Analysis of ECG Signal using Android Smart Phone-Review

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Abstract

In this polluted environment health problem are unpredictable, it is necessary to keep an eye on our health. If a particular patient of heart then one person avail for monitor patient's health. It is not always possible to monitor him with at most attention. We need a better system that always is with patient to monitor clearly and make the record of abnormalities obtained. As mobile phones commonly present in everybody pocket as a phone, so we are develop a system using smart phone which can able to alerts the user or alerts doctor or relative by making a call to family doctor or the some relative if dangerous or unconscious condition, who can care about the user by using mobile phone system. In this article, the alert system has a sensor to monitor heart condition of user. ECG is the best technique for monitoring and knowing the condition of the heart. And this sensor sends the data to the mobile phone through the Bluetooth wireless communication. The mobile phone receives the ECG signal and analyses the received signal with the reference signal which are in database. If any abnormalities of heart found in patient or users health then it will alert the patient by alarming and it make call to doctor in unconscious situations.

Keywords: Cardiac problem, Electrocardiography, Bluetooth wireless, communication, Smart Android phone

I. INTRODUCTION

In this hectic and polluted world taking care of health is necessary to live healthily particularly patients with heart problem. Heart disease is the leading cause of death in the world over the past 10 years. According to European Public Health Alliance's report, heart attacks, strokes and other circulatory diseases account for 41% of all death [6]. Treatment and prevention of heart disease are important issues for modern medicine. ECG monitoring in daily life is a necessary way for curing heart disease, and it is also a hot issue in medical and engineering fields. With the widespread popularity of smart phones and its portability, smart phone plays a role in monitoring heart nowadays [1]. Many researchers have done some studies on the application of smart phone in ECG monitoring, such as an ECG monitor system based on android smart phone.

Android operating system and equipped with wireless Bluetooth technology. The following benefits may result from the massive adoption of this technology, besides lowering ECG monitoring cost. Patients may have their ECG recorded at home, avoiding transporting to distant hospitals and moving through heavy traffic urban areas [1]. This might be quite convenient for elderly patients, chronic cardiac patients, and patients living in the countryside where doctors are not available. Perhaps this explains why home healthcare is the fastest-growing segment of the medical device industry, according to Food and Drug Administration (FDA) addition to replacing expensive and bulky traditional ECG machines, mobile phone-based ECG monitoring devices offer the paramount feature of instant warning about the heart condition of the patient [6]. This characteristic is quite appealing, for life threatening arrhythmias and ECG alterations appear before a

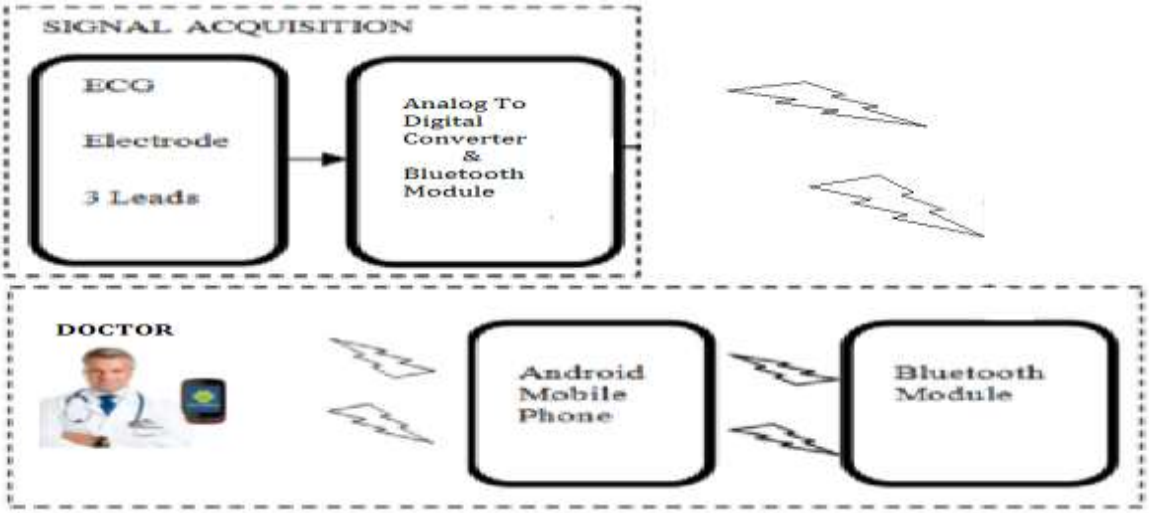


Fig. 1: The layout of the proposed system[2]

sudden heart attack occurs. Moreover, the chance to survive such an event is higher when patients are treated promptly This paper presents the design and evaluation of an ECG monitoring system deploying an Android mobile phone and Bluetooth technology.

II. RESEARCH METHOD

A. System Overview:

The designed ECG monitoring system comprises three distinct subsystems, as depicted in Fig. 2. The first one is dedicated to process the analog ECG signal, preparing it for conversion to the digital world. This is necessary, for today`s mobile phones do not include means to directly interface to analog signals from the external world. The second subsystem consists of a microcontroller and a Bluetooth module. This unit samples the ECG, serializes the samples and transmits them via the Bluetooth module to the Android cell phone. The third subsystem is the cell phone itself[6]. An application program written to the cell phone receives the ECG samples and suitably plots the ECG signal on the screen for analysis.

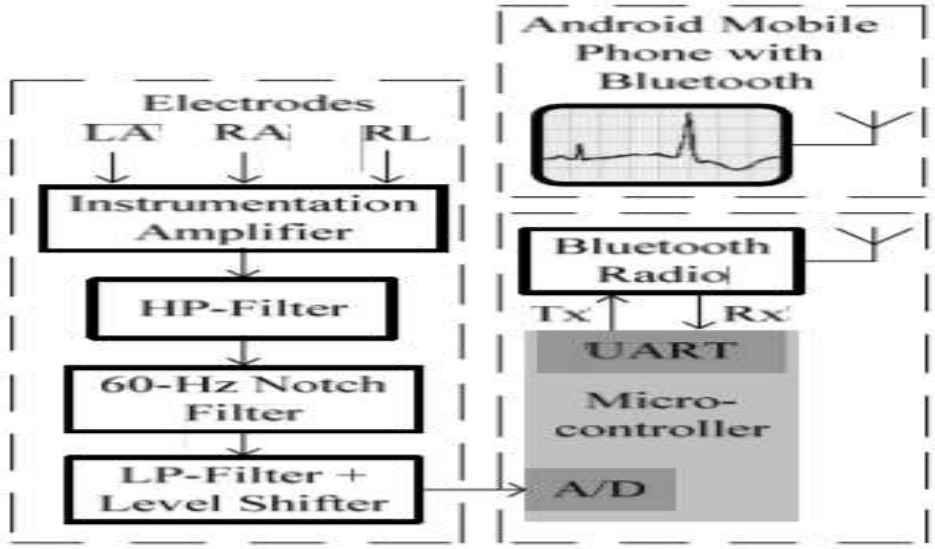


Fig. 2: Android mobile phone-based ECG monitoring system[1][6].

Fig. 3 presents the schematics Einthoven‟s triangle of the ECG conditioning circuit. An instrumentation amplifier (IA) (Texas Inst., INA101) receives the ECG detected by Ag-AgCl surface electrodes located on the patient`s right arm (RA), left arm (LA) and right leg (RL), and uses a resistor to set its gain to an appropriate value. This was experimentally adjusted. RL is the reference electrode [2]. This electrode combination is named lead I, but any other lead of the classic 12-lead ECG might have been used. Using shielded cables to connect with the LA and RA electrodes significantly improved the signal to noise ratio (SNR). Two 9-V batteries supply symmetrical voltages to IA and all the system`s operational amplifiers (Op Amps).

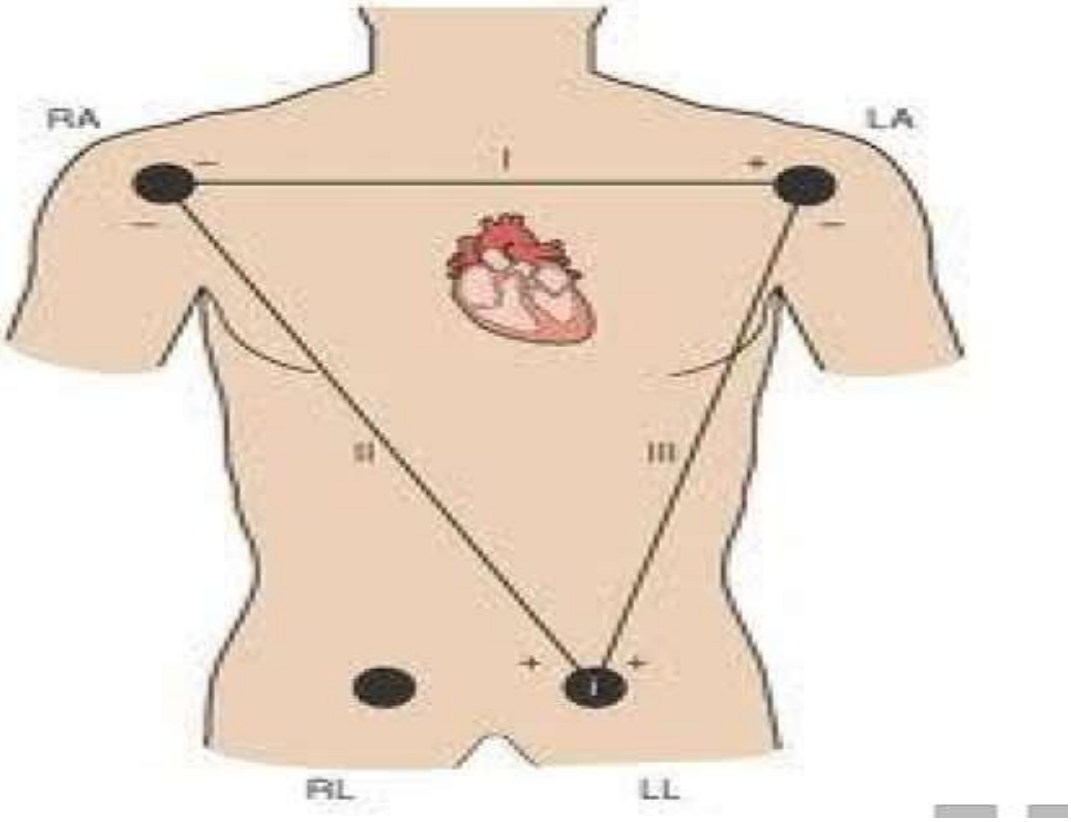


Fig. 3: Einthoven"s triangle[2]

The amplified ECG signal, as it appears at the output of the IA (pin 1), first goes through a simple RC high-pass filter (HPF). This passive filter's cutoff frequency is about 0.23 Hz and its role is to block the unwanted high-amplitude dccomponent of the signal. To filter out the main's 60-Hz interference noise on the ECG signal, this is buffered and then processed by a 60-Hz notch filter. The voltage follower is built around a precision Op Amp (Texas Inst., OP27)[2], while the notch filter deployed one Op Amp (A) from classic LM324 IC (Texas Inst.) containing four Op Amps. To limit the signal's bandwidth, and avoid errors due to aliasing during the sampling process, now the signal is processed by a second order, Butterworth active low-pass filter (LPF) that sets the cutoff frequency to 482 Hz. This active LPF further provides a voltage gain of 1.586 and is assembled around one more (B) of LM234's four Op Amps. As long as the microcontroller's analog-to-digital converter (ADC) input signal spans from zero to 3.3 V, a final analog signal processing task consisting in shifting the signal so that it fits suitably to the ADC`s input voltage range is needed. This is carried out by the third (C) Op Amp from LM324, which is arranged as a summing circuit. The appropriate offset voltage level is adjusted using the 500 kΩ trimpot. Several different processing circuits could have been utilized to condition the ECG signal. For instance, (digitally) programmable-gain IA could be quite interesting an option. Also, choosing to eliminate the 60-Hz interference noise deploying a digital filter can be quite appealing, given that very high-order digital filters are easily constructed and implemented with modern microcontrollers[2]. However, the circuit shown in this work, other than effective, enables the development team to readily modify it without the need to rewrite, compile and download control programs to the MCU.

B. ECG Sampling and Transmission via Bluetooth

An 8-bit microcontroller (Microchip, PIC18F45k20) endlessly samples the ECG signal at 150 Hz, using an embedded 10-bit ADC. The control program, written in C language, sends the incoming raw samples to an embedded USART serial port. The program reduces every 10-bit sample into a correspondent 8-bit sample, before transmission, simply by discarding the two less significant bits. The USART serializes the samples at 9600 bits per seconds, using the following settings: 8-bit data length, no parity, and one stop bit. Upon receiving the bits streaming from the USART, the Bluetooth module (Linvor JY-MCU) sends them into the air, which can be received by a nearby Bluetooth-equipped mobile phone. Pairing, however, of the Bluetooth module with the mobile phone`s Bluetooth must have been accomplished before any data transfer can take place. The control program running on the microcontroller just implements the commands supplied by the datasheet for the Bluetooth module (EGBT046S AT Command Set) to establish communication with the mobile phone. The used module is a class 2 radio (2.5-mW power and 10-m range).

C. *Android Mobile Phone*

A commercially available Android mobile phone with Bluetooth (Samsung's Galaxy Ace, GT-S5830B, Fig. 3) served as the target mobile phone during the implementation of this research project. At first, App Inventor (www. appinventor.mit.edu) served as the programming language and IDE for this research project. It worked fully and correctly, but as it had to be run on-line and our laboratory began to face Internet connection instability, our group decided to switch to a desktop-based, free and yet quite powerful IDE and compiler. We adopted Eclipse IDE (www.eclipse.org) and rewrote the entire Android application for the mobile phone utilizing the Java compiler of GCC (www.gcc.gnu.org). The ever increasing stunning processing power of the 32bits microcontrollers populating mobile phones (virtually almost 100% of these microcontrollers are manufactured under license of ARM Group) has opened up the possibility of inclusion of very complex signal processing algorithms into the applications programs[3]. Furthermore, for Android-powered mobile phones, as is the case in this study, this application inclusion into the mobile is quite straightforward and easy. In this research project, however, the application program is dedicated to receiving the ECG samples through the Bluetooth radio and processing them to properly plot the ECG trace on the mobile's screen.

III. RESULTS AND ANALYSIS

Two distinct series of tests have been carried out to assess the performance of the designed ECG monitoring system. The next two subsections describe them in detail.

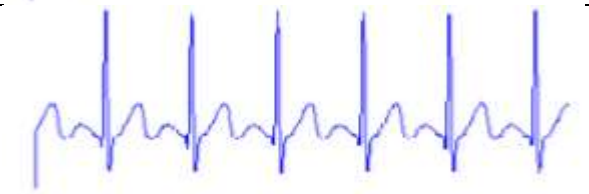
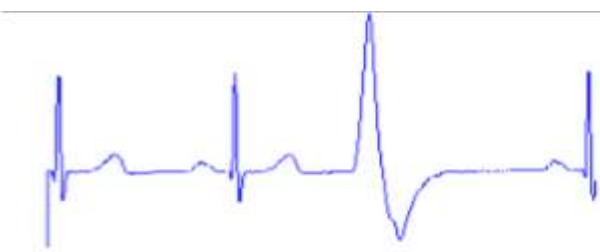
A. *Prototype Evaluation using an Arrhythmia:*

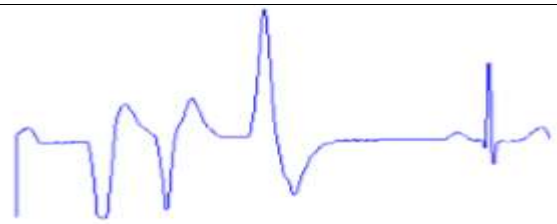
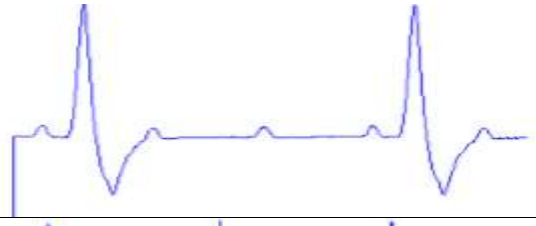
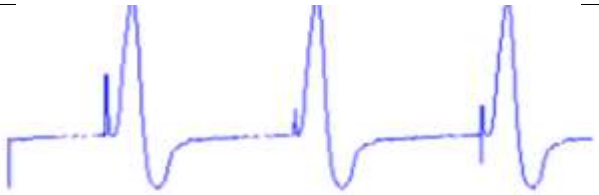
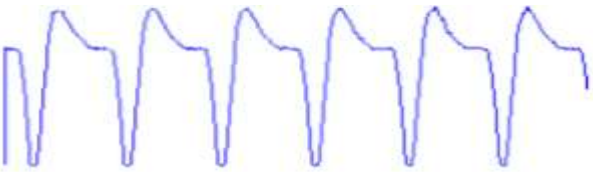
Simulator One effective method to evaluate how well a waveform recording instrument performs is to inject known signals into it and then examining its output, in this case, the quality of the recorded waveforms. The test signals must be of high quality and span across all the frequency and amplitude values the instrument under test is supposed to face in real world. An industry standard ECG and arrhythmia simulator has been deployed to assess the prototype's adequacy as an ECG recording and monitoring system. The utilized simulator is capable of synthesizing waveforms of physiological quality and is used by the industry either as a development tool or as a service tool (for instance, to test automatic arrhythmia detecting systems). The simulator has been connected to the prototype's electrodes (RA, LA and RL) and recording of more than two dozen different normal and arrhythmic ECG waveforms have been carried out by the prototype. TABLE I contains a selection of the waveforms recorded by the prototype[1][6]. These waveforms have been captured directly from the mobile phone's screen into a notebook, as image files, by means of a function on the integrated development environment (Eclipse IDE). The ECGs in TABLE I are identified using standard arrhythmia nomenclature. As could be noted, the prototype was capable of recording the several ECG waveforms with a high degree of fidelity. This could be observed by comparing the simulator's signals with the corresponding prototype's output signals. As an expert reader can easily observe, the prototype enables good quality recording of all key waveform details that are of paramount importance in ECG analysis (i.e., characteristic P and T waves and both normal and abnormal QRS complexes). One observed degradation in the sampled waveforms showed up as input signal saturation. This can be viewed in the recordings of premature ventricular contraction (PVC 2) and R-on-T phenomenon arrhythmias, where the typical V-like waves appear somewhat rounded on the vertex[6]. Solutions to this problem include decreasing amplifier gain, and adjusting the offset voltage added up to the signal just before the ADC

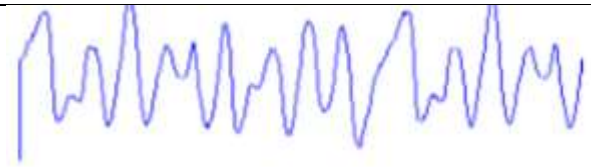
B. *Prototype Evaluation using Individuals:*

This subsection contains some results of the prototype qualitative evaluation via the ECG recording of several individuals. One person at a time had the electrodes connected to his right leg, right arm and left arm, and his ECG recorded. During the recordings, individuals remained sitting on a chair and were asked to keep as relaxed as possible. Their ages and weights span from 22 to 52 years and from 65 to 93 kg, respectively. They were all males, with no reported health problems.[1] The user counts on the buttons named Bluetooth and ECG to connect the mobile phone with the ECG module's Bluetooth and to acquire the ECG signal, respectively. So far, Sp02, Blood Pressure and Temperature functions have not been implemented. This procedure has been repeated with several volunteers, but rather than photographing the mobile`s screen, screen shots have been captured by Eclipse IDE, for documentation purposes. the ECG traces are clear enough to allow their analysis whenever needed. In particular, the signal quality is suitable for monitoring purpose[1]. Different types of noise (e.g., 60-Hz interference from power grid) can easily contaminate and destroy the millivolt level ECG signals during recordings. though not yet implemented in this project, digital filters running inside the mobile phone (as part of the ECG application) can be quite effective in wiping out several noise types.

Table – 1
Arrhythmias as recorded by the mobile phone-based ECG monitoring system [1]

Arrhythmias as Recorded by The Mobile Phone-Based ECG Monitoring System	
Normal sinus rhythm	
Sinus tachycardia	
Sinus bradycardia	
Atrial flutter	
Atrial fibrillation	
Premature ventricular contraction (PVC 1)	
Premature ventricular contraction (PVC 2)	

Multifocal PVCs	
First-degree atrioventricular (AV) block (60 BPM)	
Second-degree AV block	
Third-degree AV block	
Junctional rhythm (60 BPM)	
Asynchronous ventricular pacemaker (60 BPM)	
Ventricular tachycardia	
R-on-T phenomenon	

Ventricular fibrillation	
Asystolia	

IV. CONCLUSION

The main aim of the project was to design and implement a real time ECG monitoring system using a wearable ECG sensor and Smartphone. an android application was proposed which can continuously receive ECG signals from acquisition device wirelessly, detect QRS complex and plot the real time ECG signal on mobile phone for displaying. Also, it can send this information to concerned physician via server for medical decision. Experiments show that the proposed system is unobtrusive and can be comfortably used by the user during daily activities. The paper sets a foundation for future developments that can improve proposed application for wireless health solutions. Some of the features that can be included are detection of irregularities in the rhythms of the heart, monitoring and analysing ECG signals at home and simultaneous automatic alert to the doctor of any emergencies. It is also important to include more options like zooming functionality, which will improve the usability of the app.

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