Android Based Heart Rate Monitoring and Automatic Notification System

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Abstract- The design of an integrated portable device that can monitor heart rate (HR)continuously and send notifications through short message service (SMS) over the cellular network using Android application is presented. This paper proposes a methodology to measure a heart rate using photoplethysmogram (PPG) — a technique that uses infrared light to detect changes in the blood flow volume in tissues. The red channel of RGB signals in each picture frame recorded by smartphone returned the plethysmographic information. This contextual information will be converted into time domain signal by using Fast Fourier Transform (FFT) for further used in heart rate estimation process. The final results is the heart rate of each person recorded within 40 seconds.

The designed system shows the real time HR on the mobile screen through Android application continuously and if any abnormal HR of the patient is detected, the system will immediately send a message to the concerned doctors and relatives whose numbers were previously saved in the Android application.

Keywords—**Photoplethysmogram, Fast Fourier Transform(FFT), heart rate estimation, smartphone, non-invasive monitoring.**

1. INTRODUCTION

Monitoring vital parameters such as heart rate, blood pressure plays a very important role in detection, recognition the dangerous situation and prevent of any health diseases. Heart rate is important because the heart's function is so important. The heart circulates oxygen and nutrient-rich blood throughout the body. An abnormal rate or rhythm may be discovered during a physical exam, ECG, or other testing, even in healthy people who have no symptoms. By far, the only viable diagnostic tool that could ascertain cardiac events is HR readings.Henceforth, HR monitoring and alert system which is able to monitor the HR condition of a patient is very effective in the detection of heart diseases and Photoplethy-smogram (PPG) has been employed to compute HR. Currently, there are some Android applications that can monitor HR but do nothing when hearts condition is poor. It would be a breakthrough if an app is developed that incessantly monitors HR and if detected unusual, sends messages to all saved mobile numbers with precise GPS location of the patient and current HR. In this regard, this literature describes a system that determines the HR per minute in real time and then sends SMS alert to the mobile phone in face of emergency or user requirement.

1.1 Heart Rate Monitoring Technique

Photoplethysmogram is not a new technique for measuring pulse wave. In 1938, Hertzman [4] described a new technique that recognized the pulse wave form changes by sending an infrared light into the tissue and then measured the amount of light absorption corresponds with the variation of the blood volume. This technique called photoplethysmogram (PPG) which later implemented on smartphone by many researchers. This technique presents the simple and low-cost optical based technology that used camera on a smartphone to record the pulse in the fingertip.

1.2 Android Application

Android Application: The data is sent from hardware to application. It is then displayed on the application i.e. Heart Monitor App. The Android application for the mobile device has been developed using Android Studio. It is developed to be used on the patient side. The key features of the applications include: login, registration, logout, profile edit, report view, data input, validate the newly added data and generate a graph from it. When the application is launched for the first time, the login panel is deployed. It asks for a username and a password. If the credentials provided in the mentioned field matches with the database, the user is authenticated and the user panel on the application is launched. In case of a new user, once the fields have been filled, it checks into the database for the user. If the email address provided is unique, the user is registered and then taken to the user panel, much like the login process. Once, the user is logged in, the username and password is stored locally on the Android device using shared preferences.

2. LITERATURE REVIEW

Researches are done for evaluation in Healthcare System and also in wireless sensor network.Those are helpful in maintaining and monitoring the health of patient. The focus is on Mobile-Phone-based Remote Patient's Vital Signs Monitoring and Intelligent

Alerts System which involve automated functioning medical sensor device to ease human life and an intelligent data record system that is easy communicable with patients and their Guardians . The developed system in this paper, consists of many medical equipment which measures body temperature, heartrate, breathing rate, activity and posture . This project is only focused on providing accurate and quick readings of patients even in the absence of a doctor. Research is done in the domain Body Area Network (BAN) from 1967. There was a project named Code Blue Project By Astang Coupe in 1967. The wearable computer is made which was attached to the patient's wrist and the values are taken to predict disease [5]. In 2008 a project is made by V. Annamalai & S.K.S.Gupta named as Project Ayushman. It is a real time project which is sensor network based medical monitoring system which collect and analyse health information . The project Europian Mobihealth by Katarzyna Wac in 2009 which works as WBAN. But it has some major issues; they are security and reliability of communication resource [3]. AID-N system developed. It consist of smart dust which is a wearable computer attached to the patient'swrist. Parameters are continuously transmitted to doctors tablet device. Transmission protocol used is IEEE 802.15.4 standard. Due to this collaborative and time critical system is developed for emergency. AID-N system relieve the workload by automatically recording and analyzing the patient's vital data and alert the doctor if any abnormal condition occurred.

Author/Date	Topic/Issue	Concept/ Theoritical model	Algorithm method	Finding's
V. Devaki Dr. C. Jayanti [2019]	Pulse Rate Measurement using Android Smartphone	Photo-plethysmography is an optical technique which is used to measure the blood volume changes in the arterial blood in the peripheral circulation	FFT Algorithm. Photo-detector to detect transmitted light through led.	It monitor the change of intensity in blood volume.
Ramit Kumar Sadhukhan, Md. Mehtaul Haque [2017]	Android Based Heart Rate Monitoring and Automatic Notification System	The design of an integrated portable device that can monitor heart rate (HR) continuously and send notifications through short message service (SMS)	IR Algorithm Using GSM module present on the phone	HR monitoring using phone app. SOS System using sms
C. Rodriguez-Gallo F. Chavez-Castellanos [2015]	Heart Rate Measurement System Using Mobile Devices to Alert Arrhythmias	The present work describes the design and implementation of a portable system able to monitor the heart rate and alerts the patient and a relative when an acute arrhythmia occurs.	The mobile ECG and exercise activity monitoring system.	The system is able to warn of arrhythmias in real time using a smartphone to interact with the patient and it is responsible to alert a relative.
N. Y. Hoon, Soh-Hoon lee. [2017]	Real-time Heart Rate Measurement based on Photoplethysmography using Android Smartphone Camera	To capture blood volume changes by illuminating the finger with a light-emitting diode (LED) and measure the changes in skin illuminated light by transmitting it through photodiode present on smartphones.	Photoplethysmography (PPG)	Android application to measure HR in real time with duration about 10 second using smartphones.
Tanveer Reza, Sarah Binte Alam Shishir. [2017]	Development of Android Based Pulse Monitoring System	The developed system is based on Pulse rate sensor to measure heart pulse and Android device to support the whole system.	Accelerometer Arduino Bluetooth module	This gives a real-time heart monitoring using wireless network can solve the issue

Table 2.1 Literature Review

3. PROBLEM DEFINITION

To develop a user-friendly heart rate monitoring system on Android platform that is able to detect the possibility of heart disease in real-time basis based on reasoning and computational algorithms. To be able to calculate the Heart Rate by calculating the blood change volume in the fingertip. To suggest the user a diet according to his Heart Rate and to maintain to good health for his heart . To send notification to the concerned Doctor or relative as per stored information in the system. To track the location of the patient through GPS system.

4. PROPOSED SYSTEM OVERVIEW

4.1Software Requirements

4.1.1 Java

Java is a popular programming language. Java is used to develop mobile apps, web apps, desktop apps, games and much more.

4.1.2 Android Application Framework

An Android application framework is a software toolkit that enables app developers to piece together a finished product that meets the requirements of its proprietor. A framework provides the bones of an application, to be fleshed out with graphics, animation, special features and functionality.

4.1.4 Android SDK

Android Studio provides the fastest tools for building apps on every type of Android device. Download Not Available.

4.1.5 Android Studio

Android Studio provides the fastest tools for building apps on every type of Android device.

4.2 Hardware Requirements

4.2.1 Smartphone Camera

A camera phone is a mobile phone which is able to capture photographs and often record video using one or more built-in digital cameras. It can also send the resulting image wirelessly and conveniently.

4.2.2 Processor

The processor of your smartphone is the component that converts all your actions into visual changes on the screen. For this project we require dual core of above processor.

4.2.3 Memory

Internal memory is the manufacturer-installed storage space, usually 16, 32 or 64GB, where the operating system, pre-installed apps, and other system software is installed. Here we need 2gb or more RAM.

5. PROJECT BLOCK DIAGRAM

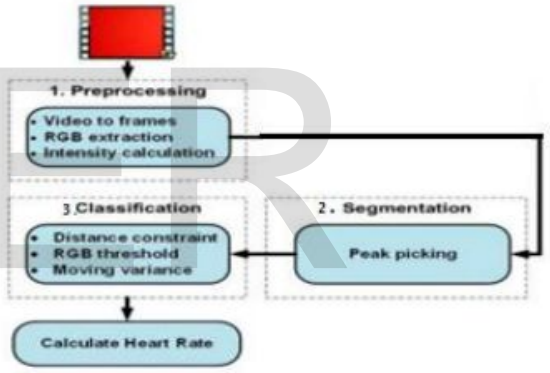


Fig 5.1 Block diagram of Heart rate Monitoring

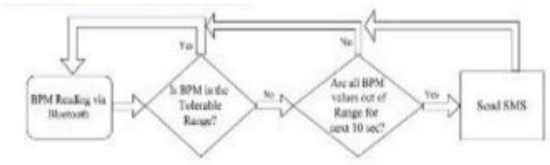


Fig 5.2 Notification System

6. IMPLEMENTATION

The processes of measuring heart rate using PPG technique are discussed in detail in this section. The Android smartphone was used in the fingertip image capturing process. The working algorithm begins with sensing raw IR sensor output voltage that is collected .. The calculated BPM value is then received in smart phone . Once our app is installed and run it will continuously perform the following steps:

• Read the incoming real time BPM. Using android application of our GUI interface anybody can check his/her BPM value anytime when he/she wants .

• If BPM is out of the normal range (60-140) it will start a countdown of 10 seconds .

• If all BPMs are out of normal range within this countdown the app will assume emergency condition .

• An SMS will be sent to all saved numbers in app. The SMS will contain: precise location co-ordinates (using GPS built in smart phone), approximate location .

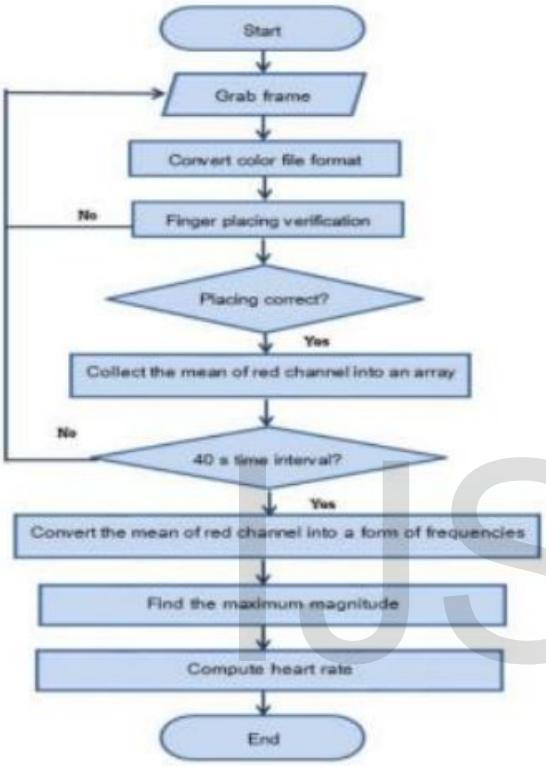


Fig 6.1 Workflow of HRM

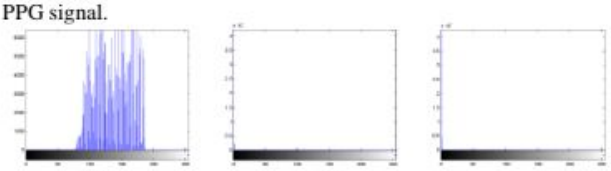
Our system concerns about two main tasks: 1) PPG imaging that grabs frame of fingertip obtained from smartphone and 2) RGB color analysis that will be further used in the heart rate estimation process. In the first task, the frame obtained from smartphone in YUV color format will be converted into RGB color format which can be used to analyses the histograms of red, green and blue channels which shown in Fig 2. Since the fingertip does not fix on the lens, it can shift from the proper position and drop its pressure on the lens. Therefore, we have ensure the area of the finger pressing fits the image boundaries. In order perform fingertip placing verification, we modified the verification color distribution threshold proposed by Kurylyak et al. [3]. The range of mean and distribution of RGB color range in our thresholds are described as below:

$\text{mean}(Red) - \sigma Red > 128,$

$\text{mean}(Green) + \sigma Green > 10 \text{ and } < 128,$

$\text{mean}(Blue) + \sigma Blue < 128$

* The distribution of each color must greater 40 This modification thresholds constructed from our investigation of RGB color histogram in each captured frame. These thresholds will perform in case that LED is used. Wefound that the color distributing in the channels of the error frames rules usually spread out of the ranges: 1) the red channel of each error frame has pixel values that concentrated in the lower half of its value range, 2) the green channel of each error frame has pixel values that less than 10 or concentrated in the higher half of its value range and 3) the blue channel of each error frame has pixel values that concentrated in the higher half of its value range. Any frame that has a mean and distribution of RGB color fits in this range is determined as a correct frame will present a central region of fingertip shown in Fig.3 (a). The correct frames will be further collected into an array. Some example of correct and incorrect fingertip placing frame are shown in Fig.3 which obviously seen that the red channel provides the most outstanding PPG signal.



(a) (b) (c)

Fig 6.2 Histogram of the correct fingertip placing frame: red channel (a),green channel (b) and blue channel (c).

Although claimed in [6, 7] that the green channel provides the strongest character of blood volume changes at the fingertip. On the other hand, [2, 3] and our experiment show that the histogram of red channel is the most prominent characteristic compared to the other color channels (Fig.2).Furthermore, the distribution of the pixels of red channels remains similar for different smartphones while the green and blue channels is not uninform [2, 3]. Therefore, only the mean values of the red channel will be collected in array for using in heart rate estimation process.

mean(Red) = 244.72,
= 16.65,
mean(Green) = 26.51,
= 4.54,
mean(Blue) = 6.00,
= 9.52
(a)

mean(Red) = 167.53,
= 50.8,
mean(Green) = 49.14,
= 4.54,
mean(Blue) = 6.00,
= 9.52
(b)

Fig 6.3. Examples of a correct fingertip placing frame (a) and incorrect fingertip placing frame (b). .

The frame acquisition processes perform within 40 seconds that is the same interval as digital pressure monitor performed. After the frame acquisition process already finished, the mean values in each frame of the red channel will be convert from a time domain signal into frequency domain signal by using Fast Fourier Transform (FFT) algorithm. Next, we have to find the maximum magnitude of frequency for calculating heart rate by using the formula which described as below:

$HR = (FPS \times FreqIdx \times 60)/N$

Where HR is a heart rate, FPS is a frame rate per second, FreqIdx is the maximum frequency and N is the number of the red channel frames.

A brief description of PPG signal processing is presented as follows. In the pre-processing stage, video goes through video-to-frames and RGB extracting block to obtain sequence of frames with separate Red Green Blue (RBG) channel. In the representation stage, mean brightness of each frame is calculated which Red channel is preferred one to obtain PPG signal. Then, PPG signals are transformed (i.e. moving average filter, or FFT) in order to highlight the peaks. Subsequently, applying peak picking is of

purpose to look for candidates peaks in segmentation stages. In classification stage, candidates peaks are reclassified based on distance constraints and RBG threshold to counter motion artifacts (i.e., noise of unstable finger) before calculating HR in the last stage .

Calculation of BMI

The BMI Calculator Application is a software programme that eliminates the need for more manual hours to calculate and locate the BMI for a specific person with a single click . This application provides all of the information including heartrate monitoring that is not available in any other application.

BMI of any individual is calculated with the help of the following formula:

Body Mass Index (BMI) = Body weight / (height × height)

Here the weight of the individual is measured in kilograms and the height is taken in metres. Now with the help of android application, criteria for underweight and obesity by BMI, the user may come to know whether this individual is under the category of underweight, normal weight, overweight or falls in the category of obesity.

• BMI table for adults: This is the World Health Organization's (WHO) recommended body weight based on BMI values for adults. It is used for both men and women, age 18 or older.

Category	BMI range - kg/m^2
Severe Thinness	< 16
Moderate Thinness	16 - 17
Mild Thinness	17 - 18.5
Normal	18.5 - 25
Overweight	25 - 30
Obese Class I	30 - 35
Obese Class II	35 - 40
Obese Class III	> 40

Table 1. BMI table for adults

7. RESULTS AND DISCUSSIONS

The experiments performed 6 persons both male and female between the ages range of 19 to 50. Their heights between 151 to 178 centimeters and their weight between 42 to 88 kilograms. The Android smartphone was used for capturing fingertip frame n. First of all, each tester had to press his/her fingertip on the camera lens and held the smartphone that faced up the screen .Each picture frame size is 320 x240 pixels and will be grabbed 30 frames per second as shown in Fig(a). From the experiment result of shown that the pulse counting duration which less than a full minute is acceptable. After finish testing, the result will represent the heart rate of the tester as shown in Fig (b) and the fingertip image will be changed to a black color.

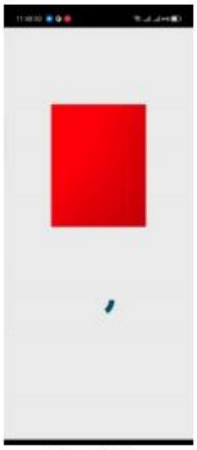


Fig. 1(a)

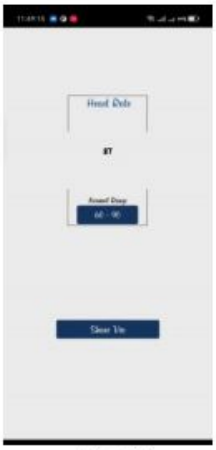


Fig.1(b)

Fig. 1. Application interfaces: (a) heart rate measuring screen and (b)the final result screen

Sr no.	Age	Heart Rate (beats per minute)
1	23	76
2	24	64
3	21	65
4	33	62
5	50	72
6	19	74

Table 7,I. The Result Of Heart Rate Measurement

Our app will send an automatic message to the previously stored numbers if an abnormality is found in HR value of the patient as shown in figs. The sent message contains details about patient's positional latitude, longitude and the current HR. Thus proper medical treatment can be provided to the patient at an earlier phase of complication. The automatic messaging option with precise GPS location of the patient and current HR in case of abnormal readings is an added feature of our android app unlike the existing apps that only monitor HR.

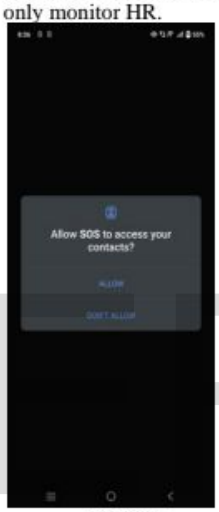


Fig 2(a)

Fig.2(b)

Fig.2 (c)

Fig.2(d)

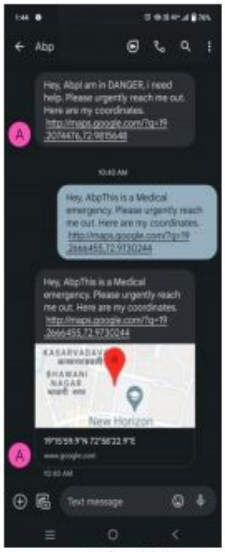


Fig. 2(e)

Fig. 2. Application interfaces: (a) allow sos to access your contacts,(b)allow sos to access the device location,(c)allow sos to send and view sms messages,(d) add emergency contacts and (e)the final sms send to contacts.

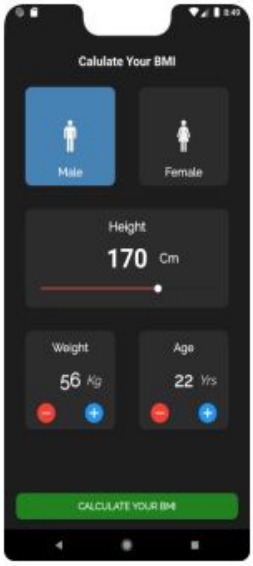


Fig.3(a)

Fig.3(b)

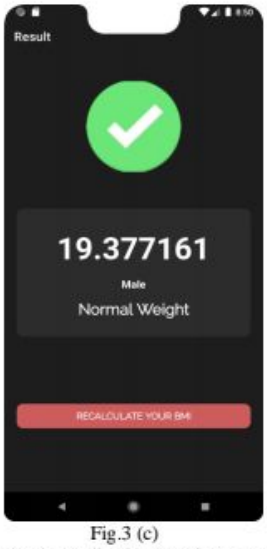


Fig.3 (c)

Fig. 3. Application interfaces: (a) select gender, age, height & weight (b) select calculate your bmi (c) final result for bmi

When you want to calculate BMI then you have to click on the application and open it. As your requirement you have to select gender, after that it will show the Enter weight and height screen, enter it accordingly and press calculate BMI button. (Refer fig 3. 1and fig 3.2).When we enter weight and height, it will calculate respective BMI and it show if that person is fit or obese.

In above fig. 3(c) it show that when we enter weight and height, it will calculate respective BMI and it show the person is normal weight.

Fig.4(a)

Fig.4(b)

Fig. 4. Application interfaces: (a) & (b) health recommendation diet

The App provides us with all of the necessary information, such as health recommendations and advice on what to eat and what to avoid. When we enter our height and weight, we are given all relevant information, such as if we are overweight or underweight.

8. CONCLUSION

This paper presents an alternative way to measure heart rate by using photoplethysmogram technique. The objective of this proposed algorithm is to develop Android application to measure HR in real time with duration about 40 seconds that optimizes for smartphones.We used a smartphone equipped with camera and LED flash to record the intensity of light obtained from the blood volume at fingertip.We focus on detecting the pulse by analyzing the RGB signals of the picture frames recorded from fingertip. Ten subjects participated in the test, placing their finger on the smartphone camera's lens for recording the changes of light intensity of fingertip. Therefore, we can conclude that our heart rate measuring application is accurate.

9. ACKNOWLEDGEMENT

The making of the B.E project needs co-operation and guidance of a number of people. We, therefore consider it as our prime duty to thank all those who helped us during this venture.

We would like to thank **Dr. Prashant Deshmukh (Principal)**, for his kind co-operation, guidance and for providing necessary facilities during the working on this report. We express our sincere thanks to **Dr. Sanjay Sharma, (Head of Computer Department)** for his support and co-ordination.

It is our immense pleasure to express our gratitude to **Mrs. Megha Gupta** as our Guide for providing us with constructive and positive feedbacks during the preparation of this project. We express our gratitude to **Ms. Aarthi Kamle** for her valuable insights and co-operation.

Last but not the least, we are thankful to all other staff members of Computer Department and our friends whose encouragement and suggestions helped us to enhance our ongoing B.E Project. We are also thankful to our parents for their constant support and best wishes.

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