NVEO
Natural Volatiles &
Essential Oils

Cost Effective Remote Health Monitoring System

Sathananthavathi V[1,*], Arunkumar [2], and Arunachalamani [3]

[1,2,3]Department of schlenk Electronics & Communication Engineering, Mepco engineering college, Sivakasi, India

Abstract

In this Corona Pandemic situation patients cannot able to get direct consultation from the Doctor. Therefore, the Doctor needs to give consultation to the patient without measuring medical parameters directly. Predicting heart disease is a complex task since it requires experience along with systems to collect sensor values for heart disease diagnosis and prediction. In this paper, a patient monitoring system is developed by sensing the required parameters like beats per minute and RR interval from ECG wave of the patient and sends a notification to Doctor and Patient Caretaker if there is any abnormality observed in the heart.

Keywords: ECG Sensor, IoT, Heart Disease, AD8232, ESP32

Introduction

Remote Patient Monitoring method is the requirement in this pandemic situation and it is the monitoring of patient through advanced digital technologies available. Mostly the detection systems were present only in the Hospital, which consists of sophisticated electronic equipment, which requires more space and more power consumption. By continuous advancement in the semiconductor industry the use of sensors and micro controllers of small size and low power consumption for monitoring the patient. It will reduce the Space needed for the larger equipment and cost. In Hospital, monitoring devices at Medical Labs or ICU (Intensive Care Unit) is used to monitor the patient's medical parameter. The Remote Patient Monitoring is the one which is use to observe the important medical parameter of the patient at his or her own place. This Remote Patient Monitoring will helpful for many people particularly the aged persons. From this Remote Patient Monitoring it is possible to reduce the direct contact of patient with Doctors. This Remote Patient Monitoring will also helpful to avoid direct contact with the patient who has diseases that transfers like Corona.

Now a day's wireless Remote patient monitoring system [1-7] became more popular. Through this wireless detection, system the data is send to the server in the cloud. However, the Limitation of this wireless Remote patient monitoring is that requires proper Internet Connection in both patient and the Doctor. Many cloud servers will have restriction to send the number of parameter to the cloud [8]. To send many parameters to the cloud platform, the patient need to pay the Subscription fee, which the normal individual cannot use. To overcome this price issue, the monitoring will do only on the important medical parameter, which is like the policing work.

A report states that there is Chronic and Cardio Vascular Disease (CVD) in all the countries of the world cause an increasing number of death for the fast few decade. CVD will affect the human blood vessels and the heart. CVD involving the failure in the blood vessel are called as vascular disease such as Coronary Artery Disease. The CVD cause Heart Failure, Cardiomyopathy, Rheumatic Heart Disease, Stroke, Heart Attack and Arrhytimas [9,10]. According to the World Health Organization (WHO), there are 17.9 million deaths every year due to CVD. It is claiming more than 86000 lives in 2016 in America. In Europe it is claimed that more than 1.8 million deaths in the year 2017. Hence the requirement of continuous observing as well as monitoring system is required for the persons who prone to heart diseases.

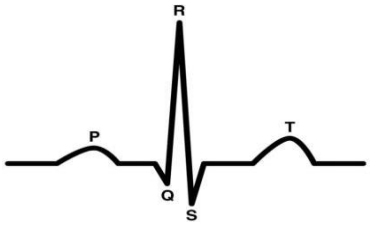
There are two types of observance system; they are Single parameter observance system and Multi parameter observance system. The example of Single Parameter Monitoring is ECG Monitoring. From the

ECG Monitoring system, ECG signal reading and heart rate and oxygen saturation are measured. In multi parameter, monitoring System it will monitors many medical parameters and justifies that the patient is alive and recovering and it will requires large spaces. Caretakers can monitor number of medical parameters from the patient and transfer the data to the Doctor through IoT.

Related Works

ECG is used to check whether the heart is functioning correctly. Heart will pump the blood in and out. This pumping action produces an electrical signal in the Heart. Electro Cardio Gram (ECG) plots the Patients Electrical signal from the heart. The first wave will be the p wave in the ECG signal. It is due to depolarization in Artia. QRS wave corresponds to Ventricular depolarization. The T-wave Ventricular repolarization. ECG features is mainly depends on accurate detection of the R peak [9]. From the ECG, the Blood Pulse per minute (BPM) is measured and the signals from the heart is monitored. ECG is a process of recording the electrical signals from the heart for a period. The electrodes are placed on the body to record the ECG. From the ECG report, Human Heart Condition will be predicted [10]. ECG waveform with P,Q,R,S and T labeling is shown in figure 1.

Figure1. Normal ECG Wave Form



If there is a lack of QRS complex then the person is suffering from Ventricular Fabrillation. During Ventricualar Fabrillation the blood is not removed from the Heart and this Ventricullar Fabrillation will occur mostly in the lower chambers of the heart. If the heart beat is in a pattern of one normal beat and one premature beat. The premature beat is caused when the artia and ventricle start the electrical signal before receiving the signal from the sinus node. This disorder is called as Bigiminy. If the heartbeat occurs in the repeated pattern then the person is having the disorder named Trigeminy [11].

In [2], the AD8232 Sensor is used to record the electrical signals from the heart. Then the ARM 7 Microcontroller will collect the Recorded Signal. Then the ARM 7 Microcontroller is connected in series with the Raspberry Pi board. Raspberry Pi act as Mini Computer and used to analyze the collected data from the sensor and transfer the analyzed data to the Cloud Platform. The abnormality is based on Patient's Heart Rate and from the ECG Signal. The Doctor can able to see the patient health condition without any direct contact. The advantages are Portability, the ECG monitoring system can be carried to any places because it is compact Remotely Analyzing the Patient ECG System. The ECG Signals can be stored. Weight of the Electronics hardware will be low. The limitations are there will be the Disturbance of Noise. The noise may affect the actual ECG Signal Graph. Good Internet Connection is needed to transfer the data to the Cloud.

In [12], the Single Lead AD8232 Sensor to monitor the ECG signals from the Heart. The DS18B20 Temperature Sensor is used to sense the temperature of the patient and Pulse Sensor is used to measure the Heart rate of a Patient. The Sensed data is then collected using Arduino. Raspberry Pi has its inbuilt camera called Pi-cam, which is used to monitor the patient physical activity. Then the data is sent serially to Raspberry Pi. From the Raspberry pi the data is sent to the cloud using the inbuilt Wi-Fi module in the Raspberry Pi. In this work, Thing Speak is used as an IoT Cloud platform. If there is any abnormal condition in patient heart rate and in ECG signal then a Notification will be sent to the Doctor. The Limitations are

compared to AD8232, KardiaMobile ECG Device is more reliable but it is five times expensive when compared to AD8232.The advantage of this system is it can be used in both hospital and at home for bed-ridden patient without any lot of trouble and spaces. The future work will be more sensors can be added to monitor the patient effectively and the security measures can be taken while transferring the data to the cloud.

In [13], the AD8232 ECG Sensor is used to sense the Electrical Signal from the Heart .Then MCP3008 IC is used as an ADC which can be capable of converting analog signal into 10 bit digital values and sends the values to the Raspberry Pi using SPI. Then the data is analyzed in the Raspberry Pi. The Analyzing part includes Peak Detection and Heart Rate Calculation. Then the abnormalities will be based on the Heart Rate and Time Intervals between the Peak R-R, QRS, P-R etc.

In [14], the peak of the ECG wave is detected using Peak Detection Algorithm. The Q, R and S Peaks are more important in the ECG Signal. To find the Peak the ECG Signal input is first sent to the Derivative function to amplify the high frequency and to attenuate the low frequency. Then a Band Pass Filter is used to remove the Base Line Wandering of the ECG signal and squaring the output from the Band Pass filter to make all the Peaks Positive for the final stage of Filtering. The advantages are this algorithm is more reliably detects QRS peaks. It detects 99.72 percent of the peak correctly.

In [15], AD8232 Sensor is used to monitor the Electrical Signals from the Heart. The Data from the Sensor will be collected by Arduino. Then the Peak detection algorithm will be implemented to detect the peak of the ECG Wave. The Heart Rate will be calculated and the Time Interval between R-R peak and S-T peak will be measured and based on that information abnormalities will be detected. The advantages of this method are ECG monitoring is similar compared to Medical Standard ECG. The future work will be to detect the other peaks and to detect the number of heart disease.

In [16], comparison of ECG signal and Respiratory Signal is done. The extraction of the ECG signal using Heartbeat Belt or Bene Gear equipment and the Respiration number is extracted using respiration equipment such as Flow Sensor, Mask and Respiratory Flow Equipment. Then the test will be made on Different Test Conditions like walking slowly, walking quickly, sit and stand etc. From the analysis the respiration number from the ECG sensor can be measured. If the ECG sensing quality is good then accuracy of respiration number is more than 90 percent. The future work of this project will be able to get heartbeat value from the ECG sensor along with the Respiration number and can make the notification to be sent to Doctor as soon as abnormal condition is occurring.

In [17], the diagnosis of Cardio Vascular Disease based on the R-R Interval using ECG signal is proposed. In the ECG signal, why and when the peak is occurring can be analyzed and the time interval between two peak and the Diseases caused due to Disorders in the Electrical signal from the heart is mentioned. Then the processing is done using Matlab and the Heart rate the position of the R-R peak is found so the PVC affected patient can be detected and the power of the signal is given by taking the variance of the signal.

Based on the survey, we infer AD8232 ECG Sensor[18] is the cost effective one and can be used to monitor the patient Heart condition. AD8232 sensor senses the electrical signals from the heart with single lead electrode and Microcontroller is used to process the data from the Sensors. Then a suitable peak detection algorithm is applied to detect the peak of the ECG wave and to find the abnormalities in the ECG signal using Arduino IDE.

The patient heart rate is measured using R-R peak interval. If there are any Abnormalities in heart rate and R-R peak intervals then a notification message will be sent to Doctor and patient's caretaker. If the patient

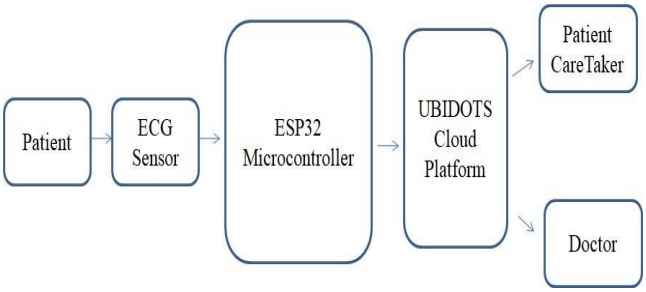
is in normal conditions then no notification will be sent. As the result the combination of Hardware and Software the Prediction of Abnormalities in Heart is increased hence patients life can be saved.

Experimental Setup

The objective of this work is to design a System to monitor the persons who are prone to Heart Disease and to send notification to the Doctor if the patient is in abnormal condition; so the Doctor can immediately call or send required message about his suggestion to the patient's caretaker.

In this work, AD8232 ECG sensor is used to sense the Electrical signal from the heart of the Patient. ESP32 Microcontroller [19] is used to analyze the sensed data, which includes the calculation of Heart Rate and the time interval between R-R peak intervals to find the abnormality in the ECG signal. Builtin Wi-Fi Module [20] is used to transfer the data to the Ubidots Cloud Platform and the notification will be send based on the abnormal condition.

Figure 2. Workflow block representation



The notification is a preferable for remote monitoring, here Ubidots Cloud Platform helped to send a notification through voice call, SMS, Email, Telegram Message. The entire workflow is given as a block representation in figure 2.

The electrode is placed in the Respective location as shown in figure 3 and the jack is inserted into the AD8232 Sensor. The sensors can be placed in the forearms and leg or can be placed around the chest to get better measurement. Then electrical signal can be analyzed in an Arduino IDE platform as the Arduino IDE includes ESP32 device Module. First install the Arduino IDE. Then set the preferences to use the ESP-32 device Module Board. Figure 4 shows the connection between the ESP32 and AD8232 ECG sensor.

Figure 3. Electrode placement in the human body

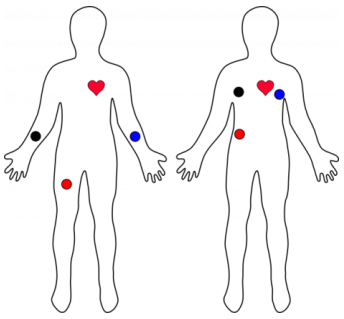
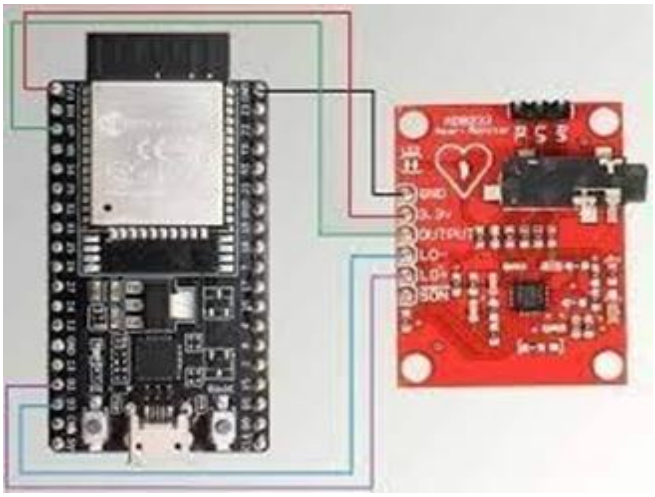


Figure 4. ESP32 and AD8232 ECG sensor connection



The abnormality in the ECG waveform is identified through the following proposed algorithms includes the algorithm for R peak detection, S peak detection, BPM calculation and RR interval calculation.

R Peak Detection Algorithm

Step 1: Start

Step 2: Read the electrical signal from the body.

Step 3: If the Electrical Signal is greater than the Threshold value.

Step 4: Then this value will be stored in a variable m. Initially previous variable (a) will be zero.

Step 5: Check whether the difference between the current value and the previous is less than zero and the value will be greater than another threshold value.

Step 6: R peak will be detected and the Count is incremented to calculate the Heart Rate.

Step 7: Then the current R peak milliseconds will be stored.

Step 8: Stop.

S Peak Detection Algorithm

Step 1: Start.

Step 2: Initialize S value to 1 in the R peak Detection Algorithm.

Step 3: Check whether the difference between the Current value and the previous value is Greater than zero and S is equal to 1.

Step 4: Then assign speak value to the previous value (S Point is detected).

Step 5: Assign s value to zero.

Step 6: Stop.

Heart Rate Calculation

By counting the number of R peaks per minute, the Heart Rate of a person is calculated. To count the number of R peaks for one minute run a program for one minute.

```
for(i=0;i<60000;i++)
```

{

R peak Detection algorithm

}

The calculated Heart Rate should be in the Range 60 to 100 for the Normal person. If the Heart Rate is greater than 100 or less than 60 then there occurs the abnormalities in the Heart Rate.

R-R Time Interval Calculation

From the R peak Detection Algorithm, R peak is detected and the time period at which the R peak is detected is stored in the current millis by using the millis function. Millis function is an in-build function that returns the current millisecond. This value is then moved to the previous millis. Then new R peak will be detected and the time period of the new R peak will be stored in the current millis. Then the Time difference will be taken between the current millis and the previous millis will be the calculated. The calculated time difference should be in the range 600 millisecond to 1200 milliseconds. If the time difference between two R –R peak interval greater than 1200 milliseconds or less than the 600 milliseconds then there will be an abnormality in R peak time Intervals**.**

Disorder in ECG Wave

The abnormality condition of heart and the relevance of this abnormality to various diseases is given below:

- If the heart rate is in range 60-100 BPM then the person is normal
- If the heart rate is above 100 BPM then the person is having the disorder named Sinus Tachycardia.
- If the heart rate is less than 60 BPM then the person is having the disorder named Sinus Bradycardia.
- If the R-R Peak time interval is greater than 1200 milliseconds or less than 600 milliseconds then the person is having
- AV Block or Escape block.

Result and Discussion

In this paper, AD8232 ECG Sensor is used to monitor the patient Heart condition. AD8232 sensor senses the electrical signals from the heart with single lead electrode and Microcontroller is used to process the data from the Sensors. Here ESP32 is used as a Microcontroller and the processing is done using suitable peak detection algorithm to detect the peak of the ECG wave and to find the abnormalities in the ECG signal in Arduino IDE. The patient heart rate is measured using R-R peak interval. If there are any Abnormalities in heart rate and R-R peak intervals then a notification message will be sent to Doctor and patient's caretaker. If the patient is in normal conditions then no notification will be sent. As the result the combination of Hardware and Software the Prediction of Abnormalities in Heart is increased, this will save patients life.

The Electrical signal from the heart is sensed using AD8232 sensor and the output will be in the form as shown in the Figure 5. The Result of the ECG wave which includes BPM, R-R time Gap and S peak point is given in the below Figure 6.

Figure 5. ECG wave at Serial Plotter

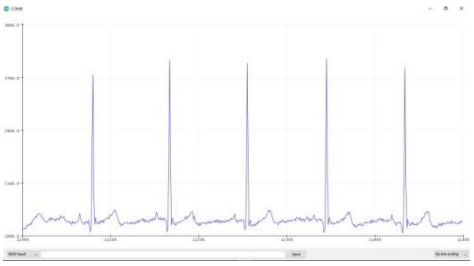
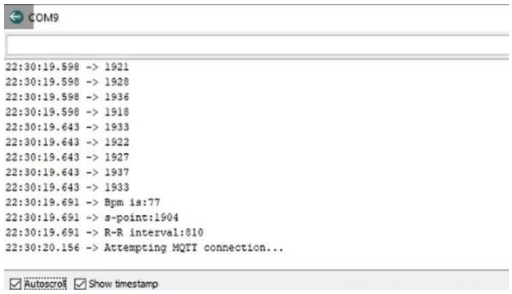


Figure 6. Measured value at Serial Monitor



Daily activity of the person, may lead to error in the measurement. The measurements during running, walking and standing also need to be included; for the proper monitoring of the patient. Hence we have included the following test cases for the patient monitoring system.

The test cases are: when person is at sitting position, when person is at standing position, walking slowly for some time and ECG signal is monitored and running fast for some time and ECG signal is monitored are taken for several persons and found whether the system works properly or not. The sample test values for the BPM for the different persons are shown in Table 1. Heart rate variation for each activity can be monitored and the stored data is highly helpful for the doctors to track the medical history of the patients.

Table 1. Test cases taken for different persons

A. Person	***B.*** Measurement under various activity			
	C. Sit	***D.*** Stand	***E.*** Walk	***F.*** Run
G. 1	***H.*** 85	***I.*** 93	***J.*** 98	***K.*** 180
L. 2	***M.*** 93	***N.*** 98	***O.*** 117	***P.*** 140
Q. 3	***R.*** 80	***S.*** 92	***T.*** 101	***U.*** 162
V. 4	***W.*** 68	***X.*** 89	***Y.*** 95	***Z.*** 144
AA. 5	***BB.*** 73	***CC.*** 86	***DD.*** 125	***EE.*** 170

These are the result which can be analyzed using ESP32 Microcontroller and can be seen in the Serial Monitor and Serial Plotter of the Arduino IDE. After the data is transferred to the UBIDOTS Cloud Platform, the ECG Signal is in the form as shown in the Figure 7.

The calculated BPM, R peak, S peak and RR interval values are stored in cloud for continuous monitoring of patients. This feature enables the medical practitioner to maintain the medical records of the patients and

for continuous monitoring. The stored BPM, R peak, S peak and RR value in the UBIDOTS Cloud Platform is as shown in the Figure 8.

To send notification to the Doctor, an Event is created in the Ubidots. After creating the event a mode is selected in which notification to be sent. Ubidots have number of modes to send the notification. There are many ways to send notifications either by a call or by SMS or by Telegram message or by sending mail to the Doctor and the caretaker's.

If the Heart Rate measured is greater than 100 or the RR interval measured greater than 1200 milliseconds or less than 600 milliseconds, then it is considered as the particular person is in abnormal condition. Then this abnormal condition is intimated along to the care taker as well as the medical person along with the data measured.

Figure 7. ECG signal at Ubidots cloud platform

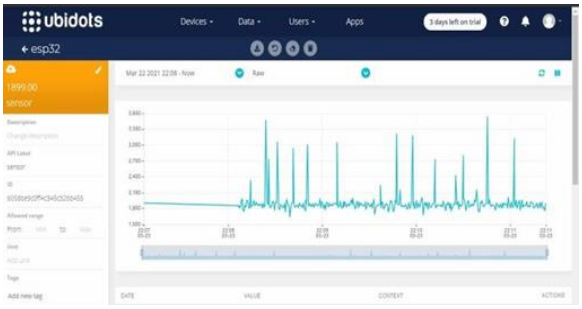


Figure 8. BPM and R-R Time Interval values at Cloud

The proposed cost effective system is helpful for continuous monitoring of heart rate of the patient. If any abnormal condition is observed then it is updated in the cloud server and the intimation is also sent to the doctor as well as caretaker. To have comfortability of patient, all the three electrodes are placed in the chest position itself. Even many smart devices are available, they are costly and not all people irrespective of their economic situation can use it. In addition, the lifetime of the device is limited and if any fault occurs, need to replace the entire device. The proposed remote monitoring system is cost effective and it can be used for long time by replacing the electrode at the user end.

Conclusions

In the proposed Patient Monitoring System using IoT can the analyze the patients' medical data including Heart Rate calculation, R Peak Detection, S peak Detection and R-R Time Interval and the analyzed value is sent to the UBIDOTS Cloud Server and the notification will be sent if the patient is in the abnormal conditions. The ECG wave from the AD8232 Sensor is similar to the Normal ECG Monitoring. The peak

detection algorithm gives the correct peak value of R and S peak. The calculation of the Heart Rate will be similar to results when compared to the Heart Rate Sensor, the time interval between the two R-R peak intervals is calculated, and it is in the given medical range of value. Then the data are transferred to the UBIDOTS Cloud platform using the MQTT broker. Then the data will be analyzed to send the notification to the Doctor. By applying the peak detection algorithm to the IoT based ECG monitoring system more information about the electrical signal from the heart will be obtained and the abnormality will be detected more effectively.

In future, the machine-learning algorithm to predict the disease possible based on the stored values on the cloud and this will be helpful for the person for maintaining his health.

REFERENCES

Li, C., Hu, X., Zhang, L., 2017. The iot-based heart disease monitoring system for pervasive healthcare service. Procedia computer science 112, 2328–2334.

Mehak Chhabra and Manik Kalsi, “Real Time ECG Monitoring system based onInternet of Things (IoT) “International Journal of Scientific and Research Publications, vol. 7, no. 8, pp. 547-550, 2017.

Yew, Hoe Tung, et al. "Iot based real-time remote patient monitoring system." 2020 16th IEEE International Colloquium on Signal Processing & Its Applications (CSPA). IEEE, 2020.

Akkasß, M. A., Sokullu, R., ErtürkÇetin, H., 2020. Healthcare and Patient MonitoringUsing IoT. Internet of Things, 11, 1–12.

Shanin, F., Aiswarya Das, H.A., Arya Krishnan, G., Neha, L.S., Thaha, N., Aneesh, R.P., Jayakrishan, S., 2018. Portable and Centralised E-Health Record System for Patient Monitoring Using Internet of Things(IoT). In: 2018 International CET Conference on Control, Communication, and Computing (IC4), pp. 1–6.

Saha, H. N., Auddy, S., Pal, S., Kumar, S., Pandey, S., Singh, R., … Saha, S. (2017). Health monitoring using Internet of Things (IoT). 2017 8th Annual Industrial Automation and Electromechanical Engineering Conference (IEMECON).P1-5.

Hassanalieragh, M., Page, A., Soyata, T., Sharma, G., Aktas, M., Mateos, G., … Andreescu, S. (2015). Health Monitoring and Management Using Internet-of-Things (IoT) Sensing with Cloud-Based Processing: Opportunities and Challenges. 2015 IEEE International Conference on Services Computing. P1-8.

Mohammed Imtyaz Ahmed, Dr G. Kannan, 2020. Overcoming Privacy and Security Challenges of Internet of Things Applications. Int. J. Future Gener. Commun. Netw. 13(1), 1550–1556.

Manikandan, M.S., Soman, K., 2012. A novel method for detecting r-peaks in electrocardiogram (ecg) signal. Biomedical Signal Processing and Control 7, 118–128.

Oresko, J.J., Jin, Z., Cheng, J., Huang, S., Sun, Y., Duschl, H., Cheng, A.C., 2010. A wearable smartphone-based platform for real-time cardiovascular disease detection via electrocardiogram processing. IEEE Transactions on Information Technology in Biomedicine 14, 734– 740

Banuleasa, S., Munteanu, R., Rusu, A., Tonţ, G., 2016. Iot system for monitoring vital signs of elderly population, in: 2016 International Conference and Exposition on Electrical and Power Engineering (EPE), IEEE. pp. 059–064.

Alvee Rahman, Tahsinur Rahman, Nawab Haider Ghani, Sazzad Hossain and Jia Uddin,“ IoT Based Patient Monitoring System Using ECG Sensor” International Conference on Robotics Electrical and Signal Processing Techniques, 2019.

Valliappan CA, Advait Balaji, Sai Ruthvik Thandayum, Piyush Dhingra and Veeky Baths, “A Portable Real Time ECG Device for Arrhythmia Detection Using Raspberry Pi” International conference on MobiHealth, 2016.

Pavan D.Paikrao, Deeplaxmi P. Shinde and V.V.Ingale “Peak Detection Algorithm for ECG Wave”, International Conference on Emerging Trends in Networks and Computer Communications (ETNCC), 2017.

Martin Clinton Tosima Manullang, Jonathan Eprillo Soaduon Simanjuntak and Ahmad Luky Ramdani, "Implementation of AD8232 ECG Signal Classification Using Peak Detection Method For Determining RST Point", Indonesian Journal of Artificial Intelligence and Data Mining, vol. 2, no. 2, pp. 61-66, 2019.

Hsien-Wei Tseng, Yang-Han Lee, Yi-Lun Chen and CHih-Hsien Hsia "Analysis between ECG and Respiratory Signal", International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS), 2017.

Mahalakshmi, Nithya, Nandhini "Diagnosis of Cardiovascular Disease Based on R-R Interval Using ECG Signals", International Journal of Engineering Research and Technology, vol. 3, no. 1, pp.2722-2728, 2014.

Zeli Gao, Jie Wu, Jianli Zhou, Wei Jiang, and Lihui Feng " Design of ECG signal acquisition and processing system", International Conference on Biomedical Engineering and Biotechnology, 2012.

Alexander Maier, Andrew Sharp, Yuriy Vagapov Comparative analysis and practical implementation of the ESP32 microcontroller module for the Internet of Things" Internet of things applications, IEEE 2017.

Hoc Tung Yew, Ming Fung Ng, Soh Zhi Ping, Seng Kheau Chung , Ali Chekimaand Jamal A. Dargham,"IoT Based Real-Time Remote Patient and its Applications", 2020 16th IEEE International Colloquium on Signal Processing & Its Applications (CSPA), 2020.