Design and Implementation of an Arduino-Based Body Temperature and Pulse Rate Monitoring System

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***Abstract*—Health is an important aspect of human existence, and vital indicators such as blood pressure, body temperature, respiration rate, and pulse rate/heart rate are widely known in the medical field. According to the World Health Organization (WHO), 2,200 people die in the United States (U.S.) each day as a result of heart disease. Each year, heart disease and stroke cost about 312.6 billion in health-care expenses. Especially during COVID 19 Pandemic outbreak, rural citizens need a more effective and affordable way for personal healthcare monitoring system before they decide to travel to the nearby medical center for medical assistance. Therefore, the Arduino-Based Body Temperature and Pulse Rate Monitoring System was proposed and developed in this project. The Arduino Software was used to write the programming for this project, which interfaced with the Arduino UNO board. The temperature sensor detects the temperature while the heartbeat sensor counts the pulse rate for a certain interval of time and calculates beats per minute. Both data are delivered to the Arduino UNO for transmission to reception. The results of the measurements will be shown on the Liquid-Crystal Display (LCD) screen. The measured data will be entered into the body temperature and pulse rate app. This App is a platform that presents a graph of the data so that the user can quickly see if the measurements have changed significantly. This app was created utilizing the AppSheet platform's user-friendly features and can be used on a number of platforms, including phones, tablets, and web browsers. The user can retrieve their measurement data anytime and anywhere so that early detection of the heart disease or symptoms of COVID-19. The typical normal temperature of the human body is between 36°C and 37 °C. Low fever is defined as 37.3°C-38 °C, whereas severe fever is defined as 38.1-41 °C. Another function for this innovation project can be used to measure the pulse rate. The normal pulse rate is 60 to 100 beats per minute. People who exceed 100 beats per minute are very dangerous, so they need to refer to the nearest clinic for further medical consultation.**

Keywords*—Pulse Rate, Heart disease, Body Temperature, Arduino UNO, COVID 19

I. Introduction

The fundamental criteria of normal levels of the body's vital signs, such as heart rate and body temperature, are used to assess physical health. The heart is the most essential organ in the human body since it is the primary organ responsible for blood circulation throughout the body [1]. Heart disease is the primary cause of mortality worldwide, according to the World Health Organization (WHO) [2]. Heart disease and stroke cost for approximately 312.6 billion dollars in health-care costs per year. Chest pain or discomfort, feeling weak, light-headed, or faint, and shortness of breath are all common symptoms of a heart attack. Pressure, squeezing, fullness, or discomfort may be felt. The advent of testing enables patients to better monitor their health. It is appropriate for individuals suffering from heart disease, diabetes, high blood pressure, and other conditions. Medical practitioners utilize heart rate to monitor patients' physical health, such as athletes who wish to monitor their heart rate to get the most out of their training. Despite huge differences in temperature outside the body, the human body's tendency is to regulate the temperature within a small, safe range. Cardiovascular disease refers to a group of illnesses that affect the heart or blood arteries. Coronary artery disease (CAD), such as angina and myocardial infarction, is a kind of CVD (commonly known as a heart attack). The underlying processes differ according to the illness. High blood pressure, smoking, diabetes, a lack of exercise, obesity, high blood cholesterol, a poor diet, and excessive alcohol consumption are all risk factors for heart disease.

People spend a lot of money to be healthy. Unfortunately, when things are non-invertible, individuals always discover that it is too late to obtain severe medical care [3]. Many people can be treated if early action are are taken in a timely way. However, most medical products on the market today have these major drawbacks, as well as limits in flexibility and portability. Furthermore, certain technologies [4-6] are available on the market that can give raw medical data computations for patients and clinicians, but the patients unable to converts med

ical measurement into the meaningful diagnoses due to lack of medical background and human literacy [7].

The need for a home-based self-health monitoring system has increased significantly in recent years. This may be achieved by employing a low-power, cost-effective, accurate, and easy-to-use gadget capable of measuring, displaying, and alerting the patient to vital data [8-10]. Therefore, an Arduino-Based Body Temperature and Pulse Rate Monitoring System was proposed and developed in this research. The benefits of this initiative are that treatment may be given to patients in priority to the ailment they have as compared to other patients, and they can be hospitalized in emergency situations. Body temperature, heart rate, and fall detection are all vital indicators. The mass-weighted average temperature of body tissues and skin temperature are measured. Especially for rural citizens, they need a more effective and affordable apparatus for self-monitoring heartbeat and temperature because rural areas are hardly approached by medical personnel. Rural citizens need a more effective and affordable way for personal healthcare monitoring system before they decide to travel to the nearby medical center for medical assistance, especially during COVID 19 pandemic outbreak.

The paper is organized as follows: Sect. II describes the technique used to create this invention, which includes the prototype model research approach, system architecture and design, Arduino software, experimental setup, and design of the Body Temperature and Pulse Rate App. The findings of the Arduino-Based Body Temperature and Pulse Rate Monitoring System are evaluated in Section III. Finally, we conclude the paper in Sect. IV.

II. Method

A. Prototype Model Research Method

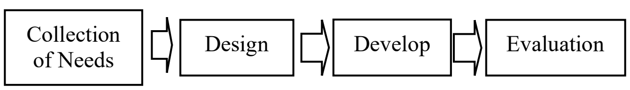


Fig.1. Prototype Model Research Method

Fig. 1 shows the prototype model research method for this paper. The demands of consumers for body temperature and pulse rate measurement devices are surveyed in this phase through conversations with sources and direct observation. Determine what instruments are necessary to address the problem after recognizing it. The gathering of needs is also carried out in the design of tools, which comprise any needed components.

This is the stage at which a tool is created to help with the problem of developing an Arduino-Based Body Temperature and Pulse Rate Monitoring System. The design addresses how the tools function, tool workflows, and code design, as well as the development of a series of tools that will lead to the production of tools in the form of prototyping [11].

Once the process of building a tool in the form of a prototype has been finished, the proposed system is presented to the user for an initial evaluation. It assists in evaluating the strengths and weaknesses of the working model, which includes numerous instruments that have performed well or poorly and may be a solution or not in order to create or repair this health monitoring system. The prototype should then be refined based on the user's comments and ideas. Based on the final prototype, the final monitoring system is built, extensively tested, and deployed to production.

B. System Architecture and Design

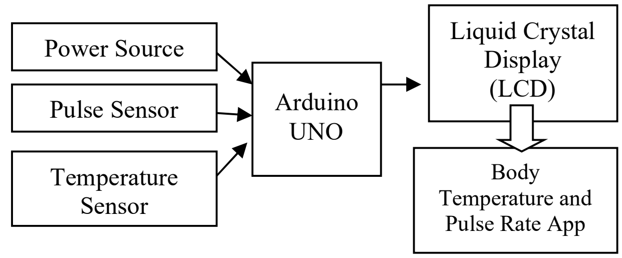


Fig 2. Health Monitoring System Block Diagram

The proposed health monitoring system may use the patient's fingertip to measure the patient's heart rate and surface body temperature and display the findings on the LCD screen. This block diagram consists of three parts, which are the transmission part, receiving part, and central processing unit as shown in Fig. 2. The diagram of the transmitter is composed of the controller. This controller is equipped with a capacity and the temperature sensor is connected. The controller is used to control the body temperature and heart rate sensors. The LCD is also linked to the body temperature, pulse rate, and Radio Frequency (RF) transmitter, which sends data to the controller's receiving circuit. The schematic design of the receiver is made up of a microcontroller that is powered by a power source and connected to the controller. A rack circuit to receive the signal transmitted by the transmitter and processed by the controller and then display on the LCD screen.

C. Software Arduino (IDE)

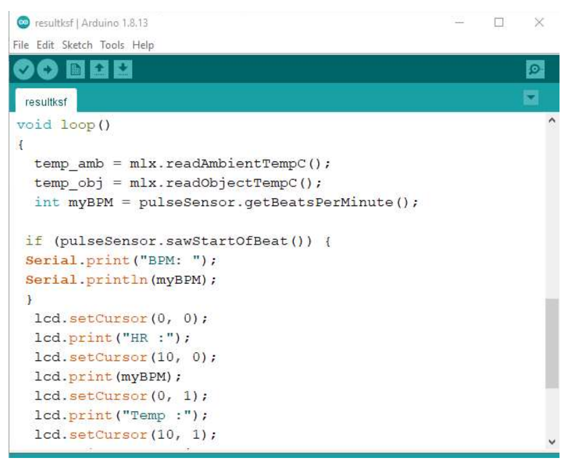


Fig. 3. Software development

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, and Linux) with built-in C and C++ functions, as seen in Fig. 3. With the help of third-party cores, it is used to write and upload programmes to Arduino compatible boards as well as other vendor development boards [12]. The IDE's source code is available under the GNU General Public License, version 2 [13].

D. Experimental Setup

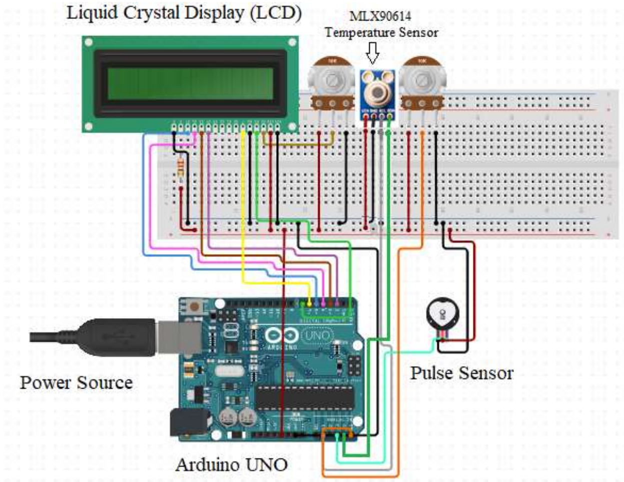


Fig. 4. Experimental setup for the proposed system

Fig. 4 presents the experimental setup for an Arduino-Based Body Temperature and Pulse Rate Monitoring System. The Arduino Uno is a microcontroller board that is open-source and operates on the Microchip ATmega328 microprocessor. This microcontroller serves as a CPU for measuring the user's body temperature and pulse rate. The power supply is utilized to power the entire circuit.

The MLX90614 is an infrared thermometer that monitors temperature without the use of any contact. The TO-39 container contains both the IR-sensitive thermopile detector chip and the signal conditioning ASIC. The MLX90614 includes a low noise amplifier, a 17-bit ADC, and a powerful DSP unit, all of which contribute to outstanding thermometer accuracy and resolution. The 10-bit PWM is developed to continuously transmit the observed temperature in the range of -20 to 120°C, with a standard output resolution of 0.14°C. Pulse Sensor is a well-designed, Arduino-compatible heart-rate sensor. The sensor is attached to a fingertip or earlobe and communicates with the Arduino via jumper wires. It also includes free open-source monitoring software for graphing your pulse in real time. The Pulse sensor has three pins; connect the pulse sensor's 5V and ground pins to the Arduino's 5V and ground, and the signal pin to the Arduino's A0. A Liquid-Crystal Display (LCD) is a flat-panel display or other electronically modulated optical device that uses liquid crystals' light-modulating capabilities in combination with polarizers. It is composed of two different states of matter: solid and liquid. On an LCD, a liquid crystal is utilized to generate a visible picture.

The circuit diagram of this system includes the transmitter (TX) section and receiver (RX) section. The temperature and heartbeat of the user's body, as well as the data sensed by the sensor, are transmitted to the ATmega328 in the TX portion. The transmitted data can be encoded into serial data over the air using a Radio Frequency (RF) module. The patient's body temperature is shown on the LCD through an antenna mounted at the end of a transmitter, and data from the transmitter is transmitted to the receiving end. The Arduino then processes the body temperature and pulse rate data and sends it to the LCD. The measured data will be entered into the body temperature and pulse rate app by the user. This App is a platform that presents a graph of the data so that the user can quickly see if the measurements have changed significantly. This App will be discussed in detail in sub-section E. The flow chart for this proposed system is depicted in full in Fig. 5.

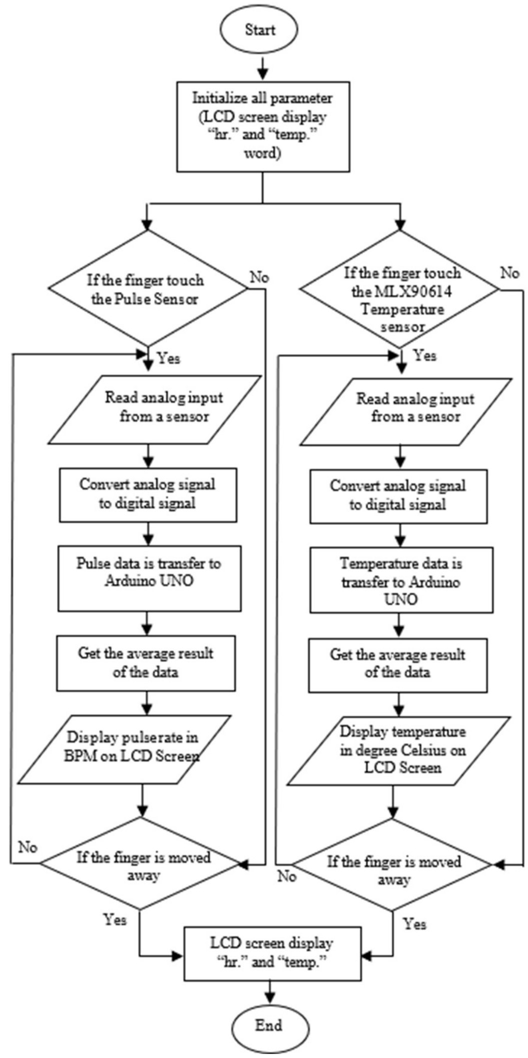


Fig. 5. Flow chart of the proposed system

E. Design of Body Temperature and Pulse Rate App

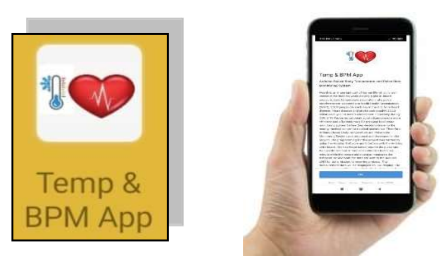


Fig. 6. Body Temperature and Pulse Rate App

Fig. 6 shows the design Body Temperature and Pulse Rate App. This App is created with the AppSheet Platform, as illustrated in Fig. 7, and consists of three (3) major steps:

- Step 1: First, all of this app's data is saved on the cloud, and Google Drive (specifically, spreadsheets) was chosen as the database storage design.
- Step 2: Second, the AppSheet Platform has been used to connect the data and develop the app with popular features in this platform.
- Step 3: Publish the app instantly and share the app with customers. The implication of this app could support a variety of devices: phones, tablets, and web browsers.

Fig. 7. Three important steps for Smart Educational App development

III. RESULTS AND DISCUSSION

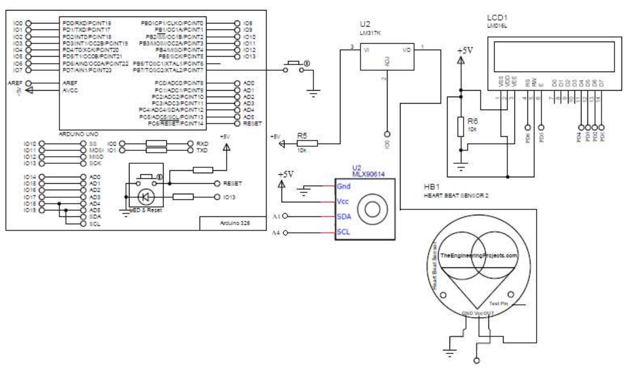
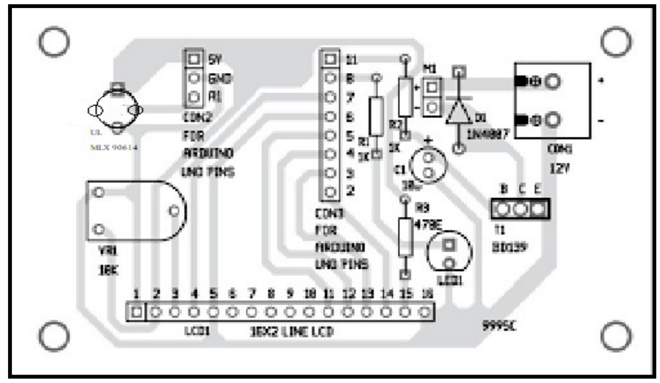
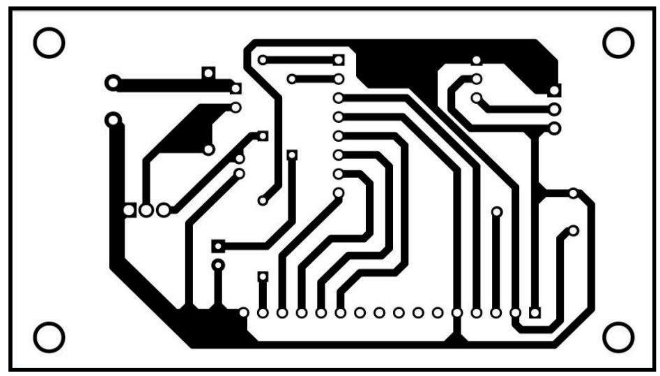


Fig. 8. Schematic Design

Fig. 8 shows the schematic design for an Arduino-Based Body Temperature and Pulse Rate Monitoring System. When the battery is inserted into the circuit, the Arduino begins reading the pulse rate from the pulse sensor and the ambient temperature from the MLX 90614 temperature sensor. An infrared LED and a phototransistor in the pulse sensor aid in detecting the pulse at the tip of the finger or earlobe. Its IR LED glows whenever it senses a pulse. The phototransistor detects the flash of the IR LED, and its resistance varies when the pulse is altered. The average adult's heart rate ranges between 60 and 100 beats per minute. To detect beats per minute (BPM), an interrupt is first configured to activate every 2 milliseconds. As a result, the Arduino's sampling rate for detecting pulses is 500 Hz. This sample rate is enough for detecting any pulse rate. Fig. 9 shows the PCB design for this proposed project.



(a) Top view



(b) Botton view

Fig. 9. Top and botton view of PCB Design

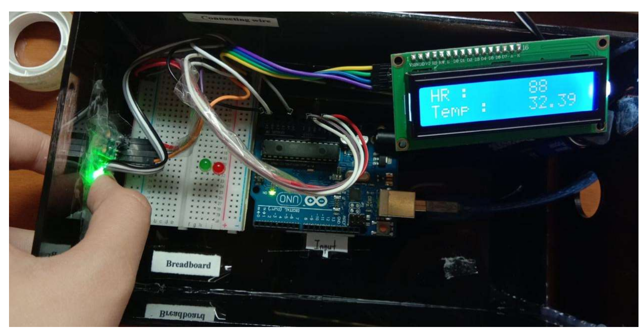
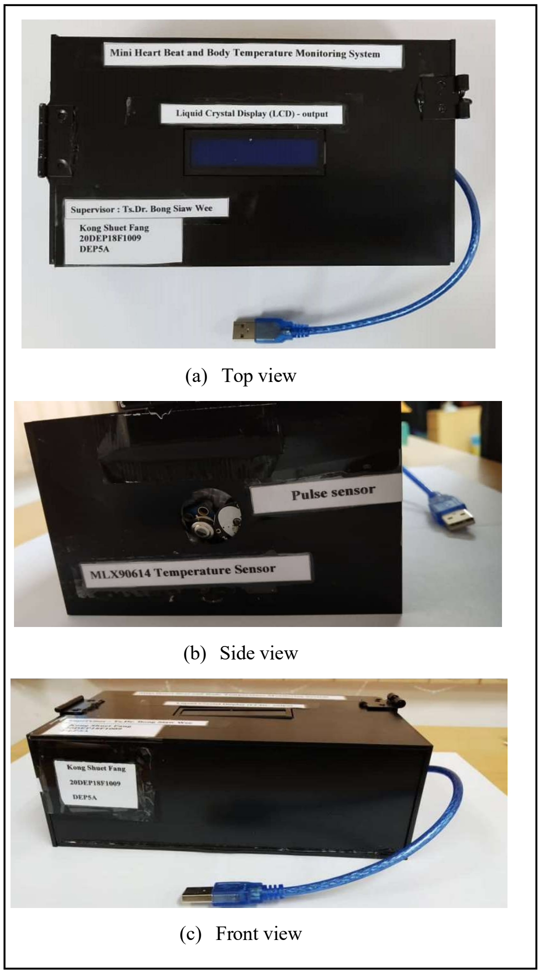


Fig. 10. The functionality of this proposed system

The functioning of this suggested system is depicted in Fig. 10. This device properly measures heart rate and body temperature. The results of the measurements are shown on the LCD panel. Fig. 11 depicts the top view, side view, and front view of this system.



(a) Top view

(b) Side view

(c) Front view

Fig. 11. Top view, side view and front view

The instruction user handbook for this proposed health monitoring system is shown in Fig. 12. There are four steps to use this system as shows bellows:-

Step 1: Connect the USB to the power bank first.
Step 2: Turn on the computer by pressing the "ON" button.
Step 3: Touch the pulse and temperature sensors with your finger.
Step 4: Read data from the LCD Display panel about your pulse and body temperature.

Fig. 12. Instruction user manual

According to the findings of pulse sensor testing in the figures above, each heart in the human body does not experience the same stress because various things affect it, both normal and unhealthy body circumstances, so the graph experiment and bpm results will change continuously. Tables 1 and 2 show the results of pulse sensor and body temperature testing using the LCD user interface.

TABLE I. PULSE SENSOR TEST RESULTS

Testing	BPM calculation results	Result
1	101	Normal
2	98	Normal
3	100	Normal
4	99	Normal

TABLE II. BODY TEMPERATURE TEST RESULTS

Testing	Body Temperature (°C)	Result
1	36.7	Normal
2	36.2	Normal
3	36.6	Normal
4	36.4	Normal

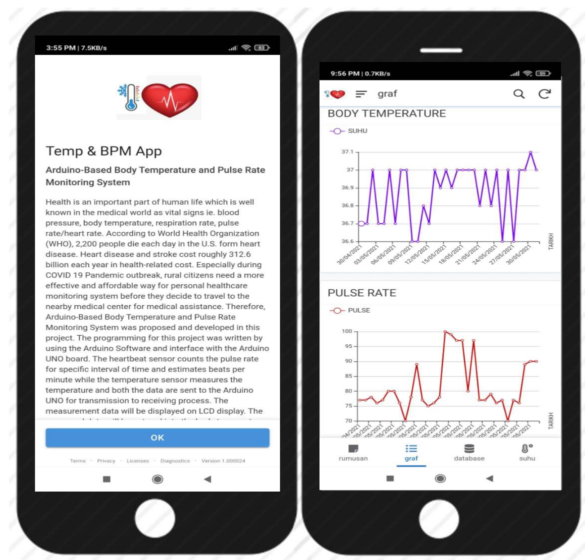


Fig. 13. Measurement graph from Body Temperature and Pulse Rate App

As illustrated in Fig. 13, the Body Temperature and Pulse Rate App is a platform that presents a data graph. As a result, it is simple for the user to identify any major changes in the measurements. This app was created with the AppSheet platform's user-friendly features and can be used on a number of platforms, including phones, tablets, and web browsers.

The user can retrieve their measurement data anytime and anywhere so that early detection of the heart disease or symptoms of COVID-19. Normally, the average normal temperature of the human body is between 36 °C to 37.2 °C. However, 37.3 - 38 °C is low fever, and 38.1- 41 ° C is high fever. Another function for this innovation project is can be used to measure the pulse rate. The normal pulse rate is 60 to 100 beats per minute. People who exceed 100 beats per minute are very dangerous, so they need to refer to the nearest clinic for further medical consultation.

IV. CONCLUSION

An Arduino-Based Body Temperature and Pulse Rate Monitoring System has been developed as a user-friendly product that able to measure the heartbeat and body temperature accurately. This project is capable of monitoring patients' heart rates and body temperatures at any time and from any location. The system calculates the pulse rate, beats per minute, and body temperature, and displays the physiological data on the LCD. The product price is less than other medical products. Thus, this product is affordable for the low-income group and suitable for residents living in rural areas. The user can detect heart disease or covid-19 earlier, then can make treatment earlier.

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