Digital Health Monitoring System Based on Android OS

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***Abstract*: In this paper we are attempting to reproduce the ECG, Pulse rate and the Body temperature signals that we observe individually on the monitor screen of the hospitals on an Android device collectively. The signals are transmitted from a data acquisition system to the Android device via Bluetooth or Wi-Fi. The system will be compatible with the Android app which is to be developed and that it would be free of cost as compared to the available apps. The system is capable of handling numerous Android devices and distributes the collected data for diagnostic purpose and evaluation taking into consideration the architecture of Android OS. Also the app that will be developed will be easy to understand and as such can be used by anyone who possess a Smartphone thereby turning it into a virtual health monitoring system.**

Keywords* --- *Android, Smartphone, Data Acquisition, Real time.

I. INTRODUCTION

In the last decade there have been a rising number of cardiac illnesses that has claimed the lives of numerous people around the globe. Many have fallen victims to cardiac illnesses that have been the primary cause of death in both the developing the developed countries. Based on many factors such as lifestyle, environment and surroundings the number of people that will fall prey to the cardiac illnesses will go on rising [9]. Hence to monitor and to prevent such kind of attacks many new advanced and sophisticated systems and techniques have been developed for early detection and recognition of these cardiac disorders. These techniques have been developed keeping in mind to provide the best possible diagnosis with the least cost to everyone so that everyone's life can be saved too. There a number of reasons as to why cardiac illnesses are not being identified early and even if they are identified majority of the time the patient is unable to receive the timely treatment which will ultimately lead to more complications and finally result in death. Some of the reasons are as follows [5]:

- Precious time being lost while transporting the patient to the hospital
- Shortage of ECG treatments and unavailability of beds
- No early warning signs known to people.

Due to the reasons mentioned above and many other reasons many are victims of cardiac illness and hence lose their lives. The heart is an amazing organ as it beats continuously and in an even rhythm for 24 hours, 7 times a week and continuously for 365 days a year without even stopping for a single second. As such there is always pressure on the heart to pump and deliver blood to each and every single cell in the body and to oxygenate the deoxygenated blood and start the entire process all over again. The contraction and the relaxation of the heart produces the P, Q, R, S, and T wave also known as the ECG wave. A normal ECG waveform is as shown below:

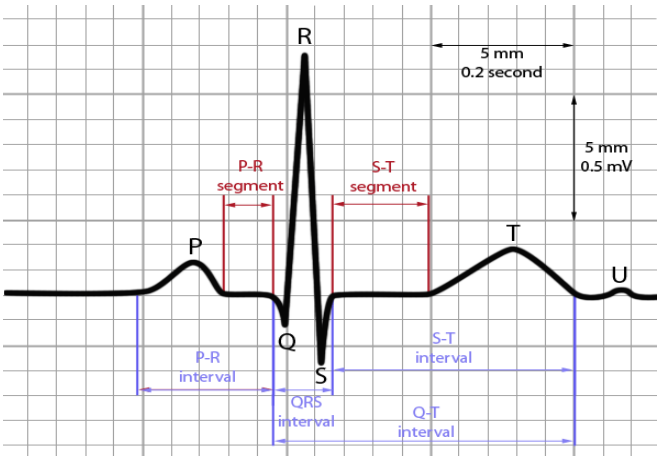

Fig.1: ECG Signal

If there are any changes in the normal ECG waveform it indicates that the person is suffering from a cardiac condition that needs to be diagnosed immediately and hence the idea to develop a portable health monitoring system. Also a person with medical expertise or someone with a basic knowledge can easily identify the difference in the waveform and accordingly take the necessary steps to prevent it.

II. OBJECTIVE OF THE PROJECT

The system that is being that developed will have both wired as well as wireless connections which will monitor the parameters in real time, process the obtained results and display the diagnosis in real time [12]. The advent of Android has revolutionized the world and has changed our perspective on how we see things daily. Now a day there is an app for everything and this was the main idea behind the development of this project as an Android app [10]. There are many 'Health Monitoring' apps in Android and most of them are paid ones

and the ones which are free are not accurate in the sense that we have to feed our details and only then does it calculate and gives the result which is not always accurate. The iOS platform also has many 'Health Monitoring' apps but most of them are paid ones and the cost of the iPhone is not feasible to everyone. Also till now no app has been designed for displaying the ECG signal in real time on Android. Hence it is for this purpose that an app must also be designed in accordance with the project so that all the three parameters can be viewed at the same time or at once. In this project we are directly taking the measurements and displaying the results instantly on an Android device [2]-[4]. Also since this is a free app it can be downloaded directly from the 'Google Playstore' and anyone with an Android device can use it to monitor their health free of cost. Also by comparing ones ECG, Pulse rate and Body temperature with a reference of their own, one can find out the difference and consult the doctor accordingly thus diagnosing the problem as early as possible. This app can also be used by doctors in situations when the appropriate ECG apparatus is not available to the doctor [11]. Moreover this data can be transmitted by technologies using Bluetooth, Wi-Fi etc to other doctors or to the hospital itself where the necessary arrangements can be made according to treat the person suffering from a cardiac disorder.

III. HARDWARE IMPLEMENTATION

The hardware section consists of the ECG amplifier circuit, the pulse rate meter and the Body temperature circuit stacked above one another. Design and fabrication of the ECG amplifier circuit was done. There was noise present in the ECG signal due to many factors such as Electromagnetic Interference, Motion Artifacts, and Baseline wander and due to Respirations and Perspirations. The ECG signal along with noise is as shown below:

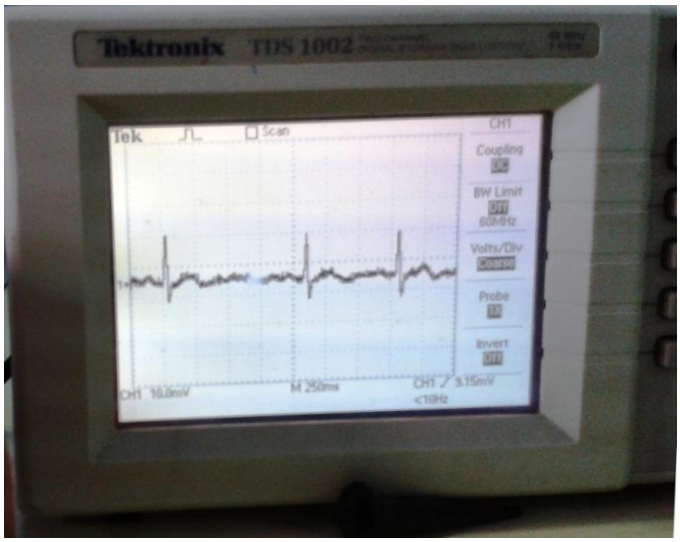

Fig.2: Observed ECG signal on oscilloscope along with noise

INA128P, LM358 and OPA2227 are the IC's that were used in the design of the circuit. After many considerations it was decided that the circuit was to be designed using INA128P and OPA2227 because of the many advantages that OPA2227 had over LM358. Following are the comparison between OPA2227 and LM358:

TABLE I
COMPARITVE STATEMENT BETWEEN OPA2227 AND LM358

PARAMETERS	OPA2227	LM358
BANDWIDTH	WIDE BANDWITH = 8MHz	LOW BANDWIDTH = 0.7MHz
OPEN LOOP GAIN	160dB	100dB
INPUT BIAS CURRENT	10nA	20nA
PRECISION	HIGH	LOW

IV. TRANSMISSION

The next step was to display the ECG signal that was obtained on the oscilloscope on an Android screen. To make this possible it was decided that the use of a Bluetooth module was necessary to display the signal directly [8]. But since Bluetooth has a lesser range typically about 10 meters and as stated above that we need to send the data over long distances the Wi-Fi technology was also considered. Raspberry pi will act as a 'Data Acquisition' device and send the signal wirelessly to the Android device. Also a microcontroller is needed for the switching and the multiplexing of the signals when they are being sent. The microcontroller that will be used will be used will depend upon many factors such as the cost, capacity and the compatibility with Android. Another option that was also considered to transmit and display the signal was by using the wired connection like the stereo cable. Stereo cable is an 'Radio Corporation of America' (RCA) cable which is a type of electrical connector that is commonly used to carry audio and video signals and is normally used in television systems, music systems and more commonly in headphones while connecting it to the mobile. The main aim behind using this cable was to ensure that the signal is displayed on the screen continuously even if the Wi-Fi connection fails. The main advantage in using this cable is that the signal is exactly reproduced and also the interference, distortions and the disturbances are greatly reduced and also it does not hampers the quality of the signals that is displayed in case of Wi-Fi if the connection is slow. The only disadvantage is that the length of the wire cannot be longer and hence the range is also smaller than Bluetooth. In this project it was decided to use an RCA cable to check if the signal is being reproduced correctly or not. For this purpose a signal generator was used whose output was connected to the oscilloscope to see the sine waveform. The function generator output was given to the Android device through the headphone pit acting as the input. After connecting the RCA cable it was found that the sine wave of the function generator and the sine wave that was being displayed on the screen were in par with each other. The frequency and the voltage on the oscilloscope were changed and the corresponding changes were noted on the android screen. To see the sine waveform we used an Android Oscilloscope. The changes that were made were duly noted on the Android Oscilloscope. Variations were made and it was observed that the sine wave starts clipping off after a certain frequency. This led to the conclusion that the range and the resolution of the Android Oscilloscope is not proper and hence for the app that is to be designed it needs to be modified accordingly. After observing the sine wave successfully on the Android screen, the next step was connecting the ECG

amplifier circuit to the Android Oscilloscope via the RCA cable mentioned above. An auxiliary cable attached to a 3.5mm jack was connected to the headphone end of the Android phone and the other end was connected to the output end of the ECG amplifier circuit. The observed ECG signal on the Android Oscilloscope along with noise present is as shown below:

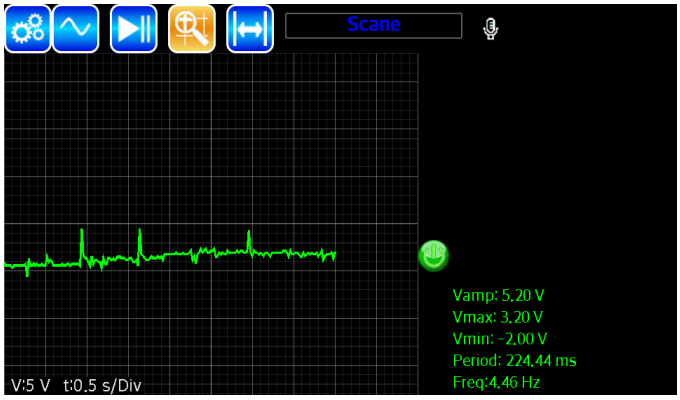

Fig.3: Observed ECG signal on Android along with noise present

From above it can be concluded that an ECG signal can be displayed on the Android screen with the help of an RCA or a stereo cable. However due to the presence of noise and also the loose contact of the cable along with the resolution of the screen a perfect reproduction of the signal cannot be achieved. Also the loose contact of the cable must also be modified so that a clear ECG signal can be achieved and displayed on the Android screen.

V. SOFTWARE IMPLEMENTATION

Since the signal has to be displayed on an Android screen an android app had to be made accordingly. The app was designed keeping in mind the current updates and the latest versions of Android in the market. The latest version of Android is known as 'Lollipop'. Also the app must also support lower versions of Android till 'Ice Cream Sandwich' so that users having Smartphone's which support this version should also be able to download and run it in their mobile without any problems. The app must be simple to use and should be user friendly so that anyone with an Android Smartphone will be able to use it [6]-[7]. The app must be both Bluetooth and Wi-Fi supported as mentioned earlier. The app must also incorporate a number of features so that the user has a number of options as to what the user wants to do with signal that he sees on the phone. The programming will be done by the 'Eclipse' software that can be easily downloaded from the internet. Also all the tools such as the 'Android Development Tool (ADT) plug in and 'Software development Kit' (SDK) needed to make an app are all available online and can be downloaded from the website of Android and hence the idea to make app in accordance with the system. Also Android is open source and free for all and hence once the app is completed it can be uploaded to the 'Google Playstore' and from there it can be downloaded easily. In Android there is an XML and a JAVA code that defines an app. The XML code contains the design and the layout of the app. The JAVA code will contain the necessary functions for the specific buttons, connecting to the kit with Bluetooth via the Raspberry pi and saving the received files. The app can also be viewed on Android tablets and it can also be seen on larger screens by simply connecting one end of the Universal Serial Bus (USB) cable to the Android phone or tablet and the other end to a large TV screen or a projector. In this way the signal can be viewed more clearly due to the high resolution and the clarity offered by the large TV screen or the projector. The architecture of an Android Operating System is as shown below:

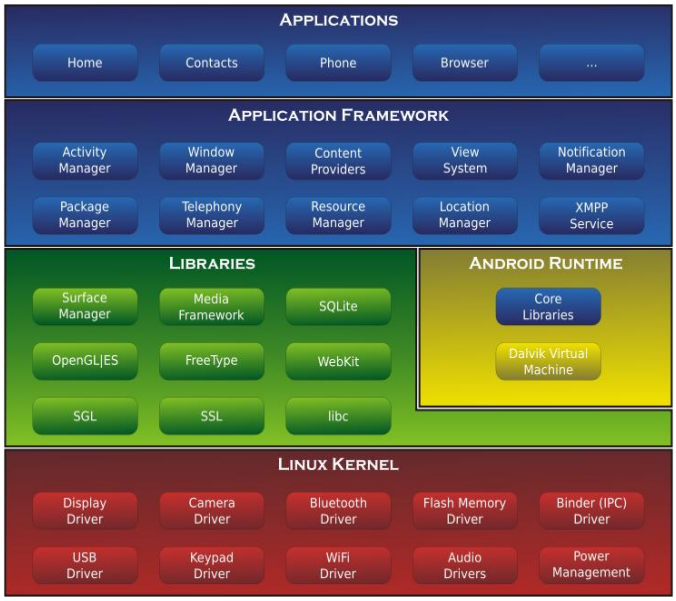

Fig.4: Architecture of an Android OS

VI. PULSE RATE AND BODY TEMPERATURE

Pulse rate and Body temperature are the two other parameters that are still yet to be designed. Till now there have been a few systems that show multiple biological parameters at the same time and also the apps that are available are mainly concentrated on the ECG signal. The purpose of this paper is to develop a system that acquires the ECG signal, Pulse rate and the Body temperature all at the same time and consequently display them on an Android screen. The final system will comprise all the three parameters stacked on top of another so as to make the entire system look compact and easy to use. Pulse rate is simply defined as the rate at which one's heart beats. Pulse rate is important to study the rhythm and strength of the heartbeat. Also changes in the heart rate or rhythm, a weak pulse, the hardening of blood vessels may lead to heart problems. Checking one's Pulse rate is crucial due to the following reasons:

- In case of an accident if the person has lost a lot of blood then it's very important to check the pulse rate to see how critical the person is.
- Since Pulse rate is directly connected to the heart rate a trained professional might immediately come to know as to what the person is suffering from and prescribe the treatment accordingly.
- In today's world there are a lot of people suffering from high blood pressure so if there is a clot in the blood vessel or a rupture it can be known with the help of the Pulse rate.

Body temperature is the normal temperature of the human body under normal conditions. The normal body temperature

is around 37°C or 98.6°F. Monitoring the Body temperature can alert us to the identification of certain specific diseases and by identifying these diseases the treatment can be adjusted or modified accordingly. When a disease inhibits the body of a particular person several changes occur on both the outside and the inside of the body. Change in Body temperature is one of the main and the most easily observed changes that can be seen readily. Hence by taking into account how much the Body temperature has changed and the noticeable changes both on the inside and the outside the specific disease, virus, bacteria can be identified and the patient can be saved in time. Body temperature can also be used to study the changes in the body that might be a precursor to cardiac illnesses. The final app that will be designed will comprise all of the above parameters and will provide the necessary information accordingly. All the three parameters can either be shown at the same time or one parameter at a time depending upon the choice of the user. Consequently the overall system must be energy as well as battery efficient.

VII. FUTURE SCOPE

The system and the app can be modified to include various other biological parameters. The raspberry pi mentioned earlier can be configured as a web server so that multiple devices can be connected to it as the same time. The system can also be configured to work as a small LAN inside a hospital so that the doctor can receive regular updates on all of his/her patients on his/her Android device [13]. It can also be modified to send alerts to the doctors in case any one of the parameter stars behaving abnormally so that the doctor or the hospital can be notified immediately and the necessary arrangements can be taken to avoid it. The hospital can maintain a complete database of all their patients in their vicinity and patients can have their own system in their homes which will be directly linked to the hospital's system so that any changes can be immediately acknowledged. Also a 'Special Emergency Distress and Service (SEDS)' can be implemented which will be fully dedicated to the database and calls the emergency service directly [1].

VIII. CONCLUSION

The main goal is to make avail the Android app which will be compatible with the proposed system which will be easy to use for the people who own an Android device. Also the tools are open source and hence available free of cost. To conclude it can be said that due to further technological advancements in the future the existing system can be modified in various ways and allowed to incorporate many more features thus making it truly a portable and a personal health monitoring system.

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