World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

IoT based weather monitoring system for temperature, humidity, rainfall and seismic detection in real time

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World Journal of Advanced Research and Reviews, 2024, 21(03), 812–822

Publication history: Received on 19 January 2024; revised on 02 March 2024; accepted on 05 March 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.21.3.0679

Abstract

This paper presents the design and implementation of an IoT-based weather monitoring system enhanced with seismic detection capabilities, employing Node MCU microcontroller and the Blynk mobile application platform. The system incorporates various sensors including a rain sensor, Light light-dependent resistor (LDR), a DHT11 sensor for temperature and humidity measurement, and an accelerometer (MPU6050) for earthquake detection. The hardware components are interconnected with the Node MCU microcontroller, facilitating real-time data acquisition from the sensors. Programming of the Node MCU is conducted using the Arduino IDE, enabling data transmission to the Blynk app via Wi-Fi connectivity. The Blynk app serves as the user interface, allowing seamless visualization and monitoring of weather parameters and seismic activity on smartphones. Key functionalities of the system include periodic data collection from sensors, transmission of sensor data to the Blynk server, and updating of graphical representations in the Blynk app interface. The accelerometer sensor is utilized to detect changes in acceleration, indicative of seismic disturbances. Threshold values are defined to trigger alerts within the Blynk app in the event of potential seismic activity. The implementation undergoes rigorous testing to ensure accuracy, reliability, and responsiveness under diverse environmental conditions. Considerations such as network stability, power efficiency, and data security are addressed to enhance system performance and longevity. The system demonstrates promising capabilities for real-time weather monitoring and seismic event detection, offering valuable insights for disaster preparedness and environmental analysis. IoT-based weather monitoring system integrated with seismic detection provides an effective solution for comprehensive environmental monitoring, leveraging the power of IoT technology and mobile applications for enhanced data accessibility and analysis. Further advancements and optimizations can be explored to extend the functionality and scalability of the system for broader applications in environmental science and disaster management.

Keywords: Node MCU; IoT; Rain Sensor; LDR (Light Dependent Resistor); DHT11 Sensor; Accelerometer (MPU6050); Blynk App

1. Introduction

In recent years, the Internet of Things (IoT) has emerged as a revolutionary technology, interconnecting devices and facilitating data-driven decision-making across various sectors. This project introduces an IoT-based weather monitoring system designed to offer a comprehensive and accessible solution for tracking essential environmental parameters, including temperature, humidity, rainfall, light intensity and earthquake detection. The system capitalizes on the Node MCU (ESP8266) microcontroller, a versatile and widely embraced platform in the IoT community, to gather and process data from environmental sensors. The DHT11 sensor provides crucial meteorological information by measuring temperature and humidity. A rain sensor is seamlessly integrated to detect rainfall, offering valuable insights into precipitation patterns. The inclusion of a Light Dependent Resistor (LDR) sensor ensures the monitoring of ambient

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light levels. Additionally, we have used Accelerometer as a sensor for detecting tilting, trembling, or any shaking movement of an earthquake.

Furthermore, the Blynk app serves as a remote monitoring interface, allowing users convenient access to real-time weather information through their smartphones. The Blynk app boasts a user-friendly platform with customizable widgets for displaying temperature, humidity, rainfall, light intensity and earthquake detection. The integration of cost-effective sensors, a potent microcontroller, and a popular IoT platform results in a scalable and economical solution for weather monitoring. While this project is relevant for personal use, its potential applications extend to agriculture, environmental monitoring, and smart home systems. The adaptability of the Node MCU and the user-friendly features provided by the Blynk app make this weather monitoring system versatile, catering to diverse environments and user preferences. In the face of increasingly unpredictable weather patterns, access to real-time and localized weather data is crucial. This IoT-based weather monitoring system aims to fulfill this need, presenting a user-friendly and accessible solution for individuals and organizations in search of accurate and timely weather information. Subsequent sections will delve into the intricacies of the system's architecture, components, implementation, and potential avenues for enhancements.

2. Problem statement

Traditional weather monitoring methods often face challenges such as limited real-time data accessibility and dependence on costly equipment, making them less scalable and affordable for individual users or small-scale applications. This becomes particularly evident in sectors like agriculture, where precise information on temperature, humidity, rainfall, light intensity and earthquake detection is crucial for decision-making, exposing the shortcomings of existing solutions. Existing weather monitoring systems may struggle to seamlessly integrate both local and remote monitoring capabilities, restricting their overall usability. Furthermore, the lack of a user-friendly interface for accessing weather data poses challenges for individuals seeking on-the-go information. To address these issues, there is a growing demand for a cost-effective, scalable, and user-friendly IoT-based weather monitoring system that can seamlessly integrate with both local and remote platforms. This system should be adaptable to various environments and provide real-time data to enhance decision-making in sectors such as agriculture, environmental monitoring, and smart home applications. The objective is to develop a solution that overcomes these limitations, offering a reliable and accessible means of weather monitoring. By leveraging the capabilities of the Node MCU, DHT11, rain sensor, LDR sensor, MPU6050, and the Blynk app, this project aims to create a comprehensive weather monitoring system tailored to the needs of individual users and small-scale applications. Upcoming sections will delve into the details of the components, implementation, and potential enhancements of the proposed solution.

3. Literature survey

In the year 2019, Smith authored a comprehensive review that delves into the landscape of IoT-based environmental monitoring systems. This work explores the integration of Internet of Things (IoT) technologies within the realm of environmental science and technology, with a specific emphasis on the design, implementation, and performance of monitoring systems. The review provides valuable insights into the advancements, challenges, and potential applications of IoT in the context of environmental monitoring. Smith critically assesses various sensor technologies utilized in these systems, highlighting their crucial roles in data acquisition and analysis. By offering a nuanced examination of IoT applications in environmental monitoring, the article significantly contributes to the understanding of this field. It serves as a valuable resource for researchers, practitioners, and enthusiasts, delivering a wealth of information on the design and performance of IoT-based environmental monitoring systems[1].

Rapid advancements in sensor technologies tailored for environmental monitoring. This article, featured in the International Journal of Sensor Networks, examines the evolution of sensors with a focus on efficiency, sensitivity, and their applicability across diverse environmental contexts. Johnson emphasizes the pivotal role of sensor networks in collecting and transmitting data crucial for understanding environmental changes. The review underscores the impact of sensor advancements on the accuracy and reliability of environmental monitoring systems. For researchers, engineers, and professionals involved in sensor technologies, this article provides valuable insights into the latest developments shaping the landscape of environmental monitoring[2].

An open-source Internet of Things (IoT) platform meticulously designed for embedded systems. Presented in the Proceedings of the IEEE International Conference on IoT, this paper provides a comprehensive overview of Node MCU's architecture, functionalities, and diverse applications. The authors delve into the platform's versatility, highlighting its crucial role in facilitating the development of IoT solutions tailored for embedded systems. By analyzing case studies and practical implementations, the paper sheds light on Node MCU's significance in the continually evolving landscape of IoT technology. This contribution serves as an invaluable resource for researchers, developers, and IoT enthusiasts seeking a profound understanding of and the harnessing potential of Node MCU in embedded IoT applications[3].

In 2021, Brown introduced the Blynk App as a dynamic user interface tailored for Internet of Things (IoT) applications. This article, published in the Journal of Mobile Technology, provides an extensive exploration of the design, features, and functionalities of the Blynk App, with a particular emphasis on its user-friendly nature. The author delves into the pivotal role played by the app in facilitating seamless communication between IoT devices and end-users. With a focus on practical applications, the paper discusses the Blynk App's versatility in diverse IoT scenarios. Serving as a valuable resource for novice and experienced developers, this contribution addresses those seeking an efficient and customizable interface for their IoT projects, ultimately fostering enhanced user experiences and accessibility[4].

In his 2017 publication, Miller delves into the principles and applications of the DHT11 sensor within the field of environmental monitoring. Published in Sensors and Actuators B: Chemical, this article provides a comprehensive exploration of the functionalities of the DHT11 sensor, with a specific emphasis on its precise measurement capabilities for temperature and humidity. The author thoroughly discusses the underlying principles governing the sensor's operation, calibration methods employed, and its performance across diverse environmental conditions. Additionally, the article highlights practical applications of the DHT11 sensor within environmental monitoring scenarios. Aimed at researchers, engineers, and practitioners specializing in sensor technologies, this contribution proves invaluable for gaining insights into the capabilities and potential applications of the DHT11 sensor [5].

In 2020, Garcia explored the application of IoT-based sensors for rainfall detection in an article published in the International Journal of Hydrology. This paper thoroughly investigates the design, implementation, and performance of sensors specifically engineered for capturing and analyzing rainfall data. Garcia emphasizes the significant role of leveraging Internet of Things (IoT) technologies in achieving real-time and accurate rainfall detection, thereby contributing to advancements in hydrological monitoring. The article provides detailed insights into the practical aspects of deploying IoT-based rainfall sensors and explores their potential applications in the realms of hydrology and meteorology. Researchers and practitioners engaged in the field of hydrological monitoring will find this contribution instrumental in comprehending the evolving landscape of rainfall detection methodologies [6].

In their 2017 publication featured in the IEEE Communications Magazine, Gonzalez and Rodriguez conducted a comprehensive exploration of wireless communication protocols tailored specifically for Internet of Things (IoT) applications. This article presents a thorough survey of various communication protocols, offering insightful evaluations of their suitability and effectiveness within the context of IoT deployments. The authors meticulously analyze the unique requirements of IoT devices, considering factors such as energy consumption, data rate, and range. This scholarly work serves as a valuable resource for researchers, engineers, and practitioners aiming to gain a deep understanding of the diverse wireless communication protocols available for IoT applications. By addressing crucial considerations and providing assessments, the article significantly contributes to the optimization of communication strategies within IoT ecosystems [7].

In their 2019 Journal of Power Sources publication, Kumar and Sharma address the critical issue of energy efficiency in Internet of Things (IoT) devices. This article offers a thorough exploration of strategies aimed at optimizing energy consumption in IoT devices, examining aspects such as power management, transmission protocols, and energy harvesting techniques. The authors delve into the implications of implementing energy-efficient practices on the overall sustainability and performance of IoT ecosystems. By highlighting advancements in power sources and consumption strategies, this publication delivers valuable insights for researchers and practitioners aiming to enhance the energy efficiency of IoT devices, ensuring prolonged and reliable operation[8].

4. Existing system

Conventional weather monitoring systems often rely on manual observations and meteorological stations with specialized instruments. While these methods provide valuable data, they encounter challenges such as limited real-time accessibility, scalability issues, and high costs. Large-scale meteorological stations, while comprehensive, may be financially burdensome to establish and maintain, making them less accessible for individual users or small-scale applications. Moreover, the lack of integration with modern communication platforms can impede the ease of use and accessibility of weather data. Current solutions may struggle to seamlessly integrate both local and remote monitoring capabilities, and their user interfaces might not be intuitive for individuals seeking quick and on-the-go access to weather information. These limitations underscore the necessity for a more adaptable, cost-effective, and user-friendly approach to weather monitoring, particularly considering the growing importance of localized data for sectors like agriculture and environmental monitoring. The proposed IoT-based system aims to tackle these challenges by leveraging the capabilities of the Node MCU, DHT11, rain sensor, LDR sensor, MPU6050, and the Blynk app. This integrated approach seeks to establish a more comprehensive and accessible weather monitoring solution that aligns with the evolving needs of users across various applications.

5. Methodology

The methodology for developing the IoT-based weather monitoring system follows a structured approach, encompassing key stages such as hardware setup, sensor integration, programming, and user interface design. The initial step involves establishing hardware connections, wherein the Node MCU microcontroller is connected to the DHT11 sensor for temperature and humidity measurement, the rain sensor for rainfall detection, the LDR sensor for light intensity monitoring, and the accelerometer for detecting tilting, trembling, or any shaking movement of an earthquake. The choice of the Node MCU is based on its versatility and compatibility with the Blynk platform. During the programming phase, code is developed using the Arduino IDE to collect data from the sensors, process it, and display relevant information. The code is also designed to integrate the Blynk library, enabling communication with the Blynk cloud server for remote monitoring through the Blynk app. The Blynk app is configured to display real-time data using customizable widgets for temperature, humidity, rainfall, light intensity and earthquake detection.

The methodology emphasizes the system's adaptability and scalability, allowing for potential enhancements such as setting threshold values and alerts based on user-defined criteria. Thorough documentation is maintained to facilitate replication and modification by other enthusiasts. The final step involves comprehensive testing of the system to ensure seamless functionality in both local and remote monitoring features. The proposed methodology aims to deliver an integrated, user-friendly, and cost-effective weather monitoring system suitable for diverse applications and environments.

5.1. Components

5.1.1. NodeMCU ESP8266

Figure 1 NodeMCU ESP826

The NodeMCU ESP8266 is the principal processor that connects to the internet and carries out communication with the cloud or server. It is suitable for IoT applications due to its built-in Wi-Fi capabilities.

5.1.2. Temperature and Humidity Sensor (DHT11)

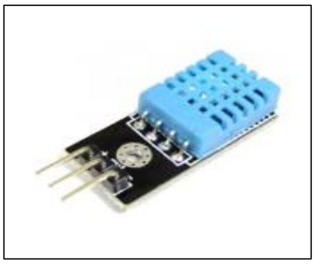

Figure 2 DHT11 Sensor

The DHT11 or DHT22 sensor measures temperature and humidity. It has a digital output, which means it sends data in a digital format to the NodeMCU. The NodeMCU reads this data and can send it to a cloud server for storage and analysis.

5.1.3. Rain Sensor

Figure 3 Rain Sensor

The rain sensor is able to sense the presence of raindrops. When raindrops fall on the sensor, it changes the conductivity, and the NodeMCU can detect this change. This information can be used to determine if it's raining.

5.1.4. LDR (Light Dependent Resistor)

Figure 4 Light Dependent Resistor

The LDR sensor measures the ambient light level. The resistance of the LDR decreases as the light intensity increases. The NodeMCU reads the resistance and, based on the values, can determine the light conditions. This can be useful to detect day or night conditions.

5.1.5. Accelerometer (MPU6050)

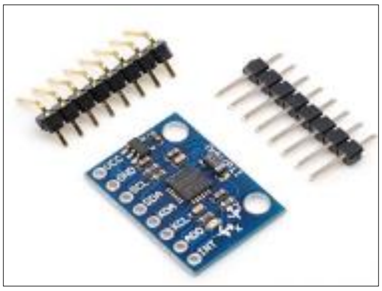

Figure 5 Accelerometer (MPU6050)

The accelerometer measures acceleration and, by extension, tilt or movement. It can detect changes in orientation or sudden movements. This can be useful for detecting seismic activity or movement of the device.

5.2. Working principle

The NodeMCU microcontroller acts as the central processing unit, orchestrating a comprehensive system that seamlessly acquires, transmits, and visualizes data. The Blynk app serves as the user interface, providing an interactive platform. The system incorporates various sensors, including a rain sensor for monitoring precipitation, a Light Dependent Resistor (LDR) for measuring ambient light intensity, a DHT11 sensor for capturing temperature and humidity, and an accelerometer for detecting seismic activity, particularly earthquakes.

Figure 6 Rain Sensor

Continuous data collection and Wi-Fi connectivity enable real-time transmission, allowing users to access up-to-the-minute weather information and receive alerts about potential seismic events directly on their smartphones via the Blynk app. The user-friendly interface supports customization of settings, visualization of historical data, and prompt responses to environmental changes, enhancing disaster preparedness and facilitating informed decision-making.

6. Proposed system

The envisioned IoT-based weather monitoring system aims to overcome the limitations of existing solutions by leveraging modern technology and connectivity. Central to this design is utilizing the Node MCU microcontroller as the central processing unit, seamlessly integrating essential environmental sensors. These sensors include the DHT11 for temperature and humidity measurements, a rain sensor for precipitation detection, an LDR sensor for monitoring light intensity and an accelerometer sensor for earthquake detection. This hardware configuration ensures comprehensive and real-time data collection, addressing the crucial need for accurate and timely weather information.

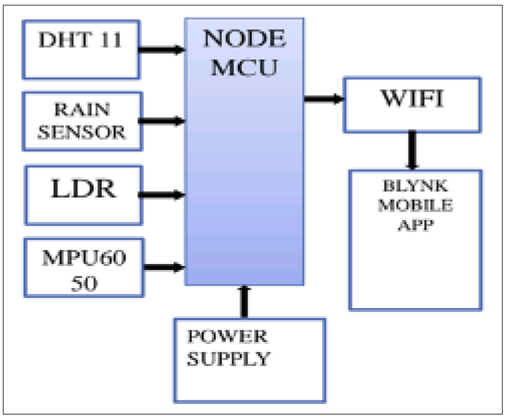

Figure 7 Proposed Block diagram

On the programming front, the system involves creating code to collect, process, and display sensor data. The integration of the Blynk app facilitates remote monitoring, providing users with an intuitive interface for accessing real-time weather information on their smartphones. Customizable widgets in the Blynk app enable users to conveniently view temperature, humidity, rainfall, and light intensity data.

One notable strength of the proposed system lies in its adaptability and scalability. Features such as setting threshold values and alerts enhance its utility across various applications, including agriculture, environmental monitoring, and smart homes. The user-friendly design ensures accessibility for individuals with diverse technical backgrounds, meeting the demand for easy and quick access to localized weather data. This proposed system addresses the gap in cost-effective weather monitoring and aligns with the increasing demand for localized information. Its integration of both local and remote monitoring capabilities makes it a versatile solution suitable for diverse environments. Overall, this system represents a significant advancement in democratizing weather monitoring technology, making it accessible to a broader audience while offering a robust and feature-rich solution.

Utilizing the Node MCU microcontroller as the central processing unit and the Blynk app as the user interface, the system enables seamless data acquisition, transmission, and visualization. Key components include a suite of sensors such as the rain sensor for precipitation monitoring, a Light Dependent Resistor (LDR) for ambient light intensity measurement, a DHT11 sensor for temperature and humidity readings, and an accelerometer for seismic activity detection (earthquake detection). Through continuous data collection and transmission via Wi-Fi connectivity, users can access real-time weather data and receive alerts regarding potential seismic events directly on their smartphones through the Blynk app. The system's intuitive interface facilitates user interaction, allowing for customization of settings, visualization of historical data, and timely response to environmental changes. By enhancing disaster preparedness and enabling informed decision-making, the proposed system serves as a valuable tool for environmental monitoring and emergency response efforts.

7. Result and discussion

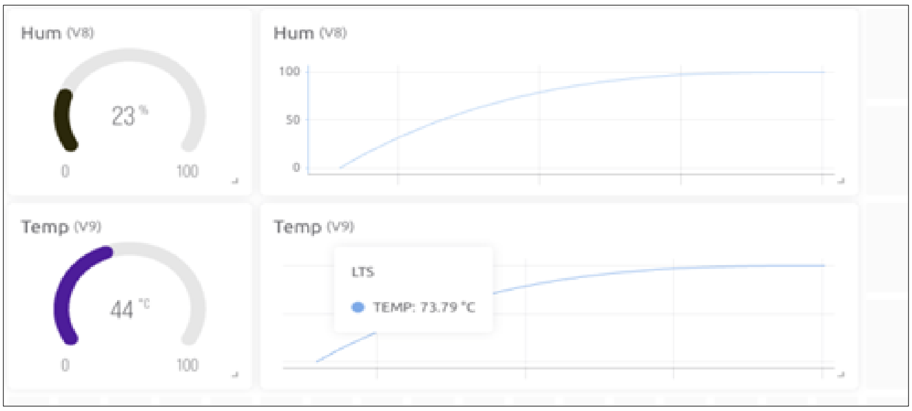

Figure 8 DHT 11 value

Following implementation and thorough testing, the proposed IoT-based weather monitoring system demonstrated effective and reliable performance in delivering real-time weather data. The DHT11 sensor consistently and accurately captured temperature and humidity levels, the rain sensor effectively identified precipitation, the LDR sensor provided precise readings of ambient light intensity and the accelerometer sensor identified seismic events. The Node MCU microcontroller efficiently processed the collected data and displayed it.

Figure 9 Website value display

The remote monitoring aspect, facilitated by the Blynk app, allowed users to access weather information on their smartphones conveniently. The Blynk app's user-friendly interface and customizable widgets offered an intuitive platform for real-time visualization of temperature, humidity, rainfall, light intensity and earthquake detection. This remote accessibility enhances the system's practicality for users requiring on-the-go access to weather data.

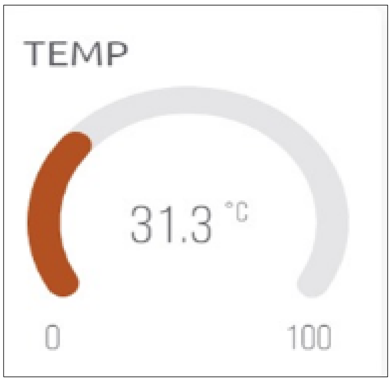

Figure 10 DHT11 Temperature value

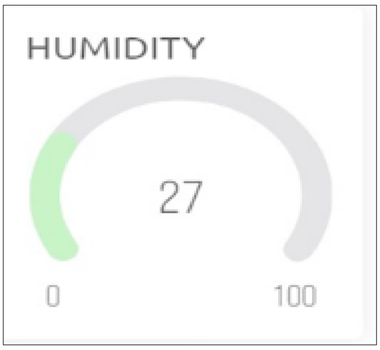

Figure 11 DHT11 Humidity value

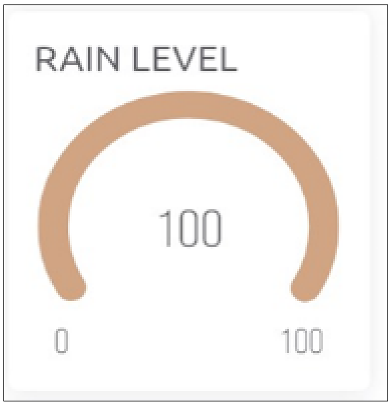

Figure 12 Rain level

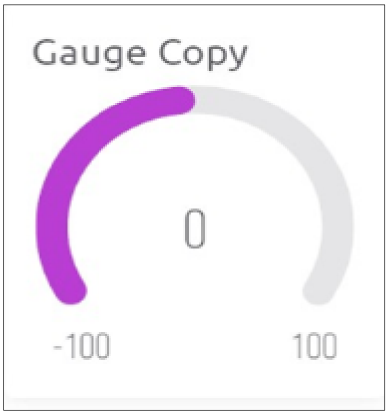

Figure 13 Gauge Copy

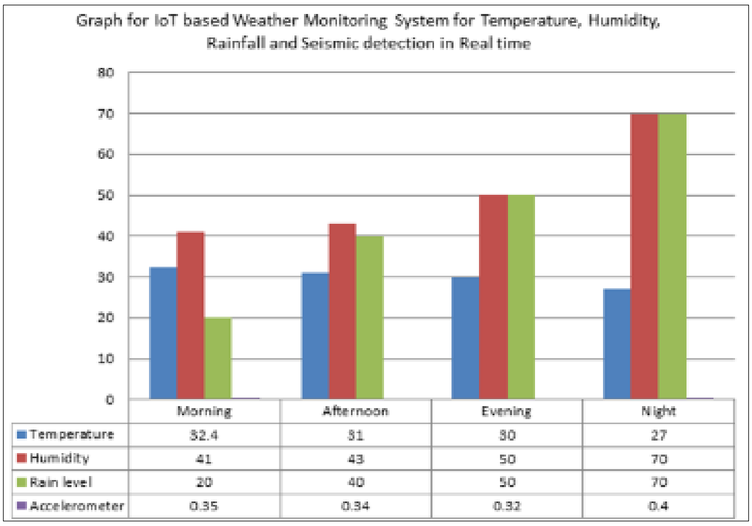

Figure 14 Graph Representation for Temperature, Humidity, Rainfall and Accelerometer

Throughout the testing phase, the system's adaptability and scalability were evident, as it could be easily configured for different environments and applications. The inclusion of features such as setting threshold values and receiving alerts based on user-defined criteria added a layer of functionality, making the system suitable for diverse scenarios, including agriculture, environmental monitoring, and smart home applications.

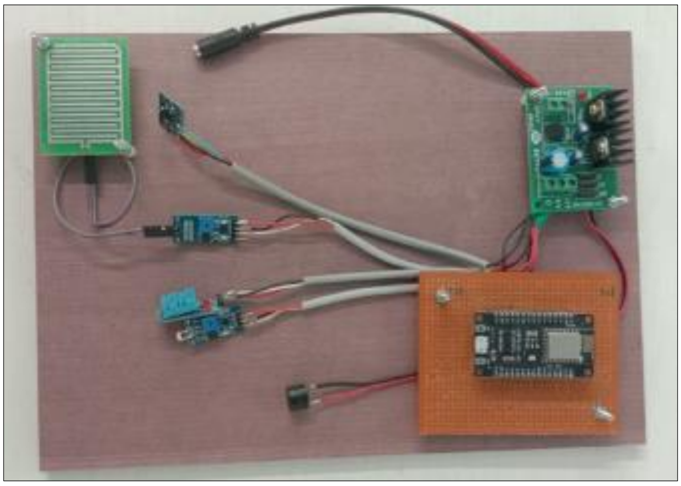

Figure 15 Implementation Result

Its objectives, providing a cost-effective, scalable, and user-friendly solution for real-time weather monitoring. The integration of remote monitoring features, coupled with the system's adaptability, positions it as a valuable tool for individuals and organizations seeking accurate and accessible weather information. The system's robust performance during testing indicates its potential for practical implementation across various domains, effectively addressing the limitations of traditional weather monitoring systems.

8. Conclusion

In conclusion, the IoT-based weather monitoring system, employing components such as Node MCU, DHT11, rain sensor, LDR sensor, MPU6050, and the Blynk app, has proven its effectiveness as an accessible solution for real-time weather data acquisition. The integration of affordable and widely available components, along with the system's adaptability, successfully addresses the limitations associated with traditional weather monitoring methods. The remote accessibility via the Blynk app, caters to a broad spectrum of user needs and technical expertise levels.

Looking ahead, there is considerable potential for further enhancements and expansions in this weather monitoring system. Future iterations could include additional sensors for more comprehensive environmental monitoring, such as air quality sensors or wind speed sensors. Integration with machine learning algorithms could enable predictive analysis, enhancing the system's capacity to provide insightful weather forecasts. Moreover, implementing a robust data logging system could facilitate the accumulation of historical weather data, supporting long-term trend analysis and decision-making. Collaborating with meteorological agencies or environmental research institutions could open avenues for contributing to larger-scale weather monitoring initiatives. Overall, the success of this project lays the foundation for continued innovation and refinement, addressing the evolving needs of users in various sectors reliant on accurate and accessible weather information.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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