International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

IOT-BASED PORTABLE ECG MONITORING SYSTEM FOR SMART HEALTHCARE

Pranay Niokse[1], Mukul Somkuwar[2], Faizan Shaikh[3], Sumeet Kolhe [4]
Prof Najma Siddiqui[1], Prof Ishraque Ahmed[2]
Department of Electrical Engineering Anjuman College of Engineering & Technology, Nagpur, Maharashtra, India

Abstract
Sudden and unexpected death due to heart failure is a major cause of mortality among middle aged and elderly people. An efficient heart monitoring system can find out the malformation of heart conditions and that can also be helpful in diagnose at critical ambience. Sometimes the distance between patients and doctors is the main barrier that people do not have access to quality health services and thus having trouble for their regular health examine. IoT-based healthcare monitoring system is one of the manifested application areas in medical science. As a significant access in diagnose heart disease ECG observing system is widely used. In this paper, a progressive method for ECG monitoring system based on Internet of Things (IoT) has been proposed. In this study, a system is designed to frequently monitor the Electrocardiogram (ECG) signal collected from patient's body using wearable sensors and the data is stored into the database which can be accessed by authorized personnel only. When any malformation is found an automatic email is sent to the users and doctors for analysing about the critical conditions of the patients and provides emergency health assistances. In order to verify the authenticity of this system tests have been implemented on several patients and the report shows that, this system is dependable and efficient for collecting real time ECG data which can be very helpful in diagnose heart diseases. This IoT-based low cost device can be reliably used to reduce the risk of disability and mortality rate due to cardiovascular diseases.

Keywords: -ECG, Heart Bat, IoT, ECG tele monitoring, healthcare, Internet of Things (IoT), telehealth care, wearable monitoring system, wearable sensors.

1. INTRODUCTION

The Internet of Things (IoT) has many purposes in medical areas such as distant patient monitoring, dietary program, testimony of chronic diseases, elderly people care etc. The elderly population is rising continually both in rural and urban areas, so observing their health regularly with the desire of staying at home and at low cost is one of the basic appeal. Healthcare personnel can assess, diagnose and prescribe elderly people by gathering medical information from remote regions by using IoT. The significant part of IoT can be used in so many medical equipment, sensors and imaging devices to primarily determine the patient's health statuses and to deliver them proper care in a shortest possible time. IoT-based healthcare services can be implemented at low cost hereby maximizing the user contentment. Thus, the main purpose of IoT-based healthcare system is its cost effectiveness and secures interconnection for individuals, clinics and different healthcare institutions. Health conditions of aged people needed to be checked in regular basis which is a greater challenge both in medical research and hospitals [1].In medical institutes or hospitals, conventional 12 leads systems are used to collect ECG signals from patient's body. This device is too expensive to use at home or personal use and cannot be used as portable. It takes huge amount of time for routine check-up during each visit to hospitals and manual recording can also cause human made error. In such a manner, a low cost portable system for continuous ECG monitoring is highly required. Most of the available ECG monitoring devices use smart phones for secondary data processing [2]. The uses of smart phones in data transfer and processing have great consequences on regular use due to its limitations of power and computational effectiveness. In our study, a wearable ECG monitoring system has been proposed and implemented occupying Internet of Things (IoT). This customized device can directly send ECG data collected from patient's body to IoT cloud using Wi-Fi. Wi-Fi has wider coverage areas and higher data transfer rate than Bluetooth or ZigBee. The whole work is done by connecting Raspberry Pi with internet. Here, ECG sensor AD8232 has been used for ECG monitoring. Data have been processed in Raspberry Pi which uses processing software and a band pass filter is used for eliminating different noises to form an electrocardiogram (ECG) graph. An automatic email will be sent to the users and authorized doctors in case of abnormalities found in patient's body. This device is hazard free and cost effective for the remote patients as they do not need to visit the doctors regularly. We have compared our customized device with standard 12 lead

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

ECG modular in generating heart rates and waveforms and the result shows that, our system can be used reliably. The rest of the paper is organized in following sections. In section II, background and related works is discussed. In section III, system architecture of IoT based ECG monitoring system has been proposed and being explained. In section IV, shows the flowchart and implementation of IoT based ECG monitoring system. We conduct several tests on patients in order to verify the reliability of the system and it is discussed as experimental results and analysis in section finally we conclude the paper in section VI and also discussed about the future scopes in the field of medical science using Internet of Things (IoT).

2. LITERATURESURVEY

Jun Liu; YaqiZhou concluded Using the ECG analog front-end and ARM Cortex-M3 processor to develop a portable ECG monitor. The STM32 as the core unit, the ADS1292 as the acquisition analog front-end, it also includes a touch screen display module, an SD card storage module and a voltage conversion module. Automatic ECG analysis algorithms including QRS complex detection, QRS width detection and ST segment detection. ECG can be divided into four kinds of heart beat and eight kinds of arrhythmia rhythm using the extracted ECG parameters. The results have been evaluated on the MIT-BIH Arrhythmia Database, the sensitivity of QRS complex detection was 99% and the sensitivity of heart beat classification was above 95%. The monitor can display the real-time ECG waveform and the current heart rate, to make recommendations for the subjects, and it stored the abnormal ECG waveform that provided to physicians for further analysis and diagnosis. Ultimately the monitor gives a composite score based on heart rate, arrhythmia and ST segment to facilitate subjects for heart health.

AbhinayVishwanatham;NarendraCh. stated Cardiovascular diseases are the major cause of mortality rate in India with more than 50 % of the patients coming from a rural background. IoT plays a crucial role in developing point of care devices which cater to the healthcare demands of the rising rural populace. ECG monitoring system plays a key role as a diagnostic tool for cardiac abnormalities. Thus it becomes important to develop a portable point of care (POC) device at an affordable price so as to monitor the patients' cardiac health without interfering in their daily schedule. We developed an end to end health care workflow comprising three important modules. Firstly, a Bluetooth Low Energy (BLE) enabled portable 5-lead ECG monitor system with small form factor. Next, a smart phone based android application, which receives, plots and analyses the data sent from ECG device. Finally, a remote server where the patient data and analysis reports are stored for future reference of a professional medical practitioner. The device was tested using real time data from a rural hospital and further the obtained ECG signatures were compared with standard GE and SIEMENS ECG machines. The results were validated by a cardiologist of a super specialty hospital.

JakobJustesen; Soren Christian Madsen described Recent miniaturization of ECG sensors and other health monitoring systems potentially allowing remote monitoring of certain diseases in the patient's own home. Exploiting the full potential of this technology poses several design challenges for both the miniaturized ECG sensor, as well as the required infrastructure for data transport, storage and diagnosis. This paper proposes an ECG sensor prototype allowing experimentation on sensor technology and signal processing as well as infrastructure. The prototype is based on the Black fin processor from Analog Devices, and uses Bluetooth for wireless communication.

JihongChai stated that

With the increasing requirements of mobile ECG monitoring, a convenient mobile ECG monitoring system solution is proposed in this paper. The monitoring terminal is designed by using MSP430 to achieve ECG signal acquisition, amplification and A/D conversion. CC2540 integrating low-power Bluetooth 4.0 BLE-Stack is also used. System has the function of mobile ECG data transmission from the monitoring terminal to the smart phone. This design can use in home healthcare, community healthcare due to the characteristics of low power consumption, small size and reliability.AmitWalinjkar; John Woods Continuous monitoring of an individual's health using wearable biomedical devices is becoming a norm these days with a large number of wearable kits becoming easily available. Modern wearable health monitoring devices have become easily available in the consumer market, however, real-time analyses and prediction along with alerts and alarms about a health hazard are not adequately addressed in such devices. Taking ECG monitoring as a case study the research paper focusses on signal processing, arrhythmia detection and classification and at the same time focusses on updating the electronic health records database in real-time such that the concerned medical practitioners become aware of an emergent situation the patient being monitored might face. Also, heart rate variability

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

(HRV) analysis is usually considered as a basis for arrhythmia classification which largely depends on the morphology of the ECG waveforms and the sensitivity of the biopotentialmeasurements of the ECG kits, so it may not yield accurate results. Initially, the ECG readings from the 3-Lead ECG analog front-end were de-noised, zero-offset corrected, filtered using recursive least square adaptive filter and smoothed using Savitzky-Golay filter and subsequently passed to the data analysis component with a unique feature extraction method to increase the accuracy of classification. The machine learning models trained on MITDB arrhythmia database (MIT-BIH Physio net) showed more than 97% accuracy using kNN classifiers. Neural net fitting models showed mean-squared error of as low as 0.0085 and regression value as high as 0.99. ECG abnormalities based on annotations in MITDB could be classified and these ECG observations could be logged to a server implementation based on FHIR standards. The instruments were networked using IoT (Internet of Things) devices and ECG event observations were coded according to SNOMED coding system and could be accessed in Electronic Health Record by the concerned medic to take appropriate and timely decisions. The system emphasizes on `preventive care rather than remedial cure' as the next generation personalized health-care monitoring devices become available.

3. METHODOLOGY

The proposed system on the architecture we design an ECG based heart rate monitoring system. The collected ECG data will be directly sent to the database server using Wi-Fi module. Wi-Fi has been used here because it can provide larger cover areas and higher data rates. Wi-Fi is used here that it can send email to the doctors or relatives in case of patient's emergency health conditions.

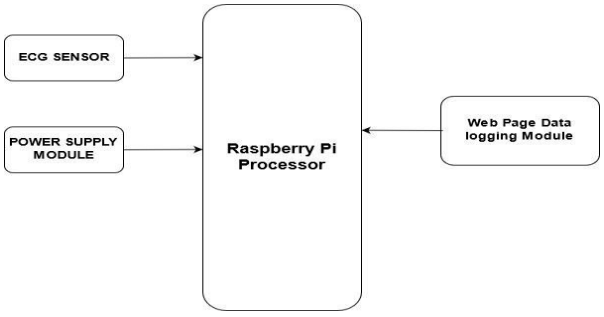

Fig. 1 Proposed blockdiagram of the system

The architecture of the IoT-based ECG monitoring system is illustrated in "Fig.1", which mainly consists of three parts, i.e., the ECG sensing network, IoT cloud, and GUI. The components used in ECG Sensing network are: ECG AD8232 Sensor, Raspberry Pi Model ECG Sensing Network: ECG sensing network is set for assembling physiological data from the body surface and pass on these data to IoT cloud through a wireless channel. In our equipment wearable ECG sensor has used to gather data from patient's body over long hours. Then the ECG signals are processed through amplification and filtering etc. to improve the signal quality. The ECG data gathered from sensors are transmitted to the IoT cloud via a specific wireless protocol such as Bluetooth, Wi-Fi, ZigBee etc. [7]. With satisfying energy consumption all these three protocols can transfer enough data rates for transmitting ECG signals. Moreover, due to limited communication ranges of Bluetooth and ZigBee, Wi-Fi is used in our proposed system. Comparisons among various types of ECG sensing networksIoT Cloud: With the
help of IoT cloud in ECG monitoring system we can store data, modify data and all the patient's information's are saved here. It can also send disease warning and protecting patients from getting injured. C. GUI: Graphical User Interface (GUI) is used for data imagination management. It contributes easy entry of the data in the IoT cloud. Users can log onto the cloud to acquire visualized ECG data in real time. Generally mobile applications and web pages are the two kinds of GUI's are available for users to visualize ECG data. Although mobile app can ensure immediate response but web pages are the best options in terms of protection and up-gradation

4. RESULT

A 3-lead placement is adequate to analysis the primary features of ECG signal [9] compared to conventional 12-lead ECG monitoring device used in hospitals. In order to best sample the ECG signal, the electrodes need to be placed around the heart and form a triangle.Abnormalities are found when the two conditions are not valid. Finally, if any disorders are found then an emergency email has been sent to the users or doctors that, they can take emergency steps to prevent severe damage of the patients. This can reduce mortality rate and any kind of damages that causes due to heart failure. To get the most proper data for sudden analysis of patient's condition 3 lead electrodes are placed in a triangular shape around the heart. "Fig.2", shows, the ECG data collected from healthy person. It is evident that the

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

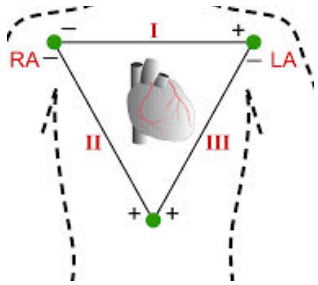

Fig. 2 A triangular shape around the heart.

We have developed a prototype system and tested our device with a 12-lead ECG machine and the experimental result shows the reliability of our system Percent Difference in "Equation (1)" is used to determine the relative difference between 12 lead and 3 lead portable ECG system.

$$\% \text{ difference} = \left| \frac{Expected - Actual}{\frac{Expected + Actual}{2}} \right| * 100\%$$

Where, expected = ECG value gained from 12-lead ECG machine and Actual = ECG value gained from ECG device prototype we can observe that, the value of our prototype is quite similar with expected value collected from 12-lead ECG device. To determine the efficiency rate of our device "Equation 2" is used to test the number of successful attempts vs. the total number of attempts.

$$\% \text{ reliability} = \left| \frac{number\ of\ successful\ attempts}{total\ number\ of\ attempts} \right| * 100\%$$

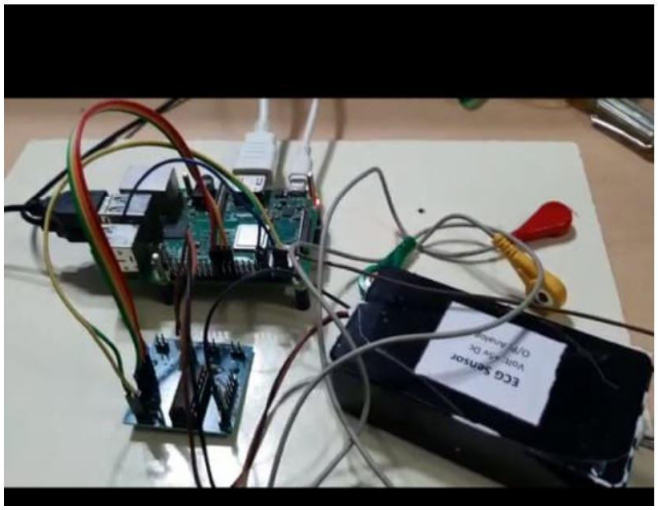

Fig.3 Hardware output

5. CONCLUSION:

The implemented prototype of our IoT-based ECG monitoring system is highly efficient, low cost device and it reduces the time and cost for regularly visiting the doctors at healthcare institutions. We have collected data from different ages' patients by using three electrodes placements in their body and achieved 80% accuracy in our system. The data collected from our device has been directly sent to IoT cloud using Wi-Fi. The IoT cloud has been used for visualizing the data to users and store it for future analysis. By using the system ECG signal can be monitored continuously. The regular use of device is very helpful for preliminary detection of heart diseases and to reduce severe damage and mortality rate due to cardiovascular diseases. Similar to this user-friendly ECG monitoring System, additional health monitoring systems such as temperature measurement, Blood Pressure, Diabetes, etc., can be developed using IoT that will greatly help decrease existing health care problems to a certain amount. The proposed system is successfully developed and tested to examine the effectiveness and reliability of the system. This is a low cost smart device which can be used for patient's health monitoring so that doctors can take precautions at proper time to avoid sudden death due to cardiovascular diseases.

REFERENCE:

[1] Abadi, M., Subramanian, R., Kia, S., and et al., DECAF: MEG-based multimodal database for decoding affective physiological responses. IEEE Trans. Affect. Comput. 6:209–222, 2015.

[2] Miao, F., Cheng, Y., He, Y., and et al., A wearable contextaware ECG monitoring system integrated with built-in kinematic sensorsof the smartphone.Sensors 15:11465–11484, 2015.

[3] E. Span, S. Di Pascoli and G. Iannaccone, "Low-Power Wearable ECG Monitoring System for Multiple- Patient RemoteMonitoring'' in IEEE Sensors Journal, July 1, 2016.

[4] S. Sneha and U. Varshney, "A Wireless ECG Monitoring System for Pervasive Healthcare," in International Journal of Electronic Healthcare, 3(1), 32-50, 2007.

[5] Kim H, Kim S, Van Helleputte N et al. (2014) A configurable and low power mixed signal SoC for portable ECG monitoring applications. IEEE Transactions on Biomedical Circuits and Systems 8:257-267.

[6] J. Dong and H. Zhu, "Mobile ECG detector through GPRS/Internet," presented at Computer-Based Medical Systems, 2004. CBMS

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

2004.Proceedings.17th IEEE Symposium on, 2004.

[7] Palattella, M., Dohler, M., Grieco, A., and et al., Internet of Thingsthe 5G era: Enablers, architecture, and business models. IEEE J. Select. Areas Commun. 34:510–527, 2016.

[8] Wang Y et al. Design and evaluation of a novel wireless reconstructed 3-lead ECG monitoring system. In: Proc. IEEE 2013 Biomedical Circuits and Systems Conference (BioCAS), Rotterdam, Oct. 2013, pp. 362-365.

[9] ECGlibrary.com: Normal adult 12-lead ECG. In: Ecglibrary.com, http://www.ecglibrary.com/norm.php. Accessed 18, Sept. 2016.

[10] Gertsch M The Normal ECG and its (Normal) variants. In: The ECG manual. Springer, London, pp. 17-36,2009.