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Analysis of different Heart Rate Measuring Sensors with Arduino and Smartphone

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ABSTRACT

This paper discuss about Arduino based heart rate measuring techniques using easy pulse sensor and pulse sensor. Heart rate monitoring and counting is performed using different software tools. The proposed framework collects input from pulse sensor by placing the patients' finger on the sensor. Then it is processed using Arduino to count the number of pulses and display the output in the smartphone via Bluetooth application. By using this framework physical presence of doctor is not needed at the time of measuring the heart rate. Such a system could be used in hospitals, for home-care, and people suffering from heart diseases.

Keywords : Heart Rate Sensor, Heart Rate Measurement (HRM), photophelthysmography (PPG), Arduino, Pulse Sensor, Bluetooth, Smartphone.

I. INTRODUCTION

Heart rate is important organ of human being. Heart functioning is indicated by using heart rate. It helps in finding the causes of symptoms, such as an irregular or rapid heartbeat, vertigo, weakness, and chest pain or breathe problem. High heart rate can cause cardiac problem. Therefore it is important to constantly monitor the heart beat rate [1]. Accurate heart rate detection is important in terms of our daily healthcare and exercise monitoring by classifying PPG signals obtained from wearable devices [2].

A simple and low-cost alternative method to estimate the heart rate is the use of the PPG signals [3]. Smartphones are used in combination with other sensing devices to capture heart rates. Pulse sensor is commonly used to measure heart rate.

The proposed design and development of a Heart Rate Measuring device measures the heart rate efficiently in a short time and with less expense without using time consuming and expensive clinical pulse detection systems [4].

The heart rate rises slowly during exercises and returns slowly to the rest value after exercise. When the pulse returns to normal is an indication of the fitness of the person. Heart rate below the normal condition is known as bradycardia, while above is known as tachycardia.

Heart rate can be measured by placing the thumb over the subject's arterial pulsation, and feeling, timing and counting the pulses usually in a 30 second period. Heart rate (bpm) is calculated by multiplying the obtained number by 2. ECG is most frequent technique to measure heart rate. But it is very expensive. PPG sensor and pulse sensor is cheaper

and useful instrument in knowing the pulse of the patient.

Heart rate may differ from person to person. As age changed, the regularity of pulse will be changed.

Smartphone market is growing rapidly in mobile phone sector, with Apple's iPhone, Android and Microsoft's Windows Phone. A substantial rise in smartphone applications would be those that are employed in the fields of health care and medicine.

The heart rate of different sensors on android smartphone is studied. Through this study, methodology helps to determine the best sensor for monitoring heart rate. To perform these operations the system uses two heart beat sensor, i.e PPG Sensor and pulse Sensor.

II. PREVIOUS WORK

Bandana Mallick et.al. monitored heart rate which is capable to monitor the heart beat rate of patient [5].

Y.S.Harish Kumar et. al. determine human heart rate, especially for heart patients who need to monitor their heart rate, it being an important indicator for prognosis and diagnosis, and also share it with their physician anytime to seek medical advice when needed [6].

Salomi S. Thomas et. al. measure body temperature and heart rate using arduino. This device will allow one to measure their mean arterial pressure (MAP) in one minute and the accurate body temperature will be displayed on the Android. The system can be used to measure physiological parameters, such as Heart rate and Pulse rate [7].

Sonal Chakole et. al. focuses on health monitoring System using sensors and can help people by providing healthcare service [8].

Prasad Kumari Nisha et. al. implemented heart rate monitoring system using low cost arduino board and other easily available resources[9].

III. EXISTING TECHNOLOGY

There are many technologies that have been developed to estimate heart rate, which could affect someone's heart rate such as motion, emotions, and stress. These technologies are very expensive.

IV. PROPOSED FRAMEWORK

This framework uses Easy pulse sensor and pulse sensor for extracting statistical parameters from the processed signals. The process signal analyzed to determine how changes would affect the heart rate of an individual.

The goal of this framework is to design home-care systems that is low in cost, consumes low power and provide reliable heart rate readings.

V. PROPOSED SYSTEM

Physical activities as well as physiological signals of the heart monitoring patient could be easily monitored with the help of wearable sensors. The whole activity can be monitored remotely by doctors, nurses, or caretakers.

The framework consists of Arduino UNO microcontroller system, transmission system and Android based application. The framework calculates heart rate (BPM) on the portable device in real time and shows it on Android based smartphone. The cost of proposed framework is affordable as compared to other developed devices

due to use of Arduino, smartphone and Android device [10].

Heart rates are recorded through the sensor nodes and transmit to the smart phone via Bluetooth. For measuring the heart rate (beats per minute) of a person, technique of PPG Sensor and pulse Sensors is used. The sensor should be placed in those areas of body where the blood is having a higher concentration. Android device is connected with Arduino microcontroller via wireless serial BLE connection.

This framework is designed for monitoring and measuring heart beats by using PPG Sensor and pulse Sensors of 10 human subjects of different age groups with smart phone and comparing result, and then identifies the best sensor.

VI. HARDWARE REQUIREMENT

Arduino Microcontroller

Arduino is an open source platform. It can use for building digital devices and interactive objects. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits. Arduino board are equipped with sets of digital and analog input/output (I/O) .

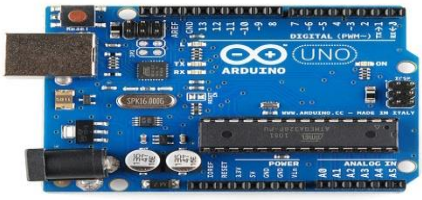

Figure 1. Arduino Uno board

Bluetooth Module HC-05:

Bluetooth Module HC-05 is intended for transparent wireless serial connection setup. It is used in a Master or Slave configuration for making it a great solution for wireless communication. It is easy to use.

The HC-05 Bluetooth Module has 6 pins. ENABLE, Vcc, GND,TXD , RXD, STATE.

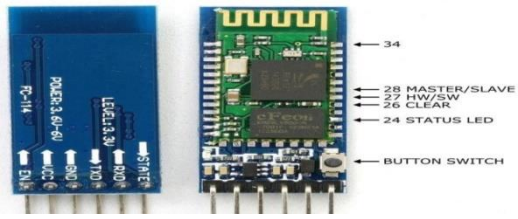

Figure 2. HC- 05 Bluetooth Module

Button Switch:

Button switch is used to switch the module into AT command mode. To enable AT command mode, press the button switch for a second. If user want to change the parameter of this module when the module is not paired with any other BT device then AT command is used. If the module is connected to any other bluetooth device, it starts to communicate with that device and fails to work in AT command mode.

Jumper Cables:

A group of electrical wire with a connector at each end is called jump wire or jumper. Jumper cables are used to interconnect the components of a breadboard with other equipment or components, without soldering.

Figure 3. Jumper Cables

Easy Pulse Sensor based on PPG Sensor

Easy pulse sensor is based in the principle of PPG sensor. PPG sensor is designed to measure the heart beat when a finger is placed on it. It is directly connected to microcontroller to measure the Beats Per Minute (BPM) rate. PPG works on the principle of light modulation.

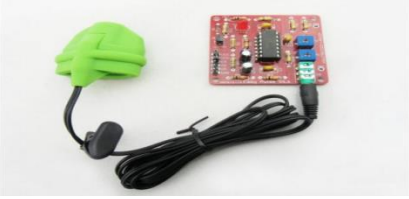

Figure 4. Easy Pulse Sensor

Photoplethysmography (PPG) is a non-invasive method for measuring the variation in blood volume in tissues using a light source and a detector. This technique is used to calculate the heart rate.

The Figure 4 shows how PPG sensor extract the pulse signal from the fingertip. A subject's finger is illuminated by an infrared light-emitting diode. Depending on the tissue blood volume more or less light is absorbed. The intensity of reflected light varies with the pulsing of the blood with heart beat.

The sensor consists of a red LED and light detector. The LED needs to be super bright as the maximum light must pass spread in finger and detected by detector. With each heart pulse the detector signal varies. This variation is converted to electrical pulse [11].

Pulse sensor:

Pulses can be recorded by holding a finger to your neck or wrist and counting the beats with watch. Pulse sensor fits over a fingertip and uses the amount of infrared light reflected by the blood circulating inside the body. Figure 5 shows front side and backside of pulse sensor.

The pulse sensor is a well designed plug-and-play heart-rate sensor for Arduino.

The small, round shape of the Pulse Sensor makes it convenient for obtaining the heart rate signal from subjects' fingers.

The sensor consists of an infrared emitter and detector build up side by-side and pressed closely against the skin. When the heart pumps, blood pressure gets rising, so amount of infrared light from the emitter gets reflected back to the detector. The detector passes more current when it receives more light.

Figure 5. Pulse Sensor

VII. SOFTWARE REQUIREMENTS

Android Programming:

The Android operating system has come in market in late of 2007. It is an Open Handset Alliance. The idea of an open source OS for embedded systems was not new, but Google helped to push Android to the forefront in just a few years.

Many wireless communication protocols have one or more Android phones available. Other embedded system, such as tablets, notebooks, televisions, set-top boxes, and even automobiles, also have accept the Android OS. Android applications are written in Java that is sometimes known as the Dalvik virtual machine.

ARDUINO Programming- A Proposed Algorithm:

Arduino programming is user friendly, more compact, and less complex, which is used to perform several tedious and repetitive tasks [12].

Arduino has low power consumption, low cost, small size, etc. so that real time monitoring is possible & patient can be treated on time with the system & is helpful in worst condition.

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started [8].

Ardunio is used because it can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights and motors. Arduino coding is needed for sensing heart rate by using arduino software.

Data Flow Diagram:

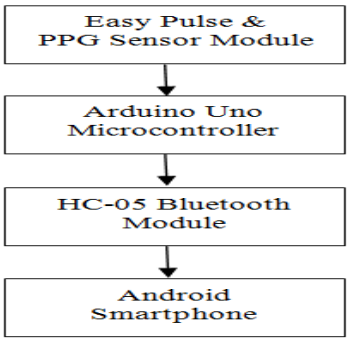

Figure 6. Basic Workflow of framework

This framework first connect PPG and pulse sensor with the Arduino Uno Microcontroller. Then send the data on Android mobile via Bluetooth. Connect Bluetooth module to Arduino Uno Microcontroller. After making the connection with Arduino, upload the Arduino sketch into the Arduino. After uploading the sketch the sensors activated. After activating the sensor, attach the Pulse sensor and PPG sensor to user finger.

Connect the android smartphone to catch the heart rate. Start the app and connect it to HC-05 Bluetooth module. After successful connection, the human heart rate will display on to the user smartphone in the unit of Beats per Minutes (BPM).

VIII. RESULT & PERFORMANCE

Different age group of patient can be tested in this paper. Following Heart Rate variations can be measured using BPM (Beats Per Minute):

Table 1. Normal Heart Rate Chart:

Your heart rate is measured in "beats per minute" or "bpm."

AGE	TARGET ACTIVE HEART RATE ZONE	AVERAGE MAXIMUM HEART RATE
20 years	100-170 bpm	200 bpm
30 years	95-162 bpm	190 bpm
35 years	93-157 bpm	185 bpm
40 years	90-153 bpm	180 bpm
45 years	88-149 bpm	175 bpm
50 years	85-145 bpm	170 bpm
55 years	83-140 bpm	165 bpm
60 years	80-136 bpm	160 bpm
65 years	78-132 bpm	155 bpm
70 years	75-128 bpm	150 bpm

Information provided by the American Heart Association

Table 2. Output Result of age group 20 to 30:

Name	Age	Direct Measure	Easy Pulse Sensor(BPM)	Pulse Sensor(BPM)
Pooja	26	98	94	85
Sakshi	24	129	121	111
Ankita	20	100	98	92
Amol	30	119	116	106
Anand	21	102	90	95

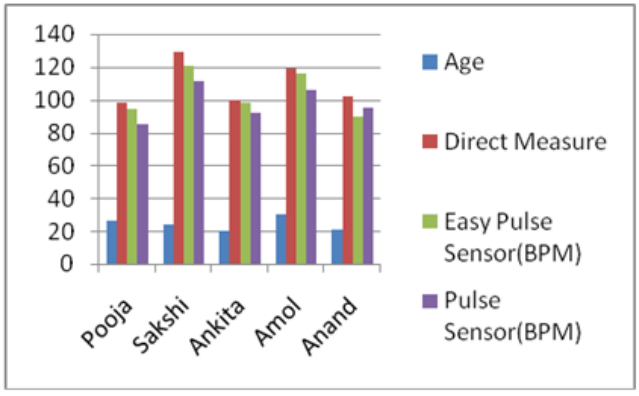

Figure 7. Output Result of age group 20 to 30: Easy pulse sensor performs better than pulse sensor

Table 3. Output Result of age group 30 to 40:

Name	Age	Direct Measure	Easy Pulse Sensor(BPM)	Pulse Sensor(BPM)
Sonali	37	108	104	100
Mohini	31	109	110	111
Sanika	35	120	113	106
Sagar	39	112	116	96
Prasad	34	98	96	91

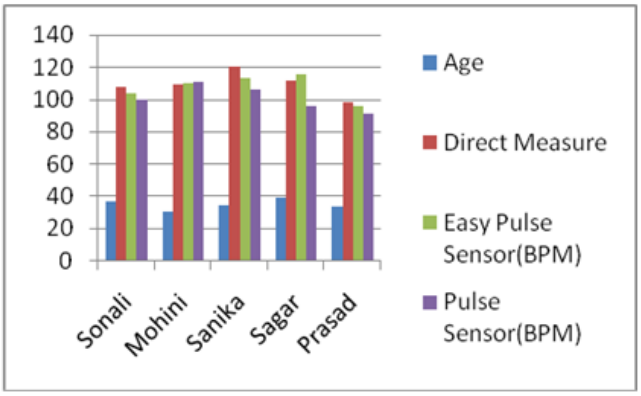

Figure 8. Output Result of age group 30 to 40: Easy pulse sensor performs better than pulse sensor

Table 4. Output Result of age group greater than 50:

Name	Age	Direct Measure	Easy Pulse Sensor(BPM)	Pulse Sensor(BPM)
Amit	55	94	88	84
Govind	75	111	105	101
Srikant	62	120	103	109
Rasika	70	102	97	100
Sita	66	96	99	89

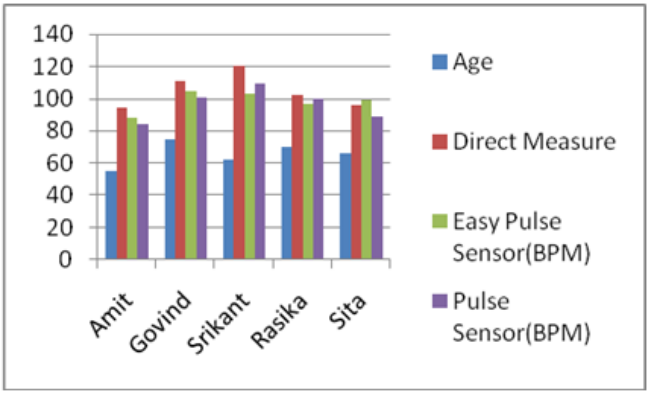

Figure 9. Output Result of age group greater than 50: Easy pulse sensor performs better than pulse sensor

IX. CONCLUSION

This paper determines the heart beat rate per minute of patient. If critical situation is occur then sends alert message to the mobile phone. As the designed system is portable, cost effective and easy to use, this will reach easily to rural people.

With the help of developed application, following points are observe -

- ✓ Easy Pulse sensor is easy to use and handle while pulse sensor not.
- ✓ Easy Pulse sensor gives more accurate result while the pulse sensor not gives accurate result.
- ✓ Sometimes, pulse sensor not gives result.
- ✓ Easy Pulse sensor is costly than the finger tip sensor.

After studying all the details about the sensors and its result, we conclude that the Easy Pulse sensor is best for measuring heart rates.

X. FUTURE WORK

- ✓ In future, the design can be extended by using WIFI or GSM or GPS for long distance communication.
- ✓ A portable heart rate monitoring system can be designed using Arduino.

- ✓ Continuous wearing of sensors was uncomfortable and irritating to users so used inbuilt sensor of smartphone.

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