Analysis of Heart Rate and Body Temperature from the Wireless Monitoring System Using Arduino

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Abstract. The Intensive Care Unit (ICU) ward situation tend to be very intense since the patients who are placed in the wards are usually critical condition patients. These patients need an intensive care by the nurses and physician since their condition are not very stable. Therefore, the nurses and physicians need to monitor them very frequent. So, the idea of this monitoring system is mainly to ease the nurses work by reducing monitoring frequency. This monitoring system also purposely built to make them alert about their patient thus, can minimize the risk of patients who are monitored. This monitoring system is using the microcontroller (Arduino Uno) which is connected to the laptop via Bluetooth to transfer the data of heart rate and body temperature of the respondent. This data was sense through Heart-Rate Grove sensor and LM35 temperature sensor. The data were processed and displayed on the laptop for every minute continuously. Different colour of LED was used as an indicator to notify the condition of the respondent’s pulse or body temperature either it was in high or low condition as a warning. For young adult with fever respondent, it shows the result of 81 bpm of heart rate and 37.63°C of body temperature with 3.83% and 0.65% of the Mean Absolute Percent Error (MAPE) respectively. This monitoring system has successfully built and able to display the data of the heart rate and body temperature of the respondent for every minute and able to facilitate autonomous monitoring tasks in the future.

1. Introduction
In this era of modernization, wireless technology is one of the hot topics that are often talked about. This wireless technology is often evolving around the human’s life lately. The term “wireless” is to describe telecommunications in which electromagnetic waves carry the signal over part or all of the communication path to convey information rather than using a normal outdated wired signal. There are few types of wireless technology and communication nowadays that are used by human such as Global Positioning System (GPS), Global System for Mobile Communication (GSM), Wi-Fi and Bluetooth. This wireless technology and communication frequently correlated with the terms of “IoT” which stands for Internet of Things. The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

In medical field especially in Intensive Care Unit (ICU) wards, the patients in the wards are usually the patients who needed a critical care due to acute, life-threatening illness or injury. Critical Care is
provided by specially trained ICU teams of physicians, nurses, respiratory therapists and other health professionals who use their expertise and ability to provide intensive resuscitation, ongoing treatment, and fully monitoring the critical patients. Usually in ICU wards, the physicians or nurses have to observe the estimation of heartbeat and body temperature as the major signs [1].

The compression of the heart to send blood around the body, causing pressure on the walls of the arteries as a result, blood vessel contraction and expansion of the cardiac rhythm which is called pulse (Lalita Achanuphab, 2014 as cited by [6]). Pulse rate or heart rate refers to how many times a heart contracts and relaxes in a unit of time (usually per minute). Heart rate varies for different age groups. For an example, the children to adult that is 10 years old and above has normal resting heart rate is around 60 to 100 beats per minute (bpm) while for infants, the normal heart rate is within 80 to 160 bpm [2]. The core temperature of human body is between 36.0°C to 37.2°C [4].

Current research was about Digitally Sense Heart Rate and Body Temperature Using Arduino whereby the system was connected to an android system (hand phone) that observe a person’s heart rate and body temperature for every minute. However, the system was not really efficient when there is an emergency, there is probability of the phone battery draining fast or it is almost dead. Besides that, only one person is in charge on that particular phone which make it very hard for other people to monitor because humans are often negligent which may cause risk on the patient [3].

Therefore, a system that can monitor the heart rate and body temperature of the patients through a PC or laptop using Bluetooth for every minute are most suitable to avoid this problem from happening. This system can make them alert of their patients before anything bad happen to the patients and minimize the risk of fatal to the critical patient. Besides that, the data of both measurements can be stored to be as a future reference.

2. Design Methodology

System Main Module

The device consists of a Grove-Heart rate sensor and LM35 IC sensor as inputs, Arduino Uno, Bluetooth module (HC-05), laptop to display the heart rate and temperature of the respondent and LEDs as indicators. They are depicted in Figure 1 and Figure 2. The heart rate data are detected by using Grove-Heart Rate sensor that is clipped on the fingertip. While, for measuring the body temperature in degree Celsius, LM35 IC is used [3]. This LM35 IC is placed and strapped at the armpit of the respondent. Both sensors are connected to the Arduino Uno and programming is required to ensure the sensors functioning well and well-integrated. The Bluetooth is a short-range radio link and low-power technology [5] allowing the data from both sensors to be transferred wirelessly between the monitoring system to the Laptop for every minute. The data is displayed using Tera Term software. Any abnormal reading or rate can be identified easily either from the active LEDs or warning messages displayed on Tera Term window.
Figure 1. Flowchart of the system processing block.

Figure 2 shows the circuit diagram of the wireless heart rate and body temperature monitoring system. There are four (4) colors of LEDs. Each LED has different warning sign. The white LED is for low heart rate while the yellow LED is for high heart rate. The green LED indicates low body temperature while the red LED indicates that the body temperature is higher than normal.

![Circuit Diagram](image)

Figure 2. Circuit diagram of the monitoring system.

**System Implementation**

Figure 3 shows the program flowchart that is implemented in the project. The device is programmed to display data that collected from both sensors as well as warning message if abnormal reading is detected. If the heart rate is within 60 bpm to 120 bpm and the body temperature is in range of 36 °C to 37.2 °C, neither warning message is displayed, nor the LED is lighting up. All the data is saved in excel file using Tera Term software so that it can be referred in the future.
3. Results and Discussion

3.1 Prototype Functionality Test
This step was performed to ensure the monitoring system could function as required. The test was done on a respondent who was a young adult with fever at age of twenty-two (22). The respondent’s body temperature and heart rate were monitored for time interval of one minute with a total of twenty (20) minutes. Then, the data were compared with the actual readings. The actual readings of temperature were measured using a thermometer while the heart rate was measured using a digital pulse monitor. Based on the difference between these two readings for each minute, the Mean Absolute Percent Error (MAPE) were calculated for both temperature and heart rate.

Figure 4(a) shows the data that can be seen from the Tera Term window. “Normal Pulse” is displayed showing the normal heart rate of the respondent. However, if the heart rate less than 60 bpm is detected, the white LED will light up and display the warning message; “WARNING! LOW PULSE!!!!!!”. If the heart rate is more than 120 bpm, the yellow LED will light up and display the following warning message; “WARNING! HIGH PULSE!!!!!!”. From the window, it can be seen that the abnormal body temperature is detected when “WARNING! HIGH TEMPERATURE!!!!!!” is displayed. It shows that the body temperature is more than 37.2°C causing the red LED lights up to alert the user. If the body temperature less than 36.0°C, it will light up the green LED and display the
warning message: “WARNING! LOW TEMPERATURE !!!!!”. Other than the both conditions, it indicates the body temperature of the respondent or patient are normal.

Tera Term exported the data to excel file so that the data could be saved and viewed as shown in Figure 4(b) and 4(c). For the body temperature sensor, the graph in Figure 4(b) shows the body temperature of the respondent which was in fever condition. The fluctuated points were at minute 1 (37.14°C), minute 5 (36.65°C), minute 6 (36.16°C), minute 7 (37.14°C) and minute 8 (37.14°C). This is due to the movement of the respondent in which eventually caused the sensor was not at the correct position. For the heart rate sensor, data in Figure 4(c) shows the heart rate readings for the respondent that was in normal condition throughout the testing. They were between 60 to 100 bpm.

Figure 4. Respondent’s data obtained from the wireless monitoring system. (a) Data that is displayed on Tera Term window (b) Graph of the body temperature (c) Graph of the heart rate.

Figure 5(a) shows five (5) points that state before which have big fluctuation of body temperature compared to the actual readings. The MAPE is 0.65%. In Figure 5(b), there were huge fluctuation in the reading of heart rate at minute of 15, 16 and 17 compared to the actual value. This is because the respondent moved her finger in which the finger did not properly placed onto the detector of the sensor. The calculated MAPE for the heart rate is 3.83%.
4. Conclusion

This project focuses on the wireless heart rate and body temperature monitoring system which is able to monitor the heart rate and body temperature reading of patient at any time. The system determines the pulse rate beat per minute and body temperature in which the physiological data are displayed on Tera Term window. The data then is manually log into Microsoft Excel to see the pattern of the reading easily on the graph. Hence, by having the system, the healthcare professionals can monitor and diagnose their patients from a laptop at any time. They can easily monitor their patients from their workstation especially for the emergency case. In contrast to other conventional medical equipment, the system has ability to save data with timestamp for future reference. Functionality of this monitoring system also has been tested on a respondent who is a young adult with fever. It is successfully functioning with minimal percentage of error when compared the value with conventional devices; thermometer and digital pulse monitor. Further work into it should be done such as provide data for more respondent with the information of ward and bed number to make it more practical to be used in the hospital.

5. References

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