MongoDB Based Real-Time Monitoring Heart Rate Using Websocket For Remote Healthcare

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ARTICLE INFO

Article history:

Received October 17, 2022
Revised November 07, 2022
Published December 21, 2022

Keywords:

Internet of Things (IoT);
Heart rate sensor;
Arduino;
NodeMCU;
WebSocket

ABSTRACT

With the gradual development of Industry 4.0, the internet of things (IoT) concept has become an even more current and fundamental study topic. Consisting of devices and objects with communication capability, IoT is a network that uses internet infrastructure, especially for data collection, display, decision-making, control, and optimization of processes. Recently, patient tracking systems have become even more critical with Covid19 and have diversified in health for IoT topics such as biomedical device tracking and disease diagnosis. Within the scope of this study, a prototype of a patient tracking system was developed over the sensor in order to contribute to the biomedical field. We aimed to observe real-time heart rates using WebSockets to demonstrate its use in the medical field via the web application. Monitoring the heart rate using a WebSocket can help doctors make faster and better diagnoses. The current technology study instantly collected the patient's heart rhythm with the pulse sensor. The pulse data collected in real time was then transferred to a web platform with the NodeMCU ESP 8266 board. With this platform, the patient was monitoring in real-time. With the opportunities provided by the study, the doctor implemented an application monitors the instantaneous pulse of the patients.

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1. INTRODUCTION

Biosensor wearable systems for monitoring health data have aroused great interest in scientific research subjects and the industry in the past. With the help of these systems, which aim to reduce the costs of health services and make life easier, the health sector will be able to improve itself [1]–[7]. This improved care will mean better quality of life for individuals. However, the technological developments of wireless communication and the rapid increase in microelectronic outcomes have led to the advancement of wearable sensor-based systems [8]. When IoT-based studies are examined, Ani et al. [9] presented a patient monitoring system for paralyzed patients for IoT-based real-time diagnosis and prediction of disease. The study, which used various classification algorithms to evaluate the critical moments of the patients, reached an accuracy of 93%. Rajanna et al. [10] have performed a real-time measurement of HRV so that doctors can assess a person's physiological state to determine the heart's health and functioning. HRV monitoring systems, IoT-based computational frameworks play a vital role in early detection, prediction and heart disease management [11], [12]. Bhardwaj et al. [13] developed an intelligent health monitoring system for remote monitoring between patients and doctors in health due to the restrictions brought by social distance and quarantine with the Covid-19 pandemic. They benefited from IoT technology by monitoring their blood pressure, heart rate, and temperature. Goel et al. [14] developed a heart rate monitoring system, which plays a vital role in the prevention and diagnosis of diseases, as a technological innovation in medical science. Over IoT, the patient's heart rate data is collected through the fingerprint sensor, and this data is transferred to local and global servers and displayed over Thingspeak. Mihat et al. [15] presented an IoT-based intelligent health monitoring system by applying Android applications and the Arduino microcontroller. The implemented system has proven that the sensor data is transmitted in real-time to the host computer and the system reading is approximately 100% accurate for real devices. Magsi et al. [16] proposed a new adaptive battery-sensitive model for data transmission in IoT-based healthcare applications. The recommended model recovers 50% more charge and has a longer battery life than conventional.

Chaudhary et al. [17] proposed a block cipher technique for secure data transmission from IoT devices so that specialists can store patient data in the health cloud and access it whenever they want. This proposed technique is based on simple operations such as swap XORing division. Bhansali et al. [18] designed an advanced IoT-based real-time monitoring and patient control system for heart patients. The experimental findings obtained from the realized prototype have proven to be reliable. The device can detect and read the user's pulse and transmit the detected data over the internet. The medical industry can use the system to help physicians seamlessly conduct their research effectively and reliably. Arbi et al. [19] developed a smartphone app with AppInventor, offering a new way to realize a lightweight, microliter-accurate, and wirelessly controlled syringe pump. They aimed to solve the health care problem through many network communication protocols through mobile-based solutions. Çoban et al. [20] developed a system and algorithm for exercise planning. Ongoing transactions can be simultaneously stored on the ThingSpeak Cloud Platform over the wireless network and monitored on a linear graph. Tebe et al. [21] presented a 5G network slicing-based mobile hospital system for medical data with eMBB (Advanced mobile network) and urLLC (Very low latency data communication) slices. The system can be used effectively to monitor the health status of patients in real-time as mobile hospital systems. Reddy et al. [22] implemented an IoT-based and interactive healthcare system. The system, which aims to provide expertise in real-time medical diagnosis and support patients without healthcare professionals, worked with 90% accuracy. Ray et al. [23] described how Blockchain and IoT technologies could be used to improve e-health systems and services. Machine learning techniques, especially repetitive neural networks and long-term memory models, can be shown as a predictor of basic time-series EHR (electronic health record) data. On the other hand, this article presents a system architecture that is easy to install, expandable, and open to development. The implemented system proposes an IoT-based advanced patient monitoring and control system using the pulse sensor. The system offers an approach to monitoring and regulating heart rates using a versatile, reliable, and comfortable sensor network and IoT technology.

The contributions of this paper are as follows; develop a real-time observing heart rate using websockets to demonstrate its use in the medical field; monitoring the heart rate using websocket notifying the doctors via web application. The rest of the paper is organized as follows. In Section 2 explains in detail the materials used in the study and the communication technologies used in web applications. Section 3 implemented the patient monitoring system to realize an example of the proposed IoT-based system. Finally, Section 4 discusses and interprets the results of the study.

2. MATERIALS AND METHOD

This section talks about the current tools and technologies used in the study. The technologies used and the necessary installations are explained. NodeMCU Esp8266 for working IoT-based heart rate measurement systems includes temperature, humidity, and heart rate sensors. The system's block diagram is given in Fig. 1

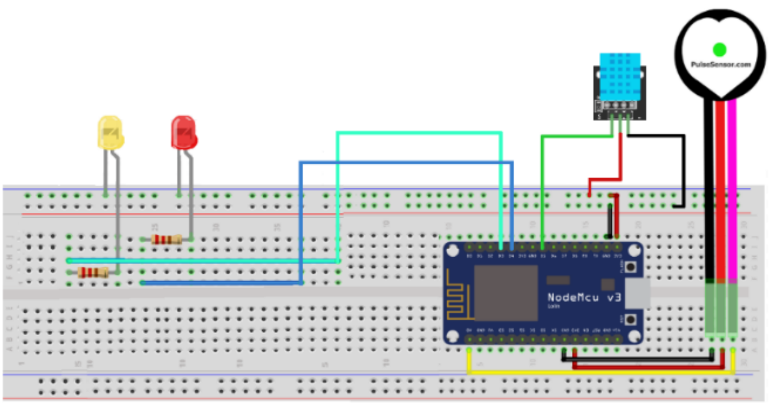

Fig. 1. Block diagram of the proposed system

There are two LEDs, two resistors, DHT11 temperature-humidity element, and one pulse sensor on the circuit. The working codes of the circuit are deployed on the NodeMCU Esp8266 development board. This way, NodeMCU Esp8266 sends the requested information to the web application via the serial port.

2.1. NodeMCU Esp8266 Wifi Module

NodeMCU Esp8266 is an open-source, programmable module with an integrated wifi card to develop IoT projects [24]. The NodeMCU development kit pin structure is shown in Fig. 2 When looking at Arduino cards, adding an extra wifi module is necessary to connect to the internet [25], [26]. In contrast, NodeMCU cards can easily connect to the internet.

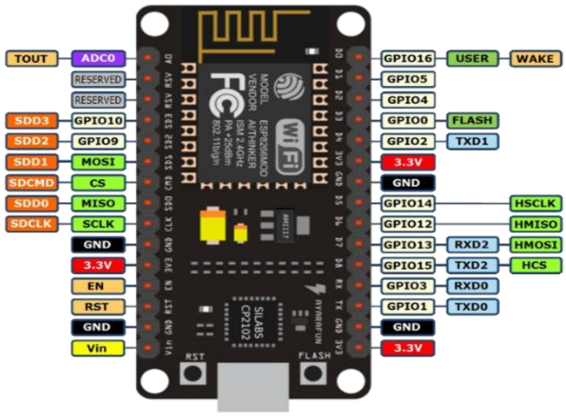

Fig. 2. NodeMcu ESP8266 development card

In this way, NodeMCU easily transfers data to the internet in many IoT projects [27]. Thanks to its open-source code and development kit, it allows the creation of IoT projects using a few lines of Lua code [28]. Although Lua script is used as the programming language, it can also be programmed with the language used by Arduino IDE and Arduino [29].

2.2. DHT11 Temperature and Humidity Sensor

DHT11 is an integrated module with a DHT11 sensor, making it easier for breadboard or different uses. As shown in Fig. 3 the DHT11 temperature and humidity sensor is an advanced sensor unit that gives calibrated digital signal output [30]. In addition, DHT11 contains an 8-bit microprocessor, which offers fast and high-quality responses. The data is received via the serial port with the DHT11 temperature and humidity sensor and graphed in real-time to display the ambient temperature and humidity. Table 1 shows the temperature and humidity sensor pin configuration of DHT11 [31].

Table 1. DHT11 temperature and humidity sensor pin configuration and its description

Pin No	Pin Name	Description
1	Ground	The system is grounded here.
2	VCC	It is connected to a supply voltage of 5V / 3.3V.
3	Signal	It signals for temperature and humidity with serial data.

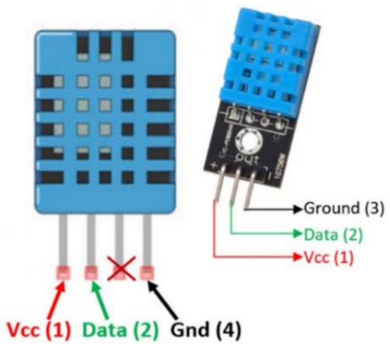

Fig. 3. DHT-11 temperature and humidity sensor view

2.3. Heart Rate Sensor

In this study, the pulse sensor given in Fig. 4 was used while sending and receiving data for the pulse signals to be communicated via the serial port. With the heart rate sensor, biometric heart rate can be easily measured. In addition to being a plug-and-play type sensor, the operating voltage of the sensor can be + 5v or + 3.3v [32]. This means that the sensor is suitable for use with NodeMCU cards [33]. The current consumption is 4mA, and the sensor includes internal amplification and noise-canceling circuitry.

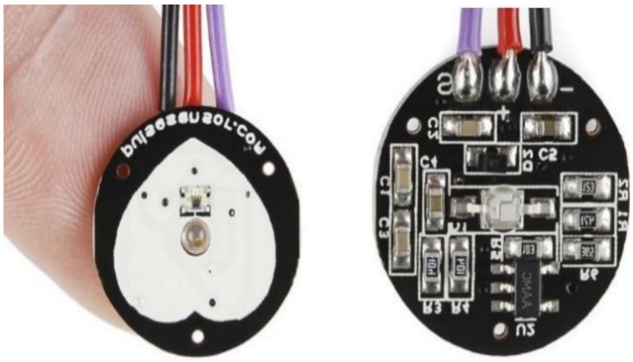

Fig. 4. Top view of the heart rate sensor

2.4. Web Applications Communication Architecture

Client-server architecture runs web applications between the server and the client. According to the types of sent and received requests, two types of communication can be mentioned.

2.4.1. Synchronous Communication

While synchronous, only one transaction is made in the same period [34]–[37]. The request sent from the web browser to the remote web server is processed on the webserver and returned to the web browser the way it came back. Of course, this process takes some time. While the synchronization is running, no other request can be sent during this time period. The synchronous operation can work well, especially if the webserver is on the same computer or on a nearby LAN [8]–[10]. However, it performs poorly if the webserver is under a heavy load or if the web browser interacts with the web server over a slow connection. During this period, the user cannot cancel the sent request. Therefore, he cannot click on another spot on the web page or switch to another tab. As seen in Fig. 5 request number one from the web browser is transmitted to the webserver. After the received request is processed, it is sent back to the web browser. Furthermore, there is no other request during this period.

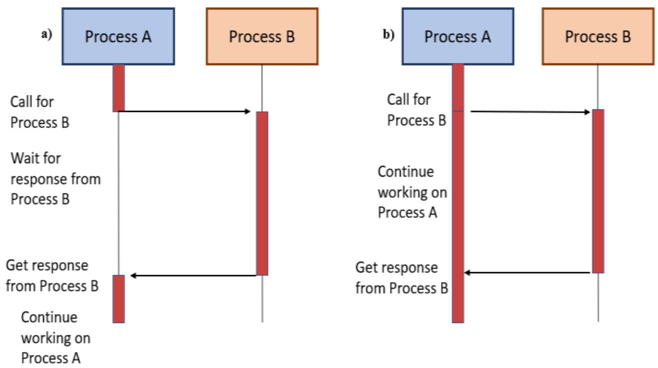

Fig. 5. Communication standarts a) Synchronous Processing, b) Asynchronous Processing

2.4.2. Asynchronous Communication

While the system is working asynchronously, more than one operation can be performed in the same period. For example, when users fill out a form on the web page, they do not have to wait for the process to finish while the information in the form is sent via AJAX [34]. Users can answer the survey in another part of the web page at the same time. Because the JavaScript engine, which is blocked while running synchronously, is free when running asynchronously [38]. This allows other requests to be sent. It accepts multiple requests in the same time frame.

3. AN IMPLEMENTATION OF THE IOT-BASED MONITORING SYSTEM

The data from the heart rate sensor is received on the server-side with the “connectOn” method by creating a socket called “message” in the NodeJS environment. This data (message) is retrieved on the client-side, and at the same time, the data is saved by making a MongoDB connection. Modern application developers and cloud computing were significantly considered when developing MongoDB, a document-based, distributed database. Since there are no predefined data structures for collections in MongoDB, data is stored in binary JSON format [39]. In this way, the effective display of data in real-time is provided in the project. However, a web interface has also been developed to display this "message" data [40].

The web interface generally consists of a user login panel (Fig. 6), register panel, and pages showing sensor data. Firstly, each user has a role, such as a doctor or patient. The user data in the login panel is checked and verified in the database and assigned to one of these two roles. Then, if the user is a doctor, he is listed so that he can watch the instant report of his patients. However, if the user is in the patient role, he sees an interface where he can only see his data. In the definitions in the study, user information is saved in the MongoDB 'users' collection. After these saved data, user data can be directed directly to the login panel with the Post method. In this way, user identification is possible. After logging in, the user is directed to the homepage. Here real-time monitoring of the activities of the sensors is provided (Fig. 7). The task of the transmitter card in the system is to transfer the data coming from the user interface program with the help of the serial port of the computer. This data is saved in the predefined MongoDB 'sensorData' collection.

Fig. 6. Developed login panel interface

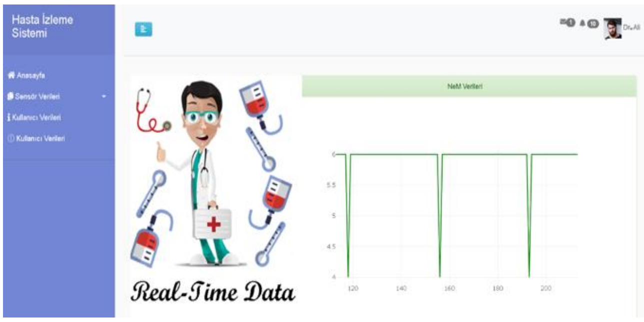

Fig. 7. Web interface of the patient monitoring system

This study prefers MongoDB for storing sensor and user data. In order to run MongoDB, it is necessary to go to the folder where MongoDB is installed and run the “mongo” command first and then the MongoDB command in a different command window. MongoDB usually listens on port 27017, and necessary commands must be executed to use this port. If these operations are not done, MongoDB will not work. Robo 3T was used in the development phase of this study to manage MongoDB since it would be difficult to manipulate the data with queries from the console (cmd) screen and take much time. Data stored in MongoDB is stored as objects in JSON format. Fig. 8 gives the code definitions for storing the sensor data in string format. As can be easily seen, there are various fields such as humidity, temperature, pulse rate, and date; therefore, the variables are stored in MongoDB. Thanks to these data, the web interface can easily control the sensor data.

```
var mongoose = require('mongoose');
mongoose.connect('mongodb://localhost/veri');

var Schema = mongoose.Schema;

var Veri= new Schema({
    nem:  String,
    sicaklik: String,
    pulse: String,
    body:   String,
    date: { type: Date,default: Date.now }
},{collection:'sensorVerileri'});

var Veriler = mongoose.model('veri', Veri);
```

Fig. 8. Sensor data collection definition in Nodejs

3.1. Developed Patient Monitoring System

A web interface has been developed to fetch data containing user information and display captured sensor data. This web interface generally has a user login panel, registration panel, and pages showing sensor data. The general internal structure of the implemented application was drawn, and simulations were carried out using Proteus ISIS programs. In the implementation phase of the project, the data coming from the heart rate sensor is created by creating a "socket" in the NodeJS environment, receiving this data on the server-side and pulling this data on the client-side, and saving the data by making a MongoDB connection at the same time. In this way, the data is effectively displayed in real-time in the project Fig. 9.

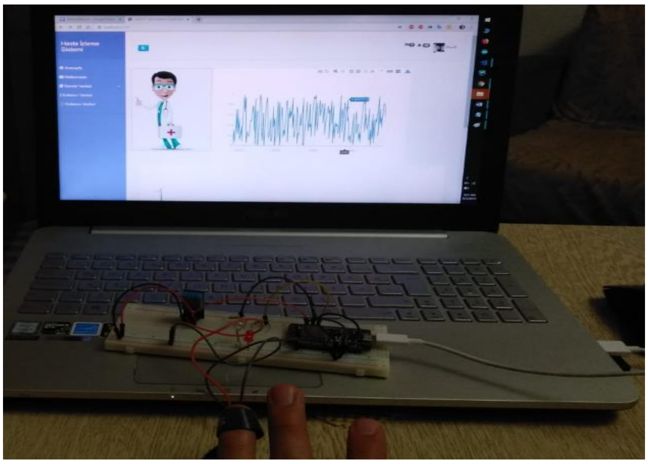

Fig. 9. Real-time accession of patient's heart rate data.

4. RESULTS AND DISCUSSION

Hospitalization of people with busy life pace forces them to stay away from their loved ones. This problem becomes fundamental for the elderly, babies, companions, and people who need constant care. Our goal monitor heart rate in real time using WebSockets to demonstrate its use in the medical field via the web application. Monitoring heart rate using a WebSocket can help doctors make faster and better diagnoses. Considering the cases in the health field, most of these people do not need to be hospitalized, but their possible conditions should be observed. In addition, considering the ever-increasing health care costs, it can be said that it will require simultaneous monitoring of individuals' health data and potentially change the future of health care.

This study presents a prototype of a patient tracking system developed over the sensor to contribute to the biomedical field. The study used various current technologies to aim for personal health services' efficiency, reliability, and safety. The circuit consists of two LEDs, two resistors, a temperature-humidity element Dht11 and a pulse sensor. The working codes of the circuit are implemented on the NodeMCU Esp8266 development board. In this way, NodeMCU Esp8266 sends the requested information to the web application via the serial interface. In this context, an application has been implemented that allows sensor data to be received via the serial port and displayed on the web interface.

The pulse data collected in real-time was then transferred to an interface on the web with the NodeMCU ESP 8266 board. NodeJS language was preferred, and Robo3T was used in the web application design. Charts and graphs were displayed in the web application, allowing authorized persons to follow this data. MongoDB database was used to store the data. Patients have fields that contain their health data and detailed records of this data. All these benefits make our system effective and efficient for following real-time patient tracking.

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