IoT: Heart Rate Monitoring Tool Using Android with Alert Messanger Telegram System

Yuhefizar¹, Anggara Nasution², Roni Putra³, Ervan Asri⁴, Deni Satria⁵
¹Information Technology Department, Politeknik Negeri Padang

*yuhefizar@pnp.ac.id

Abstract. Patients with symptoms of arrhythmias must live a healthy lifestyle and routinely conduct consultations and control the heart rate with the doctor. The most important of these is an integrated health monitoring tool. In this study a portable heart rate monitoring tool is proposed for patients at risk of low-cost IoT-based alert systems using a telegram messager. The ESP8266 Wifi module functions for communication to the web server gateway and pulse sensor to detect heart rates that converted to Bits per Minute (BPM). The heart rate data is then stored in the database server using TCP / IP communication — heartbeat information in realtime with Android display. The system alert will send to the doctor/health worker and family if the heart rate is below 60 BPM and above 100 BPM, the time required for sending system alerts with a telegram messager is around 6 to 7 seconds. Test results show an average error of the heart rate measurement of 4.75% and the entire system is running well. With this tool the patient is at risk of being able to work more safely, and the doctor and family are easier to supervise the patient.

Keywords: IoT, Heart rate, Monitoring, WiFi ESP8266, Pulse sensor, Android, Smartphone, Telegram

1. Introduction

The heart is one of the core organs in the human body, working on a continuous and never stopping mechanism, commonly referred to as heart rate. Normal heart rate in adults ranges from 60 to 100 times per minute [1]. If the heart is not functioning or not operating properly, of course, human life will be disrupted and can even be fatal such as death. Heart disease can occur due to various factors, such as genetic factors and lifestyle patterns. Some heart diseases that have been known by the public are coronary heart disease, heart failure, heart valve abnormalities, and arrhythmias. Arrhythmia is a disorder of the heart rhythm outside the normal sinus rhythm [2]. In Indonesia heart disease reaches 26.4 percent [3]. Arrhythmia is a heart disorder that is characterized by abnormal beats or rhythms, which can be too fast, too slow, or irregular. An arrhythmia occurs when electrical impulses do not function. Symptoms include slow or fast heartbeat, palpitations in the chest, chest pain, shortness of breath, dizziness, if no medical action takes quickly it can cause death. Patients with symptoms of arrhythmia must live a healthy lifestyle and routinely conduct consultations and control heart rate with a doctor/health professional [4]. The development of information technology today marked by the presence of the Internet of Things (IoT). IoT is an internet service that integrated with the use of certain types of sensors [5] - [7]. IoT is now widely used for agriculture [8] - [10], smart city management [11] - [13] and manufacture [14] - [15].

In the health sector IoT is used for monitoring the health condition of patients [16] - [18]. In his research David L et al. measured the patient's heart rate using an infrared sensor and photodiode, the patient's heart rate data is then sent to a smartphone using Bluetooth communication if the patient's heartbeat is abnormal the patient's smartphone will call the doctor or family of the patient who determined. The limited Bluetooth communication distance which is only 10 meters becomes an obstacle besides emergency telephone calls are also limited [19]. Using Bluetooth heart rate module to detect heart rate Muhammad Farouq et al. developed a cellular application for heart patients. This android-based application has a feature to detect heart rate and SMS notifications and the position of the patient if the heart rate is not normal. Limited Bluetooth communication distance is also an
obstacle in this study [20]. G.Vijay et al. also developed a monitoring tool for heart rate and blood pressure and body temperature. The data is then saved to the database and displayed on the website. Patient data can be seen by doctors at any time. Data communication using Bluetooth with a limited distance, there are no notifications such as panic buttons, SMS, and E-mail if the patient is in an emergency [21].

Using wireless communication Andrej Škraba et al. [22] developed a prototype tool for heart rate monitoring groups. All patient data for heart rate monitoring groups are displayed on one page using a web browser. There are no notifications such as panic buttons, SMS or e-mail if the patient is in an emergency. They are utilizing the Node-Red cloud application via the MQTT Puneet et al. protocol [23] measuring the heart rate of patients using the PPG technique by implementing an infrared sensor. Patients' heart rate data is saved to the database and displayed on the android application; they also add the feature of the nearest hospital address and distance to the patient. Data communication is still using cable, so it requires infrastructure costs, besides SMS and e-mail notifications are only sent to only one person / certain if the patient is in a dangerous situation. In this paper we develop a heart rate monitoring system for patients at risk based on wireless. This system uses an android application for monitoring the patient's heart rate. For notifications if the patient's condition is abnormal, we use the Telegram messenger application, besides this tool is also equipped with a panic button if the patient is in an emergency condition. With this tool the patient is at risk of being able to work more safely, and the doctor and family are easier to supervise the patient.

2. Methodology

The system block diagram can see in Figure 1, where the system divided into two parts: the first is a heart rate detector and the second is the heart rate monitoring application. The hardware consists of a heart rate sensor, LCD and esp8266 wifi module. Data from the pulse sensor is processed by the 8266 nodemcu microcontroller; then the data is sent to the database with the HTTP protocol. The database used by the Firebase Realtime Database hosted on the cloud. Data is stored as JSON and synchronized in realtime to each connected client. When creating cross-platform applications with the Android SDK, iOS, and JavaScript, all clients will share a Realtime Database instance and receive the latest data updates automatically.

![Figure 1. Block diagram of the system](image-url)

The electronic circuit of the device can see in Figure 2. This tool uses a pulse sensor to detect the patient's heartbeat. Pulse sensors work by utilizing light. When these sensors placed on the surface of the skin, most of the light is absorbed or reflected by organs and tissues (skin, bones, muscles, blood), but some light will pass through body tissues if they are thin enough. If the amount of light intensity that hits the pulse sensor still eats the signal value will be around 512 (the middle value of the 10-bit
ADC range). The greater the light intensity, the higher the ADC value. The signal generated by the sensor produces waves called a photoplethysmogram (PPG) shown in Figure 2. PPG in the medical world is used to measure respiratory rate and heart rate. Pulse sensors have three pins that used differently. Pin 1 used as a data pin connected to pin A0 on the microcontroller. When the heart pumps blood throughout the body, each pulse that occurs accompanied by the emergence of pulse waves such as shock waves that propagate through the arteries to the capillary layer of the hands (fingers) where the pulse sensor installed. The speed of blood flowing slower than pulse waves. Determination of the number of heartbeats per minute (BPM = beat per minute) with this sensor done by dividing 60000 (in milliseconds) the average value of ten IBI (interbeat interval) that passed. IBI is the time difference between a point and a point

Next, the point value is 50% of the P (peak) value minus T (valley) when the graph has risen sharply

![Figure 2](image-url). (a) Pulse sensor, and (b) Hardware design

The heart rate information stored in the database then displayed on the android application on the smartphone. The application will also display the patient's medical history, doctor's data, and patient's family mobile number. The application system flowchart can see in Figure 3 (a). The alert system will function if it is smaller than 60 BPM and greater than 100 BPM, then the SMS will be sent to the doctor. Likewise if the patient presses a panic button, then the system alert will be active, and an SMS will also be sent to the patient's family, as shown in figure 3 (b).

![Figure 3](image-url). (a) Flowchart system, and (b) The flowchart of Alert system
The process starts from the initiation of UART, SSID and password, pulse sensor and LCD. Heart rate would appear on the LCD if it connected to the network. Furthermore, the patient's heart rate data is sent to the database server to be stored using the TCP / IP protocol. Then the system will check, if the panic button (PB) = ‘1’ then the buzzer will sound and information sent to the database server.

3. Result and Discussion

To observe system performance, several tests performed in each part of the whole system. Pulse sensor testing with ESP8266 Wi-Fi module and system alert testing.

A. Pulse Sensor Testing and Applications for Heartbeat Detection

This test aims to measure the accuracy of the sensor and heart rate information displayed on the smartphone application and observe how accurate the measurement of the human heart rate by comparing the measurement results of the pulse sensor with an oximeter. An oximeter is a device used to measure heart rate (HR = heart rate) and used for premature babies or patients in special conditions. In this experiment, measurements made by placing a pulse sensor on the fingertips of adult human hands, as shown in Figure 4. The test results can see in table 1.

![Pulse sensor testing with ESP8266 Wi-Fi module](Figure 4)

| Testing (person number) | Age (Year) | Measurement using Pulse Oximeter (BPM) | Measurement using Pulse Sensor on LCD (BPM) | Error (%) |
|-------------------------|------------|---------------------------------------|------------------------------------------|-----------|
| 1                       | 18         | 76                                    | 79                                       | 3.94      |
| 2                       | 21         | 65                                    | 70                                       | 7.69      |
| 3                       | 24         | 69                                    | 72                                       | 4.34      |
| 4                       | 25         | 70                                    | 73                                       | 4.28      |
| 5                       | 30         | 76                                    | 80                                       | 5.26      |
| 6                       | 33         | 72                                    | 75                                       | 4.16      |
| 7                       | 35         | 79                                    | 83                                       | 5.06      |
| 8                       | 42         | 80                                    | 83                                       | 3.75      |
| 9                       | 46         | 77                                    | 81                                       | 5.19      |
| 10                      | 54         | 79                                    | 82                                       | 3.79      |

| Average Measurement Error | 4.750 |

Pulse sensors can measure and detect heart rates, which displayed on the LCD with an average error of 4.750% as seen in table 1. In the heart rate monitoring application, the patient's heart category marked with color. Yellow level indicates the patient's heart rate below 60 BPM, categorized as a patient suffering from bradycardia. Red level if above 100 BPM categorized as tachycardia. While the green level indicates the normal patient's heart rate is in the range of 60 / minute - 100 / minute. The
test is carried out to compare the patient's heart category, as shown in Figure 5. The test results show
the monitoring application can display the results of the pulse sensor reading placed on the human
finger.

**B. Testing Alert System Using Telegram Messenger**

Making a Telegram Bot requires bot registration by a BotFather account for the bot name and
obtaining an API key. The API key used for every API request to the server telegram. Server bot
applications are built using the PHP programming language and MySQL database. Communication
from Telegram server to bot server utilizes webhook with https protocol. The activating system alerts
on this system if the heart rate is below 60 BPM and above 100 BPM is counted ten times; then the
system will send a message to the telegram messager application. The test results can see in Figure 6.
The time required for sending system alerts is about 6 to 7 seconds based on testing from table 2.

| Trial | Telegram Notification | Time (seconds) |
|-------|-----------------------|----------------|
| 1     | exist                 | 5              |
| 2     | exist                 | 6              |
| 3     | exist                 | 5              |
| 4     | exist                 | 5              |
| 5     | exist                 | 7              |
| 6     | exist                 | 9              |
| 7     | exist                 | 10             |
| 8     | exist                 | 6              |
| 9     | exist                 | 5              |
| 10    | exist                | 8              |

**4. Conclusion**

In this study, we implemented an IoT-based heart rate monitoring system with WiFi
communication using the ESP8266 wifi module. Heart rate values can display on the LCD and
smartphone applications in realtime. Patients and doctors can see heart rate information at any time.
Telegram messager alert system will be active if the heart rate is below 60 BPM and above 100 BPM,
and there is an emphasis on the panic button.

**References**

[1] I. B. A. Menown et al., “Resting heart rate and outcomes in patients with cardiovascular
disease: Where do we currently stand?” Cardiovasc. Ther., vol. 31, no. 4, pp. 215–223, 2013.
[2] R. Weber, D. Stambach, and E. Jaeggi, “Diagnosis and management of common fetal
arrhythmias,” J. Saudi Hear. Assoc., vol. 23, no. 2, pp. 61–66, 2011.
[3] https://ugm.ac.id/id/berita/13416-kematian-akibat-kardiovaskuler-masih-tinggi
[4] Yoga Yuniadi, “Mengatasi Aritmia, Mencegah Kematian Mendadak.” eJKI Vol. 5, No. 3,
December 2017
[5] S. H. Shah, “A Survey : Internet of Things ( IoT ) Technologies, Applications, and Challenges,”
2016 IEEE Smart Energy Grid Eng., vol. 1, pp. 381–385, 2020.
[6] X. L.D., H. W., and L. S., “Internet of things in industries: A survey,” IEEE Trans. Ind.
Informatics, vol. 10, no. 4, pp. 2233–2243, 2014.
[7] P. V. Paul and R. Saraswathi, “The Internet of Things - A comprehensive survey,” 6th Int. Conf.
Comput. Power, Energy, Inf. Commun. ICCPEIC, 2017, vol. 2018–Janua, pp. 421–426, 2018.
[8] J. Bauer and N. Aschenbruck, “Design and implementation of an agricultural monitoring system
for smart farming.” 2018 IoT Vert. Top. Summit Agric. - Tuscany, IOT Tuscany 2018, pp. 1–6, 2018

[9] “IoT-based Intelligent Irrigation Management and Monitoring System using Arduino,” TELKOMNIKA (Telecommunication Comput. Electron. Control.), vol. 17, no. 5, pp. 2378–2388, 2019.

[10] S. R. Prathibha, A. Hongal, and M. P. Jyothi, “IOT Based Monitoring System in Smart Agriculture,” Proc. - 2017 Int. Conf. Recent Adv. Electron. Commun. Technol. ICRAECT, 2017, pp. 81–84, 2017.

[11] L. B. Campos, C. E. Cugnasca, A. R. Hirakawa, and J. S. C. Martini, “Towards an IoT-based system for Smart City,” Proc. Int. Symp. Consum. Electron. ISCE, pp. 129–130, 2016.

[12] M. Rosmiati, M. F. Rizal, F. Susanti, and G. F. Alfisyahrin, “Air pollution monitoring system using LoRa module as transceiver system,” TELKOMNIKA (Telecommunication Comput. Electron. Control.), vol. 17, no. 2, p. 586, 2019.

[13] R. H. Putra, F. T. Kusuma, T. N. Damayanti, and D. N. Ramadan, “IoT: smart garbage monitoring using android and real-time database,” TELKOMNIKA (Telecommunication Comput. Electron. Control.), vol. 17, no. 3, p. 1483, 2019.

[14] H. P. Breivold and K. Sandstrom, “Internet of Things for Industrial Automation-Challenges and Technical Solutions,” Proc. - 2015 IEEE Int. Conf. Data Sci. Data-Intensive Syst. 8th IEEE Int. Conf. Cyber, Phys. Soc. Comput. 11th IEEE Int. Conf. Green Comput. Commun. 8th IEEE Inte, pp. 532–539, 2015.

[15] A. Caputo, G. Marzi, and M. M. Pellegrini, “The Internet of Things in manufacturing innovation processes,” Bus. Process Manag. J. vol. 22, no. 2, pp. 383–402, 2016.

[16] S. B. Baker, W. Xiang, and I. Atkinson, “Internet of Things for Smart Healthcare: Technologies, Challenges, and Opportunities,” IEEE Access, vol. 5, no. c. Pp. 26521–26544, 2017.

[17] P. Gupta, D. Agrawal, J. Chhabra, and P. K. Dhir, “IoT based smart healthcare kit,” 2016 Int. Conf. Comput. Tech. Inf. Commun. Technol. ICCTICT 2016 - Proc., pp. 237–242, 2016.

[18] V. Vippalapalli and S. Ananthula, “Internet of things (IoT) based smart health care system,” Int. Conf. Signal Process. Commun. Power Embed. Syst. SCOPES 2016 - Proc., pp. 1229–1233, 2017.

[19] David L Larkai, Ruiheng Wu, "Wireless Heart Rate Monitor in Personal Emergency Response System," IEEE 18th International Symposium on Design and Diagnostics of Electronic Circuits & Systems 2015

[20] Muhammad Farouq Bin Mustapha, Toni Anwar, "Mobile Heart Rate Monitor for Myocardial Infarction Patients," IEEE 6th ICT International Student Project Conference (ICT-ISPC) 2017

[21] G.Vijay Kumar, A.Bharadwaja, N.Nikhil Sai, "Temperature and Heart Beat Monitoring System Using IOT," International Conference on Trends in Electronics and Informatics ICEI 2017.

[22] A. Škraba, A. Koložvari, D. Kofjač, R. Stojanović, V. Stanovov, and E. Semenkin, “Prototype of group heart rate monitoring with NODEMCU ESP8266,” 2017 6th Mediterr. Conf. Embed. Comput. MECO 2017 - Incl. ECYPS, 2017; Proc., no. June 2017.

[23] P. Bansal, M. Malik, and R. Kundu, “Smart heart rate monitoring system,” 2018 IEEMA Eng. Infin. Conf. eTechNxT 2018, pp. 1–4, 2018.