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A Comparison Between Two Sensor Devices for Measuring Heart Rate Using IOT

Mahmoud H. Hasan
Alasmarya Islamic University,
Zliten – Libya
tea_mhs@asmarya.edu.ly

Hadya S. Hawedi
Alasmarya Islamic University,
Zliten – Libya

Eenas M. Huwaydi
Alasmarya Islamic University,
Zliten – Libya

Abstract— **Heart health has become a critical issue in our modern world. The elevated risk of heart disease is an important problem for every person. The Internet of Things is among the most innovative new technologies to appear in recent years. An example of such a development is the heart rate monitor. In this paper, we propose a remote heart rate monitoring system based on Internet of Things technology to facilitate communication between the doctor and the patient. This system is designed using electronic sensors (Pulse Sensor, Easy Pulse Sensor V1.1) that measure the heart rate and then send it to the NodeMcu board, which in turn sends the data to the Firebase database, where an Android application was created and designed using the Android Studio program, which uses the Java programming language to receive data from the database in real time. We tested the system and compared it with both sensors, revealing that the Easy Pulse V1.1 sensor outperforms the pulse sensor in terms of accuracy.**

Index Terms— **NodeMcu, easy pulse sensor, Firebase, real-time heart rate monitor.**

I. INTRODUCTION

The human cardiovascular system correlates with heart rate, a crucial health metric. The Internet has ingrained itself into our daily lives. Those who utilize it have seen changes in their lives. Most people use the internet for education, among other purposes. Through its connections to the Internet, the Internet of Things is able to control items. For the purpose of continually monitoring a patient's pulse rate, a pulse monitoring system is required. This pulse rate monitoring system's primary benefit is that the data is accessible from anywhere at any time. Physicians can receive text messages on their phones alerting them when a patient's condition deteriorates. The health sensor's sensors include heartbeat sensors. The health sensor is able to analyze the signal and determine if it is in excellent shape or not [1].

One of the most vital organs in the human body is the heart. It maintains the body's functionality by acting as a pump to distribute blood and oxygen throughout the body. A heartbeat is the heart's two-part pumping activity that lasts for nearly a second. Cardiac contraction generates this rhythm. The American Heart Association (AHA) states that the heart rate is a crucial, critical indicator that reflects the heart's efficiency. The AHA defines heart rate as the "frequency of cardiac contractions per minute" and highlights its importance in evaluating cardiovascular well-being and levels of physical effort. In order to determine heart rate, it is customary to locate the pulse at several areas of the body, such as the wrist (radial artery) or neck (carotid artery), then tally the number of beats within a designated time period, typically one minute. Medical experts extensively utilize and endorse this approach [2].

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II. RELATED WORK

In the intensive care unit (ICU), patient health monitoring requires periodic checks of vital signs. In [1], the authors proposed a continuous patient monitoring system. Where the cloud contains data on health parameters (thinkspeak), Thinkspeak receives temperature sensor data over a nodemcu connection, fetches it, and then sends it to the Blynk app, enabling clinicians to periodically view patient data. The doctor must install a cloud program on their phone to easily check the incoming data. Abdullah 2019 developed a system that utilizes a simple pulse sensor in [3]. The system measures heart rate and transfers the data to the NodeMcu board, which then uses the internet to send the data to the desired location. The heartbeat's fundamental functions This design used the photoplethysmography (PPG) concept to collect vital heartbeat data from the skin's surface. He used two approaches to compute the heart rate: first, he tracked the peaks in the PPG waveform, and second, he calculated the frequency of the digital output waveform, which we calculated simultaneously with the heart rate pulse. The initial findings indicate that the new system produces good and optimal outcomes, is more dependable, and is less expensive than other IOT microcontroller-based systems.

A NodeMCU ESP8266-based heart rate monitoring device has been developed in [4]. where heart rate is determined via a pulse sensor. Following this, a WiFi network connection will transmit and display heart rate data from the monitoring results on the smartphone.

The authors present a project in [5]. that describes the design of an affordable, Bluetooth-enabled wrist-worn heart rate monitor. The Android software, the Bluetooth module, and the heart rate module are some of the components that make up the overall system. Using a noninvasive method called photoplethysmography, the Heart Rate (HR) module measures the subjects' (patients') heart rates and uses a Bluetooth module to wirelessly transmit the signals to a computer or Android application. It is possible to accept and integrate this technology into the telemedicine component. We can access and save the heart rate module's data for later medical use. A variety of clinical studies can apply the results of this gadget prototype, as the Bluetooth signal can travel up to 20 meters in radius.

The results showed that the heartbeat rate was low if it was between 40 and 60, medium if it was between 60 and 100, and high if it was between 100 and 150.

III. THE PROPOSED SYSTEM

The Internet of Things-based heart rate monitoring system is an innovative solution in healthcare because it relies on Internet of Things technologies and takes advantage of NodeMCU's capabilities to connect devices. In the proposed system, a heart rate sensor is placed on the patient's finger. The sensor reads pulse signals, converts them into digital data, and sends it to the NodeMCU board. The NodeMCU then receives this data and transmits it to the Firebase platform, which houses a database for data storage. An Android Studio-designed Android application allows the doctor to access this data on an Internet-connected mobile phone. This system allows effective and immediate monitoring of heart rate without the need to be near the patient. Fig. 1 shows the general diagram of the system.

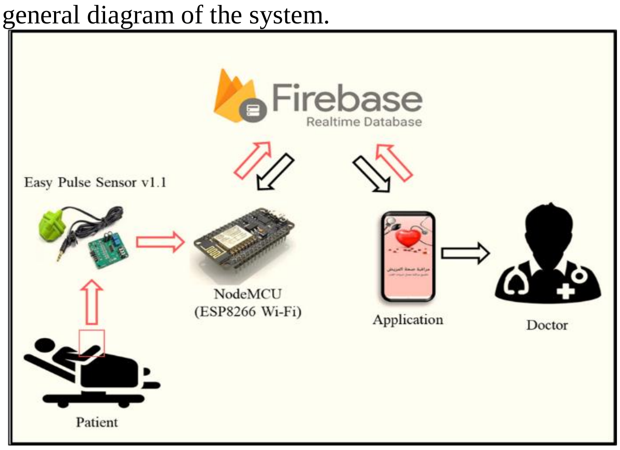

Figure 1. General diagram of the proposed system

A. *NodeMCU*

The ESP8266 microcontroller chip, a highly integrated Wi-Fi-enabled system-on-a-chip (SoC), serves as the foundation for the NodeMCU board. The ESP8266 chip provides Wi-Fi connectivity, General Purpose Input/Output (GPIO) pins for interfacing with external devices, and a powerful microcontroller unit. In additional Specifically, the NodeMCU board serves as a development platform for the ESP8266 chip. It integrates the ESP8266 chip with additional components, such as a USB-to-serial converter, voltage regulator, and flash memory. These components enhance the functionality and ease of use of the NodeMCU board. The NodeMCU board offers various features that make it suitable for IoT development, such as Wi-Fi connectivity. The ESP8266 chip on the NodeMCU board provides Wi-Fi connectivity, allowing devices to connect to wireless networks and the internet. where as The NodeMCU board incorporates a micro USB port that allows for easy power supply and programming. You can power it directly via USB and program the ESP8266 Core for Arduino using the Arduino IDE and a USB cable. As depicted in Fig. 2, the NodeMCU board included an integrated ESP8266 chip.

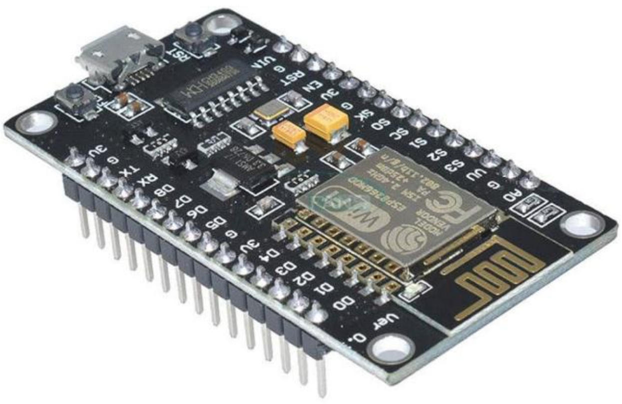

Figure 2. NodeMCU board included an integrated ESP8266 chip.

B. *Pulse Sensor*

"The number of times the heart contracts or expands in a minute is indicated by the heartbeat, which is measured in beats per minute, or bpm [6]".
Open-source software is available for this non-invasive heart rate monitor, which falls under the category of photoplethysmography (PPG) devices [5]. It measures heartbeats in real time and computes bpm using Arduino-developed methods. The typical operating voltage and current are +3.3V or +5V and 4mA, respectively. The sensor has two sides: circuitry that amplifies signals and filters out noise is located on one side, which has an LED and an ambient light sensor. The pulse sensor is depicted in Fig. 3.

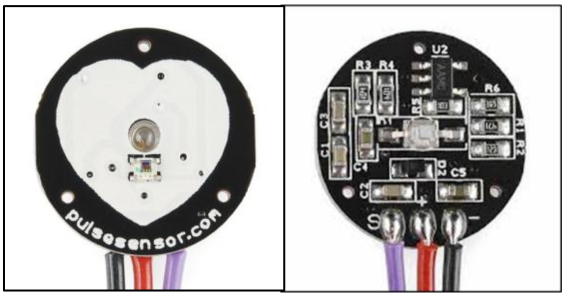

Figure 3. Tow sides for the pulse rate sensor.

C. *Easy Pulse Sensor (Version 1.1)*

For recreational and educational purposes, the Easy Pulse sensor serves as an example of PPG, a non-invasive optical method that detects the heartbeat from the fingertips. An infrared light source illuminates one side of the finger, while a photodetector on the opposite side detects slight fluctuations in the transmitted light intensity. There is a correlation between changes in blood volume inside the tissue and fluctuations in the photodetector output. We filter and amplify the signal to create a crisp, clean PPG waveform in rhythm with the heartbeat. The first iteration of Easy Pulse senses blood variations in finger tissue using the TCRT1000 reflecting optical sensor and generates a digital pulse that beats in time with the heart. Easy Pulse Version 1.1 introduces several improvements over the initial design. The updated version offers both the digital pulse signal and the analog PPG waveform as distinct outputs. Fig. 4 shows Easy Pulse version 1.1 and how to install it with a finger [7].

D. *Firebase Realtime Database*

Utilize a NoSQL cloud database to store and sync data. Every client syncs data in real time, so even if your app is offline, it will still be accessible. The Firebase Realtime Database is a cloud-hosted database. We synchronize data in real time with all connected clients, storing it as JSON. With our JavaScript, Android, and Apple platform SDKs, we can create cross-platform apps that sync all of your clients' data seamlessly and share a single real-time database instance [8].

We designed the patient information table using the Firebase database, as shown in Fig. 5 We store patient data such as age, registration date, disease diagnosis, patient gender, heart rate, name, personal phone, and the heart rate sensor's reading time.

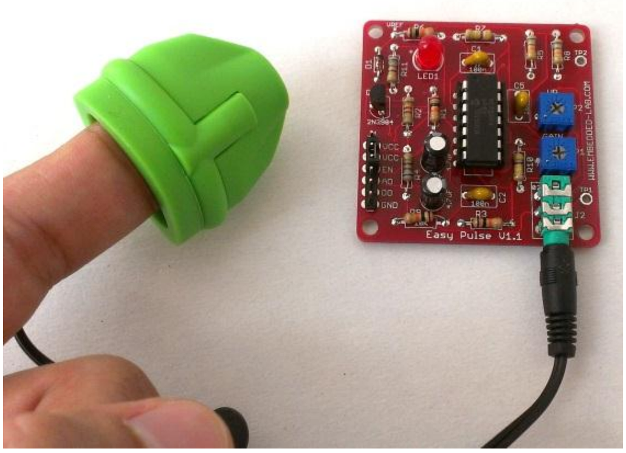

Figure 4. Easy Pulse version 1.1 and how to install it with a finger.

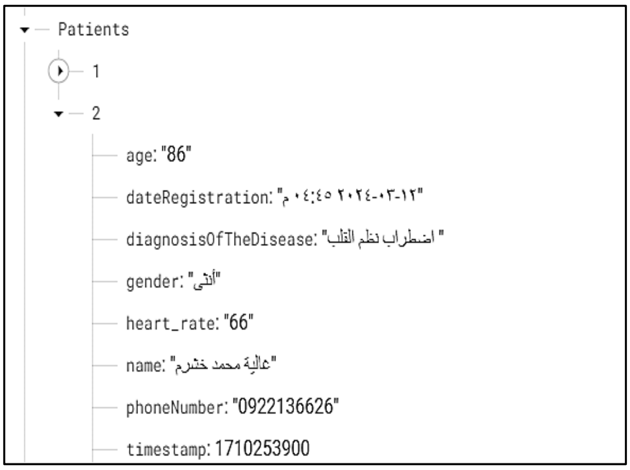

Figure 5. Data table of patient designed on the Firebase platform

E. *Android Studio IDE*

Specifically designed for developing Android applications, Android Studio is an integrated development environment (IDE). It provides a comprehensive set of tools and features to streamline the app development process.

Android Studio is the official IDE for Android development, developed and maintained by Google. It offers a rich set of tools and resources that aid developers in designing, coding, testing, and debugging Android applications. Android Studio has a powerful code editor with features like syntax highlighting, code completion, code refactoring, and more. It supports multiple programming languages, including Java and Kotlin. It includes a visual layout editor that allows developers to design the user interface (UI) of their app by drag-and-drop. Developers can preview how the UI will look on different devices and screen sizes. Android Studio uses the Gradle build system, which simplifies dependency management and builds automation. It helps manage libraries, resources, and other dependencies required for the app. The IDE includes an Android emulator that allows developers to test their apps on virtual devices with different configurations and Android versions. It helps ensure app compatibility across various devices. Android Studio provides powerful debugging and profiling tools for identifying and fixing issues in the app.

Developers can track performance, memory usage, and network activity to optimize their app's performance. Android Studio seamlessly integrates with various Google services, such as Firebase, the Google Cloud Platform, and the Google Play Store. This integration facilitates tasks like analytics, cloud storage, authentication, and app distribution [9].

To support the latest Android SDKs and frameworks, Android Studio regularly updates with new features and improvements.

IV. RESULTS AND DISCUSSIONS

We conducted a study to determine the efficiency of the proposed system. We conducted a comparison between the heart pulse reading we obtained from the traditional heart pulse measuring device and the reading we obtained using the Easy Pulse Sensor and Easy Pulse Sensor v1.1 for twelve cases.

Fig. 6 and Fig. 7 show the proposed system implementation using Easy Pulse Sensor v1.1 and Easy Pulse Sensor, respectively.

Table I shows the comparison between a traditional heart pulse device and an easy pulse sensor v1.1, whereas the result of the calculations of the error rate for these readings, the error ratio for the pulse sensor v1.1 is 1.28. Table II shows the comparison between a traditional heart pulse device and an easy pulse sensor, whereas the result of the calculations of the error rate for these readings, the error ratio for the easy pulse sensor is 7.85.

When applying the proposed system and comparing the results obtained from two sensors to the results obtained from the traditional heart pulse measurement device, we found that the Easy Pulse sensor v1.1 was more precise than the Easy Pulse sensor, where the error ratio was 1.75 and 7.85, respectively.

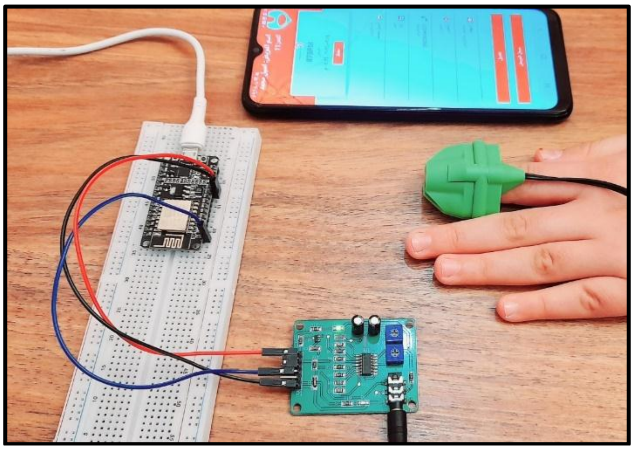

Figure 6. System implementation using Easy Pulse Sensor v1.1

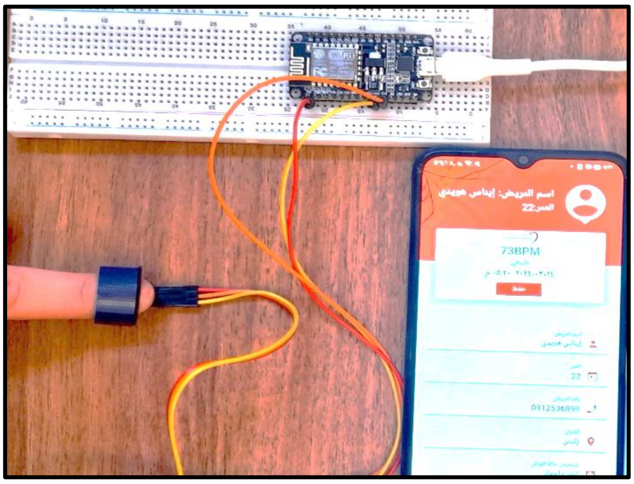

Figure 7. Implementation of the system using the pulse sensor.

Fig. 8 shows the patient's heart rate readings using the Easy Pulse Sensor V1.1 device, which displays the heart rate values and the measurement time for each value for approximately 12 hours. We designed a graph for the Android application that illustrates the relationship between heart rate values and time. We have programmed the system to monitor your heart rate approximately every half hour.

Fig. 9 shows the patient's heart rate readings using the Easy Pulse Sensor device, which displays the heart rate values and the measurement time for each value for approximately 12 hours. We designed a graph for the Android application that illustrates the relationship between heart rate values and time. We have programmed the system to monitor your heart rate approximately every half hour.

These charts allow the doctor to monitor the patient's condition remotely by saving the values in the Firebase database and showing them when needed.

TABLE I. COMPARISON BETWEEN THE TRADITIONAL HEART RATE DEVICE AND THE EASY PULSE SENSOR VERSION 1.1

No	Age	Gender	Traditional heart (BPM) pulse measuring device	Easy Pulse sensor v1.1	Error ratio
1	11	Female	92	91	1.09%
2	22	Female	84	84	0%
3	14	Male	87	85	2.29%
4	48	Female	78	76	2.56%
5	20	Male	88	88	0%
6	86	Female	67	65	2.98%
7	54	Male	84	83	1.19%
8	23	Female	85	85	0%
9	19	Female	87	88	1.14%
10	4	Male	98	95	3.06%
11	7	Male	94	95	1.06%
12	10	Male	90	90	0%
Average error ratio					**1.28**

TABLE II. COMPARISON BETWEEN THE TRADITIONAL HEART RATE DEVICE AND HEART RATE PULSE SENSOR

No	Age	Gender	Traditional heart (BPM) pulse measuring device	Pulse Sensor	Error ratio
1	11	Female	92	89	3.26%
2	22	Female	84	82	2.38%
3	14	Male	87	95	9.19%
4	48	Female	78	72	7.69%
5	20	Male	88	86	2.27%
6	86	Female	67	59	11.94%
7	54	Male	84	84	0%
8	23	Female	85	90	5.88%
9	19	Female	87	84	3.44%
10	4	Male	98	124	26.53%
11	7	Male	94	107	13.82%
12	10	Male	90	97	7.77%
Average error ratio					**7.85**

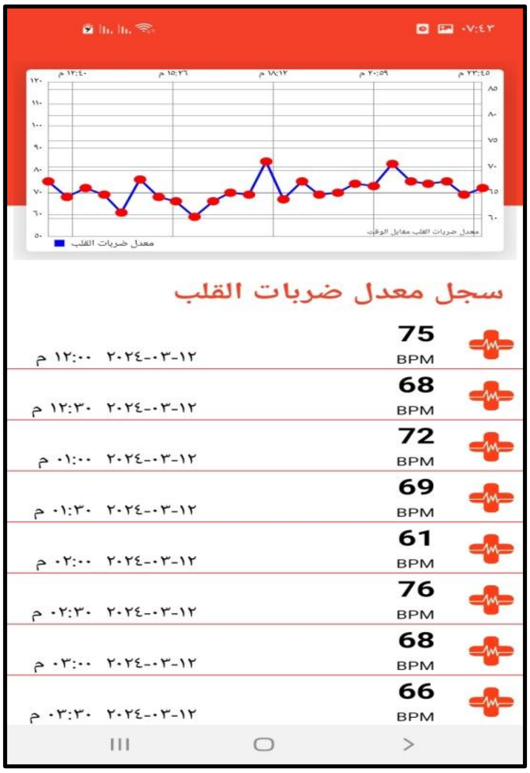

Figure 8. Patient's heart rate graph using heart rate pulse sensor

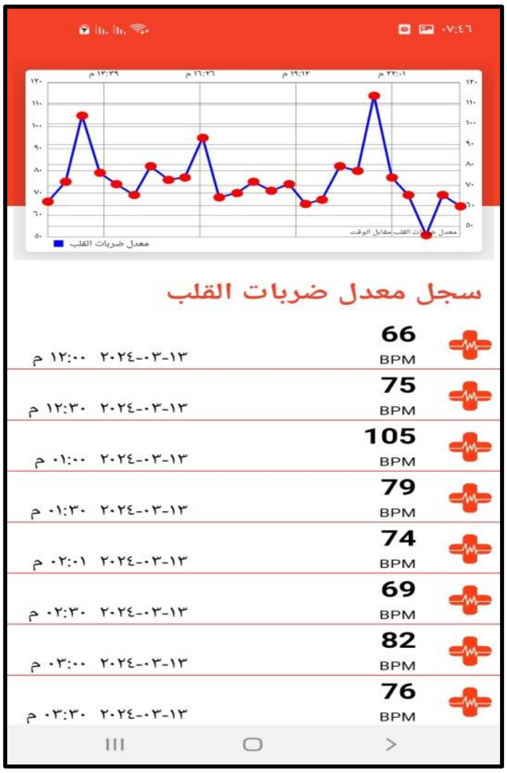

Figure 9. Patient's heart rate graph using Easy Pulse Sensor version 1.1

V. CONCLUSION

The monitoring system allows for constant observation of the patients. We can use the Firebase database to store the health parameter data in real time. Many industries stand to benefit from the Internet of Things, or IoT, but the healthcare industry stands to gain the most. In this paper, we calculated the error rates and accuracy of all simulation cases, as shown in Table I and Table II, and found that the Easy Pulse Sensor V1.1 has high accuracy and is closer to the real values than the Pulse Sensor, where the error ratio was 1.75. We recommend using it for remote patient care, particularly when patients require 24-hour heart rate monitoring.

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