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Real time ECG Monitoring: A Review

Ms. Dhanashri Yamagekar
Electronics Technology, Department of Technology,
Shivaji University, Kolhapur, Maharashtra, India

Dr. Pradip Bhaskar
Electronics Technology, Department of Technology,
Shivaji University, Kolhapur, Maharashtra, India

ABSTRACT

Day by day the scope & use of the electronics concepts in bio-medical field is increasing step by step. In this paper the review of newly developed concepts is done for the monitoring of the ECG signal. This paper also reviews a power and area efficient electrocardiogram (ECG) acquisition and signal processing application sensor node. Further the study of IoT frame work for ECG monitoring has been carried out.

Keyword: IoT (Internet og things), Electrocardiogram (ECG) signals, data acquisition

I. INTRODUCTION

The word electrocardiography is evolved from Greek word Kardia which means Heart. ECG that is electrocardiography is a process of interpretation of heart activity over the period of time and is detected by electrodes attached to the surface of body. An ECG is used to measure the heart's electrical conduction system. It picks up electrical impulses generated by the polarization and depolarization of cardiac tissue and translates into a waveform. The waveform is then used to measure the rate and regularity of heartbeats, as well as the size and position of the chambers, the presence of any damage to the heart, and the effects of the drugs or devices used to regulate the heart, such as a pacemaker. A typical ECG tracing of normal heartbeat consists of a P wave, a QRS complex and a T wave. The variety of QRS complex shape morphologies causes the performance of QRS complex detection algorithms that use FIR filter and fixed width integration windows to decrease when the QRS morphology changes. To avoid this problem, a new approach to QRS complex detection based on FIR filter is to be used.

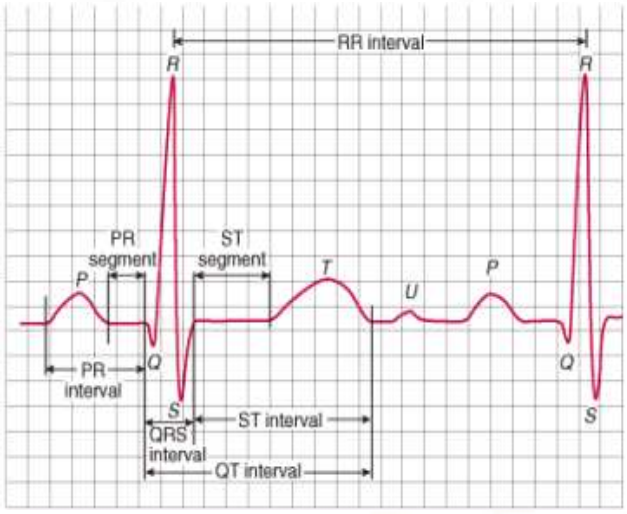

Fig.1. An example of ECG signal with specified waves, intervals and segmentation

In 1901, Willem Einthoven was invented an ECG machine by a string galvanometer to measure ECG and assigned letters P, Q, R, S and T to the various deflections and form ECG signal as shown in Figure 1. Now a day's medical science still shows clear results for diagnosis. The processing methods require realtime for the diagnosis of cardiac diseases accurately. The ECG wave shape of the cardiac cycle is accounted with high energy concentration in QRS complex and low energy concentration in T wave and U wave. This two wave (T and U) is normally invisible in 50 to 75 % of ECGs.

II. LITERATURE SURVEY

In the last few years, there are different Real time ECG monitoring systems proposed by many researchers.

D Zazula, **A** SoStariE, D KoroSec, D Korie, M Vezjakt, M Spegelt, P Reinhradtj [1994], describes a real-time software package for monitoring and processing the exercise electrocardiograms (ECG). The package consists of programs for on-line analysis and for the post-exercise verification of the on-line results. Principles **of** operation under the MS-DOS operating system on PCs are disclosed. Real time performance is evaluated, whereas the computer obtained analysis results are compared to the manual readings.[2]

Yongming Yang I, Xiaobo Huang 1, Xinghuo Yu, [2007], presented the design and development of a real-time ECG monitoring system based on FPGA with EDA technique. The system integrates the functions of ECG data collection, storage, processing and transmission with integrated hardware and software. It has advantages such as low power consumption, high integrated level, good stability, convenience to carry around and long usage time. The system achieves most real-time monitoring functionalities in one FPGA chip, and can be improved or added with some other modules with software modification. It is more intelligent compared with existing portable ECG monitoring system.[3]

Borromeo S, Rodriguez-Sanchez C, Machado F, Hernandez-Tamames JA, de la Prieta R, [2007], present a new system for Electrocardiogram (ECG) acquisition and its processing, with wireless transmission on demand (either the complete ECG or only one alarm message, just in case a pathological heart rate detected). Size and power consumption are optimized in order to provide mobility and comfort to the patient. It is design a modular hardware system and an autonomous platform based on a Field Programmable Gate Array (FPGA) for developing and debugging. The modular approach allows to redesign the system in an easy way. Its adaptation to a new biomedical signal would only need small changes on it.[4]

Brian A. Walker#, Ahsan H. Khandoker#, and Jim Black, [2009], this paper present the designing, building and testing a complete ECG data logging system has been fulfilled. Electrodes were constructed, an amplifier was designed and tested, firmware was programmed into a USB microcontroller interface which successfully digitized the incoming ECG signals, and finally a program in Visual C++ was written to successfully display the ECG signals on both a PDA running the Windows Mobile 6.0 Classic Edition Platform, and a laptop running Windows XP. The results have so far been good, and they have not deviated significantly from results obtained using commercial equipment. Different types of electrodes - both commercial and homemade – have effectively been utilized which have resulted in ECG signals with SNRs approaching a value which would result in a measured heart rate having an error which is within 1 beat per minute. ECG signals were successfully displayed on a Windows PC via its USB port, and on a PDA using Bluetooth.[5]

Ondrej Krejcar, Dalibor Janckulik, Leona Motalova, Karel Musil, [2010], presents a problem of Real Time processing of ECG signal from patients by mobile embedded monitoring stations. Two ECG measurement devices were used in real tests. A two ECG channel bipolar ECG core Belt and a 12 channels ECG device Blue ECG. Both devices are products from Core Science Company. Due to a problem of processing a 12 channels ECG from ECG device by Bluetooth to mobile stations, the problem of packet parsing was discussed and two possible solutions were focused on. Another important part in biomedical data processing is visualization. A Windows Presentation Foundation solution was presented and tested. Mobile embedded monitoring stations are based on Microsoft Windows Mobile operating system. The whole system is based on the architecture of .NET Framework, .NET Compact Framework, .NET Micro Framework and Microsoft SQL Server.[6]

Ankit J. Gordhandas and Thomas Heldt and George C. Verghese [2011], present a real-time ECG processing algorithm that “compresses” the raw data by identifying and retaining clinically relevant landmarks of the ECG on a beat-bybeat basis. The retained landmarks are the kinds of variables a clinician uses to interpret the ECG, such as the width and height of the QRS complex or the elevation of the ST segment. Furthermore, the algorithm keeps a running average of each landmark and triggers an alarm whenever significant changes are detected. When such an event is triggered, the algorithm automatically stores the raw ECG data from five beats preceding to five beats following the anomaly, for the benefit of review by a clinician. While our data compression algorithm is inherently lossy, a cartoon-type ECG beat can be

reconstructed that conveyes most of the relevant information on which clinical decisions are based.[7]

Abhilasha M. Patel, Pankaj K. Gakare, A. N. Cheeran[2012], proposed the development of an efficient arrhythmia detection algorithm using ECG signal so that detection of arrhythmia at initial stages is possible using a smart-phone which is readily available anywhere which makes complete system mobile. Subjects for experiments included normal patients, patients with Bradycardia, Tachycardia, atrial premature contraction (APC), patients with ventricular premature contraction (PVC) and patients with Sleep Apnea. Pan-Tompkins algorithm was used to find the locations of QRS complexes and R Peaks. The algorithm to detect different arrhythmia is based on position of P wave, QRS complex, R Peak and T wave and on interval between these waves on android smart-phone. The algorithm was tested using MIT-BIH arrhythmia database. Results revealed that the system is accurate and efficient to classify arrhythmias as high overall performance (97.3%) for the classification of the different categories of arrhythmic beats was achieved. The proposed arrhythmia detection algorithm may therefore be helpful to the clinical diagnosis.[8]

Sonal K. Jagtap, M. D. Uplane[2012], proposed the Digital filter is the preeminent solution that caters the noise reduction up to satisfactory level. A digital Filter technique is best suited for ECG analysis and thereby helps in improving the quality of ECG signal with the help of Chebyshev Type II filter. From the results, it is seen that the filters reduces the low and high frequency components. The power line noise is also reduced. It is seen tip of the QRS complex is distorted. The outputs of the Chebyshev II filter shows that after using filter there is distortion in the ST part of the waveform. Both the filters work Satisfactory. Further this work can be applied on different types of filters and then depending on performance final model can be implemented to estimate the better quality signal.[9]

Sayanti Chattopadhyay1, Susmita Das2, Avishek Nag3, Jayanta Kumar Ray4, Soumyendu Bhattacharjee5, Dr. Biswarup Neogi,[2012], proposed work is done in a bridge with biomedical & signal systems. Here peak analysis is done and frequency domain analysis (Fourier Transform) will be done in future. Apparent change in wavelet domain will be analyzed. An ECG signal defines heart characteristics. As disease changes ECG signal changes. If these two signals are compared then a good work can be done. Till now the analysis is done with R-peak but in future the work will go on with the other peaks too. A computational intelligence is created for different heart diseases. The PC-based ECG signal simulator designed for ECG data supply to the hardware can be used for any other research based processing procedures of ECG signal where parallel data transfer scheme in required.[10]

Masudul Haider Imtiaz & Md. Adnan Kiber, [2013], proposed algorithm obtains an average sensitivity rate of 93.7% and average error rate below 8% after analyzing 25 records. To our knowledge, only the R spike detectors based on Li's algorithm obtained the comparable results with sensitivity between 99.7% and 99.9%. However, that algorithm makes use of several heuristic rules and requires the setting of many empirical parameters. Here the proposed algorithm achieves comparable performances with a simple non-parametric thresholding method and without any need of advanced post processing stage comparing to that article. Also, the presented the software implementation of this algorithm proves that the accurate diagnosis is always satisfactory utilizing this detection logic. The large variety of ECG feature extraction algorithms and the continuous efforts for their enhancement proves that universally acceptable solution has not been found yet. In this study, emphasizing on wavelet thresholding, relevant noise removal and utilization of simple detection logic for the ECG characteristics detection is present. A robust and efficient tool for fast, less complex practical software is also provided that can be interfaced efficiently with commercial ECG machines. The complete verification of the proposed software can lead a massive utilization in even rural areas where the presence of the physicians is not so available.[11]

Bhushan N. Patil,[2014], present a real-time on-chip ECG signal processing system is designed. The proposed design includes an analog ECG acquisition front-end and a digital QRS peak detection module. The QRS peak detection scheme is based on the four-scale wavelet transform algorithm, and can achieve accurate QRS peak detection performance using multi-scale wavelet based denoising procedure. The result show that by using wavelet transform, the proposed ECG signal processing system consumes ultra low power and small silicon area, and thus is extremely suitable for long term cardiovascular monitoring WBAN applications.[12]

Prerana N Gawale1, A N Cheeran2, Nidhi G Sharma3 M. Tech. Student, Electronics and Telecommunication, VJTI, Mumbai, Maharashtra, [2014], develop a prototype android ECG application that works with existing ECG acquisition device. The application will be used for the realization of ECG data signals that are sent from the ECG acquisition device via Bluetooth communication, calculate heart rate and plot it on android mobile phone, and also send this information to the concerned physician through server. We have tested this application in real time by collecting the ECG from the patient in stationary as well as moving conditions. In both situations the application fulfills requirements of the proposed system. The Electrocardiogram (ECG) is an important tool to interpret a wide range of heart conditions. Early warning and patient awareness are critical in preventing permanent heart damage and saving much of the heart muscles. These critical conditions motivated us to propose an application that shows promise for long term ambulant ECG monitoring.[13]

Luca Catarinucci, Danilo De Donno, Luca Mainetti, Luca Palano, Luigi Patrono, Maria Laura Stefanizzi, and Luciano Tarricone, [2015], proposes a novel, IoTaware, smart architecture for automatic monitoring and tracking of patients, personnel, and biomedical devices within hospitals and nursing institutes. Staying true to the IoT vision, we propose a Smart Hospital System (SHS) which relies on different, yet complementary, technologies, specifically RFID, WSN, and smart mobile, interoperating with each other through a CoAP/6LoWPAN/REST network infrastructure. The SHS is able to collect, in real time, both environmental conditions and patients' physiological parameters via an ultra-low-power Hybrid Sensing Network (HSN) composed of 6LoWPAN nodes integrating UHF RFID functionalities. Sensed data are delivered to a control center where an advanced monitoring application makes them easily accessible by both local and remote users via a REST web service. The simple proof of concept implemented to validate the proposed SHS has highlighted a number of key capabilities and aspects of novelty which represent a significant step forward compared to the actual state of art.[14]

Sudip Deb, Sheikh Md. Rabiul Islam, Jannatul RobaiatMou,Md. Tariqul Islam [2017], proposes a low cost portable ECG wireless system and feature extraction and cardiovascular disease detection algorithm. 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. The advantages of this system could be useful before, during, and after a cardiac arrest for real time monitoring of a patient at any place. It could also reduce death due to heart attack and other cardiovascular diseases and more specifically providing health service by specialized doctors, to rural areas. This proposed research is more beneficial for health security with low cost.[15]

Udit Satija, Student Member, IEEE, Barathram. Ramkumar, and M. Sabarimalai Manikandan, Member, IEEE [2017], propose a novel signal quality aware IoT-enabled ECG telemetry system for continuous cardiac health monitoring applications. The proposed quality-aware ECG monitoring system consists of three modules: ECG signal sensing module; automated signal quality assessment module; and signal-quality aware ECG analysis and transmission module. The proposed framework is tested and validated using the ECG signals taken from the MIT-BIH arrhythmia and Physionet Challenge databases and the real-time recorded ECG signals under different physical activities. This study further shows that the transmission of acceptable quality of ECG signals can significantly improve the battery lifetime of IoT-enabled devices. Also, the result show that, there is SQA method and IoT framework is used. This method is highly demand robust methods for accurate and reliable detection and measurement of morphological and RR interval features from noise-free and noisy ECG signals. So, it gives the quality of ECG signal and noise free ECG, accuracy and robustness of QRS complex detection. [16]

R.Harini1, B. Rama Murthy2 , K.Tanveer Alam, [2017], The purpose of the present study is to use handheld tele-electrocardiogram (ECG) to identify heart condition in the rural underserved population where the doctor-patient ratio is low and access to health care is difficult. The objective of the study was clinical validation of handheld ECG as a screening tool for evaluation of cardiac diseases in the rural population. The proposed system for the electrocardiogram (ECG) monitoring controlled by the Arduino UNO microcontroller and implemented in the form of android app application. This proposed system presents the implementation of patient ECG monitoring and real time feedback mechanism in Smartphone. The result show that by using Arduino IDE the information can be used to monitor the patient

in real time to get sensitive data in order to be subsequently analysed for medical diagnosis data can sent to the cloud in order to perform or visualized in real time by sending the data directly to a laotop or smart phones and android application have been designed in order to easily see the patient information.[17]

III. CONCLUSION

After going to various literature reviews in regards of different techniques for Real time ECG system. It has been understood that IoT framework based real time ECG Monitoring produced results with less complexity, and less power consumption, so to improve the results by using digital filter. Real time ECG monitoring system with FIR Filter provides the enhanced results with more accuracy in SNR and de-noising the base line wonder drift. Further various scopes on the real time ECG monitoring system for the signal quality assessment for IoT framework based on the implementation on FPGA. Also, this system presents the implementation of patient ECG monitoring and real time feedback mechanism in smart phones. So, the SQA method and IoT framework is found to be best algorithm for real time ECG monitoring. Hence, signal quality aware paradigm is a promising technological solution for the IoT that has great potential significantly improve the resource utilization efficiency and improve the accuracy and reliability of unsupervised cardiac health monitoring and diagnostic system. Therefore, this method is more applicable in various applications of ECG monitoring. And further it can be implemented on hardware platform in optimized manner. The work of various researchers is narrated in brief. Use of optimization technique using FPGA platform will improve the quality and processing time.

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