence. Most of the accidents among older drivers are due to medical problems such as stroke, heart disease and psychoactive medications [1]. Another main factor contributing to road accidents is drowsiness. 21% of fatal road accidents were due to drowsiness according to the AAA Foundation for Traffic Safety between the year 2009 to 2013 [2] and 54% of adult driver's drive despite in the state of drowsiness [3].

The development of *BT-Heartomotive* device is to address the road safety issue among old drivers, people with medical problems and drowsiness. The mechanism of action of *BT-Heartomotive* is based on the measurement of the heart rate by a sensor. Many information can be extracted from the heart rate data. The most important data is the state of drowsiness. According to a study done by Abdul Rahim et al. [4], there is a big difference in the heartbeat between normal and drowsy states. In a normal, relaxed state, the heart beats in the range of 70 to 100 BPM but, only in the range of 45 to 65 BPM in an early drowsiness state.

Other than drowsiness, the measurement of heart rate can reveal information about the health state of an individual such as the risk of having the cardiovascular disease [5], undetected heart attack, blood pressure condition as well as the level of blood electrolyte [6].

BT-Heartomotive can also monitor blood pressure and blood oxygen saturation level (SpO_2) level. The degree of hemoglobin binding to oxygen (lung factor), hemoglobin concentration (anemic factor) and cardiac output (cardiac factor) are the three factors that can affect the quantity of oxygen transported throughout the body. Oxygen saturation is the ratio of the amount of oxygenated hemoglobin compared to the amount of hemoglobin in the blood to indicate the sufficiency or insufficiency of oxygen in our body. The level of healthy SpO_2 ranges from 96% to 99%. The level decreases significantly for patients with pulmonary or cardiovascular chronic diseases [7].

In this paper, the *BT-Heartomotive* device was developed. We are working on the functional prototype to improve the consistency and reliability of the data so that it can be used for the intended purpose. Essentially, the data is could be stored, and always reliable and usable. The proposed device would use the data to send an alert to the driver and passengers that they're in precaution. They should pull over and take action as early as possible to prevent a motor-vehicle accident. The device is also simple, easy to use, and automated.

2. METHODOLOGY

This *BT-Heartomotive* device consists of three main components; smartwatch, monitoring system, and mobile application as shown in Figure 1. The details of each component are described in this subsection.

2.1 Smartwatch

Consists of MAX30100, integrated pulse oximetry and solution of heart-rate monitor sensor that combines one photodetector, optimized optics, low-noise signal processing and two LED to detect heart-rate signal and pulse oximetry from which the heart rate, blood pressure, and SpO_2 level can be obtained. The body of smartwatch was developed using Flexible TPU filament.

2.2 Monitor System

In this monitoring system, the device displays the heart rate, blood pressure and SpO_2 level of the driver after receiving the value of heart rate in BPM from the microcontroller via a Bluetooth system. In order to develop this device. the microcontroller Arduino-Uno is used. Arduino Uno is an open-source electronics platform based on easy-to-use hardware and software. Arduino intended for making the interactive surface. The function is to obtain the value of heart rate in beats per minute (BPM) based on the photoplethysmograph (PPG) data from MAX30100. For the body of the monitor, the SUNLU PLA filament materials was used as shows in Table 1.

2.3 Mobile Application

The mobile apps. is developed to record and display the heart rate, blood pressure and SpO2 data trend of the driver. The data keep in the storage system as a black box function. These data will use as the emergency tread record or research activity.

Figure 1 The final design of *BT-Heartomotive* device.

3. RESULTS AND DISCUSSION

Figure 2 shows the process flow of the *BT-Heartomotive* device operate. In this study we consider the driver's heart rate monitoring problem to decide the heart rate level for safety driving. To detect the heart rate of the driver, we adopt the oximeter sensors. This system consists of three parts as detecting, analysis, and feedback. The detecting part processes driver's physiological data and environment. The analysis part extracts the heart rate of the driver and determines whether the driver is an early stage of Brady-tachy or not. When the driver becomes or close to the Brady-tachy syndrome, the feedback part is triggered to stimulate/alert the driver. One of the direct information about the heart rate (heartbeat) is attained involved in the driver's body. Another drawback of the sensor based system is to mount some piece of the sensor to the driver body. The system seems to be attractive by its contact-free property but the effect of active detecting to driver's health is not clear.

Table 1Material specification.

Material	**Flexible TPU**
Print Temperature	200-230^{0}C
Length	335mm
Diameter	1.75mm +/- 0.03mm
Printing Speed	20/60mm/s
Material	**SUNLU PLA**
Print Temperature	190-220^{0}C
Length	330mm
Diameter	1.75mm +/- 0.05mm
Printing Speed	20/60mm/s

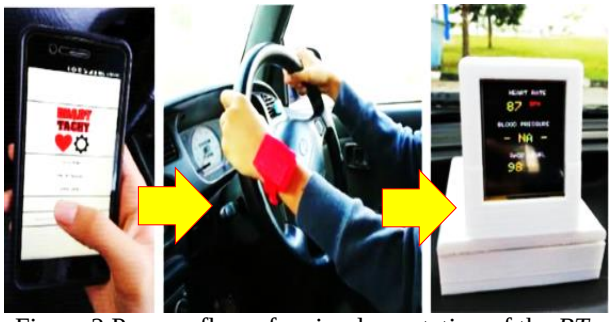

Figure 2 Process flow of an implementation of the *BT-Heartomotive* device.

4. SUMMARY

As a summary, the proposed *BT-Heartomotive* device would use the data to send an alert to the driver and passengers that they're in a deterrent. They should pull over and take action as early as possible to prevent a motor-vehicle accident. The *BT-Heartomotive* device is still in the early development with positive progress. The device is also simple, easy to use, and automated.

ACKNOWLEDGEMENT

A big thank you dedicated to University Malaysia Pahang (UMP) for providing us with a good environment, facilities and funding under research grant RDU 180330 in order to complete this research. By this opportunity, we would like to thank Dr. Zakri Ghazalli and Mr. Idris Mat Sahat from Human Engineering Group, Universiti Malaysia Pahang for sharing valuable information in accordance with our research interest. We would face many difficulties without their assistance.

REFERENCES

[1] Rolison, J.J., Regev, S., Moutari, S., Feeney, A. (2018) What are the factors that contribute to road accidents? An assessment of law enforcement views, ordinary drivers' opinions, and road accident records. *Accident Analysis & Prevention*, 115, 11-24.

[2] Tefft, B.C. American Automobile Association (AAA) Foundation for Traffic Safety, 2014.

[3] National Sleep Foundation, *National Sleep Foundation*, 2010.

[4] Abdul Rahim,H., Dalimi, A., Jaafar, H. (2015) Detecting drowsy using pulse sensor. *Jurnal Teknologi*, 73(3), 5-8.

[5] Hamill, V., Ford, I., Fox, K. (2015) Repeated heart rate measurement and cardiovascular outcomes in left ventricular systolic dysfunction. *The American Journal of Medicine*, 128(10), 1102-1.

[6] The Ford Motor Company, *The Ford Motor Company*, 2011.

[7] Konica Minolta, *Konica Minolta Sensing Inc*, 2006.