Real Time Pacemaker Patient Monitoring System Based on Internet of Things

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Abstract. Daily, the Internet of things is becoming increasingly popular in the field of remote monitoring as well as the increasing number of patients with cardiac pacemakers, especially those who need a pacemaker. In this research, a new method of monitoring ECG has been developed for patients who are implanting pacemakers. The system is the ability to transfer the display screen that exist in the special website (www.thinger.io) by using the Wi-Fi protocol, helping them to transmit their data over long distances and different places in real time depending on Internet objects (IoT). The system helps to transfer the ECG, temperature and the detector of magnetic field across the website to solve the problem of the inability of the doctor to monitor the patient from home continuously, as well as in the case of a doctor in another country. In the end of paper the system will be reliable to display ECG data with 70 beats, temperature with 37.12c and warning in the form of light if a magnetic field comes near the system, which can help facilitate patient follow up after implantation of the pacemaker.

Keywords: ECG sensor, internet of things (IoT), magnetic field, pacemaker, website

1. Introduction

Population and medical expenses are increasing, health care has become the issue of the age for every world specialized in the field required, patients' heart pacemaker is increasing and need to follow-up continuous and the lowest possible costs. Because of the large number of patients with pacemakers and the need to follow them continuously, ECG has been applied before implantation and after implantation, the patient is usually associated with 12 electrodes and then combines electrocardiogram which is good in the short term not to enter Hospital for a long period of time, increasing the burden on hospitals. A portable ECG system that helps these patients after implantation of a pacemaker has been discovered and can be returned to his home to follow up with the doctor without going to hospital. Increased development of Internet technologies will allow things to speak about fifty billion devices attached to the cloud of Internet by 2020 [1], which are worn by human sensors that are increasingly focused among others because they help monitor health conditions and vital signs of patients. A product developed existing in the global market for biomarker identification, health monitoring and work body for sports and for medical use; these products are used for long-term patient monitoring, management and real-time transportation. The technique is to collect, analyze and store IoT-based data for review as soon as possible[2,3]. Continuous development of Internet networks provides open source access to a worn ECG system. Through the idea of creating a cloud depend on the Internet of things and use the computerized cloud for the application of health care, for example, an approach to monitor the ECG of a patient and display the signal by smartphones [4]. Sequential monitoring of the patient's ECG is made possible by the use of low-cost devices that help the pacemaker patient in the costs of hospitalization as well as the ability of the doctor to follow him, even
if elsewhere and at any time. The data transmitted for observation can be linked with the patient's companion records and utilized in medical studies and compared with other data to help and provide the doctor with a set of suggestions for diagnosis and treatment [5,6]. Wi-Fi technology has been used to provide higher data rates and broader coverage and availability in many places compared to other technologies such as Bluetooth or Zigbee, the system can transfer data directly via Wi-Fi without the need for a mobile terminal [7].

In this paper, A Simple IoT cloud-based system is proposed, which can monitor wearable in a low-power, rechargeable and light-weight manner using an ECG sensor, temperature sensor, and magnetic field detector to detect ECG signal, heart rate and temperature patient. This is connected to a monitoring system with a low-power, high speed Wi-Fi network that will transmit data directly to the cloud (www.Thinger.Io). Anyone can visit this cloud via any browser on your pc or smartphone [8,9].

2. Structure of the proposed system

The beneficial and variable health effects of a pacemaker patient are studied to help determine whether the patient needs to be examined by a doctor. The sensors are placed on the patient's body and the data is taken from the patient and then filtered and amplified by the microcontroller unit. This data is then transferred via Wi-Fi to the selected browser on the patient's personal computer or smartphone. The follow-up doctor can open this browser at any time in conjunction with the patient to monitor the data. [10] Figure 1 showed the Structure of the proposed system. Patient sensors that help in the proposed system:

2.1. ECG sensor

Using the EC8232 ECG sensor, ECG data is collected from the patient's body, which consists of three colored electrodes. The signal passes through the filtering phase to remove unwanted frequency outside the calculated frequency range of the signal (0.5 Hz and 100 Hz), then amplified by the operational amplifier. Finally, the sensor operates from (0 to 3.3V) taken from the transformer within the system machine [11, 12].

2.2. Temperature sensor

A small apparatus to measure the room temperature or human body temperature with analog output voltage in Celsius (°C) The LM35 sensor transfers its ambient temperature to an analog voltage. The relationship between warming The LM35 transistor and the resulting voltages are linearly proportional [13].

2.3. Heart rate

Taking the measurement of heart rate through the ECG signal and calculate the number of the wave called (R WAVE) per minute and write in the programming code for programming chip used [14].

2.4. Determination of magnetic field (hall effect sensor)

This piece is used to catch the magnetic fields. it designed to make us to know how much voltage is change with the analog output because the current and voltage pass through the sensor in relation to the presence field finally the voltage appears as digital output [15].
Figure 1. Structure of the Proposed System.

3. Design of the device
The idea of the system is to develop a wireless monitoring system. The develop system is the ability to transfer of the display screen that exist in the special web (www.thinger.io) by using the Wi-Fi protocol. Also, using the web (the browser) and open it anywhere possible in the world, all at low cost. This system helps the patient to walk around the house and the doctor in the hospital or any other place or even in another country and continuous monitoring of the patient's pacemaker after implantation of the device is necessary for the heart such as planning, heart rate and body temperature as well as the presence of a magnetic field sensor that affects this patient.

The patient's pacemaker is monitored in real time using an ECG unit with a heart rate measurement taken from the ECG signal, a magnetic field sensor and a temperature sensor. It is easy to create a profile in this website (www.thinger.io) and display the signal in a graph or a digital counter according to the interface used in the display, as well as the ease of linking this website to the console and the controller is linked to a chip to store information for retrieval by a file (Microsoft excel) can show later any time. This system has a number of advantages over wired alternatives, including: ease of use, reduced cost used by the patient and by the manufacturer of the device, reduced patient discomfort, enhanced mobility and complete confidentiality of patient information and other possible features that can be developed by the website.

3.1 Hardware
The ingredients used for the device design are listed below:
1. ESP Wroom 32 a microcontroller: the controller used to control all the processor that need to work in the system.
2. ECG sensor: the EC8232 ECG sensor, ECG data is collected from the patient's body, which consists of three colored electrodes that read the heart single and transfer it to the microcontroller.
3. LM35 sensor: A small apparatus to measure the room temperature or human body temperature with analog output voltage in Celsius (°C) The LM35 sensor transfers its ambient temperature to an analog voltage.
4. Hall Effect Sensor: This sensor is used to detect magnetic fields.
5. Battery 3.7 chargeable: used to gives the power to the system.
6. Step up boost Dc power: used for raising the voltage in the system and when using it the input voltage must be greater than the nominal voltage.
7. System Pc: used to display the screen monitor.
8. Led: used to know if the sensor hall effect is work or not.
9. 3-D Printer: used to design the system in final form.
10. SD-Card module: used to store the data.

3.2 Software
1. Operating system(pc). windows xp,7,8.
2. Autodesk Fusion 360 for design
3. Coding of Microcontroller by using the Arduino language C/C++ functions.
4. The website (www.thinger.io).

3.3 Work Steps
**Step 1:** We draw the electrical circuit using the website (www.circuito.io)
**Step 2:** Before connecting the circuit, the chip (ESP WROOM 32) was programmed and it loads the library of the (Thinger.io) site, as shown in Figure 2 and Figure 3.

![Figure 2. The choose of Thinger library.](image-url)
Step 3: After completing the programming process, the electrical circuit was connected and a box of plastic was designed to hold the circuit using a 3-D printer as shown in Figure 4.

Step 4: A website was opened and a profile was created for the patient's name and a special password given by the site as shown in Figure 5.
Figure 5. The patient profile

Step 5: By starting from the site settings, three points were selected which were the links between the chip code and the site to transmit information via Wi-Fi, as shown in Figure 6.

Figure 6. Three-point links between the site and the controller

Step 6: Finally, from the site three screens display were selected, the first graph to display ECG signal, the second to display temperature and the third to display heart rate, as shown in Figure 7.
Figure 7. The Site three screens display.

Step7: The proposed electrical circuit was designed as shown in Figure 8 with mention of each part.

Figure 8. The proposed electrical circuit for the system.

Step8: By implementing in real design with real volunteer as shown in Figure 9a and Figure 9b.
4. Results and Discussion
a. Monitoring system applied in the website (www.Thinger.io) with observation measurements for a real patient with normal heart condition as shown in Figure 10.
b. By Applying the proposed system on patient with pacemaker condition has a pacemaker as shown in Figure 11.

![Figure 11](image.png)

Figure 11. Monitoring system applied in the website with pacemaker heart condition.

c. The collected results from 10 volunteers for testing the heart rate from the system presented in Table 1.

| Volunteers (NO.) | Heart Rate from proposed system |
|-----------------|---------------------------------|
| 1               | 75                              |
| 2               | 73                              |
| 3               | 83                              |
| 4               | 78                              |
| 5               | 76                              |
| 6               | 80                              |
| 7               | 72                              |
| 8               | 78                              |
| 9               | 73                              |
| 10              | 78                              |

d. Comparisons of the heart rate with the presented heart rate in previous studies with results in the proposed system were investigated by previous relevant studies as shown in Table 2.
Table 2. The Comparisons of heart rate in previous studies with results in the proposed system.

| Research work [16]                        | Research work [17]                        | Proposed system                        |
|-------------------------------------------|-------------------------------------------|----------------------------------------|
| heart rate from IoT Based Advanced Universal Patient Health (UPH) Observation System Using Raspberry Pi 3B | heart rate from Wireless Remote Monitoring System for Patients with Cardiac Pacemakers | Real Time Pacemaker Patient Monitoring System based on Internet of Things |
| 116.4 beat/min                             | 79 beat/min                               | 70 beat/min                            |

e. A piece of magnet was applied to the device, light is on when this piece is rounded as shown in Figure12.

![Figure 12. Apply a piece of magnet to the device.](image)

5. Discussion
This paper presented the design and implementation of the proposed system. The main interface of the website displays the appearance of patient’s reading watch as it shows the real time during which data is sent where it shows the real time. The paper made a comparison between a volunteer who does not implements a peacemaker and someone who implements a peacemaker. The results of the proposed system are presented in terms of monitoring for each sensor, including temperature, ECG, heart rate, and magnetic field sensor work. Then recorded readings for 10 volunteer to show the system if areal reading has, also, take one read to compare with previous studies to demonstrate SMART MONITORING system preference.

6. Conclusion
The patient affects the work of the pacemaker and that helps the patient in his daily life and helps the doctor to know the vital signs of this patient such as ECG, heart rate and temperature are measured using the remote control patient monitoring system Real-time transmission of this information does not require the patient to go to the hospital and may reduce the costs and momentum of the hospitals. These
measurements are transmitted via Wi-Fi to access the patient's browser and the patient can give this browser to the doctor or even a relative to continue. This project is characterized by light weight, ease of use and low cost as well as satisfactory results were obtained for the accuracy of the signal and acceptable heart rate and moderate temperature and sensitive operation that detects the magnetic field and in the end can be obtained by any patient and can be used by any type of patients who need these vital signs to follow their health remotely.

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