ISSN 2278-3091
Volume 8, No.1.6, 2019
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse6781.62019.pdf
https://doi.org/10.30534/ijatcse/2019/6781.62019

The Development of Heart Beat Detection and Monitoring System Using IoT

Siti Khadijah Binti Ismail[1], Nadzmi Amir Bin Mohd Asri[2]
[1, 2] Industrial Automation Section, Universiti Kuala Lumpur Malaysia France Institute,
Section 14, Jalan Teras Jernang, 43650 Bandar Baru Bangi, Selangor, Malaysia.
[1]sitikhadijah@unikl.edu.my
[2]nadzmiamr@gmail.com

ABSTRACT
This paper presents the development of heart beat detection and monitoring system using Internet of Things (IoT). The monitoring system gives real time reading of heart beat of patient measured by pulse sensor. The input values from the pulse sensor will be transmitted to an IoT platform called Blynk applications, through the medium of an open source microcontroller board: NodeMCU. The heart beat detection and monitoring system in Blynk will alert the users by notification whenever the heart rate of patient is in low or high conditions. This IoT-based system will help doctors or concern people to monitor the heart rate of patient from anywhere via devices with internet connection.

Key words: Heart beat detection, Internet of Things (IoT), Pulse sensor.

1. INTRODUCTION

1.1 Research Background
The heart rate is the number of times the heart beats in the space of a minute. The heart is a muscular organ in the centre of the chest. When it beats, the heart pumps blood containing oxygen and nutrients around the body and brings back waste products. The pulse rate is exactly equal to the heartbeat, as the contractions of the heart cause the increases in blood pressure in the arteries that lead to a noticeable pulse.

Heart rate is varying according to age, person physical and activity condition. Human heart rate of healthy adult is around 60 to 100 Beats per Minute (BPM), baby is around 120 to 160 BPM and children's heart rate is around 75 to 110 BPM. However, the heartbeat with rates around 40–50 BPM is common and is considered normal during sleeping. The heartbeat with rates around 100 to 160 BPM is considered normal during exercise activities.

When the heart rate of the person is beyond their normal range, the person is at many risks and might get a heart attack. A heart attack occurs when the flow of blood to the heart is blocked. The blockage is most often a build-up of fat, cholesterol and other substances, which form a plaque in the arteries that feed the heart (coronary arteries). The plaque eventually breaks away and forms a clot. The interrupted blood flow can damage or destroy part of the heart muscle. Heart disease has remained the principal cause of death among Malaysians over the past 10 years (2005-2014), recording 13.5 per cent in 2014, based on the findings of the Statistics Department. This shows that heart disease is one of the leading cause of death for Malaysians. The first few hours are critical in saving much of dying muscles and preventing permanent heart damage or fatal. Unfortunately, the symptoms vary and the most common reason for critical delays in medical treatment is lack of early warning and patient unawareness.

1.2 Contributions
By developing this project, there will be a lot of contribution to be provided for everyone especially to heart attack patients. All these significance make this project become more valuable and interesting. First and foremost, it is significant for the heart attack patient him/herself. Second is significant to the people nearby the heart attack patient as the caretaker for the patient.

This project could help the doctors or concerned person to be alerted as they will be notified with notification on the Blynk Apps when the patient have abnormalities range on their heart rate. The patient will not have to wait a longer time for help from doctor or concerned person therefore they could be saved right on time. The doctors will get the benefits of this project. By using this system, the doctor does not have to record all the data of the patient's heart rate manually as the project is integrated with IoT system. This system can reduce the human error when recording the data of the patient's heart rate manually. The data of the heart rate of the patient will be stored in the IoT cloud. Doctors can import the data anytime as they can analyse and monitors the pattern of the patient's heart rate.

Besides that, this project will also help the patient's caretaker when they are not around with the patient. Some of the caretakers are not full-timely taking care of the patient. They need to do other tasks or works which make them away from the patient. As this project is integrate with IOT system, caretaker could monitor the patient via Blynk App.

2. METHODOLOGY

2.1 Framework and Conceptual Design for Control Box

This project use one analog input devices which is pulse sensor to measure the heartbeat of patient. Figure 1 shows the process flow diagram of the heart beat detection system. The system starts with the microcontroller NodeMCU being initialized. Then, the pulse sensors will detect the heartbeat and NodeMCU will measured heartbeat of patient. These measured data are stored in cloud and can be monitored through the IoT platform. The system will alert the user when the heartbeat of patient is low condition (lower than 60 BPM) and high condition (greater than 100 BPM)

Figure 2 shows the conceptual design control box of the heart beat detection and monitoring system. The control box is made of plastic with size of 4 Inch x 6 Inch x 3 inch. The pulse sensor is connected outside of the control box with a long wire in order to ensure this project become portable for patient. On the control box, there are 3 LEDs which are red, green and yellow. The Light Crystal Display (LCD) is assembled on the top left of the control box. The size of the LCD display is 16 cm x 2 cm. The LCD display is used to display the condition of the patient. The buzzer is used to indicate and notify the doctor or concerned person about the condition of the patient. When the heart's rate of the patient is low or high, the buzzer will turn on with a beep sound. The buzzer will not turn on as the heart's rate of the patient is normal.

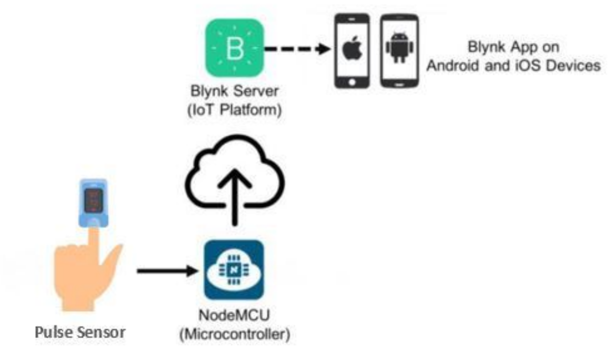

Figure 1: Process flow diagram of the proposed work

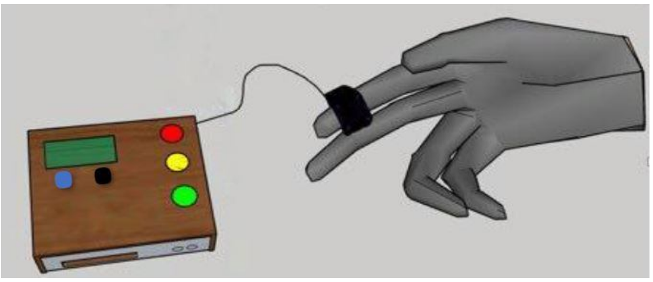

Figure 2: Conceptual design for control box

2.2 Hardware Components

A. Pulse Sensor

Figure 3 shows pulse sensor used on this project. Pulse sensor is a well-designed plug-and-play heart-rate sensor for NodeMCU. It can be used to incorporate live heart rate data for projects. The sensor clips onto a fingertip or earlobe and plugs right into NodeMCU. It also includes an open-source monitoring application that graphs user's pulse in real time. GND pin of pulses sensor is connected to GND of NodeMCU. Then, the VCC of pulse sensor is connected to 5V of NodeMCU. Lastly, A0 of pulse sensor is connected to A0 of NodeMCU.

B. Liquid Crystal Display (LCD)

The GND pin of the LCD display is connected to the any GND of the NodeMCU. Then, the VCC pin of the LCD display need to be connected to the VIN pin (5v) of the NodeMCU. Then, connect the SDA pin of the LCD display to the D2 pin of the NodeMCU. Lastly, the SDL pin on the LCD display must be connected to the D1 pin of the NodeMCU. LCD is shown in Figure 4.

C. Light Emitting Diode (LED)

Figure 5 shows the LED connection to the NodeMCU microcontroller. The cathode/negative terminal of the LED is connected to 330ohm resistor and GND pin on the NodeMCU. The anode/positive terminal of the LED is connected to any digital pin on the NodeMCU. In this wiring diagram, the yellow LED is connected to the D4, the red LED is connected to the D5, and lastly the green LED is connected to the D5 on the NodeMCU.

D. Piezo Buzzer

The red wire of the piezo buzzer is called as the anode or positive terminal. The black wire is known as negative or cathode terminal. The anode is connected to the D3 pin of the NodeMCU. The cathode is connected to GND of the NodeMCU. The connection of piezo buzzer is shown in Figure 6

E. NodeMCU Lua V3 ESP8266 Wi-Fi with CH340G

Figure 7 shows the NodeMCU Microcontroller. NodeMCU is a low-cost open-source development board that runs on the ESP8266 Wi-Fi microchip. This board integrates 16 General Purpose Input/Output (GPIO) pins, Pulse Width Modulator (PWM), serial 2-wire bus interface (Inter-Integrated Circuit, IIC), 1-Wire interface and Analog to Digital Convertor (ADC). It features 4MB of flash memory, 80MHz of system clock, around 50k of usable RAM and an on chip Wi-Fi Transceiver. NodeMCU operates on an external DC voltage supply of 6 to 24 volts. The recommended voltage range is between 7 to 12 volts. NodeMCU is ideal for building IoT projects as it consists of all the necessary components as described above, and can be programmed via Arduino IDE.

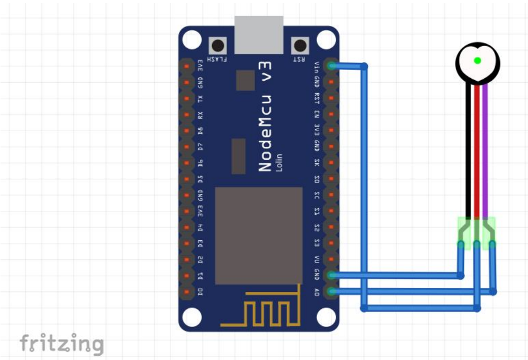

Figure 3: Pulse Sensor connection

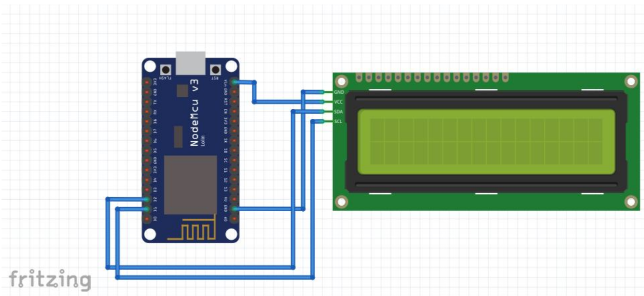

Figure 4: LCD connection

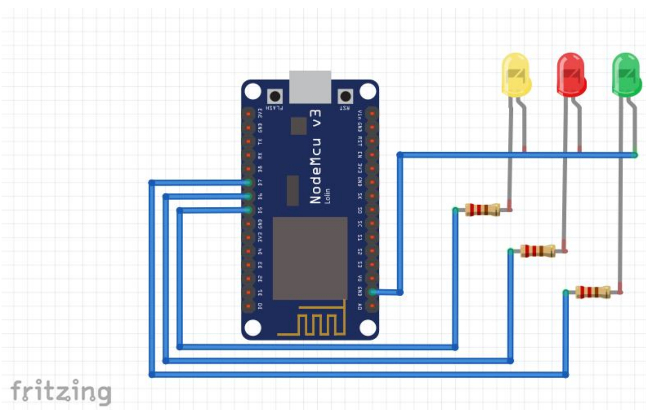

Figure 5: LED connection

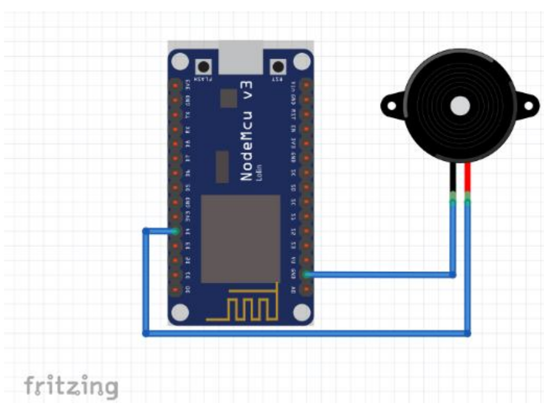

Figure 6: Piezo Buzzer connection

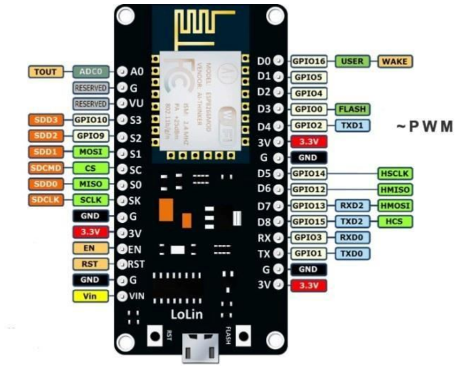

Figure 7: NodeMCU Lua V3 pins assignment

2.3 Software

A. Arduino IDE

Arduino IDE (Integrated Development Environment) is an open-source software based on the C/C++ language. The algorithm for the monitoring system is first coded using this software and then programmed to the compatible microchip. All the measured data collected from the sensors will be processed by NodeMCU and transmitted to Blynk platform.

B. Blynk

Blynk is an open-source IoT platform that enables user to use their portable devices operating on Android and iOS to communicate with microcontroller board such as Arduino, Raspberry Pi and others. Users are able to create an interactive dashboard with widgets, control, and video streaming. In this work, Blynk is used as the platform to monitor the heart rate of patient.

2.4 System Flow Chart

Figure 3 shows a flow chart of the heart rate monitoring system. There are 3 conditions that will differentiate the pulse of the patient. When the data of the patient’s pulse is measured, it starts to compare whether the pulse is below 40 BPM or above than 100 BPM. If the pulse sensor is between 40 BPM to 100 BPM, the green LED will turn ON and the LCD will display “BPM IS NORMAL”. On the Blynk App, it will display the value of the patient’s pulse with the plotted graph. The indicator green light also will turn on to indicate the condition of the patient.

If the pulse measured is beyond 40 BPM to 100 BPM, it will start to compare with below 40 BPM or higher than 100 BPM. If the pulse is below 40 BPM, the yellow LED and the buzzer will turn ON and the LCD will display “BPM IS LOW”. On the Blynk App, it will display the value of the patient’s pulse with the plotted graph. The indicator yellow light also will turn on to indicate the condition of the patient. Lastly, the notification will pop out on the Blynk App to notify as the condition of the patient’s pulse is abnormal.

If the pulse measured is higher than 100 BPM, the red LED and buzzer will turn ON and the LCD will display "BPM IS HIGH". On the Blynk App, it will display the value of the patient's pulse with the plotted graph. The indicator red light also will turn on to indicate the condition of the patient. Lastly, the notification will pop out on the Blynk App to notify as the condition of the patient's pulse is abnormal.

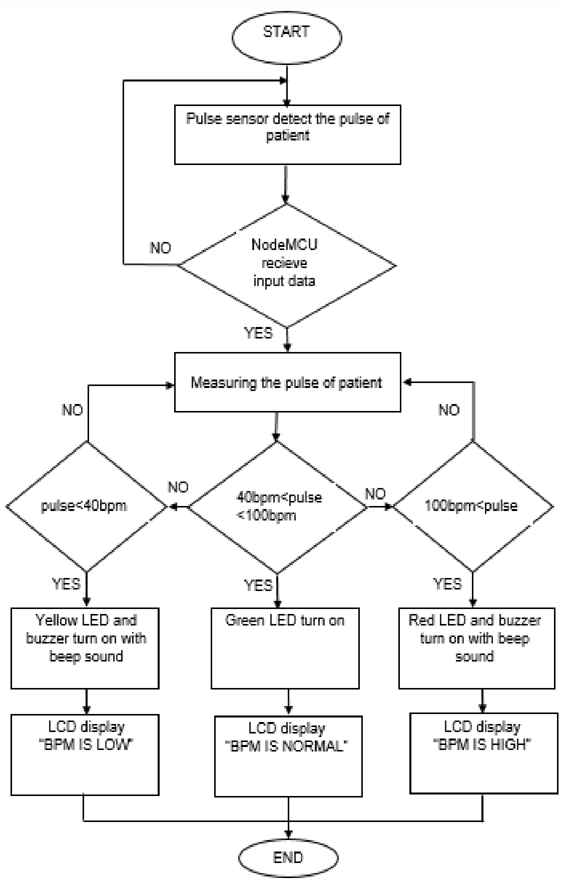

Figure 8: Heart rate system flowchart

3. RESULT AND DISCUSSION

3.1 Testing and Result

The project will be tested on hardware and software to its functionality. The project should display three different conditions which is low, normal and high.

For low condition, the pulse should be below 40 BPM. The alarm and yellow LED should turn on when the low condition is achieved. For the normal condition, the value of the pulse should in between 40 to 100 BPM. The green LED should turn on when this condition is achieved. And lastly, for the high condition, the value of the pulse should be higher than 100 BPM. The alarm and the red LED should turn on when this condition is achieved.

Figure 9: Blynk Application

Figure 10: Control Box

Figure 9 and Figure10 shows the software and hardware are successfully being tested. It can display based on certain condition achieved. If the condition of the person is low or high, the notification message will pop out on the Blynk App as a reminder.

3.2 Data Analysis

15 adult's men is required to undergo 3 events which are sleeping, resting and after they playing a futsal. The heart rate and the calories burned of the samplers is recorded to be analyze. The data collected is to analyze a correlation between the heart rate with the energy used. In statistics, a correlation coefficient is a quantitative assessment that measures the strength of the tendency to vary together. The formulas to calculate the calories burned are shown below.

1. Calories burned while sleeping for 10 minutes (Kcal) = $\frac{0.925 \text{ x Weight in kg}}{60 \text{ minutes x } 10 \text{ minutes}}$

2. Calories burned while resting for 10 minutes (Kcal) = $\frac{(88.362 + (13.397 \text{ x weight in kg}) + (4.799 \text{ x height in cm}) - (5.677 \text{ x age in years}))}{(24 \text{ hours x } 60 \text{ minutes}) \text{ x } 10 \text{ minute}}$

3. Calories burned after playing futsal for 10 minutes (Kcal) = $\frac{[(\text{Age in years x } 0.2017) + (\text{Weight in kg}) \text{ x } (0.09036) + (\text{Heart Rate x } 0.6309) - 55.0969] \text{ x } 10 \text{ minutes}}{4.184}$

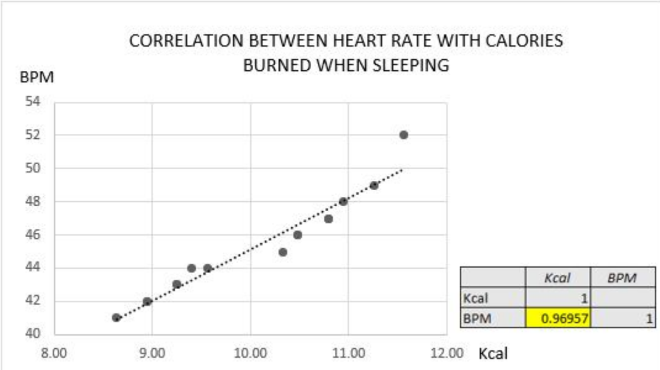

Figure 11: Correlation for First Event

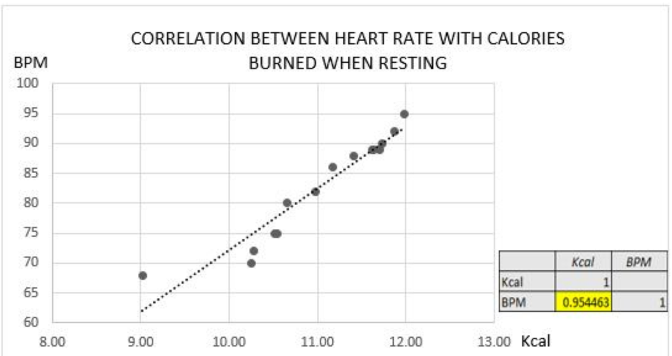

Figure 12: Correlation for Second Event

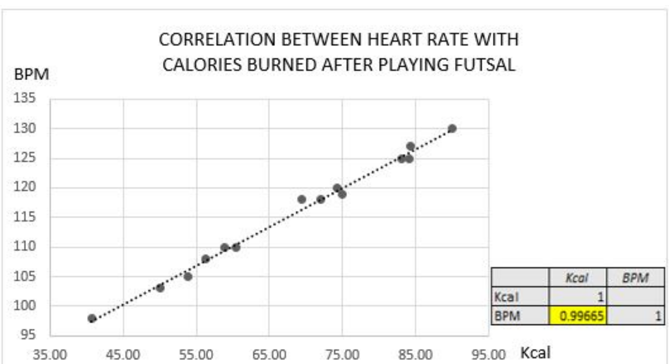

Figure 13: Correlation for Third Event

Based on the correlation graph in Figure 11, Figure 12 and Figure 13, the correlation between heart rate with calories burned is strongly positive. It is proven by the data and the graph that the two variables are associated. This experiment has come out with a statistical hypothesis; the more the calories burned, the higher the heart rate of the normal person.

4. CONCLUSION

Based on the results of project testing and the data analysis, the development of the heart beat detection and monitoring system using IoT is completely functional. The data analysis has proven that the heart rate of the person is rely on their movement of the body and the energy used. So, if the heart rate of the person goes abnormal, the person might be in danger.

The project is successfully can store the heart rate data and can notify the user by notifying with an alert message to smart phone based on the condition of the patient. So, this project can be apply to the real patient in order to overcome the problem that stated in the problem findings. With this project, it could help the doctor to retrieve the patient's heart rate automatically. The project will avoid false recording on the patient's heart rate data if there is a human error when recording the data of the patient manually. The doctors or concerned person also will get an alert of abnormalities of patient's heart rate immediately and the patient could be saved right on time.

4.1 Limitations

One of the limitations on this project is, the result of the data analysis may be not accurate as the samplers of this experiment are only 15 person. The accuracy of the data analysis result varies according to the number of samplers. The more the number of the samplers, the more the accuracy of the data analysis result. In addition, the project only used pulse sensor as a parameter. So, the project can only measure and display the heart rate of the patient. Finally, the project is portable. But, when using 9V battery, the project cannot operate in a long time due to the insufficient power of the battery. However, the project can still operate by using 9Vdc adapter.

4.2 Future Works

This project can be improved in future works. This project used Wi-Fi as it is easier to link between the NodeMCU with Blynk App. Instead of using Wi-Fi, the personal hosting sever is recommended. By hosting a server, the project could integrate with the Bynk Apps without network limitation.

Besides that, the project can be improved by adding the temperature sensor to the project. This project only use pulse sensor to detect the heartbeat of the patient. This is because, the project is focusing on the abnormalities of the heart rate. So, in order to make the project become multipurpose, the other sensor is need. For example, temperature sensor (DHT11). The study and the correlation also can be tested between the temperatures with the heart rate of the patient.

Lastly, the project can stay portable longer by adding another 9V battery with holder. So, if the current battery is low, it can be change to another battery. This will make the project become portable for a long time. However, for this current project, the control box is too small. Only one battery holder can fit in as it cannot be portable for a long time.

4.3 Summary

In conclusion, the concept of the project is relevant to the growth of industrial revolution 4.0. This project would help in medical industries. The problem findings can be solved as this project can contribute its advantages to many people. By commercializing the project to the medical industries, it can help doctor to manage their works well. The patient also can be saved on the right time. However, this project has a lot of room for improvements especially in this time of technological advancement.

REFERENCES

[1] Boyi Xu, Li Da Xu, Honggming Cai, Cheng Xie, Jingyuan Hu, and Fenglin Bu. (2014). Ubiquitous Data Accessing Method in IOT Based Information System for Emergency Medical Scervices. IEEE Transactions on Industrial Informatics, Vol. 10, No. 2. https://doi.org/10.1109/TII.2014.2306382

[2] Cristina Elena Turcua, Cornel Octavian Turcua. (2013). Internet of Things as Key Enabler for Sustainable Healthcare Delivery. Procedia- Social and Behavioral Sciences Vol.73, pp. 251-256.

[3] Deepti Ameta, Kalpana Mudaliar.(2015) Medication Reminder And Healthcare-An Android Application, Ijmpict, Vol. 6, No. 2, pp 67-69.

[4] Eleonara Borgia. (2014).The Internet of Things vision: Key Features, Application and open issues. Communication Computer, Vol.54, pp 131. https://doi.org/10.1016/j.comcom.2014.09.008

[5] Franca Delmastro. (2012). Pervasive Communications in Healthcare. Computer Communications.Vol.35, pp.1284-1295

[6] G. Vijay Kumar, A. Bharadwaja, N. Nikhil Sai. (2017). Temperature and heart beat monitoring system using IOT. International Conference on Trends in Electronics and Informatics (ICEI), pp 692 – 695.

[7] Hao Ran Chi. (2013). The Design of Dual Radio ZigBee Homecare Gateway for Remote Patient Monitoring. IEEE Transactions on Consumer Electronics,Vol. 59, No. 4 https://doi.org/10.1109/TCE.2013.6689686

[8] Hasmah Mansor, Muhammad Helmy Abdul Shukor, Siti Sarah Meskam, Nur Quraisyia Aqilah Mohd Rusli, Nasiha Sakinah Zamery.(2013).Body Temperature Measurement for Remote Health Monitoring System. IEEE International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA).

[9] Jieran Shi, Lize Xiong, Shengxing Li, Hua Tian. (2012). Exploration on intelligent control of the hospital infection the intelligent reminding and admistration of hand hygiene based on the technologies of internet of things. Journal of Translational Medicine.Vol.10. No.2, pp.55.

[10] Kaleem Ullah,Munam Ali Shah,Sijing Zhang.(2016).Effective Ways to Use Internet of Things in the Field of Medical and Smart Health Care:, IEEE Journal 2016.

[11] Karandeep Malhi, Subhas Chandra Mukhopadhyay, Julia Schnepper, Mathias Haefke, and Hartmut Ewald. (2012).A Zigbee-Based Wearable Physiological Parameters Monitoring System.IEEE Sensors Journal, Vol. 12, NO. 3, 423-430.

[12] K.Mathan Kumar, R.S.Venkatesan. (2014).A Design Approach to Smart Health Monitoring Using Android Mobile Devices. IEEE International Conference on Advanced Communication Control and Computing Technologies (ICACCCT). pp 1740-1744. https://doi.org/10.1109/ICACCCT.2014.7019406

[13] Mohammed Riyadh Abdmeziem, Djamel Tandjaoui. (2015). an end-to-end secure key Management protocol for e-health applications. Computers and Electrical Engineering.Vol.44, pp.184-197.

[14] Mohammad S. Jassas, Abdullah A. Qasem, Qusay H. Mahmoud. (2015). A Smart System Connecting e-Health Sensors and the Cloud A Smart System Connecting e-Health Sensors and the Cloud. Conference on Electrical and Computer Engineering Halifax, pp 712-716.

[15] Surya Deekshith Gupta, Vamsikrishna Patchava, Virginia Menezes. (2015).Healthcare Based on Iot Using Raspberry Pi.Green Computing and Internet of Things (Icgciot). https://doi.org/10.1109/ICGCIoT.2015.7380571

[16] Ngo Manh Kohi, Karan Mitra. (2015). An Efficient IoT-Based Remote Health Monitoring System for Smart Regions, 17th International Conference on E-health Networking, Application & Services (HealthCom).

[17] N Pughazendi, R Sathishkumar, S Balaji, S Sathyavenkateshwaren, S Subash Chander, V Surendar. (2017). Heart attack and alcohol detection sensor monitoring in smart transportation system using Internet of Things. International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), pp 881-888.

[18] P.Karthick, C.Sureshkumar, P.Arunprasad, S.Pusparaj, M.Jagadeeshraja, N.Suthanthira Vanitha. (2014). Embedded Based Real-time Patient Monitoring System. International Journal of VLSI and Embedded Systems-IJVES. Vol 05, Article 0223.

[19] S.V.R.K.Rao, M.Saritha Devi, A.R.Kishore, Praveen Kumar (2019). Wireless sensor Network based Industrial Automation using Internet of Things (IoT). International Journal of Advanced Trends in Computer Science and Engineering pp 82-86

[20] Pooja Mittal, Navita (2019). A Survey on Internet of Things (IoT) Based Healthcare Monitoring System. Vol 8, , International Journal of Advanced Trends in Computer Science and Engineering pp 1646-1653 https://doi.org/10.30534/ijatcse/2019/90842019