Energy Efficient QRS Detection Method for Wearable Wireless ECG Body Sensors – A Review

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Abstract: *The ECG monitoring is the course of monitoring to find any irregularities in the heart beat rate of the person being investigated in the health checkups. With the rise of the rise of the technology, body wearable sensors are coming into existence and they are being used to live monitor the patient's heath using regular ECG monitoring on medical database server in many countries or hospitals. The body wearable sensors are usually connected to the medical databases using cellular networks, Wi-Fi or zigbee like mediums (for the controlled environments). The patients can not monitor their heart rates, but they have to become dependent on the medical database officials or the server sending updates on fixed time intervals which may be weekly, fortnightly or monthly. Sometimes, when patient is out of network coverage, and the buffer memory completely goes full, the ECG data drops due the limited buffer memory on the ECG sensor device. This flaw can be corrected using the smart phone connectivity between ECG sensor and smart phone. In this research, we are proposing the solution based on the connectivity between ECG sensor and smart phone. An energy efficient heart rate detection (QRS-detection) algorithm for the smart phones will be developed along with the buffer handler. The smart phone will be also used to forward the ECG data to the medical database. Our research will facilitate the patient to monitor his/her heart beat rate live using smart phone. Also the ECG data will be forwarded to the medical database using the smart phone. The new algorithm will consume the less memory in comparison to the existing QRS detection algorithms.*

**Keywords:** ECG, QRS detection, Energy efficient algorithm, Wearable sensor, ECG compression

1. Introduction

The cardiac disease is one of the most common in the people among the world so, the management of cardiac disease is Electrocardiogram (ECG) analysis.QRS detection algorithm is essential method in development of real-time ECG analysis system. a step to reach this objective to develop an evolution methodology to compare different QRS detection under combination of noise and QRS morphologies. Limitation of earlier composed method is that an ECG is composed of multiple noise level and verity of beat morphologies. A good example of a is study comparing QRS detector. They compared nine simple QRS detection algorithm with respect to gold standard ECG waveforms the waveform was corrupted with five type of artificial noise, modelling typically clinical noise. The author concluded on the best of nine is QRS detectector by comparing their average performance and clearly exhibiting that each detectors performance is related to the noise context.

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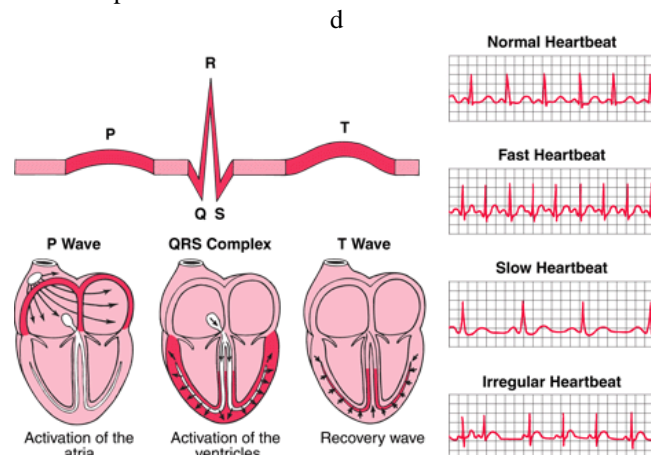
Figure 1: An representation of Electrocardiogram with respect to heart beat

The QRS complex is most striking waveforms within the ECG. Since it reflects the electrical activity within heart during the ventricular contraction, the time of its occurrence as well as its shapes provides much information about the current state of the heart. The QRS detection provides the fundamental for all automated ECG analysis algorithm. In this paper, we are going to develop and evaluate a robust single-lead electrocardiogram (ECG).
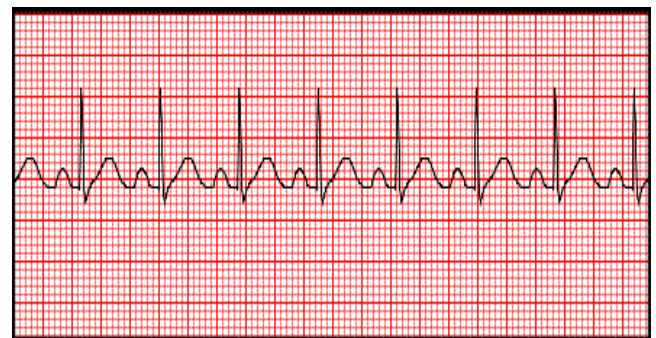
Figure 2: Representation of simple ECG print of sinus in ECG signal obtained by ordinary ECG monitoring device

Firstly, QRS complexes are detected than each QRS is de-linerated by detecting and identifying the peaks of individual waves as well as the complex onset ends. Finally determination of P and T wave's peaks onsets and ends is performed To create different context signals, typical clinical noise and QRS morphologies were extracted from actual ECG records. Since the filtering stage is taken into account in every real application of QRS detection, the ECG waveform was filtered in order to reduce noise. The tested detectors were chosen considering both complexity and efficiency but prioritising the low complexity against the efficiency, since the paper is devoted d real-time.

2. Literature Review

Nehla DEBBABI, Sadok EL ASMI have proposed Algebraic Approach for R-peak Detection in the ElectroCardioGram (ECG) Signal. In this paper, authors have presented a novel method for R-peaks detection in ECG signal in real time environment with noisy ECG data. They have interpreted R-peaks occurrence as an regular process to find the peaks in the signal to count the heart beat. Therefore, the authors have transformed the problem of R-peaks detection into irregularity instants estimation. To check these irregularities, authors have used an mathematical approach based on differential algebra and operational calculus. To increase the accuracy of R-peak detection algorithm, authors have proposed new decision rule permitting the accurate distinction between R-peaks and false alarms. The numerical simulations are performed on the signals obtained from the MIT-BIH arrhythmias database. These are performed to yield out the performance of the proposed method. The results obtained have shown the effectiveness of the algebraic method in the context of complicated pathologies as well as to various types of noises. Won-Jae Yi and Jafar Saniie have proposed Smart Mobile System for Body Sensor Network. This paper is based on the smart mobile application for wearable body sensor network that is used to collect, display, analyze and stream the ECG sensor data to a centralized database server. There are multiple wireless techniques like Bluetooth, cellular data network, Wi-Fi and Near Field Communication (NFC) for the ECG data propagation. The Intelligent Personal Communication systems (iPCS) can use smart phones connected to the data collection sensor. The other processes like pre-processing, analysis and transmission are done by the smart phones. ECG data collected by body wearable wireless sensor data is processed and the results can be generated by the smart phone, which are represented in the simple human readable form for the patient. The ECG data undergoes the QRS detection method for the calculation of heart beat rate, which is performed by smart phone's computation feasibility for real-time signal processing. The major benefit of using smart phones is their ability to communicate with sensor nodes on-demand and to acquire realtime multiple sensor data simultaneously. The proposed smart sensing system is not restricted to body sensor network, but also can have other applications for other critical health monitoring environment that requires instantaneous and remotely accessible monitoring system. Xiangdong Peng et. al. have developed an ECG Compressed Sensing Method of Low Power Body Area Network. Aimed at low power problem in body area network, an ECG compressed sensing method of low power body area network based on the compressed sensing theory was proposed. Random binary matrices were used as the sensing matrix to measure ECG signals on the sensor nodes.

3. Problem Formulation

Trend of wearable ECG sensors is in its rising mode. ECG sensors run on batteries, hence carry a limited battery life. ECG sensors are used to create the ECG signal based on heart beat and forward to the other calculation algorithms, which perform various calculations on the ECG signal and produce the results. These destinations are not directly accessible directly to the patients. So the patients have to depend upon the doctors or other technical biomedical personnel over phone or visit to know his/her details. Hence, the process becomes longer and hectic.

In today's world, body sensors are being used at a large to monitor the patients in their routine activity post- or pre-treatment. Wearable body sensors usually sends data to the medical databases directly through the wireless mediums (cellular networks, Wi-Fi, Zigbee, etc.). The patients are informed by the medical database centers about their health on weekly or monthly basis by sending reports to their home or on their emails. In our research, we are proposing a novel algorithm for the heart patients which can monitor their heart beat and disease by receiving the data from wearable body sensor. Existing algorithms are not specifically designed for the smart phone, so consume a lot of energy which choke the battery power quickly and occupy large amounts on memory and CPU, which lowers the performance of the smart phones. Our proposed algorithm will help the developers to create Heart Beat monitoring applications using our QRS detection algorithm specifically designed for smart phones, which will be faster and lighter than the existing algorithms. In this research, we are trying to solve this problem. Wireless sensors, usually, get connected with WiFi or WiMAX. They can also be connect on mobile networks or personal networks (GSM, CDMA, Bluetooth, Irda, etc). Hence, the ECG data can be sent to the smart phones via any of the above mentioned methods. Smart phones can be used as ECG data processing units. But to run ECG analysis on ECG data, it consumes a handful amount of energy, so can badly affect the battery life of smart phones.

4. Proposed Algorithm

Because personal computers are losing popularity in these days and they are bulky carry everywhere. Now-a-days, smart phones are being most popular among any other personal gadgets. Hence in this research, we are targeting them as the ECG data processing device. In this research, we will work on development of an energy efficient algorithm for QRS detection. QRS detection is a technique used to analyze the digital ECG signal to calculate the Heart Beat. In general, the QRS detection algorithms perform a number of computations to calculate the heart beat from ECG signal, hence consumes higher amount of energy. This can lower the battery life of smart phone devices. So, we are proposing all new balanced QRS detection algorithm to calculate the heart beat from ECG signal, which will make this algorithm energy efficient and faster. For the final results, this algorithm would be compared with the existing ones to prove its superiority over the existing algorithms. We will implement this algorithm in MALTAB because it is the most compatible and flexible among any other simulators or languages.

5. Objectives

A. To study the literature on composition and behaviour of ECG signal
B. To study the existing QRS or R-peak analysis algorithms for heart beat calculation

C. Find the possibilities of energy efficiency in the existing algorithms
D. To implement the new energy efficient QRS detection algorithm
E. To obtain and analyze the results

6. Methodology

At first, the literature on the ECG signal and ECG peak analysis processes would be studied in detail. Then the proposed algorithm flow would be reviewed and improved in case any changes are required. Afterwards, the algorithm would be programmed in MATLAB. The experiment results would be thoroughly analyzed and compared with the existing algorithm results. This is also very important to get the information about the other parameters used for ECG signal analysis. This project would be implemented in the MATLAB Simulator. A thorough performance and feature testing approach would be designed and applied to evaluate the performance of the simulated ECG QRS peak analysis algorithm, to detect the errors and to recover them. Afterwards, the experiment results would be thoroughly analyzed and compared with the existing QRS detection or R-peak analysis algorithm on ECG signal to examine the performance of the new ECG signal analysis algorithm.

7. Conclusion and Future Work

The rise of smart phones is the key inspiration behind this research project. The smart phones can be used to monitor the heart beat rate continuously by receiving the data from the wearable ECG sensor based on Bluetooth or Wi-Fi connectivity. The use of smart phone can provide the patient a regular monitoring to track his/her health by herself and additionally the smart phone can be used to forward the ECG data to the medical database also, which means there is no need of the internet connection or other end to end connection between ECG sensor and medical database, which can also minimize the battery life of the ECG sensor because Bluetooth consume far less power than the Wi-Fi or cellular network connectivity. In the future, we will develop the proposed system using the MATLAB environment. The proposed system will be thoroughly tested and compared with the existing system after its successful implementation.

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