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REAL-TIME IOT-BASED WIRELESS INTERACTION SYSTEM FOR PATIENTS WITH DISABILITIES

Mahfujur Rahman

Jahangirnagar University, Department of Institute of Information Technology, Savar, 1342, Dhaka, Bangladesh

Author. E-mail: mahfuj.ece@gmail.com

ORCID ID: 0009-0006-3298-3242

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ABSTRACT

The increasing population of disabled patients in hospitals highlights the critical need for solutions that address their unique and timely healthcare requirements. Traditional methods, such as employing full-time caregivers or implementing round-the-clock monitoring systems, are often costly and require substantial resources. This study presents a cost-efficient and real-time solution designed to enhance communication between nurses and multiple patients using a motion-based wireless interaction system.

The system incorporates a mechanism for monitoring blood oxygen levels and heart rate alongside a motion-based messaging component. It utilizes the MAX30100 sensor module (Pulse Oximeter and Heart Rate sensor), MPU6050 sensor (Accelerometer and Gyroscope), and ESP8266 NodeMCU. These devices are mounted on a movable part of the patient's body to enable efficient communication. Wireless messages are sent to a central receiver located at the nurse's station, displayed on a screen, and supported by auditory alerts to ensure timely responses. Repeaters are employed to maintain seamless communication for wards located over 40 meters away, ensuring broader coverage.

This system significantly lowers manpower demands and operational expenses while improving patient satisfaction and healthcare quality through automated caretaking and consistent monitoring. The design and architecture underwent comprehensive testing at different stages, culminating in a fully functional prototype. This innovative system addresses the challenges of continuous patient monitoring, providing a scalable and effective solution to advance healthcare services for disabled patients.

KEYWORDS: *Internet of Thing, NodeMcu ESP8266, Heart Rate Sensor, Oximeter, Monitoring System*

INTRODUCTION

The healthcare industry is experiencing a significant transformation with the integration of IoT (Internet of Things) technologies. Many healthcare start-ups are driving innovations in medical technology, offering advanced solutions for diagnosis, treatment, and monitoring. However, a key aspect often overlooked is the communication system between patients and their caregivers, especially nurses or attendants. This communication gap is particularly concerning for disabled or paralyzed patients, who struggle to express their needs effectively.

In numerous healthcare facilities, high patient-to-nurse ratios compromise the quality of care, which is a common issue in resource-limited settings. This problem is worsened during nighttime hours when attendants may not be easily available, making it challenging for patients to request assistance in emergencies. This challenge affects not only disabled patients but also those with other urgent needs. Hospitals in developing or underprivileged regions face difficulties in maintaining adequate staffing due to the growing number of patients, putting additional strain on resources and reducing service quality.

This project addresses these challenges by introducing an IoT-Based Wireless Interaction System designed to facilitate efficient communication between patients and their attendants. The system integrates advanced IoT components such as the **NodeMCU ESP8266**, **MPU6050 sensor**, and **MAX30100 sensor** to offer a cost-effective and real-time solution for communication and monitoring. The system uses motion-based messaging and vital sign tracking to ensure continuous interaction between patients and caregivers, regardless of time or patient volume.

By enabling hospitals to manage a large number of patients with minimal staffing, this project provides a scalable and effective solution to improve healthcare services. It ensures that patients, particularly those who are disabled or critically ill, receive prompt care, thereby increasing their satisfaction and overall well-being. This work plays a significant role in closing the communication gap in healthcare settings, enhancing service quality, and improving operational efficiency.

PROBLEM STATEMENT

The patient, with minimal movement, can call or communicate with an attendant at any time. The patient's hand is connected to a wearable device that includes two sensors (MPU6050 and MAX30100), along with a buzzer and NodeMCU. A set of pre-determined messages, agreed upon by the patient and the authority, can be sent simply by twisting the hand in different directions. Each patient's device operates independently. A central unit receives all the messages on a screen, which are also recorded and notified on a web server. The NodeMCU ESP8266 is used to transfer messages in near real-time. An alarm is triggered when a "Need Medicine" message arrives at the central unit to capture the attendants' attention. It is easy to determine if any messages are missing from the records. This web-server-based wireless message system, combined with real-time heart rate and blood oxygen monitoring, is simple for both attendants and patients to use. With this technology, it is possible to efficiently serve a large number of patients without compromising quality, even with limited staff.

METHODOLOGY

The methodology for this project involves several essential steps to create an IoT-based communication system for healthcare. Initially, the **ESP8266 NodeMCU** is explored for its capabilities in communication and processing. Next, appropriate sensor circuits, including the **MPU6050** for motion detection and the **MAX30100** for monitoring heart rate and blood oxygen levels, are chosen. These components are integrated with the NodeMCU to facilitate real-time communication and data transmission. The wearable device is developed, enabling patients to send motion-triggered messages while their vital signs are continuously monitored. Finally, the system undergoes testing and evaluation to ensure it meets the needs of both patients and healthcare providers, allowing for the effective management of large patient volumes with minimal staff. This methodology provides a scalable, efficient solution to enhance patient care and operational efficiency in healthcare settings.

Figure-20: Block Diagram of IoT Based Wireless Interaction System

The Block Diagram shows that the power supply is use to start the system, and MAX30100 sensor and MPU6050 Sensor send input data to the Node MCU ESP8266.And in the output input data shows in the web server and the buzzer started to beeping after getting the command that is "Need Food" when the patient move or tilt his/her hand to the right, then the MPU6050 Sensor detect the command "Need Food" and then buzzer started to beeping.

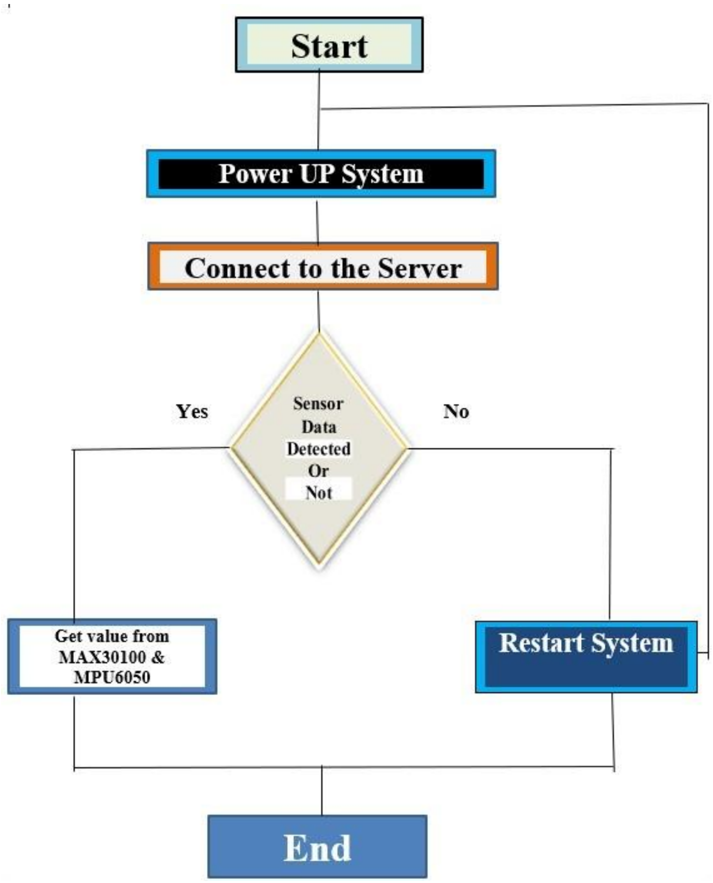


Figure-21: Flow Chart of the project

SYSTEM IMPLEMENTATION

Working Principle:

The working principle of this project is simple yet highly effective. The main goal of our project was to develop an IoT-based Wireless Interaction System for disabled patients. The system is built using the ESP8266 chipset-based Node MCU motherboard. Two types of sensors are used in this project: the MPU6050 (Accelerometer and Gyroscope) sensor, which operates as a 3-axis (x, y, z) sensor, and the MAX30100 (Blood Oximeter and Heart Rate) sensor.

The system operates via an ESP8266 web server. Readings from the sensors, especially the MPU6050 sensor, are continuously displayed on the web server. The MPU6050 sensor is attached to the patient's hand, so when the patient tilts their hand to the right, the sensor sends the command "Need Medicine" to the web server, and a buzzer is activated to alert nearby caregivers. The MAX30100 sensor, which is attached to the patient's thumb, collects data on heart rate and blood oxygen levels, which is also displayed continuously on the web server via I2C interfacing with the Node MCU motherboard using the I2C protocol.

The I2C protocol involves two connections: SDA (serial data) and SCK (serial clock). By using these two connections, the sensors are interfaced with the microcontroller. The output is generated in two ways: when the patient tilts the MPU6050 sensor to the right or left by 20 degrees, a specific command is sent to the web server. Two commands are defined for different hand movements: "Need Medicine" for a right-hand tilt and "Need Food" for a left-hand tilt.

When the patient moves their hand to the left, the "Need Food" command is displayed on the web server, which is monitored by doctors or nurses. The "Need Medicine" command is activated when the patient tilts their hand to the right, triggering the buzzer to beep. The sound of the buzzer alerts nearby ward attendants or nurses to attend to the patient.

The project functions successfully after uploading the program code to the Arduino IDE and powering the Node MCU through a USB cable connected to a laptop. The Node MCU connects to Wi-Fi using a smartphone, laptop, or personal computer via a Wi-Fi LAN or hotspot. The web server is accessible using a specific IP address, which can be found by setting up a Wi-Fi hotspot with the username "Nut Boltu" and password "scorpio12." Anyone connected to the hotspot using these credentials can access the web server using the IP address, which can be found using the Network IP Scanner app on any Android device

How to Use MPU6050 Sensor

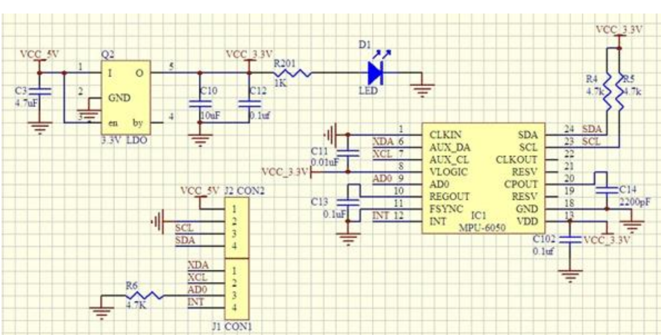


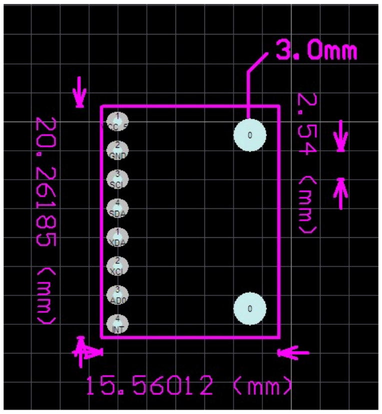
Figure-6: MPU6050 Sensor

The hardware of the module is quite simple, consisting primarily of the MPU6050 as the key component, as shown above. Since the module operates at 3.3V, a voltage regulator is also included. The IIC lines are pulled high with a 4.7k resistor, and the interrupt pin is pulled down using another 4.7k resistor.

The MPU6050 module allows data to be read via the IIC bus. Any motion changes are reflected in the mechanical system, which in turn alters the voltage. The IC uses a 16-bit ADC to accurately measure these voltage changes and stores them in the FIFO buffer, triggering the INT (interrupt) pin to go high. This indicates that the data is ready to be read, and an MCU is used to retrieve it from the FIFO buffer via IIC communication. Although it sounds straightforward, interpreting the data can be challenging. However, there are many platforms, such as Arduino, which allow you to start using this module easily by taking advantage of the available libraries, as explained below.

2D Model of MPU6050

Figure-7: 2D Model of MPU6050



Working of the MAX30100 Oximeter

Working of an oximeter:

The sensor consists of a pair of light-emitting diodes that emit monochromatic red light at a wavelength of 660 nm and infrared light at a wavelength of 940 nm. These specific wavelengths are selected because oxygenated and deoxygenated hemoglobin exhibit significantly different absorption properties at these wavelengths. As shown in the graph below, there is a noticeable difference between HbO2 (oxygenated hemoglobin) and Hb (deoxygenated hemoglobin) when exposed to these particular wavelengths.

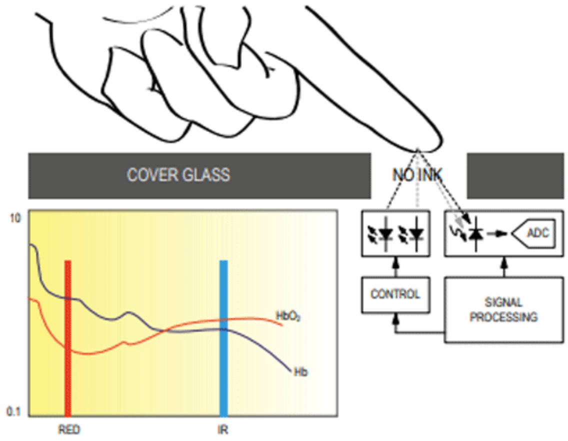


Figure-9: Working of an oximeter

Functional Block and the Circuit Diagram of MAX30100 Module

Below is the functional block for the MAX30100 module. The module consists of two LEDs (IR and RED) both of specific wavelengths, along with a photodetector to detect the received light.

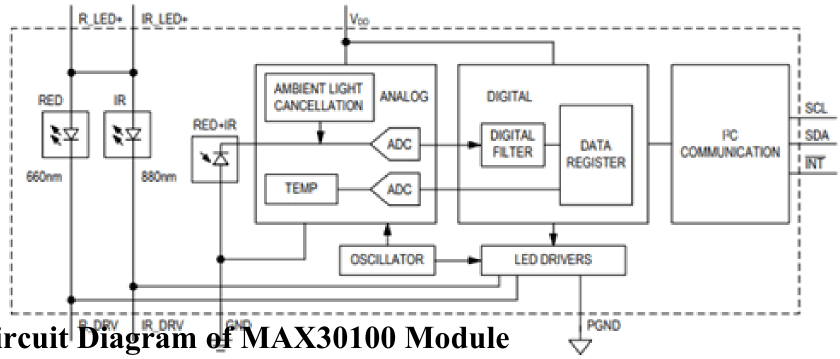


Figure-10: Circuit Diagram of MAX30100 Module

The output from the photodiode is sent to the analog-to-digital converter, which then transmits the digital data through a filter to the digital data register. The data can be retrieved from the register and sent to the microcontroller via the I2C communication protocol.

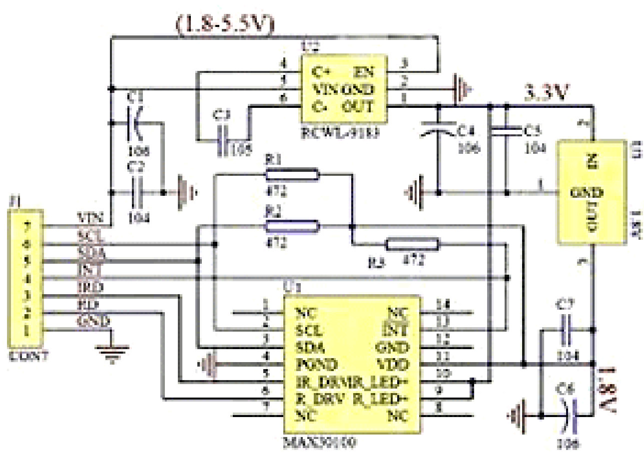


Figure-11: Functional Block Diagram of MAX30100 Module

The image above showcases the internal circuitry of the MAX30100 module and can be used as a reference circuit while designing your own custom module.

Circuit Diagram:

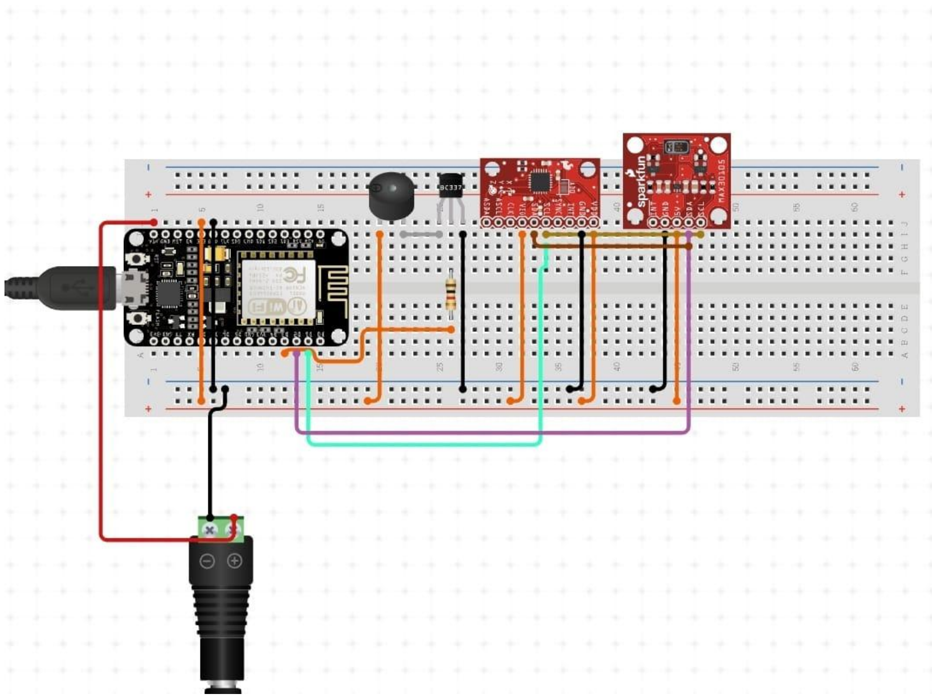


Figure-19: Circuit Diagram of IoT Based Wireless Interaction System

In this Circuit Diagram of the project. Here, In the Dot Vero Board we build up our circuit connections by the ESP8266 chipset based Node MCU is connected to the MPU6050 (Accelerometer & Gyroscope) Sensor, and the small buzzer is interfaced with Node MCU ESP8266 and the MPU6050 (Accelerometer & Gyroscope) Sensor. Then the 5 pins (3V3, D1, D2, D0 and GND) is connected by jumper wires to the 5 pins (VIN, SCL, SDA, INT, GND) of the MAX30100 (Pulse Oximeter and Heart Rate) Sensor. A USB cable is used at the USB port the Node MCU as power supply of the overall project. In this way the circuit connections of the project is created.

Results

The performance of the system has been tested so as to achieve its desire goal. It can successfully able to convey message from the patient's hand to the webserver and can show us real time heart rate and blood oxygen measurement in the web server. Output or result of this project is shown in the given screenshot below:

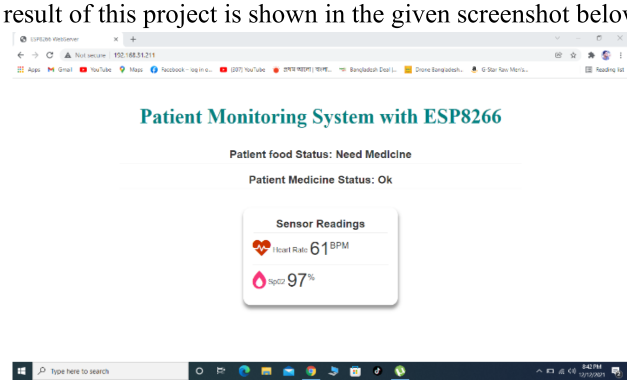


Figure-1: Output of the project from the web server

DISCUSSION

The primary benefit of this system is its ability to bridge the communication gap in healthcare settings, especially for disabled or paralyzed patients who struggle to express their needs verbally. Traditional communication systems often require manual intervention or rely on nursing staff availability, which can be limited, particularly in hospitals with high patient-to-nurse ratios or during nighttime hours when staff may be reduced. This wireless interaction system allows patients to communicate their needs with minimal effort, thus improving the speed and efficiency of care.

The motion-based communication feature, where patients can tilt their hand to signal "Need Medicine" or "Need Food," offers a novel way for patients to interact with caregivers. This reduces the need for constant verbal requests, making it easier for patients with limited mobility to signal their needs. Additionally, the real-time data displayed on the web server enables healthcare providers to monitor patients remotely, minimizing the need for physical presence and optimizing staff allocation, thereby reducing caregiver workload.

The incorporation of the MAX30100 sensor to track heart rate and blood oxygen levels ensures continuous monitoring of the patient's health. Abnormal readings, such as low oxygen levels or irregular heart rates, can prompt immediate action, preventing potential emergencies. This proactive monitoring ensures that patient care is anticipatory rather than reactive, significantly enhancing health outcomes.

The system's scalability and affordability make it an attractive option for healthcare facilities, especially in developing or underserved regions where resources are limited. Its ability to be deployed across multiple wards or remote healthcare settings allows for efficient patient monitoring, reducing the strain on healthcare staff while enhancing patient safety and satisfaction.

CONCLUSION

The project described in this paper addresses the issue of providing care and attention to paralyzed and disabled individuals without requiring 24-hour monitoring for every patient. In comparison to previous work on this topic, our prototype offers several significant improvements. For instance, it features an extended range due to the use of the ESP8266-based web server and the ESP8266 chipset-based Node MCU motherboard. The circuit for our project was designed and implemented on a Dot Vero Board. The project successfully measures heart rate and blood oxygen levels, and it is also capable of transmitting motion-based messages from the MPU6050 sensor to the ESP8266-based web server.

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