Low Cost ECG Monitoring System for the Patient using Smart Device: Design and Implementation

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ARTICLE INFO
Received 9 November 2017
Accepted 3 December 2017
Published 8 December 2017

ABSTRACT
The Cardiovascular Disease (CVD) is the leading cause of death in the world. Due to the changing life style heart attack rate is increasing day by day. In India, current heart attack rate is about 25%. The main cause of heart attack is a lack of medical care at the right time. To avoid this there is a need of regular checkup of health. In some cases it might be required to monitor ECG frequently. But it is not possible due to the high cost of healthcare equipment as well as time consuming process. This is the limitations of existing system. So, there is a need of low cost, portable, low power and time saving ECG monitoring device. With the use of this portable device patient can monitor their ECG anytime, anywhere and send the report of ECG to the doctor and can effectively communicate with the doctor. In case of any abnormality doctor may call the patient. This paper presents the development of Low cost, low power, portable and time saving ECG monitoring device. Android is the platform of choice because of its availability on most mobile phones apart from strong existing and future growth prospects.

Keywords: Android; Electrocardiogram (ECG); Cardiovascular Disease (CVD); low cost ECG signal; heart disease detection.

1. Introduction

Electrocardiography (ECG) is the process of recording the electrical activity of the heart.
i. ECG (Electrocardiograph) service in android phones and tablets.
ii. A compact sensor, is used to monitor the heartbeat in analog form.
iii. Signals sent through Wi-Fi technology.
iv. We can Store the signal as history
v. We can send the signals to doctor via Email.

Figure 1. Represents a typical ECG

Our proposed system implement a device which aims to develop an ECG monitoring system based on a smart phone platform. It is a low cost heart rate monitoring solution based on a low power MSP 430 microcontroller which is fully integrated with sensing electrodes on the transmitter side. Android is a platform of choice because of its availability on most mobile phones apart from strong existing and future growth prospect. The android platform based
smart phone will be used for diagnosis and will also be transmit captured images or videos to a care givers , health care centers or medical professionals for specialist advice.

**ECG Signal Capturing:**

i. ECG machines use electrodes to convert the ionic signals from the body into electrical signals to be displayed and used for data analysis.

ii. General approach: Place electrodes at multiple places on the body surface.
   - Measure potential difference across a lead (i.e. a pair of electrodes)
   - Exploit the fact that body tissue is a conductive medium that can relay cardiac potentials.

iii. Commonly Used electrode- Ag/AgCl.

**Challenges in ECG Acquisition:**

i. Due to the size of the signals and outside noise, ECG requires amplification and filtering to produce high quality signals.

ii. Raw ECG signals often low in amplitude and distorted by noise sources

iii. Magnitude range: 0.1 to 5 mV

iv. Sources Of Interference: 1) Internal Interference, 2) External interference

v. Problem with having poor signal quality: Hard to obtain physiological insights:
   - Low signal level => Difficult to detect
   - High noise level => May mask out useful clinical info.

**Goals and Objectives:**

i. To design and implementation of low cost ECG monitoring system for the patient using smart device.

ii. To monitor the patient and his own condition at any time, though this he can save the life.

iii. This system is to be available at reasonable prices.

iv. Embedded technology is to be use for monitoring the patient condition easily.

**2. Problem Statement**

To design and implementation of low cost ECG monitoring system for the patient using smart device. We have also proposed extraction and detection algorithm for detecting of CSD. This proposed idea is to contribute to bring under control heart diseases and also act as an expected results in health care service to patients in remote area.

The Android platform (Linux based) which is the most widely used operating system on smart phones and hand held tablet devices is important target for mobile application developers and hardware manufacturers. The aim of this system is to develop a prototype android ECG application that works with the ECG analog end unit discussed previously. The application will be used for the realization of ECG data signals that are sent from the heart rate monitoring device via Wi Fi communication. We believe that the system layouts a foundation for present and future research and development works that can be carried out in this regard.

**3. Related Work**

Electrocardiographic (ECG) equipment plays a vital role for diagnosis of cardiac disease. However, the cost of this equipment is huge and the operation is too much complex which cannot offer better services to a large population in developing countries like Bangladesh. In this system, we have designed and implemented a low cost portable single channel ECG monitoring system using smartphone having android operating system and Arduino. This manuscript also demonstrates the use of Android smartphone for processing and visualizing ECG signal. Our designed system is battery powered and it gives wireless feature. This system can also be used with desktop computer or laptop having either Windows, Linux or Mac OS. For this purpose a software is developed [1]. An Android application is developed using Processing IDE, which requires Android version 2.3 and API level of 10. This application does not need
USB host API. For this reason, around 98 Android smartphone in the market can be used for this system.

This paper discusses the implementation of a project which aims to develop an ECG monitoring system based on a smart phone platform. It is a low cost heart rate monitoring solution based on a low power MSP430 microcontroller, which is fully integrated with sensing electrodes on the transmitter side [2]. The controller converts the analog signal to a digital signal via an inbuilt analog-to-digital converter, conditions and filters it for transmission via a Bluetooth transceiver IC compatible with the MSP430. The Bluetooth is chosen for its near-ubiquity in mobile phones apart from its lowest consumption as compared to Wi-Fi and GPRS.

IBGStar glucometer [3] and is pirometer for measuring blood glucose and volume of air respectively are the success stories of Smartphone medical applications integrated with sensors. Management of diabetes, chronic pulmonary disorders and other chronic diseases are expected to play a larger role in market growth. It has been reported that cardiac monitoring devices have the most demand since insurers are likely to pay for them and heart disease is the one of biggest chronic disease for a high mortality rate in third world countries.

The Cardiovascular Disease (CVD) is the leading cause of death in the world. Due to the changing lifestyle heart attack rate is increasing day by day. In India, current heart attack rate is about 25%. The main cause of heart attack is a lack of medical care at the right time. To avoid this there is a need of regular checkup of health. In some cases it might be required to monitor ECG frequently. But it is not possible due to the high cost of healthcare equipment as well as time consuming process. This is the limitations of existing system [8]. So, there is a need of low cost, portable, low power and time saving ECG monitoring device. With the use of this portable device patient can monitor their ECG anytime, anywhere and send the report of ECG to the doctor and can effectively communicate with the doctor. In case of any abnormality doctor may call the patient.

In existing proposed ECG sensor nodes are based on a dedicated integrated front end, that sometimes includes a DSP, and require a second off-the-shelf chip to implement the radio link. However, power consumption mostly in such sensors is mainly due to the radio link and therefore the optimization obtained by the use of the dedicated front-end has a limited impact on the power performance of the complete sensor. In addition, the following sections will show that a general purpose high-performance and high resolution standard ADC can outperform the noise performance of many dedicated front-end chips.

**Drawbacks of Existing System:**

i. The disadvantage of this system is it increases cost per patient.

ii. It may not work, if the wireless infrastructure of the system gets changed.

**4. Proposed Work**

We develop an ECG monitoring system based on a smart phone platform. It is a low cost heart rate monitoring solution based on a low power MSP430 microcontroller, which is fully integrated with sensing electrodes on the transmitter side. The controller converts the analog signal to a digital signal via an inbuilt analog-to-digital converter, conditions and filters it for transmission via a Wi-Fi module. The real time data is received at the smart phone end and displayed in real-time. Android is the platform of choice because of its availability on most mobile phones apart from strong existing and future growth prospects.

The android platform based smart phone will be used for diagnosis and will also be able to transmit captured images or videos to a healthcare center or a medical professional for specialist advice. The benefits of the project are low cost, supporting mobility, readily available connectivity for transmitting information, early diagnosis and emergency healthcare via symptom moderating drugs.

![Figure 3. System Architecture](image)

The proposed system consists of four units: a sensor unit consisting of ECG Electrodes and patient cable, a signal conditioning unit consisting of amplifier,
Filter, a power supply unit and a Microcontroller unit consisting a Wi Fi module. ECG electrodes unit of this system is to sense the weak bio-potential signal generated inside the human body due to activities of the heart. To capture this weak electrical signal ECG unit is used.

Analog amplifier and filtering unit of the system is analog bio-potential amplifier and filtering unit. This unit is very important due to weak values of the electrical signal itself as well the environment and the apparatus in which the measurement is done. The weak electrical signal is amplified using an instrumentation amplifier and filtered using a passive band pass filter.

Microcontroller and processing unit is used for the digitization of the ECG signal Microcontrollers are low-cost, low-power, programmable, cheap and high-speed data acquisition systems. Microcontroller generates the communication protocol for transmission to a PC.

5. Proposed Algorithm:

Feature extraction method using wavelet transform and support vector machines. The system presents a new approach to the feature extraction for reliable heart rhythm recognition in which is proposed a novel approach for ECG feature extraction based on wavelet transform and recognition of abnormal heartbeats.

Algorithm: Feature Extraction and Detection Algorithm:

Step 1: Get raw ECG signal.

Step 2: Filtered of ECG noisy signal by using FFT/FIR filter to remove of noise.

Step 3: Detection of R-R interval from filtered ECG signal to measure of heart rate (HRM).

Step 4: Apply proposed threshold on ECG signal.

Step 5: The peak of R waves is detect after filtering using threshold (T). Absolute and square are two common used rectification methods. So we can detected R wave.

Step 6: Repeat procedures for HRM.

Input: The sampling rate must chosen into the proposed system. The low sampling frequency may produce variation of estimate R wave.

Step 7: Calculate RR interval gives the heart rate in beats per minutes.

Step 8: Find the abnormalities condition of heart and identify or detect the disease of heart based on the duration of R-R interval.

6. Future Scope:

Multiple parameters like Blood pressure, retinal size, age and weight can be included as controlling parameters in the future.

7. Conclusion:

The system design consists of a portable ECG signal generator circuit, a data transfer device and a smart device. Someone can easily check the possibility of any heart disease using this system.

i. Portable and easy to use.

ii. Prevention is better than cure.

iii. Modern technologies have developed that promotes comfortable and better life which is disease free.

8. Acknowledgement

I would like to thanks to my project guide Prof. Borhade B. M. who always being with presence & constant, constructive criticism to made this paper. I would also like to thank all the staff of computer department for their valuable guidance, suggestion and support through the paper work, who has given co-operation for the project with personal attention. At the last I thankful to my friends, colleagues for the inspirational help provided to me through a paper work.

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