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Microcontroller-based Wearable Blood Pressure Monitoring Device with GPS and SMS Feature through Mobile App

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ABSTRACT

Blood pressure (BP) is one of the vital signs measured in a patient during a medical check-up. Abnormality in BP values is an indication or symptoms in most cardiovascular diseases. Innovations were established in dealing with the measurement of BP for the past years. In this paper, the researcher presented a wearable blood pressure monitoring device with SMS notification. Its design and processes were explained in this paper to further demonstrate the content of research. This paper aimed to determine whether the prototype is reliable enough with a novel approach for blood pressure monitoring purposes. The project is a device worn in a wrist using a microcontroller, battery and a cuff. The patient has a mobile app installed in his/her mobile phone. Information should be entered in the mobile app such as contact number and the normal blood pressure of the patient. The mobile phone is connected in the wearable device through Bluetooth. The user or patient will have to wait 5 minutes before the blood pressure will start measuring. This is to let the patient rest for a while. A beep sound indicates that the device starts measuring. After 10 seconds, the cuff will inflate and another 30 seconds time is intended for the blood pressure measurement. The measured valued is displayed in the mobile app, and then sends SMS only if the patient's BP is higher than normal. Its design is a microcontroller-based project, equipped with a Global Positioning System (GPS) module to be able to locate the user, a Bluetooth module to be able to connect to a smart phone installed with the Blood Pressure Monitoring App. The device was carefully programmed and tested to ensure its workability.

Key words: Blood pressure, microcontroller, Bluetooth, Global Positioning System, SMS, mobile app

1. INTRODUCTION

The major causes of death in the world are heart-related diseases, wherein blood pressure (BP) measurement can detect the early symptoms of cardiovascular diseases [1]. Since BP is a good marker for the likelihood of having cardiovascular disorders, it is then needed an efficient monitoring system and constant care for the patient [2].

Traditionally, measuring blood pressure requires sphygmomanometer and a stethoscope. The sphygmomanometer consists of a nanometer, an inflatable bladder in a cuff, and an inflation-deflation device [3]. The standard measurement of BP is located at the brachial artery, however, wrist and fingers have become prevalent nowadays [4]. In this paper, it involves a microcontroller, a cuff and a mobile app to display its measurement.

With the emergence of new and smaller electronic devices, the innovation of non-invasive blood pressure (BP) measurement is advancing quickly. One new technology is the ambulatory BP monitoring which is reliable and performs efficiently even when the patient is moving from one place to another [5]. These are wearable blood pressure monitoring device that has a reliable system and can be used for daily events and somewhat small in size [2]. It can also check blood pressure on a real-time basis to prevent and correct hypertension abnormalities during pregnancy [6]. Medical record is used to monitor the health condition of the patient [7], however, this study can only monitor the blood pressure of the patient.

There is also a technology using a finger-wearable device for a regular, periodic and whole day monitoring blood pressure measurement [8]. BP values are collected in the wearable device. These values are sent in a mobile via Bluetooth connection and displayed through a mobile app [9]. This paper is similar to a remote patient monitoring system based on cellular phone technology using SMS to inform the patient about the measurement of their health status [10]. However, this paper deals with the use of microcontroller that serves as the brain of the prototype, a cuff for more reliable measurement, a mobile app with features like alert system and records of the blood pressure values obtained and a GSM module for its capability in sending SMS to the patient for abnormalities of the result.

2. MATERIALS AND METHODS

2.1 General System Design

The system architecture shown in figure 1 is the system architecture of "Microcontroller-based Wearable Blood Pressure Monitoring Device with GPS and SMS Feature through Mobile App". This is a wearable blood pressure (BP) device that monitors the user's BP and send the gathered data to the microcontroller and result will be displayed in a connected smartphone. If there is an abnormal blood pressure

reading, the wearable blood pressure device that has built with sound alert and the smartphone will alarm to notify the BP status of the user. This alarm also indicates that there is a need to check and repeat the BP measurement to further validate the result of the reading.

The result also will be displayed in the mobile app and will denote the user if the blood pressure is normal or high. Its system architecture includes a charger module for the battery to power up the device, a pressure sensor for the measurement of systolic and diastolic pressure.

It also includes a microcontroller that serves as the processor of its intended functions, a motor pump and arm cuff for accurate BP measurement, and the alarm triggers which composed of light emitting diode (LED) indicator and a buzzer. It has also Bluetooth module for smart phone connectivity to display the reading in a mobile app, an alarm system and SMS notification.

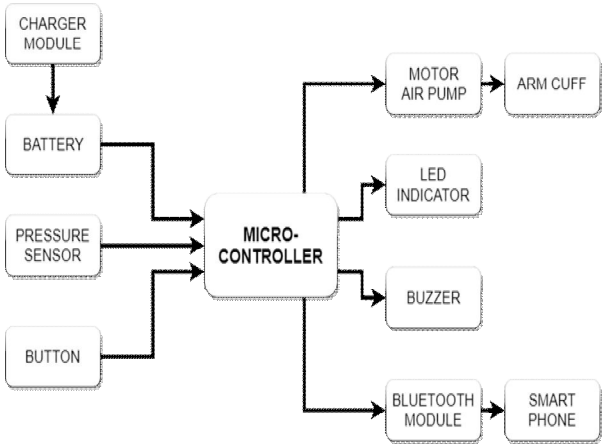

Figure 1: System Architecture of the Microcontroller-based Wearable Blood Pressure Monitoring Device with GPS and SMS Feature through Mobile App

2.2 System Flowchart

The system flowchart of the Wearable Blood Pressure Monitoring System with SMS Notification is shown in figure 2. It shows the step by step process of how the system works. The blood pressure sensor detects the blood pressure from the user while the battery and the button may be interrupted if unexpected things happened. If the user's blood pressure is not normal, it will notify their loved ones about the user's condition.

Aside from notifying and alerting their loved ones about the current blood pressure reading, the system also includes the user's current location using the Global Positioning System, commonly known as GPS. The researcher also added an LED indicator that will show that the blood pressure is high using the red color LED. Another red colored LED will turn on if the battery of the device is charging.

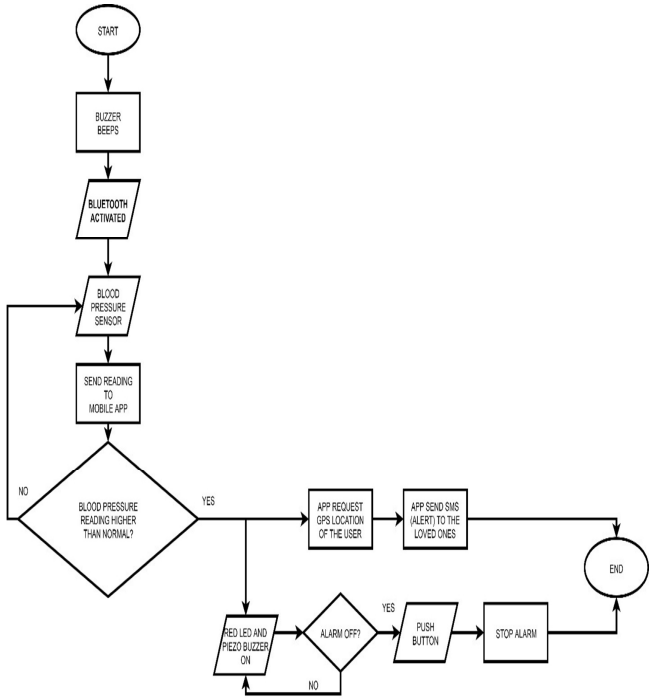

Figure 2: System Flowchart

2.3 Wiring Diagram

The wiring diagram of Blood Pressure Monitoring shown in figure 3 acts as a guide in connecting each of the electronic components. The main device utilized is the Arduino nano microcontroller that serves as the head of all components connected. The blood pressure sensor serves as an input that triggers each components such as the SMS notification to the smart phone, buzzer and LEDs.

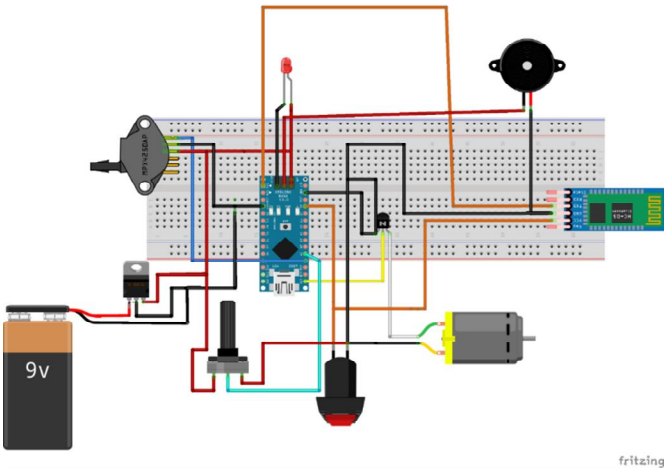

Figure 3: Wiring Diagram

2.4 Mobile App development

Part of the system is the development of mobile app as shown in figure 4. This is the design of its interface. This application is a visualization tool to monitor the blood pressure reading of the user connected via Bluetooth to the device.

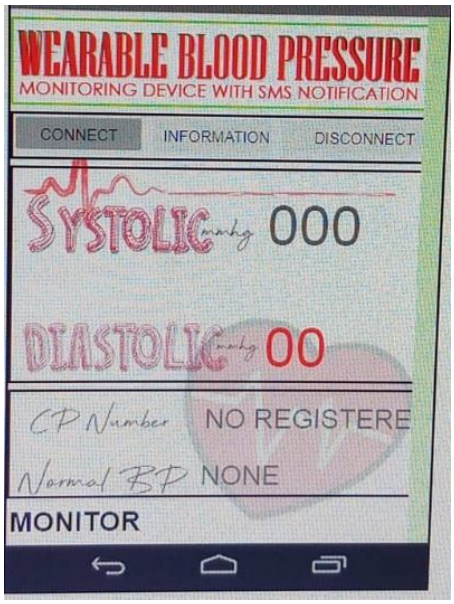

Figure 4: Mobile App Interface

3 RESULTS AND DISCUSSION

3.1 Mobile App Test Result

Mobile app development is one of the objectives of this paper. Hence, the author developed an app to display the results of the pressure sensor. Figure 5 shows one (1) example output from several tests done.

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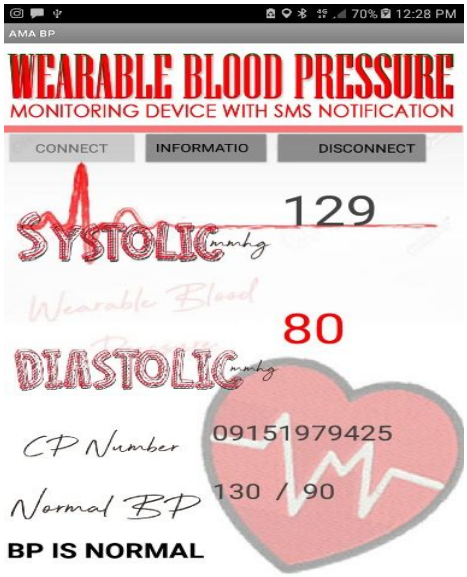

Figure 5. Mobile App sample reading

3.2 Results of Testing

Testing the functionalities of the device includes unit testing, acceptance testing and integration testing to attain the best accuracy. Table 1 shows the result of the testing of the accuracy of the device. There are ten (10) persons engaged to try the developed device and the developed device. Each person's blood pressure were measured using three (3) trials. The results showed that the difference between the existing digital BP monitor compared to the developed BP monitor is only -6 to +6. It means that the presented device is accurate and reliable enough

Table 1: Blood pressure device test

Person No.	**Trial**	**BLOOD PRESSURE READING**		**Difference** (Current Device minus Proposed Device)
		Existing Digital BP Monitor *(Systolic/ Diastolic)*	Developed BP Monitor *(Systolic/ Diastolic)*	
1	1	119/73	114/70	+5/+3
	2	114/63	111/65	+3/-2
	3	113/69	115/66	-2/+3
2	1	143/103	144/100	-1/+3
	2	141/102	142/105	-1/-3
	3	141/104	141/103	0/+1
3	1	117/68	115/63	+2/+5
	2	114/69	113/65	+1/+4
	3	112/63	113/61	-1/+2
4	1	116/61	113/61	+3/0
	2	119/68	116/65	+3/+3
	3	120/70	118/65	+2/+5
5	1	89/59	91/61	-2/-2
	2	89/60	90/61	-1/-1
	3	91/61	90/59	+1/+2
6	1	119/74	114/70	+5/+4
	2	114/63	111/65	+3/-2
	3	113/60	115/66	-2/-6
7	1	114/58	119/64	-4/-6
	2	116/60	120/66	-4/-6
	3	112/65	116/70	-4/-5
8	1	133/89	133/86	0/+3
	2	133/77	131/79	+2/-2
	3	129/87	133/81	-4/+6
9	1	116/54	113/57	+3/-3
	2	115/58	118/59	-3/-1
	3	112/58	110/61	+2/-3
10	1	104/70	98/65	+6/+5
	2	98/71	100/73	-2/-2
	3	100/69	99/68	+1/+1

3.3 Design Output

Figure 6 shows the final prototype of the "Microcontroller-based Wearable Blood Pressure Monitoring Device with GPS and SMS Feature through Mobile App". Its main body is a tiny casing made up of plastic for the safeguard of the integrated components. Inside the casing are the materials used such as the Bluetooth module, buzzer, motor air-pump, switch, potentiometer, LED, arduino Microcontrollers, rechargeable battery and an adapter for recharging purposes. This is worn in the wrist to make it more convenient and portable.

Figure 6: Final design output of the Microcontroller-based Wearable Blood Pressure Monitoring Device with GPS and SMS Feature through Mobile App

4 CONCLUSION

The project entitled "Microcontroller-based Wearable Blood Pressure Monitoring Device with GPS and SMS Feature through Mobile App" helps monitor the user's blood pressure easier. The project was conceptualized by the author through detailed researching about the challenges in blood pressure monitoring. Tasks included in this paper are the identification of the problems in the current BP measurement device, establishing its new design, development of the prototype and testing the reliability and performance of the over-all project. The prototype was tested and proven according to its reliability and accuracy based from several tests done.

The major component used in the design project is the blood pressure sensor, which is a non-invasive sensor intended to measure human blood pressure. It also used a piezoelectric buzzer with a piezoelectric effect for generating sound and has the capability to produce the assigned pre-recorded sound. It has also two buttons for switching the wearable device on/off and for stopping the continuous alarms used in measuring blood pressure.

Finally, it is integrated with a smartphone to display the systolic over diastolic blood pressure values. Overall, the innovations established in this paper are the integration of mobile app, an alarm system and the SMS capability.

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