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Vital Sign Scanner with Bluetooth Capabilities Connecting to Android Application using Raspberry PI

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ABSTRACT: The negligence of the health is prominent in medical facilities, with some caused by the availability of equipment, the environment to which the patient is in, and the lack of information. The group intended to make a vital sign scanner with Bluetooth capabilities connecting an Android application using a Raspberry Pi. The device scans the body temperature, blood pressure, and heart rate. The Android application can register users into the database, receive data from the device and display it via Bluetooth. The results gathered provide a 90% accuracy for patients and the database works as intended. With this, the group intends to help simplifying of the mobility of the medical devices and the efficiency of medical devices.in taking in the patient's vital signs.

Key Words – Vital signs, Android, Bluetooth, Raspberry Pi

1. INTRODUCTION

As people continue to develop their lives to what they aspire to become, the body either delivers changes depending on the person's lifestyle. Certain aspects also play effect in the wellbeing of people such as how the environment is, and the stress handled by them. A study has been done on the history of medical negligence which produces problems for the patients. People would need a constant reminder to check their health.

The Raspberry Pi, with its current 3rd iteration in pocket computers. In its small form, it can produce the same work as a regular computer. With this portability and efficiency, there is a lot of development in using it. Raspberry Pi can function as a mini-computer and able to store in data and perform programs more than a microcontroller.

Prior to this development, combining 2 devices was used to create a web-based health monitoring system that transfers data from an Arduino for data collection and the raspberry pi for display it on the web.

Android is a mobile operating system developed by Google for mobile touchscreen devices. It has been used to develop different applications, ranging from entertainment to medically useful applications. With each iteration of the Android, it becomes more powerful and able to do more.

1.2 Prior Studies

One of the studies done on health management is by making portable medical devices that can scan and monitor their current health state. Studies in making wearable medical devices were made in 2015. The lack in the approach in this study that it can only monitor certain medical aspects like heart rate and respiration. This would lead to problems when the user is on non-ideal situation with less health care. Medical devices should provide an easy access in contacting medical facilities when used.

Android applications are also being designed for medical information. These applications may serve as a basis for some but may not provide an accurate diagnosis. The mobile phone also provides a limitation in this case which may include the camera, the current Android operating system, the processor, etc.

Below is a list of literatures discussing how the current technology of smart phones is advancing and medical integration has becoming increasingly available. Advancements to powers saving and security is also discussed as sensitive data is being processed.

Table 1 – Existing Work Done

Title	Description
Privacy Protection for Wireless Medical Sensor Data	Protection of a wireless network with medical reports as its data
Security for Medical Sensor Networks in Mobile Health Systems	Enhancement in security to medical systems
A Wearable Medical Sensor for Provisional Healthcare	Wearable vital signs sensor applied on the chest area
Wearable Medical Sensor-Based System Design: A Survey	Wireless based system (WBS), wireless medical sensor (WMS), the limitations, and possible future uses.
A system review of healthcare applications for smartphones	Demographic of the users between patients and professionals.
Perioperative Smartphone Apps and Devices for Patient-Centered Care	Medical data to the patient for surgery.
Design on mobile health service system based on android platform	Medical sensors, android app, database, Bluetooth, and the internet to create a medical report.
Mobile based home automation using Internet of Things (IoT)	Communication via Bluetooth at home, and via internet when outside.
Android based smart home system with control via Bluetooth and internet connectivity	Communication via Bluetooth at home appliances, and via internet when outside.

1.3 Objective

- To develop a device that scans and monitors vital signs (temperature, blood pressure, and heart rate) and displays it, stores the data in a database, and connects to an Android application for easy user interaction.

1.4 Specific Objective/s

- To create an Android application that will generate a vital signs report concerning the user, using MySQL database.
- To produce a vital sign report that concerns the user via Android application.
- To be able to test the application's functionality on at least three (3) different Android phones having Android Software Operating System Version 5.0 or higher.
- To develop a device that can scan the following: blood pressure, temperature, and heart rate.
- To build a device that can show the data collected in less than three seconds after scanning.
- To develop two prototypes to be tested simultaneously for comparison in server capability.
- To develop a device that is at least ninety percent (90%) accurate in scanning vital signs in comparison to a commercially available analog and digital equivalent device for each sensor.
- To have the maximum device size at 7" x 5" x 4".
- To allow simultaneous prototype inputs to the server and be able to hold 200 recipients or more.
- To transmit the data to server and display it on the LCD screen once all sensors are finished reading and a connection to the server has been established.
- To have both prototypes certified by three medical practitioners.
- To implement a security protocol in the server and the Android application to prevent possible data leakage.

1.5 Scope

The mobile phone model that will be used may be a potential problem as it may give off issues with the Android application made. The device is made for indoor use therefor there is no protection against outside interferences. The Raspberry Pi may be connected to the Android application but may have fluctuations in connection at a certain period

2. METHODOLOGY

2.1 Components

The Raspberry Pi 3 is used for the system. This microcomputer can power the system and the addition of the upgradeable specifications. The addition of the touchscreen LCD would improve user interface.

2.1.1 Python 3

Python 3 is a built-in development environment in the Raspberry pi platform where it can be used to directly code for efficiency. This is the main tool to develop the GUI and data collection.

2.1.2 Android

Android is an operating system for mobile devices developed by Google. It was based on the Linux kernel as designed specifically for touchscreen devices. This is where the app will be built upon.

2.1.3 MySQL

MySQL is database management system that is open source under the GNU General Public License. MySQL allows users to get, put, edit and delete files from their databases using different platforms and languages. (i.e. PHP, Linux, Apache, Python, etc.) This is used to store the user data.

2.1.4 Bluetooth

Bluetooth is a wireless technology standard that is used to exchange data over a short distance (less than 30 feet It uses the UHF radio waves in the ISM band from 2.4GHz to 2.485 GHz). A general rule of thumb is that if the device is going to be used indoors or within a building where Wi-Fi cannot penetrate then Bluetooth is the way to go.

2.1.5 Thermal Conduction

The DS18B20 is a digital sensing device that monitors the system. The temperature at any point in the medium depends on the duration of the heat that is being conducted by the body. The DS18B20 has a metal casing that used to transfer the heat from an outside source and the heat with steady-state conduction will heat up the system to the temperature equal to the one being measured.

2.1.6 Oscillometric Measurement

This method is use for long-term measurements and general practice thus is an ideal for the system that is being built. The device used is an electronic sphygmomanometer that can do all the measurement even without the training required for non-digital readings.

2.2 DESIGN CONSIDERATIONS

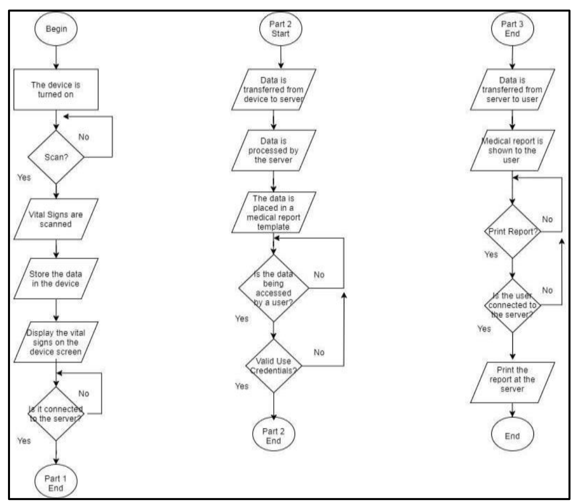

Figure 1 – Flowchart of the System

The step by step usage of the device is as follows: the device is turned on, next is for the user to put the device to his/her arm, press the scan button, the vital signs are taken using the sensors, the data is shown to the user, and if the device is connected to a phone it transmits the information to the phone. The phone on the other hand receives the data, retrieves the user's data, and stores it into the database

2.2.1 System Design

The system consists of three main parts: the device, the server, and the Android phone. In the figure below, the device is connected to an LCD display to which the data will be displayed. The sensors are connected to the device for data processing. The device can either send that directly to the server via Wi-Fi or send it to the mobile app via Bluetooth.

From the Android application, the user can print out the data or send it through social media/text message. The user will also able to access their data on the Android application.

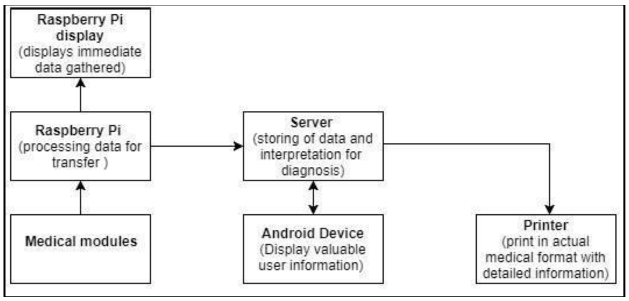

Figure 2 – System Block Diagram

2.2.2 Body Design

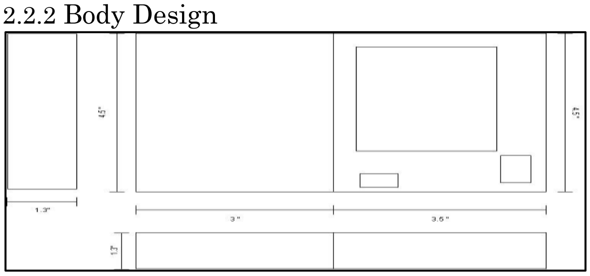
Figure 3 – Dimensions of the Body of the Device

The figure above shows the measurements of the device enclosure. This coincides with the maximum device size that was stated in the specific objectives as the length of the design is only at 6.5", the width at 4.5", and the height at 1.3".

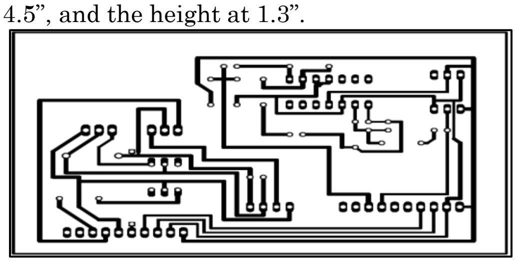
Figure 4 – Printed Circuit Board Design

The figure above shows the printed circuit board designed using EagleCAD with a board dimension of 9.5cm x 6.5cm.

2.3 Implementation


Figure 5 – Hardware design

The Raspberry Pi, Lithium-ion battery, motor, and sensors are held into place by a Silicon adhesive. The sensors are arranged and soldered in a printed circuit board that the group designed and developed. The figure below shows the first prototype.

To get the temperature using the DS18B20, a prediction formula is used to acquire the temperature in a faster rate. The formula used is available below.

$$T_{b_{(i)}} = T_{e_{(i)}} + (T_{b_{(i-1)}} - T_{e_{(i)}}) \times \exp(-Kt).$$

Eqn. 1 – Prediction Formula for Thermal Conduction

To get the heart rate, we use the number of times the pressure sensor can sense a change in pressure due to detected heartbeats. The number is counted for a threshold consisting of the first 13 heart beats and then the heart rate is calculated by using the code below.

```
if (heartCount == 14):
    interval = (time.time () - startTime) * 1
    heartRate = int((heartCount * 60 )/ interval)
```

Formula. 1 – Heartbeat Counter Formula

To get the systolic and diastolic parts of the blood pressure. The heartbeat with the highest pressure that is detected by the pressure sensor, is assigned as the systolic, and the lowest one before a significant pause is assigned as the diastolic pressure.

```
if heartCount == 4 and heartCount > 2:
    systolic = int ((adc.read_adc (0, gain=GAIN)) * 0.007103 + 40.3999)
```

Formula 2 – Blood pressure Systolic Formula

```
if heartRate > 0 :
    if  (change_pulse >= .5 or intervalDias >= 2.3):
        diastolic = int ((adc.read_adc (0, gain=GAIN)) * 0.007583 + 40.3999)
```

Formula 3 – Blood pressure Diastolic Formula

Data Transmission

The code used for the data transmission of the Android application and the device to the server uses HTTP request methods. The parameters used for the application and the device are:

- given_name
- family_name
- patient_email
- patient_password
- user_level

The parameters take in the patient, doctor, or admin's personal details. This is to allow the server to arrange the data per user. The user level parameter distinguishes whether the user is a patient, doctor, or administrator.

The code used for the data transmission between the Android application and the device uses Bluetooth. The device sends the data to the Bluetooth address.

3. RESULTS AND DISCUSSIONS

3.1 Database Test

The results from this test show that the online database can hold at least 200 recipients and no server lag. The testing was done by starting with the two prototypes sending data simultaneously. This is then continued with the Android devices that the researchers had as well used emulators to run the said application to send to the database. The table below shows the data that was received in the database were just the same data but in multiple instances. There was also no delay observed in sending the data as all devices provided the response message simultaneously. The 200 recipients were also established as the data gotten from the accuracy provided with more than 200 recipients.

SIMULTANEOUS DATA SENDING TEST								
	Devices Used							
Test #	Prototype 1	Prototype 2	Android Device 1 (Samsung S9+)	Android Device 2 (Samsung Galaxy Note8)	Android Device 3 (Huawei J6)	Android Device 4 (Pixel XL - Emulator)	Android Device 5 (Pixel 2 XL - Emulator)	Delay
1	Data Sent	Data Sent	-	-	-	-	-	None
2	Data Sent	Data Sent	Data Sent	-	-	-	-	None
3	Data Sent	Data Sent	Data Sent	Data Sent	-	-	-	None
4	Data Sent	Data Sent	Data Sent	Data Sent	Data Sent	-	-	None
5	Data Sent	Data Sent	Data Sent	Data Sent	Data Sent	Data Sent	-	None
6	Data Sent	Data Sent	Data Sent	Data Sent	Data Sent	Data Sent	Data Sent	None

Figure 6 - Database Test

3.2 Accuracy Test

The collected data from the Pressure sensor shows that the heartbeats of a patient is detected by the system. Using an oscilloscope the data can pe shown to be detectable by the system and be 90% accurate for interpretation and use. The minor changes in quality is due to signal degradation from the wire quality. The first strike on the green line is the systolic and the last one before the long pause is the diastolic.

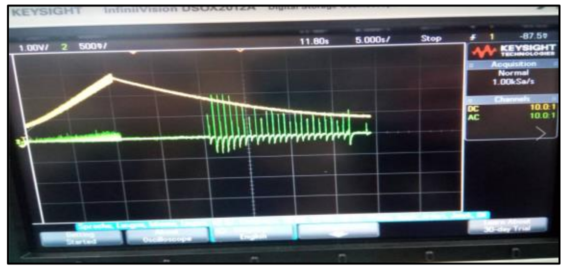

Figure 7 – Sample Collected Data on the Pressure Sensor

The figure above shows the current pressure within the cuff (yellow DC voltage line) and the green strikes represent the heart pulse from the user of the cuff.

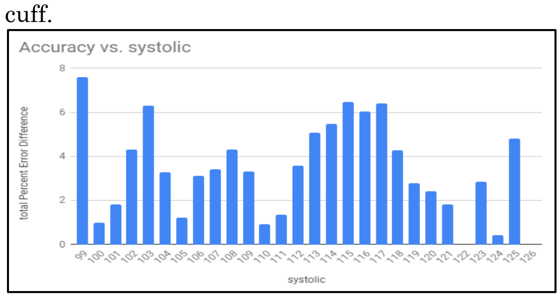

Figure 8 - Accuracy of the systolic in relationship with the result

This shows the average data Error Percentage for each Systolic pressure, ranging from 99-125mmHg

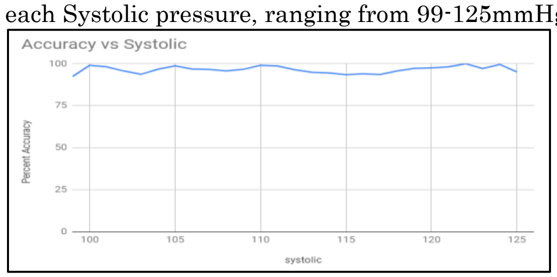

Figure 9 – Accuracy of Systolic under Normal Blood Pressure (99-125mmHg)

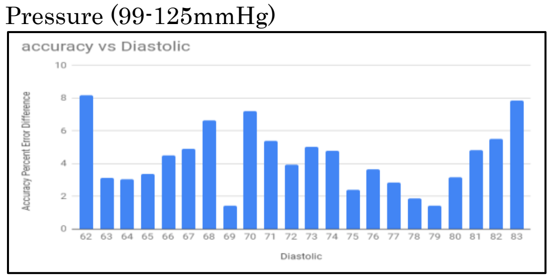

Figure 10 - Accuracy of the diastolic in relationship with the result

This shows the average data Error Percentage for each Diastolic pressure, ranging from 62-83mmHg

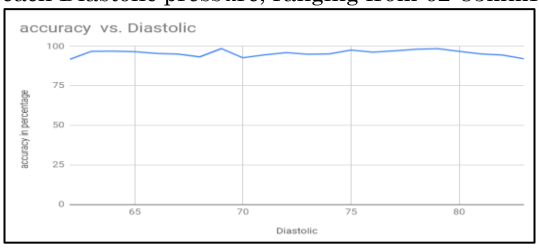

Figure 11 – accuracy of Diastolic under Normal Blood Pressure(62-83mmHg)

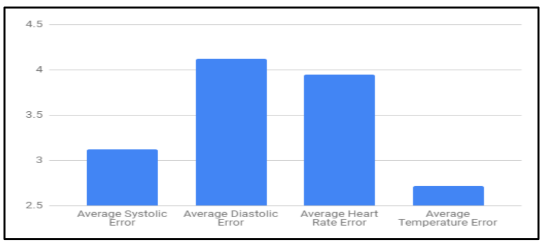

Figure 12 - Average accuracy of the Systolic, Diastolic, Heart rate, and Temperature.

The average difference between the device and commercial instrument in the temperature, heart rate, diastolic, and systolic are two-point seven percent (2.7%), three-point nine percent (3.9%), four-point eleven percent (4.11%), three point fifteen percent (3.15%) respectively.

3.3 Android Version Test

The results for the Android application test provided insights as to what the minimum version of the Android operating system can handle the application. The table below shows the different devices and their versions used to do the test. The figure below shows the test of different devices on the use of the application.

ANDROID VERSION TEST					
Test #	Device	Android OS Version	Login	Data Sending	Data Receiving
1	Samsung S9+	8.1 (Android Oreo)	Working	Working	Working
2	Samsung Galaxy Note5	7 (Android Nougat)	Working	Working	Working
3	Huawei J5	5 (Android Lollipop)	Working	Working	Working
4	Pixel XL (Emulator)	6 (Android Marshmallow)	Working	Working	Working
5	Pixel 2 XL (Emulator)	7.1.1 (Android Nougat)	Working	Working	Working
6	Google Nexus 6P (Emulator)	4.4 (Android Kit Kat)	Working	Working	Working

Figure 13 - Android Version Test

4. CONCLUSIONS

To conclude the research, the data taken from the tests were consistent with the objective of gaining ninety present (90%) accuracy on people that are with normal blood pressure. High blood pressure results were less accurate. The system can use a direct Wi-Fi connection and a Bluetooth connection to an Android device to transmit data within 3 seconds of collecting the systolic, diastolic, heart rate, and temperature of the user. The whole system is approved by doctors to be working and accurate for normal blood pressure. The system also meets the device size requirements. The integration of the Android application with the Raspberry PI and connecting both to a database to manage the data works with Bluetooth and Wi-Fi. This system is now portable and can work without problems even if the system lost its connection with the server.

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