Intelligent Quad Cane with GPS Allocation for Tachyarrhythmia

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***Abstract*— This paper aims to present the development of an Intelligent Quad Cane with Global Positioning System (GPS) Allocation for Tachyarrhythmia. Heart attack symptoms vary between individual. Usually, senior citizen or cardiovascular patient is not aware of their heartbeat rate. Lack of early warning is the most common reason of the patient die because of a heart attack. Thus, this project offers an early warning for the cardiovascular patient to the charged person. Furthermore, this project is able to analyze and indicate an abnormality in heart rate pulse for the user. Sinus tachycardia and Supraventricular tachycardia was chosen as a research subject because this disease is an early complication of the heart attack. The uses of Global System for Mobile (GSM) and GPS modules in this project can make the charged person receives the notification from the patient via Short Message Service (SMS) which contains the exact location together with patient's condition. This condition shortens the time of ambulance to arrive.**

***Index Terms*—GPS; GSM; Arduino; Quad Cane; Tachyarrhythmia.**

I. INTRODUCTION

Tachyarrhythmia or Tachycardia is a disease that involving heart and blood vessels which lead to a heart attack, chest pain, stroke or even sudden death. In Malaysia, coronary heart disease is the top killer regarding diseases and health problem. Heart disease remains the leading cause of death among Malaysians over the last ten years with 13.5 percent deaths in 2014 based on the Department of Statistics survey. Pneumonia was identified as the second-highest cause of death in the country with 12 percent followed by cerebrovascular disease; 7.1 percent, septicemia; 6.1 percent, and road accidents; 5.6 percent. Further studies showed that deaths from heart disease accounted for the highest percentage of men with 15.2 percent. However, five leading causes of death for men and women in 2014 remain unchanged from 2013. The study also found that heart disease was identified as the leading cause of death for people aged 15 to 64 years old with 13.8 percent in 2014 [1].

Tachycardia disease is an episodic state with a rapid start and termination that manage to Sudden-Cardiac-Death (SCD). Tachycardia will attack to adults when the heart rate is more than 100 Beats per Minute (BPM). The heartbeat frequency for a normal person is generally from 60 to 100 BPM. The Tachycardia disease heart rate range is between 100 to 300 beats per minute. When this situation happened, the alert system will be high to indicate the person in danger. Tachycardia can be classified into three types; Sinus Tachycardia, Supraventricular Tachycardia and Atrial Flutter. Sinus Tachycardia occurred when the heartbeat reaches 100 BPM to 140 BPM at rest. Then, heart rate 140 BPM to 200 BPM will cause Supraventricular Tachycardia. Heat beating when Atrial Flutter is more than 150 BPM [2–12].

Irregular heartbeat or arrhythmia is one of the symptoms of Tachycardia. According to Yayasan Jantung Malaysia; 2016, arrhythmia referring any changes from the normal sequence of electrical impulses. This condition can cause heart rate too slow or too fast. Supraventricular Tachycardia is a very serious arrhythmia initiated in ventricles. Heart Center; 2016 reports that the range of heart rate for Supraventricular Tachycardia is between 140 to 200 BPM can cause heart pumps less efficiently and blood flow to the rest of body as soon as the heart rate rapidly beats. The higher heartbeat becomes the increasing demand for oxygen at the heart muscle. Table 1 shows normal heart rate for an adult was in between 60 and 100 beats per minutes.

Table 1: Heart rate for different ages

Age	Heart rate (beats/min)
Newborn	100-160
0-5 month	90-15
6-12 months	80-140
3-5 years	80-120
6-10 years	70-110
11-14 years	60-105
14+ years	60-100

Table 2: Statistics percentage adults with heart disease and stroke risk factor in 2005-2006

Risk Factor	Percentage (%)
Inactivity	39.5
Obesity	33.9
High Blood Pressure	30.5
Cigarette Smoking	20.8
High Cholesterol	15.6
Diabetes	10.1
Risk Factor	39.5

The risk factor for inactivity, obesity and high blood

pressure has a large percent for heart disease and stroke. Table 2 above shows statistics of percentage adult with heart disease and stroke risk factor in 2005-2006. Nowadays, by using medical technology, many of scientists had developed various algorithms, programs and device to detect heart attack of patients early. Mostly scientist used conventional medical equipment to produce a result and detect heart attack accurately. Besides, most of the basic function called vital signs can be measured, which indicates physical condition from the patient. Pulse was defined as rhythmic expansion and contraction of the arteries corresponding to each beat of the heart in the medical science field. For human heartbeats, pulse rate is used for measurement of the heartbeats [13]. The prominent spots for measuring the pulse are wrist; radial artery, neck; carotid artery, inside of the elbow; brachial artery, behind the knee; popliteal artery and ankle joint; posterior tibial artery. Pulse rate is important to determine problem of the human body but cannot be used for diagnosis. The pulse rate is varying depends on age, the physical and psychological effect on the body [14].

Generally, elderly or heart attack patients are not aware of their heart rate changes. A heart attack usually comes suddenly and the symptoms of the heart disease are different for each patient. Lack of early attention is the main reason for critical postponement [15-17]. Patients should get strict monitoring of the doctor or heir to prevent a sudden heart attack. The community mostly panics and did not know what happens to them when the heart attack occurs in public. It makes the people take time to call for emergency. After a heart attack occurs, the first few hours are important to save the heart muscle which stops due to lack of oxygen and prevents the patient from permanent heart damage. The unconscious patient only has three minutes to make Cardiopulmonary Resuscitation (CPR) before permanent heart damage occurs. When the community knows these symptoms, they can take action to give CPR to the unconscious patient before the emergency arrived.

There is no comprehensive method to solve this difficulty based on the above situation. Therefore, this project aims to introduce the intelligent quad cane with GPS Allocation for Tachycardia Disease. For this project, a single-board microcontroller; Arduino is used as a platform for system development.

II. Overall System Design

Essentially, the Intelligent Quad Cane with GPS Allocation system design divides into two sections; hardware and software design implementation. Figure 1 shows the overall system block diagram.

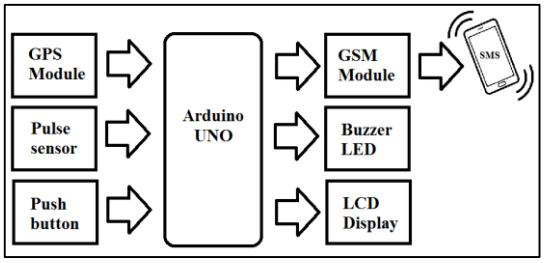

Figure 1: Overall system block diagram

The block diagram comprises Arduino UNO as a controller unit, Sim 900A GSM Module and NEO-6 GPS Module as the communication unit, pulse sensor as the sensor unit and input-output unit which includes a push button, buzzer, Light-emitting Diode (LED) and Liquid Crystal Display (LCD). The interfacing between the units is categorized as hardware implementation while the algorithm and method to get the system effectively function are classified as the software design implementation.

III. Hardware Design Implementation

The typical hardware design setting of this project consists of three main units; controller unit, a sensor unit, communication unit and input/output unit.

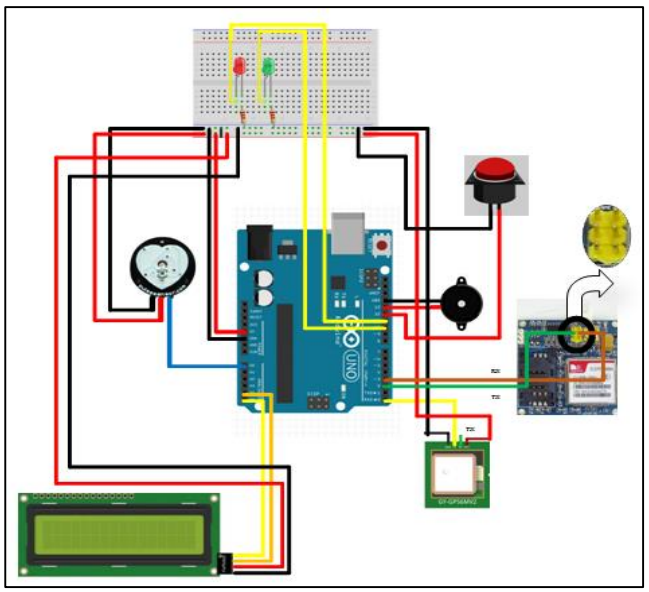

Figure 2: Hardware design circuit

Hardware design circuit which is shown in Figure 2, illustrates the connection between the units. The pulse sensor has three pins; voltage supply (VCC), ground (GND) and signal pins; where the signal pin is connected to the analog input (A0) inside the Arduino. Besides, GSM module has 4 pins; transmitter (Tx), receiver (Rx), VCC and GND. Tx and Rx pin are connected to pin 2 and 3 Arduino. Meanwhile, GPS module also has 4 pins; VCC, GND, Tx and Rx. Tx pin is connected to pin 0 using serial directly to Arduino. While, Rx pin is left unconnected because GPS module is only used to get the current location coordinate.

In addition, LCD display is using I²C module and being connected to Serial Data Line (SDA) and Serial Clock Line (SCL) pin in Arduino. Next, the green LED indicator is connected to the output pin 13 output Arduino and the red LED indicator is connected to the pin 12 Arduino. Finally, the buzzer is connected to pin 8 in Arduino. All the connectivity will be controlled and programmed through software design implementation.

A. Controller Unit

Arduino is the microcontroller ATmega328 based which has 14 digital input-output pins where six of the pin can be used as PWM output. Besides, Arduino Uno features include 6 analog input pins, Universal Serial Bus (USB) connector, In-Circuit System Programming (ICSP) connector, 16 Megahertz (MHz) quad-crystal and power jack. Besides, the Arduino Uno features that have USB boot loaders that allow the user to reprogram their firmware easily.

B. Sensor Unit

The pulse sensor is used as a sensor unit for this project. This sensor will inspect and read the light intensity data through the human skin. Light intensity varies based on actions in human capillaries. Besides, volume change also affects the amount of light transmitted through the skin. Infra-red LED and photodiode from the sensor is used to read the analog value through the pulse. The photodiode sensor generates voltage and small current when an explosion occurs with photons while the infra-red LEDs using a photon blaster. This infrared LED is designated inside the sensor because it has thin wavelength which is enough to pass through the human body tissue. Additionally, this module is also affordable, small and easy to put anywhere on the human body.

C. Communication Unit

The communication unit for this project consists of two modules; GPS module and GSM Module. When the patient pushes the emergency button, GPS module will get the exactly current coordinate of the quad cane and send to the controller. Then, the controller will read the coordinate and send it as a google maps link through SMS. Next, GSM module will take part to send an emergency SMS with google maps location to the personal doctor or family member.

NEO-6 module series was family stand-alone GPS receivers that used as a GPS module for this project. This module offers a flexible and cost-effective receiver. Furthermore, size for this GPS module thick and compact architecture suitable for a portable system. GPS module had six positioning engines that can boast location under a second. GPS module interface in serial pin Arduino Uno and sent location link through SMS. Furthermore, Sim 900A is a low-cost GSM module and smaller in size and lightweight. It is easy to attach with Arduino. Sim 900A offers three baud rates configurable from 9600-115200 by using AT command to send the SMS alert as in Figure 3.

```
AT+CMGF = 1
AT+CMGS = < mobile number > < message >
AT+CMGD = < integer >
```

Figure 3: AT Command to send an SMS through GSM module

AT+CMGF = 1 allows the user to read and write SMS messages in ASCII format instead of the standard hexadecimal format used in serial ports. AT+CMGS sends SMS to the mobile number input in the argument. The mobile number should include everything like the country's area code. For example: "+6014644****". AT+CMGD deletes excess SMS stored in the serial device; it allows the user to prevent saturation of data in the GSM module. The argument is the value of the SMS recorded in the serial port.

D. Input Output Unit

LCD, LED, buzzer and a push button have been used as the input output unit for this project. LCD has 16 characters, two-line, and alpha-numeric liquid crystal display. LCD is normally interfacing with a microcontroller to allow the programmer to display the characters on the screen. For this project, LCD displays a warning message at the quad cane and heartbeats reading from the pulse sensor to make the community being alert on the situation. LCD using I²C for interfacing with Arduino that needs only two analog pins for the communication. Furthermore, LEDs and buzzer task is to get the attention of people nearby to help in case of danger.

IV. Software Design Implementation

Figure 4 illustrates the whole system flowchart. Start with initializing all peripherals and device such as GPS module, GSM module, pulse sensor and LCD display. Then, Arduino will get the data from the sensor and check the heart rate condition. LCD will continuously display heart rate; buzzer and red LED will turn OFF until Arduino reads more than 100 BPM of the heartbeat. When the heartbeat is in between 100 to 140 BPM, LCD will display TACHYCARDIA in the first row and EMERGENCY in the second row. The same result will occur when the heartbeat is in between 140 and 200 BPM. LCD will display SUPRAVENTRICULAR in the first row and EMERGENCY in the second row. For both conditions, the red LED will blink and buzzer will go high to alert people around about the emergency situation. In addition, the function of push button become enable at pulse rate more than 100 BPM. When the patient press the push button, an emergency message together with current location coordinate link will be sent to the in-charge doctor or family via SMS.

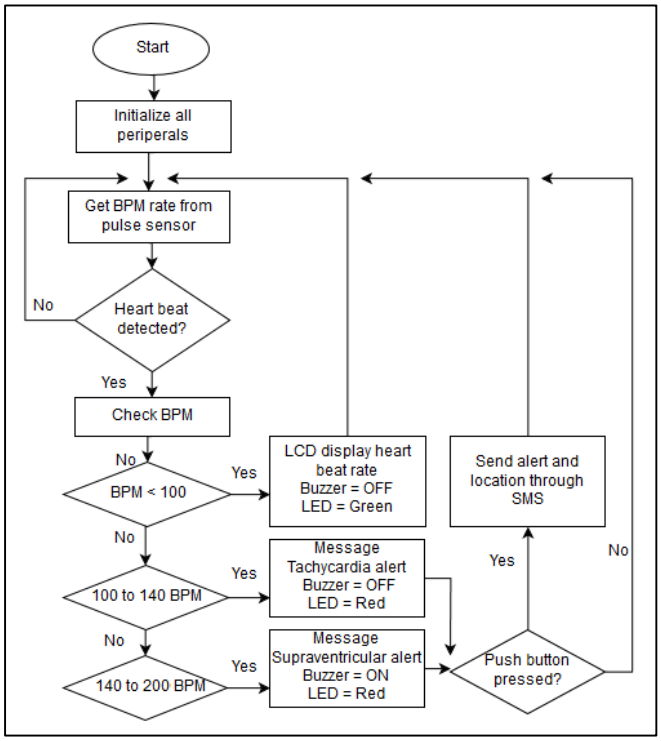

Figure 4: Overall System Flowchart

V. Result and Discussions

A. Experimental Result

Figure 5(a) shows the normal pulse condition where the pulse sensor read less than 100 BPM heartbeat. Green LED blink and LCD shows the heart rate reading in BPM. Figure 5(b) illustrates the Sinus Tachycardia condition where the heartbeat is in between 100 to 140 BPM. In this condition, red LED blink and LCD shows Tachycardia emergency message. Lastly, Figure 5(c) demonstrates the Supraventricular condition where the heartbeat is in between 140 to 200 BPM. Red LED blink and buzzer will turning ON to indicate the patient is in a critical situation. In this situation, emergency aid needs to provide immediately because the

heart attack can occur anytime to the patient.

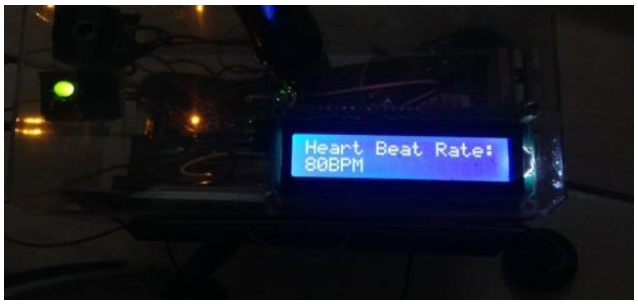

Figure 5(a): Normal Condition
80 BPM to 100 BPM

Figure 5(b): Sinus Tachycardia Condition
100 BPM to 140 BPM

Figure 5(c): Supraventricular Tachycardia Condition
140 BPM to 200 BPM

Figure 6 shows the content of the emergency message that received from the quad cane. Arduino will immediately send the data after the patient press the emergency button. GSM module will send an emergency message with the link of google maps that content current coordinate of the patient. Front and back view of design prototype is shown in Figure 7.

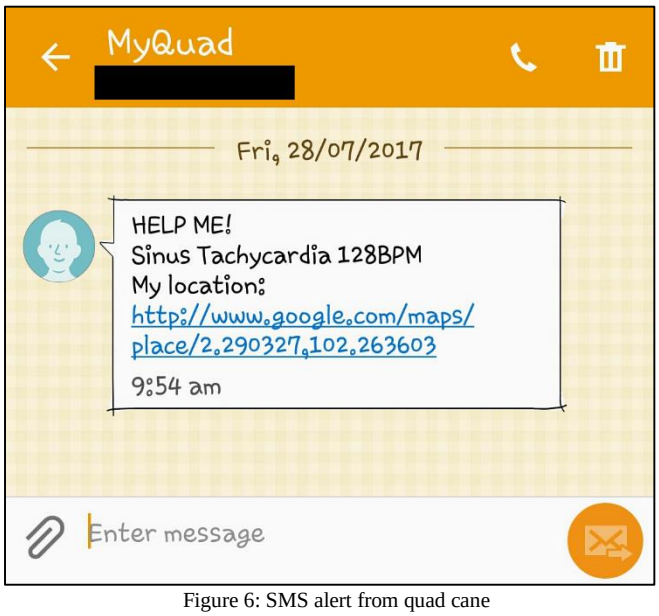

Figure 6: SMS alert from quad cane

Figure 7: Front and back view of the design prototype

B. Experimental Graph

Figure 8 shows the view of pulse wave by using Arduino Serial Plotter. There is a variable in the pulse sensor that determines how the serial output is formatted. The variable is called output type. There are two options for setting this variable; processing visualizer and serial plotter. This tool needs to be set serial plotter option with baud rate is 115200. Then, the plotter will sketch three graphs which are Inter-beat Interval (IBI) in yellow color, signal variable in red color and BPM in blue color. Furthermore, Figure 9 shows the BPM analysis that conducted to check the heartbeat reads from the prototype. Based on the graph, the heartbeat of an adult is in between 60 to 100 BPM which is proved that the system is working.

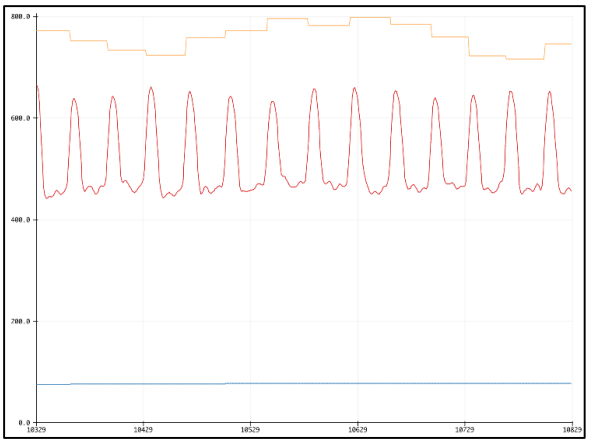

Figure 8: Arduino serial plotter
(Yellow = IBI, Red = Signal Variable, Blue = BPM)

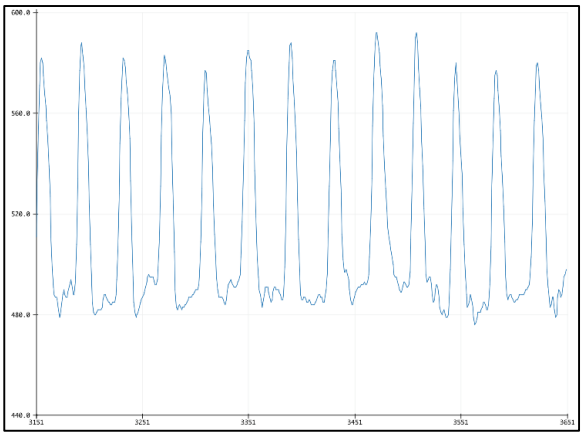

Figure 9: Graph beats per minute (BPM) from Arduino serial plotter

VI. CONCLUSION

The outcome of this project presented that the symptom of heart attack among senior citizen and the cardiovascular patient can be detected earlier through intelligent quad cane with GPS Allocation for Tachyarrhythmia. The precise location and patient's condition would be informed to the charged person immediately as soon as an emergency occurs. In addition, this project can be used as a portable Electrocardiogram (ECG) machine for Tachyarrhythmia patients. Contrasting to ECG machines, this project is not only affordable but it also can be a portable heartbeat monitoring device. Additionally, it is important to make the smaller circuit for the prototype is due to the limitations of the quad cane size. It also becomes more practical and easy to make troubleshooting or maintenance to be implemented in the future.

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