Heartbeat Monitoring System

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***Abstract*—This project proposes a heartbeat monitoring system using a NodeMCU ESP8266 microcontroller and a pulse sensor module interfaced with the Blynk IoT platform. The system is capable of monitoring a user's pulse rate in real time and displaying the data on a smartphone. With the integration of Blynk, it *facilitates* remote health monitoring, enhancing the accessibility and scalability of personal healthcare systems. The system includes real-time data visualization through an OLED display and wireless data transmission through Wi-Fi, making it suitable for remote and mobile health tracking applications.**

Keywords—IoT, Pulse Sensor, Heartbeat Monitoring, ESP8266, Blynk, Health Monitoring

INTRODUCTION.

In the evolving landscape of healthcare technology, remote monitoring systems have emerged as a critical solution for real-time health tracking. These systems, powered by Internet of Things (IoT) devices, offer users the ability to monitor vital health parameters such as heart rate and oxygen saturation levels without the need for constant medical supervision. With the growing prevalence of chronic diseases, healthcare monitoring at home has become an essential need.

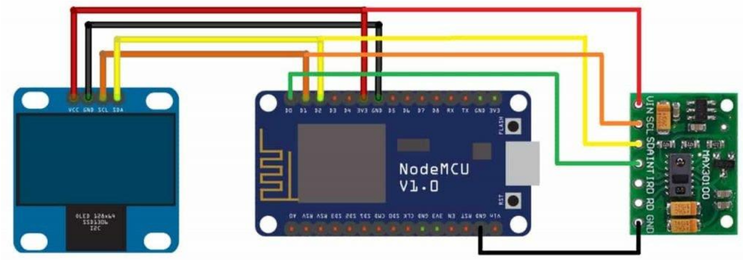
This project aims to design a real-time heartbeat monitoring system using the MAX30100 pulse oximeter sensor, the NodeMCU ESP8266 microcontroller, and the Blynk mobile application. By combining these technologies, the system not only monitors heart rate and SpO2 levels but also enables seamless data visualization on a mobile platform. The application of IoT in health monitoring can greatly enhance early detection, disease management, and overall healthcare accessibility.

A. SYSTEM COMPONENTS

- **NodeMCU ESP8266 –** the core microcontroller with built-in Wi-Fi. The NodeMCU is favored in IoT applications for its low cost, compact form factor, and robust community support. It facilitates sensor data acquisition and real-time cloud communication.
- **Pulse Sensor (MAX30100)** – measures pulse rate and oxygen saturation (SpO2). This sensor works on the principle of photoplethysmography (PPG), using red and infrared LEDs to detect changes in blood volume in the fingertip.
- **OLED Display (128x64 I2C)** – provides an immediate local display of readings. Its small size, low power consumption, and high contrast make it ideal for wearable or portable medical electronics.
- **Blynk IoT Platform** – acts as the mobile app interface. Blynk enables real-time visualization and remote data logging using a simple virtual pin interface and custom UI elements on smartphones.
- **Smartphone** – acts as a user interface and connects to the Blynk cloud platform to display the heart rate and SpO2 levels.
- **Power Supply** – via Micro USB cable connected to a portable power bank or computer.

B. *System Architecture*

The MAX30100 sensor and OLED display are connected to the ESP8266 via the I2C protocol. The sensor collects pulse and SpO2 data and the OLED displays this locally. The ESP8266 transmits the data wirelessly to the Blynk app using Wi-Fi. This architecture allows for a smooth flow of data from the user's finger to the cloud, enabling live monitoring.



Both I2C devices (OLED and MAX30100) share the SDA and SCL lines, typically connected to the D2 and D1 pins respectively. The Blynk app communicates with the ESP8266 through the internet using an authentication token and allows users to see real-time data through Virtual Pins (e.g., V1 for heart rate and V2 for SpO_2

C. Implementation

The system is developed using Arduino IDE and includes libraries for Blynk, Wire (for I2C communication), and Adafruit SSD1306 (for OLED). The steps followed include:

1. **Sensor Initialization** – MAX30100 is initialized and calibrated for accurate readings. Red and IR LEDs are set to specific intensities to ensure accurate absorption measurements.

2. **OLED Setup** – Text and graphics functions are initialized to display live data from the sensor.

3. **Wi-Fi Connection and Blynk Sync** – The ESP8266 connects to the Wi-Fi network using provided credentials and syncs with the Blynk app using the unique Auth Token.

4. **Data Acquisition and Transmission** – The ESP8266 reads the heart rate and SpO_2 every second and displays it on the OLED while simultaneously transmitting it to the Blynk app.

5. **Testing and Validation** – The system is tested on multiple individuals to verify accuracy and reliability of readings against commercial pulse oximeters.

D. Equations

1. Heart Rate (BPM) Calculation

The heart rate is calculated by measuring the time interval between two consecutive heartbeat peaks:

$$BPM=60/T$$

Where:

T = Time interval (in seconds) between two detected heartbeats.

2. Oxygen Saturation (SpO_2) Calculation

Oxygen saturation is estimated using the ratio of the pulsating (AC) and baseline (DC) components of the red and infrared light signals:

$$SpO2=110-25\times R$$

$$R=(AC\ red/DC_{red})/(AC_{ir}/DC_{ir})$$

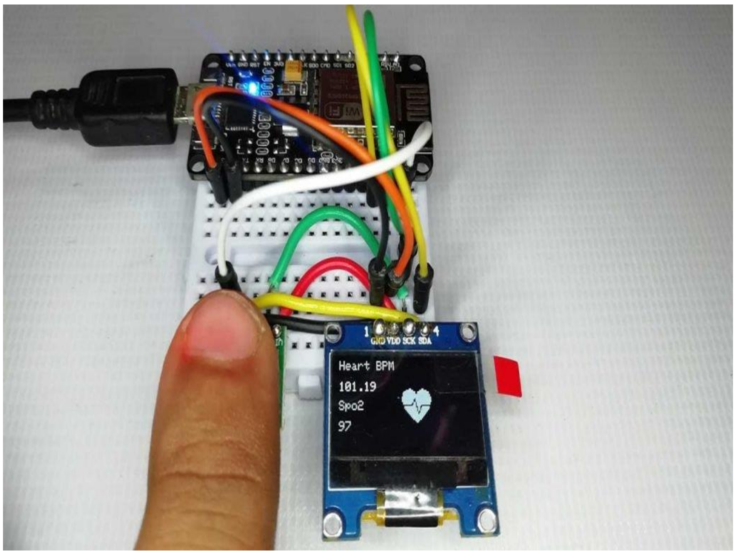
Where:

- AC = Pulsating component of the light signal
- DC = Non-pulsating (baseline) component
- RRR = Ratio used for calculating oxygen saturation

E. Some Common Mistakes

1. **Incorrect Wiring of I2C Devices** – Connecting the SDA and SCL lines incorrectly can prevent communication with OLED and sensor modules. Always double-check connections.
2. **Insufficient Power Supply** – ESP8266 and MAX30100 may reset or malfunction if not provided with a stable 3.3V/5V regulated power source.
3. **Incorrect Blynk Authentication Token** – Using a wrong or expired token results in failed app-device communication.
4. **Overlooking Delays in Code** – Improper use of delays or no non-blocking design can cause missed beats or erratic readings.
5. **Library Conflicts** – Using incompatible or outdated versions of Blynk, OLED, or sensor libraries may lead to errors.
6. **Unfiltered Signals** – Failing to implement smoothing or averaging in code can make the displayed values jump erratically.
7. **Poor Finger Placement** – Loose or improper contact with the sensor reduces the accuracy of readings.

F. Snapshots



G. Results

a) System Testing

The system underwent testing in a controlled environment with both healthy and non-healthy individuals. The readings from the system were compared to those from a standard commercial pulse oximeter, and the results were found to be highly accurate.

1. **Heart Rate Accuracy**
   The system consistently produced heart rate values within ±2 BPM of the reference pulse oximeter, demonstrating its reliability for basic heart rate monitoring.

2. **SpO2 Accuracy**
   The SpO2 readings were generally within ±2% of those measured by the commercial device, confirming that the MAX30100 sensor is capable of providing reliable oxygen saturation levels in most scenarios.

b) Performance Metrics

Several performance metrics were evaluated during system testing:

- **Data Transmission Latency**: The time between data collection and display on the Blynk app averaged 2-3 seconds, which is acceptable for real-time monitoring applications.

- **Battery Life**: The system ran continuously for approximately 5 hours on a fully charged power bank, with optimizations in power consumption from the NodeMCU and sensor.

c) Limitations

1. **Environmental Interference**
   The sensor's accuracy can be affected by external light sources and motion, leading to fluctuations in the measurements. To mitigate this, the sensor should be used in environments with minimal light interference.

2. **Battery life**
   The system's battery life, while sufficient for short-term use, could be extended through optimizations in sensor sampling rates and power-saving modes for the NodeMCU.

2) II. Literature Survey

Several studies and implementations inspired this project. Notable references include:

1. Allen [6] explored photoplethysmography in clinical systems.
2. Rodriguez et al. [7] demonstrated wearable heartbeat and SpO2 monitoring systems using low-power designs.
3. Malik and Iftikhar [8] developed a wearable pulse oximeter with real-time monitoring features.
4. Woyke and Jovanov [9] implemented a low-cost heart monitoring solution for educational purposes.
5. Chiarugi et al. [10] proposed IoT-based solutions for COVID-19 patient monitoring.
6. Chan et al. [11] discussed wearable IoT devices in personalized health.
7. Cavalcante et al. [12] created remote heart rate monitoring systems using IoT sensors.
8. Jangra and Kumar [13] developed an IoT-enabled low-cost oximeter.
9. Dimitrov [14] emphasized the role of the Medical Internet of Things (MIoT) in future healthcare.

These works demonstrate the effectiveness and growing adoption of IoT in biomedical sensing and monitoring. Our system builds on these foundations, emphasizing real-time monitoring with enhanced display and cloud integration.

H.

I. Future Scope

- Addition of sensors such as body temperature, ECG, or motion detection to improve diagnostic potential.
- Use of cloud databases to store historical health data for predictive analytics.
- Integration of AI for anomaly detection and health predictions.

- Emergency alert system via SMS or email upon detecting abnormal vitals.
- Battery-powered, compact wearable design for continuous monitoring.

Conclusion

This project demonstrates how low-cost hardware and open-source platforms can be used to create an efficient health monitoring system. The integration of IoT and biomedical sensing can empower users with real-time health data and improve response times in medical emergencies. The combination of ESP8266 and MAX30100 sensor with the Blynk platform forms a practical base for smart, personal health devices.

Acknowledgment

We would like to thank COEP Technological University and the Department of Electronics and Telecommunication Engineering for supporting us throughout this project. Their encouragement and technical guidance made this IoT-based biomedical application possible.

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