Wearable Heart Rate and Body Temperature Monitoring Device for Healthcare

Aslina Abu Bakar¹*, Sarminadira Shaikh A. Rahim², Ahmad Rashidy Razali¹, Emilia Noorsal¹, Rosfariza Radzali¹, Alhan Farhanah Abd Rahim¹

¹ Faculty of Electrical Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang, 13500, Pulau Pinang, Malaysia
² Jabil Circuit Sdn Bhd, Free Trade Zone, Bayan Lepas, Pulau Pinang, Malaysia

*aslina060@uitm.edu.my

Abstract. The Development of a wearable sensor that can monitor a heart rate and body temperature based on ESP8266 NodeMCU microcontroller is proposed in this project. To realize the system, two biomedical sensors are used which are MAX30205 and SEN11574 Pulse Rate Sensor. The sensors should be wearable to make it easy to be used by the patient. All the data that are collected from the sensors are sent via internet and displayed on a mobile apps to be observed by the guardian. MAX30205 is used to measure the temperature and SEN11574 pulse rate sensor is used to measure the heart rate. The data then will be sent through ESP8266 NodeMCU microcontroller and connected to a mobile apps via the internet. Patient can remotely send the information which are heart rate and body temperature from home to the clinic or hospital. Thus, doctors can have the patients’ health history prior to the patients visit.

1. Introduction

In the recent years, wearable sensor is on demand for home health monitoring system especially to the young people who have their parent at home that need their care all the time [1,2]. This is essential for elderly to ensure their health is always in good condition. Everyday our population is rapidly increasing in all regions. The use of technology will allow the patient to monitor their own vital signs from their home and communicate with their guardian wirelessly [3]. After they leave the hospital a system will continue monitor their physiological parameter such as body temperature, blood pressure, heart rate and etc. A wearable sensor device of health monitoring system will enable the guardian to view patient’s health status online and will contact the hospital if there any necessary medical checkup [4]. This project will develop the above system which can be accessed by the guardian and also the patient but more focused on body temperature and their heart rate measurement. The system has the potential to change the way healthcare is currently delivered [5]. Population ageing might be challenges to individuals, families and societies. The main challenges to keep this population ageing healthy is our limited sources. Although they are numerous achievements have been known in the health care sector over the recent years, but the health care expense is still high, and it has become an issue even in the developed countries [6]. V. Vippalapalli et al has proposed Internet of things (IoT) based smart health care system using a Zigbee module [7]. The proposed systems transmit the sensors data i.e. temperature and blood pressure wirelessly to the Arduino receivers which is connected to the patient’s computer and the data are read.
in LABVIEW which is connected to the internet. An URL then is generated by LABVIEW which can accessed from any computer. Zigbee module use low power consumption but has a drawback as the module only has a limited transmission distance.

Overall, the proposed home health monitoring system is important as it helps to measure physiological parameter which is the body temperature and heart rate that can be observed by the guardian anywhere at any time with the presence of the internet. This also helps to reduces the expense related to the medical services.

2. Methodology and Operation of the System

2.1. Basic Operation

This system will use two sensor and one push button as the input of the system. The pulse sensor function to measure the heart rate of the human body, the temperature sensor to detect the temperature of human body and the push button act as a button for offline mode monitoring. One microcontroller is used which is NodeMCU that play an important role in this project. It will be programmed and collect the data received from the sensor before sending it to the cloud by using IoT platform.

![Figure 1. Block Diagram of The System.](image)

Figure 1 above show the block diagram of the health monitoring system. As the data sent by the microcontroller, it will connect to mobile apps via the WIFI so the caretaker or guardian can monitor their elderly heart rate and body temperature using phone with the presence of the internet.

2.1.1. Operation of the Pulse Sensor

![Figure 2. The operation of heart rate Sensor.](image)

When people are not exercising, the heart rate is at rest so the heart will pump the lowest amount of blood. Same goes when people are sitting, relaxing or not doing something that require much energy, the heart rate normally range from 60-100 in beat per minute. But it might be differed when running and exercising. As in Figure 2 above, the reading of human heart rate can be read by the sensor which use LED and light detector to detect the variation of human blood causes by the heartbeat. When the LED covered by human skin (finger) some of the light from LED will reflect and being receive by the light detector and some will be absorbed by the blood. The output from the light detector are in the form of electrical signal which proportional to the heart rate. The signal then filtered by using two stage of high pass-low pass circuit. Comparator circuit will convert to digital pulses which then are fed up to the microcontroller. Microcontroller will analyze and calculate the heartbeat rate based on the formula of:
\[ Bpm(\text{Beats per minute}) = 60 \ast f \]

where \( f \) is the pulse frequency.

2.1.2. \textit{Operation of Temperature Sensor}. Body temperature is one of the elements that keep changing based on our activity and health status \([9,10]\). It can be measured in many ways but the common one under the armpit, in the mouth, in the ear and in the rectum. Normal temperature of the body usually around 35-37 measured in Celsius. If it higher than that 37.8°C it will be considered as fever. If we do not control or monitor the temperature and it keep rising, this may lead to heart stroke especially for the elderly.

The measurement can be read by the amount of voltage across the diode. The sensor is accurate and it will record the voltage drop between the transistor terminal of base and emitter as in Figure 3 which occur if the voltage increase and the temperature also increase. The analogue signal will be generated if the difference of the voltage is amplified. The principle is simply based on the temperature coefficient of a base emitter junction forward voltage drop.

\textbf{A. Selection Mode}

![Figure 4. Selection mode by the user.](image)
First user can choose whether to monitor using online or offline mode as shown in Figure 4. If the push button is pressed, it means they want to monitor by offline mode which can be seen by the user only, so the flow will continue to B. Otherwise, if they want to monitor via the online mode which is by the mobile apps, user need to make sure the WIFI connection is on so that the flow will continue to mode A.

![Diagram](image)

**Figure 5.** (a) Online mode monitoring (b) offline mode monitoring.

Online and offline mode monitoring as in Figure 5 can be accessed by the phone via an application which is called the Ubidots. The red button is for emergency if the user needs to contact their caretaker or guardian when anything happens. If the button pressed by the user, it will directly notify the guardian in the form of text. Or else, sensor which is body temperature and heart rate will read the data collected from the parameter measure from the patient. Then, the data sent to the cloud through a microcontroller which is NodeMCU microcontroller. The received data will be displayed on the mobile apps which Ubidots in term of GUI (graph user interface). If the reading of temperature and heart rate is normal, the system will continuously be working but if it is not, it will send the notification to the guardian. Offline mode does not require an internet. Only the user can see the reading received from the sensor. The body temperature and heart rate sensor will read the data collected from the patient. Then, the received data will be displayed on OLED LCD.
B. Hardware Design

The design of this wearable sensor must be attached to the wrist of the user. The main component will consist of MAX30205, pulse rate sensor, push button, battery and NodeMCU microcontroller.

1. MAX30205 Temperature Sensor

In this project, many of temperature sensor have been carefully selected to use such as LM35, MAX30205, Thermocouple and Thermistor. After some research and analysis had been done, MAX30205 are selected to use in this project since it meets the requirement of this project which can measure human body temperature at 0.1°C accuracy with low voltage operations.

![Figure 6. Application circuit for MAX30205](image)

Figure 6 shows the application circuit for MAX30205. The operating voltage range of this sensor is from 2.7-3.3V with low supply current at 600µ and an I2C make it ideal for this wearable application. The sensor also can measure temperature in the range of 0°C to 50°C with a 8-pin available device.

2. SEN11574 Pulse Rate Sensor

![Figure 7. Pulse rate sensor module.](image)

Figure 7 shows the Pulse Rate Sensor Module is a tiny and easy to use module, that gives out digital pulse corresponding to the heartbeat rate or pulse rate of the user. The advantage of this sensor is that there is no configuration, calibration and adjustments are required. The module is a truly plug and play sensor, just connect it to power and the output pin starts giving out digital pulses corresponding to the heart rate. The pulse sensor has three wire which red wire connected to the VCC from +3V to +5V, black wire connected to the ground and purple wire connected to the port that are declare in the coding.
3. NodeMCU Microcontroller

![NodeMCU Microcontroller](image)

Figure 8. NodeMCU microcontroller.

Figure 8 shows NodeMCU Microcontroller with operating voltage used is 3.3V with current consumption of 10µA-170mA. Since it smaller in design it is only providing one input for analog to digital which is a bit disadvantageous compared to others microcontroller. But in this project only use one analogue input which is heart rate sensor. The operating voltage used is 3.3V with current consumption of 10µA-170mA. Since it smaller in design so it only provides one input for analog to digital which is a bit disadvantageous compared to others microcontroller. But in this project only use one analog input which is heart rate sensor.

4. Ubidots (Mobile Apps)

![Ubidots Sign up](image)

Figure 9. Sign up Ubidots.

Ubidot is a huge platform for developer use it to expand their application. This project use Ubidot as an app that can display the GUI and can be monitored by the guardian as shown in Figure 9. There are a lot of things can be done by this app, but for this project we are focusing on the result reading from the sensor.
3. Result and Discussion

The result from the system are presented below:

![Figure 10. Graph for Heart rate and the display.](image)

The Figure 10 shows the graph of heart rate versus time and the reading for heart rate in BPM. The graph and the reading show that the heart rate of the patient is over the normal limit which is 141bpm. When it reaches the limit set by the guardian, Ubidots will notify user by text message as shown in Figure 12.

![Figure 11. Graph for body temperature and display.](image)

Figure 11 shows the temperature versus time and reading for body temperature of the patient measured in Celsius. Both figures show the reading of body temperature is above the normal reading which is 39.37°C. Notification also be sent to the guardian by text message as to alert with the high changing in the reading. The received message is set on Ubidot by the user or the guardian. It can be set based on our preferences. Also, it can be chosen either the notification sent through text message, email or telegram. The user or guardian can decide on which one they prefer and comfortable to use.
Figure 12. Summary for heart rate and temperature displayed by Ubidots.

Figure 12 shows the table of summary for heart rate and temperature reading that have been recorded by the same users. The reading is normal so there is no notification will be received. As for the offline mode, the OLED LCD will display the reading of heart rate and body temperature for the user. It does not require any internet connection. But it cannot be viewed by the guardian.

4. Conclusion
The wearable sensor for home health monitoring system have been designed by all the parameters such as sensor and microcontroller being carefully chosen. The sensor that have been used are pulse rate module which will measure the heart rate and the MAX30205 to detect the body temperature of the patient. As for the microcontroller, NodeMCU is used to program all the system and Ubidot is the apps that use in the mobile phone to show the user data. A smaller wearable sensor device should be developed in order to make it user friendly with the patient as the user is mostly the elderly. Various sensor also can be added to monitor the physiological signal such as blood pressure, blood glucose, electro-cardiogram (ECG) and etc. All of these features can be added to make the system more reliable.

Acknowledgement
The authors gratefully acknowledged Universiti Teknologi MARA, Cawangan Pulau Pinang, Malaysia for the financial support.

References
[1] AlSharqi K, Abdelbari A, Abou-Elnour A and Tarique M 2014 Zigbee Based Wearable Remote Healthcare Monitoring System for Elderly Patients *IJWMN* 6 53
[2] Sunehra D and Ramakrishna P 2016 2nd *Int. Conf. on Contemporary Computing and Informatics* (Noida) p 568-74
[3] Raymond S A, Gordon G E and Singer D B 2007 Health monitoring system ed Google Patents
[4] Škraba A, Koložvari A, Kofjač D, Stojanović R, Stanovov V, and Semenkin E 2017 6th Mediterranean Conf. on Embedded Computing (Bar, Montenegro) p 1-4
[5] Mehad S H, Islam S, Rahman M, and Khan N R 2016 Design and development of a wearable health monitoring system for elderly people (BRAC University)
[6] Baig M M and Gholamhosseceini H 2013 Smart health monitoring systems: an overview of design and modeling *J. Med. Syst.* 37 9898
[7] Vippalapalli V and Ananthula S 2016 *Int. Conf. on in Signal Processing, Communication, Power and Embedded System (Odisha)* (Piscataway: New Jersey/IEEE) p 1229
[8] Mansor H, Shukor M H A, Meskam S S, Rusli N Q A M and Zamery N S 2013 *IEEE Int. Conf.*
[10] Tortora G J and Derrickson B H 2013 Principles of Anatomy and Physiology (New York: Wiley Global Education)