

Research Article

Biological Parameter Monitoring using Android Smartphone

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Abstract

This paper describes work in progress regarding personalized heart monitoring using smart phones. Our research combines ubiquitous computing with mobile health technology. We have introduced a system called CUEDETA. This system will continuously monitors the ECG signals of the patient and send alerts to his/her contacts, medical professional and ambulance services. The alert also includes a URL which can be used to find the exact position of the patient using Google maps. The alerts are arranged in fashion, so that the patient and his/her social contacts have a chance to detect false alerts before contacting medical professionals, this is possible by connecting wireless heart rate monitoring device to the body and interfacing it with a smart phone.

Keywords: Cuedeta; heart monitoring; alert; Smart Phone.

1. Introduction

Nowadays more and more people are undergoing all types of cardiovascular diseases (CVDs) in both developing and developed countries, and CVD has become one of leading underlying causes of death. A recent report from American Heart Association acclaims that 81.1 million American adults more than one third) are estimated having one or more types of CVDs, and they account for 34.3% deaths in 2009 as the underlying causes [Sheng Hu, Zhenzhou Shao, JindongTan *et al* (2011)]. Among all types of CVDs, arrhythmias are responsible for most sudden cardiac deaths and indicative of other high risk diseases. However, the current diagnosis approaches still do not satisfy the people's demand due to their large response time. So we have introduced a system called CUEDETA. The name CUEDETA comes from the word cuerpo which means human body and detalles which means details.

Electrocardiogram (ECG) monitoring has been widely used in heart diseases treatment. General ECG monitoring systems use Holter system to monitor ECG signal and force the patient lying on bed. Comparing to which, a wireless ECG monitoring system with no restrictions on patient's movement proves to be more user-friendly [S. Hu and J. Tan *et al* 2009]. Traditional personal monitoring systems typically use laptop computers and/or external storage media later to a desktop computer for analysis. Newer personal monitoring systems incorporate smaller mobile computing units (e.g., cell phones). However, many systems are not interactive [Mitchel.M *et al* Jan 2011]; gathered sensor information lacks real-time feedback from the monitored users. Others tend to rely on

third-party service for data storage and analyses, which impose unnecessary constraints on the deployment model and associated power consumption. Mobile computing units (e.g., cell Phones). However, many systems are not interactive [Mitchel.M *et al* Jan 2011]; gathered sensor information lacks real-time feedback from the monitored users. Others tend to rely on third-party service for data storage and analyses, which impose unnecessary constraints on the deployment model and associated power consumption.

This home-based mobile cardiac monitoring solution have been developed, which incorporates a design of an integrated electrocardiogram (ECG) beat detector, supported by the PDAVersion of Personal Health Information management System (PHIMS) and Facilitated Accurate Referral Management System (FARMS) through wireless network. This system is designed to use in a home environment whereas the proposed system is capable to be used for continuous monitoring of the patients at different environments such as home, hospital, work place, and practically anywhere. The clear and stable ECG waveform is the paramount concern, because the accuracy of further processing are all based on the quality of raw ECG morphology. Therefore, ECG analog front-end is carefully designed, such that most noises are cancelled out before they are fed into an analog-to-digital convertor (ADC) [G. Yang, J. Chen *et al*, 2008].

2. Electrocardiography

The electrocardiogram (ECG) is an interpretation of the electrical activity of the heart over time captured by placing electrodes on the surface of the body. The signal recorded, is graphically displayed in a two dimensional graph, where the height represents the measured electrical

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activity in mill volts and the width the interval of time in seconds. Fig shows a Typical ECG waveform.

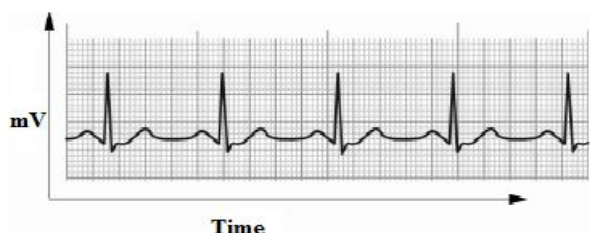


Fig. 1 Typical ECG waveform

2.1 Three Lead Electrocardiography

The ECG works by detecting the electrical changes on the skin, caused when the heart muscle depolarizes. This is done by placing pairs of electrodes on either side of the heart. The output of a pair of electrodes is known as lead and is said to look at the heart from a specific perspective. These leads are also called bipolar leads, as they measure the voltage difference between two electrodes. Based on the number of leads recorded, several types of ECG's are differentiated. For example 3-lead ECG, 5-lead ECG and 12-lead ECG. These types of ECGs mainly differentiate from each other by the precision and accuracy of their recordings. A 12-lead ECG for example records more leads than a 3-lead ECG and therefore has a broader view on the heart. Consecutively the 3-lead ECG will be described in more detail, as it was used in this project.

Lead 1 (LA-RA): measures the potential difference between the right arm electrode and the left arm electrode .Lead 2 (LA-LL): measures the potential difference between the right arm electrode and left leg electrode .Lead 3 (RA-LL): measures the potential difference between the left arm electrode and left leg electrode .This 3-lead system provides three different views, able to monitor multiple regions of the heart and consequently yields three different signals[Roshan Issac M.S Ajaynath et al ,2012, Sheng Hu, Zhenzhou Shao, Jindong Tan et al 2011].

2.2 Interpretation of a Electrocardiograph

The recorded ECG signal shows a series of waves that relate to the electrical impulses, which occur during each beat of the heart.

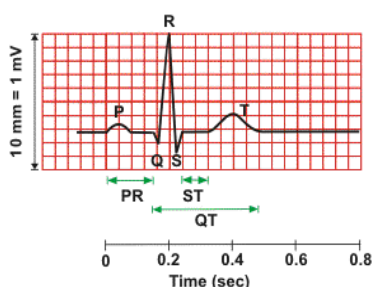


Fig. 2 Normal ECG waveform

These waves are labelled with successive letters of the alphabet P, Q, R, S, T, and U, as shown in Figure 2. When it comes to the interpretation of an ECG signal, the

attention turns to the segment and intervals, also illustrated in Figure. [S. Hu and J. Tan, et al.2009; W. Chung, Y. Lee, et al2008]

3. Operation Process

3.1 System Architecture

ECG sensor collects the ECG signal from the human body and transmits it to the smartphone via Bluetooth.2 ECG electrodes are employed for sensing the ECG signal. A negatively charged ion is an anion and a positively charged ion is action. The current flow in the human body is due to ion flow, not electrons. A bio potential electrode is a transducer that senses ion distribution on the surface of tissue, and converts the ion current to electron current. An electrolyte solution/jelly is placed on the side of the electrode that comes into contact with tissue; the other side of the electrode consists of conductive metal attached to a lead wire connected to the instrument.

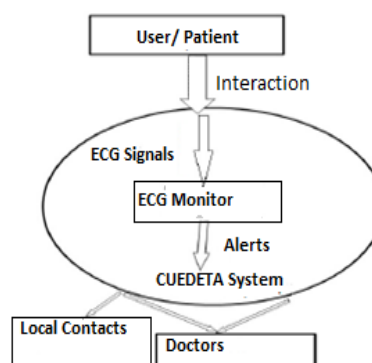


Fig.3 System Architecture

A chemical reaction occurs at the interface between the electrolyte and the electrode. A signal processing module is used to process the ECG signal from the electrodes and removes the noises present in the signal. The Bluetooth module receives the processed signal and transmits the signal to the mobile phone via Bluetooth link. An android enabled Smartphone needs to be employed for generating the results. Here we used Samsung Galaxy S Plus for the development and debugging purpose.

The mobile platform that we used is Android 2.3(Gingerbread) which was developed by Open Handset Alliance led by Google. We used Eclipse IDE halios (3.6) for the developing environment; in order to provide the location of the patient we integrated Google Map API for geocoding and map views[Roshan Issac M.S Ajaynath,et al 2012, Sheng Hu, Zhenzhou Shao, Jindong Tan et al2011].

3.2 Electrical Components

The operation amplifiers used in the application was chosen based on the electrical characteristics. The requirement that was essential for the operation amplifier that had to be fulfilled. High output current, the operation amplifier should be able to put out enough current so it can drive the Right Leg Drive function for an efficient

reduction of 50Hz noise. Low input offset, DC offset on the input will escalate and disturb the base line off ECG-signal. Low power consumption, the application will be power by battery and less power leads to longer battery life time.

The microcontroller AVR was chosen due it has become more or less a standard device in low voltage application and is well suited for this application. The microcontroller is also compatible with available software and hardware, MikroC, MPLAB IDE 7.30 and PICSTART Plus[W. Chung, Y. Lee et al,2008].

The RN42 is a small form factor, low power, highly economic Bluetooth radio for OEM's adding wireless capability to their products. The RN42 supports multiple interface protocols, is simple to design in and fully certified, making it a complete embedded Bluetooth solution. The RN 42 is functionally compatible with RN 41. With its high performance on chip antenna and support for Bluetooth® Enhanced Data Rate (EDR), the RN42 delivers up to 3 Mbps data rate for distances to 20M[G. Yang, J. Chen et al, 2008].

4. System Module

4.1. ECG Sensor platform

When the device is turned on it first initializes the serial port and set the baud rate so that the communication is synchronized.

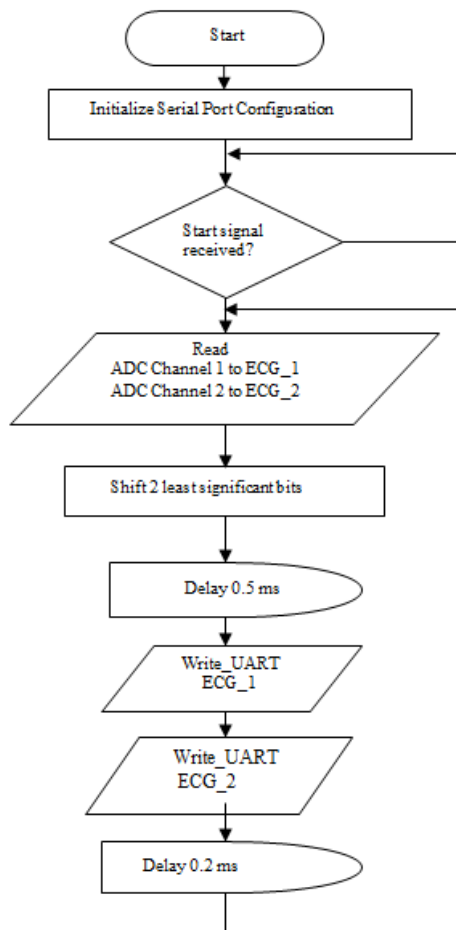


Fig. 4 Flow chart of Microcontroller

Then it goes to wait state where it waiting for a ready signal from the Bluetooth module. We have used the binary one as the start signal.

The received data from the Bluetooth module is fed to the microcontroller. When a ready signal is written the microcontroller ready the input values from the electrodes and then shifts the values so that we can send the value to the Bluetooth module. After sending the 2 bytes of data it again returns to the wait state [Roshan Issac M.S Ajaynathet al, 2012, Agarwal S, Lau CT et al,2010].

4.2 ECG mobile platform

Cuedeta App on the PDA is required to handle the output signal from the ECG sensor system. The main tasks for the app will be:

- Connect to the ECG sensor system.
- Send start signal.
- Read output from ECG sensor system.
- Graphical display of signals.
- Analyze the ECG.
- Send Alert.
- Send stop signal before exiting program.

With the help of the data sent from the Bluetooth module we can plot the ECG using the java layout. The APP uses java layout instead of the XML because XML parsing is slow as compared to java and java layout is suited for real time plotting.

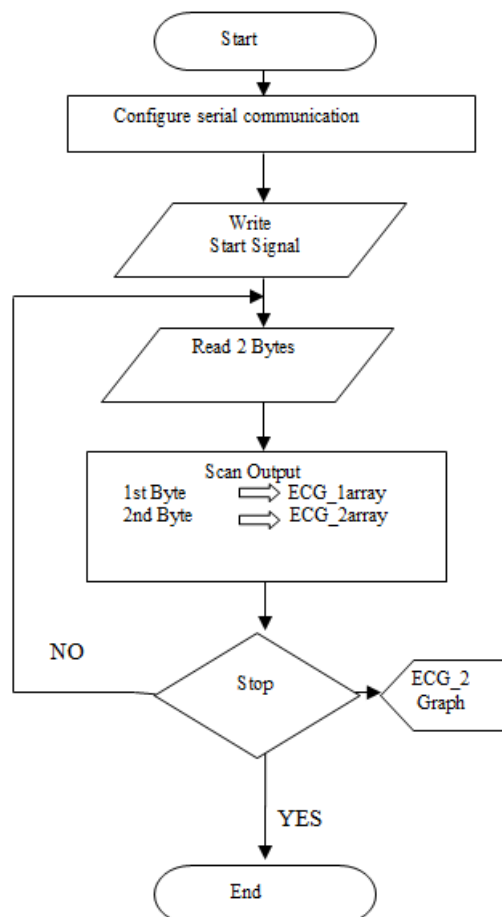


Fig. 5 Flowchart of cuedeta APP

The ECG signal is analysed one cycle at a time and the number of spikes is counted. The spike value is computed by collecting the highest value during the data connectivity.

The detailed algorithm is described in the following section. The core part of the algorithm is that it remembers the spikes and detects a failure if the number of spikes is lower or higher than threshold value. The algorithm listens for 3 complete cycles and the only send the alert. The Geocoder package in android is utilized for sending alerts. Before actually sending the alert a countdown timer (10sec) is initiated. This is provided so that the patient can sense the false alert and cancel the alert. If no response from the patient is recorded then automatically the alert propagation start. Whenever an alert is detected the APP will initiate an alert call to primary contact save in the settings activity.

We have used shared preferences for saving the contact information than SQLite because we can easily retrieve the information than connecting to a database. The SMS alert is initiated right after the call ends. Geocoding is used to get the nearest address of the patient [Miller M,2010, developer.android.com.].

5. Challenges

There are three major challenges involved in the design of a wearable ECG sensor node. First, the clear and stable ECG waveform is the paramount concern, because the accuracy of further processing are all based on the quality of raw ECG morphology. Therefore, ECG analog front-end is carefully designed, such that most noises are cancelled out before they are fed into an analog-to-digital convertor (ADC). Moreover, the wearable ECG sensor node is an energy-limit system. Energy efficiency considerations include low power hardware and software design, and power efficient networking. All the components in this system are carefully chosen with the sleep mode, such that they can be configured into sleep mode according to the requirements of applications. Last, the wearable sensor node should be low profile, such that the patient's daily life will not be annoyed [Sposaro F. and Tyson G et al ,2009, Zeman E.,July 2010].

5.1 Noise Handling and Grounding

For an ECG monitoring and diagnosis system, any noise on ECG waveform will limit the resolution of further analysis and diagnosis, hence the ECG analog front-end circuit design is the paramount concern in most ECG systems. The unconditioned ECG from the electrode is an extremely weak signal ranging from 0.5mV to 5.0mV, while magnitude of the coupled noises could be up to ± 300 mV. Therefore, the noise must be handled in order to pick up the valid ECG waveform. ECG on-node pre-processing-although many approaches are employed in the analog front-end circuit to remove the 50/60Hz noise; it can be coupled into analog signal flow at any point. Therefore, a digital filter is a better solution than the filter in analog domain [Xu J, Kochanek KD et al, 2010, S. Hu and J. Tan et al, 2009].

5.2 Power Consumption

The greatest challenge of developing this wireless electrocardiograph is the power consumption. When constructing a reliable ECG-sensor that will be powered by a battery usually used for cellular phones the power consumption must be as low as possible without interfering with the performance. For example there are operation amplifiers that have a lower consumption than the TS924, but it will not be able to supply the right leg drive function with the acquired output current and the noise reduction will not be efficient enough. The RN-42 Bluetooth module consumes about 45 mA when connected and programmed as spp_slave as required in this project, the spp_master configuration consumes less than half with 20 mA [Zhang Let al, 2010, Sposaro F et al, 2009].

Conclusion

A real-time CUEDETA system successfully monitors the patient's ECG and identifies its cardiac arrhythmia in real time. The ECG waveform and the cardiac arrhythmia classification result are displayed in a smart phone, rather than a bulky resting ECG instrument.

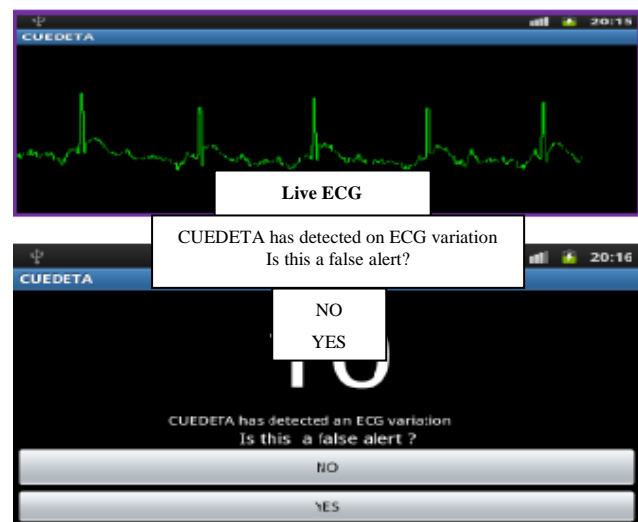


Fig.6 Variation Detection of ECG

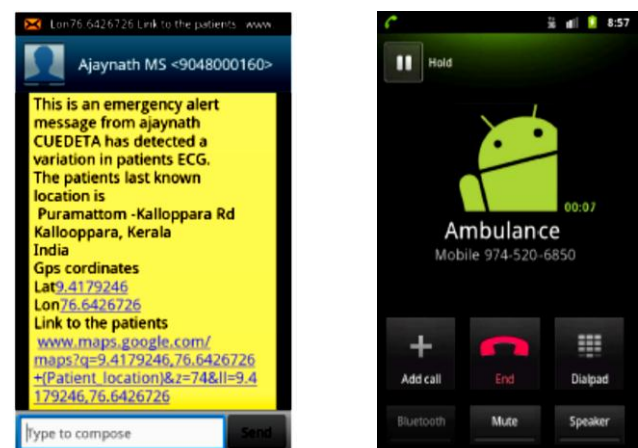


Fig.7 SMS Alert & Call Alert

Once the abnormalities are detected, the alarm message will notify the patient or clinicians via telecommunication infrastructure. Further, the patient can utilize this system to monitor their heart status when the daily lifestyle changes, in such a way that the patient can adjust to living in a comfortable lifestyle and potential risk would be decreased. The system was tested in real time and outputs were verified. As a future advancement we can add an option for sending ECG signal to a doctor at a remote location so that he can analyse the patient's current condition. Also fixing problems regarding the sensor connectivity and power management is a future advancement.

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I could not complete my work without support of my internal guide.

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