Efficient Telemedicine System Based on Android

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***Abstract*—Telemedicine systems are developedusing telecommunication technologies, advanced hardware and softwares. Compact low power embedded hardware technology and advanced signal processing platforms has introduced some new platforms to design more efficient Telemedicine devices. Under emergency situations like heavy rain, traffic, rural areas it is not possible to get urgent remedies from physician. By using present telemedicine systems real-time monitoring of such patients is possible. However the size and cost are major factors for specific task oriented telemedicine devices. This paper describes the development and implementation of portable, low cost and advanced emergency telemedicine system based on Android Smartphone. By using sensors and prototyping board IOIO, the patient's data can be monitored on Android Application. Further it can be stored on SD Card in the form of screen shot of mobile device. Stored results can be shared with concern physician via new communication techniques like WhatsApp, Facebook, email, and Instagram.USB Open Accessory Mode from Android is used to ensure a minimal latency of hardware while monitoring. Proposed telemedicine system is useful for all people especially for the emergency movement and diagnoses the heart related (Cardiac), diabetes patients, elder peoples as well as accidental victim. The main aim of this system is to provide emergency provisional help to patients before they get hospitalized which can save lives of many before the contact of expert doctors.**

Keywords— Telemedicine, Android based ECG, IOIO, Low cost telemedicine, Portable Telemedicine Kit

I. INTRODUCTION

Nearly about 25 percent of deaths occur because of heart diseases as per recent study by the Registrar General of India (RGI) and the Indian Council of Medical Research (ICMR). According to report average 10 percent people die because of lack in communication and tracking of patient is in critical conditions [1].Under emergency situations like heavy rain, traffic, etc, it is possible to provide urgent remedies from physician with the help of telemedicine's, on time to avoid danger up to certain limit.At least 8% of these cases may have 50% chance of survival, if adequate pre-hospital care is provided by means of telemedicine [2].

Emerging techniques in communication systems, VLSI and Medical fields enhanced availability of telemedicine among the people by means of Smartphones like Android, Windows, I-phones, etc. By using telemedicine can share patient's information over a distance using telecommunication. But existing systems are limited to certain techniques like voice calls, video conferencing, etc.

Smartphones can provide new era to telemedicine services with help of advanced level hardware and software systems. Using Smartphones it's feasible to carry telemedicine device on the move, which can provide patients accurate data on time. Its new way to get the help from physician, on desired place by saving time and money.

Using sensors like 2 lead ECG, SPO2, breath analyzer, body temperature, Galvanic Skin Response (GSR) and Electromyography (EMG) along with communicating devices like Raspberry Pi or IOIO, it's possible to track and maintain the accurate data on Android devices.

Indian Govt. has already initiated telemedicine programs in various States, to provide advanced medical help in rural developing areas. Organizations like (National Informatics Center) NIC,Indian Space Research Organisation (ISRO),Center for Development of Advanced Computing (C-DAC) are working for Village Empowerment, Health Education, Empowerment of the disabled and Rural Connectivity with the help of Telemedicine Systems [3].

II. LITERATURE SURVEY

Telemedicine was first proposed to use with video telephony and video conferencing. These techniques are very useful to operate surgeries in rural areas, where travelling time is major issue [3].Innovations under telemedicine created different new approaches in it, like real time synchronization, online data base management, use of computer cloud system. Telepathology, Tele-cardiology, Telesurgery, Teleradiology are Specific application based telemedicine systems where huge development is going on [4].

The existing telemedicine devices can keep track of include blood pressure, blood glucose, heart rate, weight and haemoglobin. Telemonitoring is effective forproviding information aboutcrucial signs, before reaching the necessary monitoring equipment at target location of patient. Relying on the severity of the patient's constraint, the provider may check these enumerations on a daily or weekly basis to determine the best course of treatment [5].

Studies have also shown that 12-lead ECG performed within an ambulance increase available time to perform thrombolytic therapy effectively stopping a heart attack in progress and preserving heart muscle function [9]. This means the patient is more likely to return to a normal lifestyle after a cardiac event [2].In accidental cases, an emergency ambulance system along with EMG, ECG, Spirometer and oxygen kit become more effective. However its conditional solution depending upon environmental situation, cost and availability.

Currently different telemedicine systems are available in the market. Some of are sponsored projects from Govt. of India like m-Health Toolkit. This telemedicine kit consists of a Laptop,

wireless broadband internet, software basedvideoconferencing system, Non Invasive Blood Pressure(NIBP), Spirometer, ECG, SPO2 and Telemedicine software, which was specifically designed anddeveloped for this kit [6].

Another innovative system "e-Health" based on biometric shield for Arduino and Raspberry Pi was developed by Libelium Communications, Spain. Using different sensors information is collected. Itcan be used to observe the real time state of a patient or to get crucial data in order to be subsequently analyzed for medical diagnosis.This data can be transferred to the Cloud systemsin to perform permanent storage or for graphical viewing in real time by sending the data directly to a laptop or Smartphone. By means of different operating systems of mobile phone, these applicationsare developed [7].

Along with this, small scale specific task oriented systems on (ECG/SPO2) are also available, but such systems are not cost effective. Today AndroidSmartphone is becoming more powerful computing, sensing and communication platform. Due to its omnipresence, cost effective, multiple sensors feature and convenient programming environment.It's being used in different sectors in automotive, medical, educational fields [11].The proposed system based on Android provides compact, cost effective option with multiple biomedical sensors.

III. PROPOSED METHODOLOGY

This system uses Open Source platforms of hardware and Software. It contains different biomedical sensors with analog and digital interface. The main task is to capture the real-time data from them and plot the graph along with some calculations based on obtained values. But using only Android Phone, it's not feasible. Because they are not compatible to interface with third party inputs and outputs directly. To overcome on this situation, new hardware IOIO can be used as USB Open Accessory.

Android itself supports USB peripherals and accessories. There are two possible modes, USB accessory and host. Using USB accessory mode, the external USB hardware can acts as the USB host, which gives Android-powered devices the ability to collaborate with USB hardware. The IOIO works in USB accessory mode [8].

Android IOIO is an I/O prototyping board designed for Android device (OS versions 1.5 and greater). The IOIO board contains a single PIC24 microcontroller that acts as a USB host and interprets commands from an Android app. As companion, the IOIO can get across with peripheral devices in the same way as most MCUs. Digital Input and output, I2C, SPI, PWM, Analog Input and UART are peculiar lineaments from theIOIO. The board provides a connection to an Android device via a USB or Bluetooth connection [9]. The system interface is as shown in Fig. 1

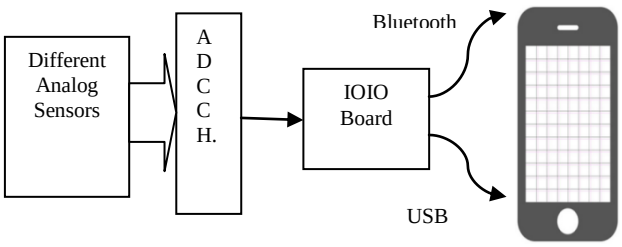

Fig. 1 Functional block diagram of the Telemedicine system

Advantage of using IOIO is that need only to do programming in Android Phone, to access all peripherals of PIC 24. I/O's of this board works on 3.3V, so in order to access the analog input, must provide desired rated sensors. In this system, two different biomedical signals can be accessed namely ECG and SPO2.

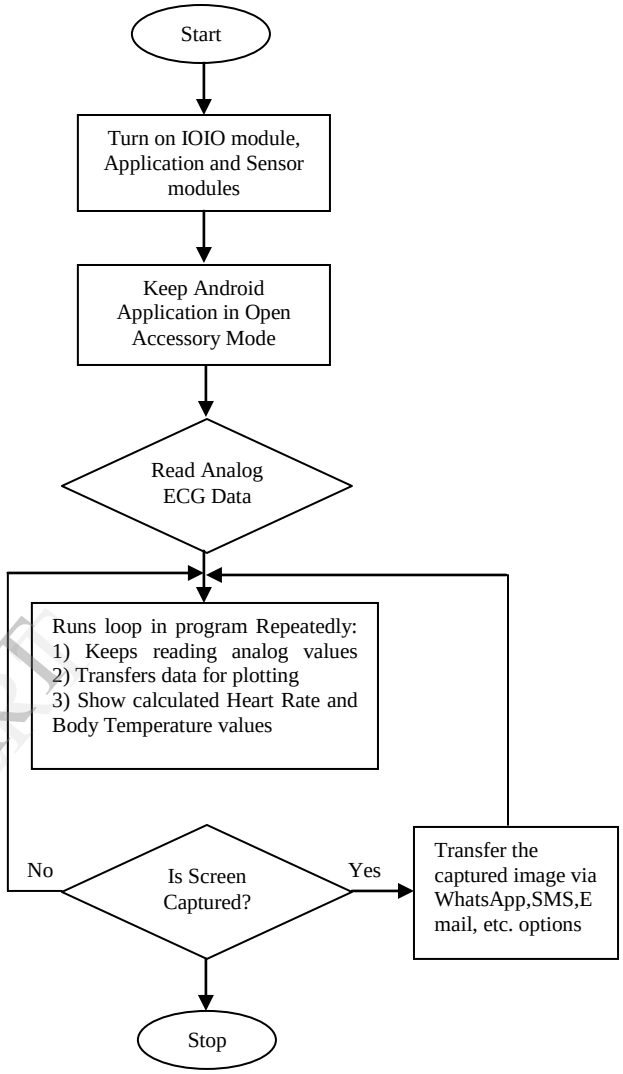

Fig. 2 Flow chart of the Telemedicine system

The board can be powered up via external USB or 5VDC adaptor.ECG system is based on 2 lead and providing scaled analog output between 2.5V to 3.3 VDC. SPO2 and Body Temperature can accessed via analog or digital form on its operational environment [9].To access IOIO from Android phone, different Application Programming Functions are provided.

Using this API's the programming done in Java language via Eclipse and Android SDK. For Android OS versions greater than 2.3.7, IOIO can be accessed as Open Accessory. The Android application is based on Java programming language. The flow of execution is shown if Fig. 2. It's really critical to build an application with plotting data points very quickly on top of general UI with a continuously-updating UI thread.

Separate IOIO libraries are required to link along with main Android Application, which provides excellent programming

platform. Little hardware related permissions are needed to grant in application's Manifest.xml file from the user via software in order to access the Android Phone's internal features. The execution of analog value's reading is kept in looping format.

Separate threading through Main Activity can be used to read the multiple analog and digital values and display on screen. After receiving the data values from analog input, the plotting of the ECG signal performed via Third party Plotting Libraries in JAVA language. This plotting can be done in real-time. The received values can be stored using database management systems from Android and retrieved later for future use.

IV. RESULTS AND DISCUSSIONS

Using this Telemedicine system, Person's ECG,Oxygen saturation (SPO2) and body temperature can be received via IOIO and Android. The real time screen showing results is captured via screen shot option by clicking button provided with software.

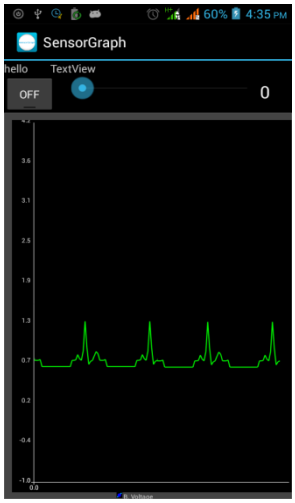

Fig. 3 ECG chart using 2 lead ECG system

Subsequently the bio-signalis measured and the Heart Rate can beestimated by the Android mobile system, which is essential to monitor the heart beat rate. Here Fig. 3 shows the obtained ECG pattern on Android application's screen from IOIO and 2 lead ECG system. In such type of ECG, R to R interval may vary considerably, however each QRS complex is preceded by P wave and PR interval, this scientific phenomena is known as sinus arrhythmia.Interval can be measured on horizontal axis in seconds. By measuring these consecutive intervals between heart beats (R to R continuation value) and using Eqn. 1, the Heart Rate can be easily calculated.The QRS, QT and PR are the intervals, which should be mainly scanned on every ECG. Here Table I. Shows interval considerations based on time duration [12].

TABLE I. TYPICAL PQRS INTERVAL CONSIDERATIONS

Sr. No	Interval	Effective time duration (in sec)
1	PR (beginning of P to next QRS)	0.12to 0.20
2	QRS (beginning of Q to the end of the S wave)	0.06 to0.10
3	QT (beginning of QRS to end of T wave)	$\leqslant$ 0.40

The inverse of the time difference between the normal heart beats gives the Heart Rate. HR is expressed in beats per minute (bpm) unit.

$$HR(bpm) = \frac{60}{RR\ continuation\ \ interval\ \ (sec)} \quad (1)$$

Considering the duration of RR interval is 10 seconds. In this example,

$$R\ to\ R\ interval\ value = 12 \quad (2)$$

Using the value of RR interval from Eqn. 2 and Eqn.1 in Eqn. 3, the Heart Rate can be calculated,

$$HR(bpm) = 12 \times 6 = 72 \quad (3)$$

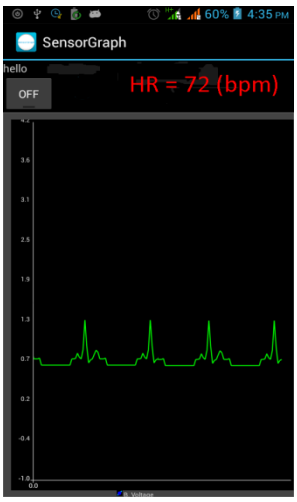

Fig. 4Showing Heart Rate in bpm

Fig.4 shows the calculated HR on screen based on predicted values. The prototypical relaxing heart rate in adults is 60–80 beats per minute (bpm). To predict HR from an ECG, RR variability must be notified. If any abnormal HR is detected, that is, outside the normal range[10], the mobile device alerts by notifications.

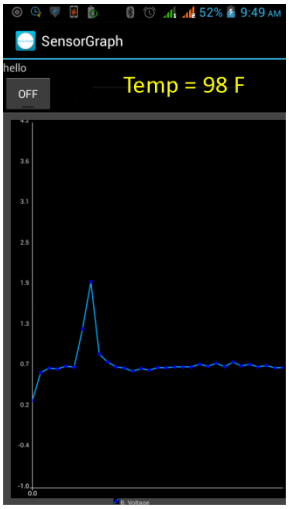

Fig. 5Monitoring variations of human body temperature

A number of deceasesarediagnosed by doing analysis of body temperature. By using body temperature sensor, variations in temperature are measured. Fig. 5 shows the Human body temperaturein F^0. It can be represented by graph. And can be stored in the form of pdf or jpeg images.

On clicking SEND button, the captured screenshot of the results windows can be stored on SD Card in Mobile. The data storing can done with file management based on date and time. Another good feature is that, these results can be shared with concern Physician by means of different communication options like MMS, Facebook, WhatsApp, SMS or E-mail as shown in Fig. 6.

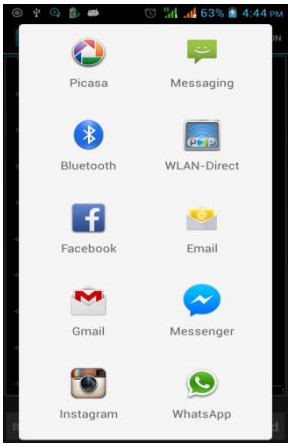

Fig. 6 Captured Result sharing via different techniques

In order to keep the privacy of the patient's data, it's possible to utilize secured emailing or encrypted messaging.It can be transferredonline to document Printer via Cloud computing or WIFI direct Printer.

V. CONCLUSIONS

Telemedicine system using Android based device, can provide a remedial option at patients adverse situation. In this system by measuring ECG and plotting its graph, the prior diagnostics can be possible. Another feature of measuring human body temperature can helpful for basic clinical diagnosis of the patient.

The accuracy of an ECG depends upon the Front End Analog Circuit. By increasing the number of leads with proper shielding, its possible to enhance the accuracy of ECG signal. An IOIO device is available in low cost with many great features. This device can be used as a telemedicine to enhance the safety in emergency conditions by recoding the data and sharing results via new mobility techniques with physician.

Using this device, the user's health status can be monitored seamlessly and in real time. To ensure a minimal latency of hardware the USB Open Accessory Mode is used.

VI. FUTURE SCOPE

Open Accessory Mode is very useful for Medical equipments as well as for Home automation Systems. By using this IOIO board it's possible to monitor up to 9 different analog biomedical sensors. Using Cloud Monitoring system, the real-time time data can be shared with Physician in long term. Upcoming Android OS versions greater than 4.3 are supporting Low Energy Bluetooth Sensors. Sensors with Bluetooth Medical Profile are just plug and play type of devices, which can be interfaced directly. Wearable sensors are outputs of recent nanotechnology innovations with superb efficiency and accuracy. Use of such sensors with this telemedicine system can offer more compact, handy and tranquility while handling overall unit.

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