# AFFORDABLE EMERGENCY TELEMEDICINE SYSTEM BASED ON SMARTPHONE

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***ABSTRACT***
*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. 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. 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, Affordable 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, 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].

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 Organization (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].

The physiological parameters like temperature, heart rate, ECG, breathing rate and SpO2 are acquired from the patient monitoring system [14].The existing telemedicine devices can keep track of include blood pressure, blood glucose, heart rate, weight and hemoglobin. Telemonitoring is effective for providing information about crucial 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]. 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 based videoconferencing system, Non Invasive Blood Pressure (NIBP),

Spirometer, ECG, SPO2 and Telemedicine software, which was specifically designed and developed 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. This data can be transferred to the Cloud systems in 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 applications are developed [7].

Today Android Smartphone is becoming more powerful computing, sensing and user friendly platform due to its omnipresence, cost effectiveness, 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.

**Organization of manuscript:**

Sec. 2 gives an idea about the problem identification; Sec. 3 covers the methodology part along with flowchart; overview of corresponding results are given in Sec. 4. Concluding remarks and discussions are explained in Sec.5.Finally future scope is presented in Sec. 6.

## II. PROBLEMS IDENTIFICATION

After reviewing the literatures, concluded with problem statement that Emergency device should be required which can be easily available in low cost and should be easily accessible by common man. Though some devices are available in market but having some of following issues:

1. Availability of Device in local Market.
2. Total Cost of device to purchase and maintain its licensing through Vendor.
3. Its size and weight are major factors.

## III. PROPOSED METHODOLOGY

This system uses Open Source platforms in combination with different biomedical sensors, analog and some digital interfaces. The main task is to capture the real-time data from them and plot the proper graph along with some calculations based on obtained values. But using only Android Phone, it's not feasible, because they are not compatible to directly interface with third party inputs and outputs.

Android itself supports USB peripherals and different third party 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 based techno devices. Here in this proposed methodology an IOIO device is used as USB accessory in coordination with sensors [8].

Android IOIO is an I/O prototyping board designed for Android device (OS versions 1.5 and greater) [4]. 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 the IOIO. Connection with Android device can be established via ADB mode, Bluetooth or USB OTG [9]. The system interface is as shown in Fig. 1

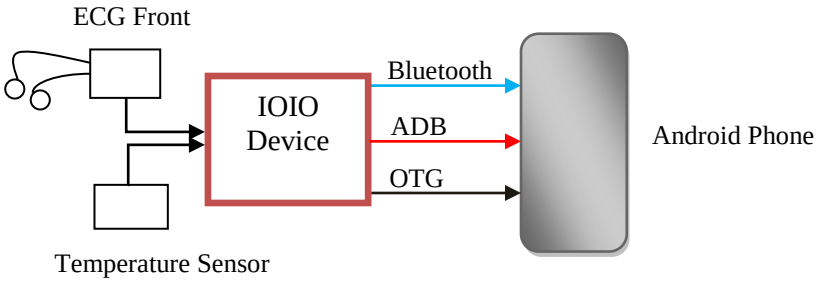


**Fig. 1** Functional block diagram of the Telemedicine system

Advantage of using IOIO is that, programming is required only on Android Phone to access all peripherals of PIC 24.Prototype Board is already preprogrammed with necessary libraries ported image on it. I/O's of this board works on 3.3V but can be accessed by 5VDC constant power source. In this system, two different biomedical signals are accessed namely ECG and Body Temperature.

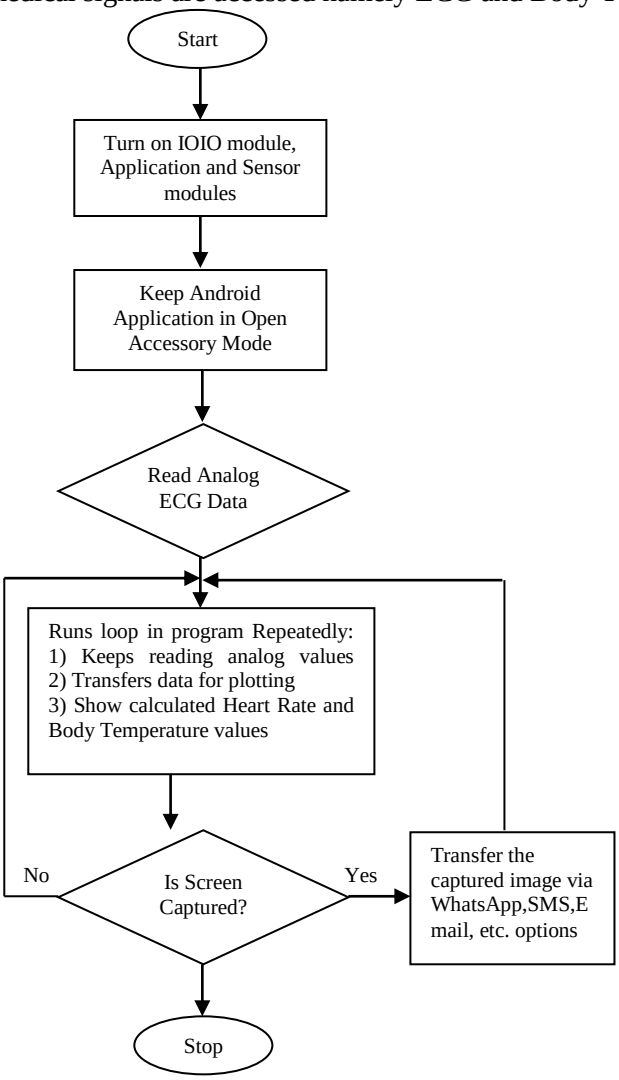


**Fig. 2** Flow chart of the Telemedicine system

ECG system is based on 2 lead front end and providing scaled analog output between 0 V to 3.3 VDC. Body Temperature can accessed via analog form on its operational environment [9]. Using API the programming is done in Java language via Eclipse and Android SDK. IOIO can be accessed as Open Accessory Device on Android Versions greater than 2.3.7.The flow of execution is shown if Fig. 2.

Separate IOIO libraries are required to link along with main Android Application, which provides excellent programming platform. Some 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 can be captured via screen shot by clicking button provided with software.

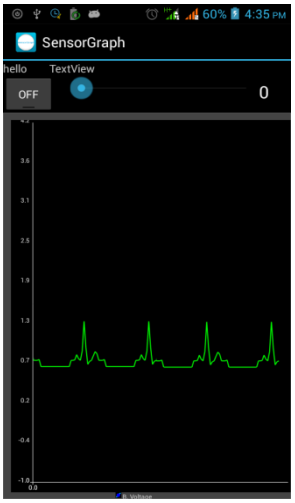


**Fig. 3** ECG chart using 2 lead ECG system

Subsequently the bio-signal is measured and the Heart Rate can be estimated 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. 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) | 0.12 to 0.20 |
| 2 | QRS (beginning of Q to the end of the S wave) | 0.06 to 0.10 |
| 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.

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

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

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

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

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

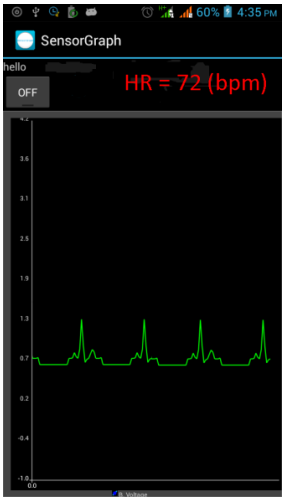


**Fig. 4** Showing Heart Rate in bpm

Fig.4 shows the calculated HR, 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, outside the normal range [10], the mobile device alerts by notifications.

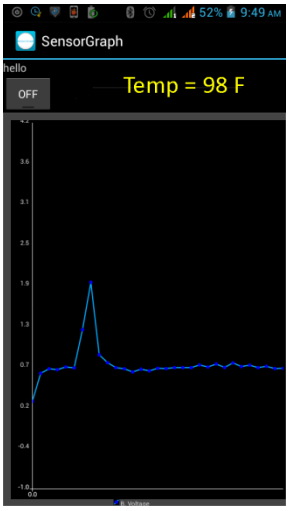


**Fig. 5** Monitoring variations of human body temperature

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

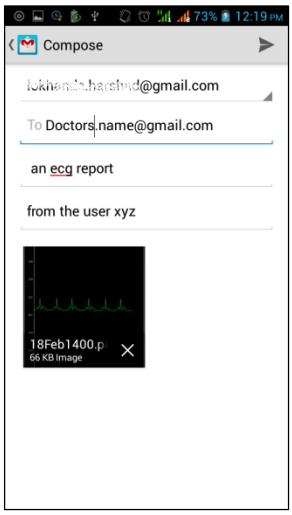


**Fig. 6** Secured Emailing of Report via Android

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

In order to keep the privacy of the patient's data, it's possible to utilize secured emailing or encrypted messaging. Here the Fig. 6 shows the secured email sending along with attached data report. By using latest Android release "Kitkat" , the screenshots of the received data can transferred to online document Printer via Cloud computing or WIFI direct Printer. And even the mobile's screen can be recorded live in mp4 or 3gp format.

## 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.

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 in monitoring and efficient health tracking system the USB Open Accessory Mode from Android is used.

## VI. FUTURE WORK

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. Android OS versions greater than 4.3 are supporting Low Energy Bluetooth Sensors with Health Profile Feature. Thus energy management system will optimize the usage of battery consumption. Using wearable sensors the modularity and compactness of this telemedicine system can be tailored to next level.

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## BIOGRAPHY

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