IoT-Enabled Weather Monitoring System for Fishery

Abstract

This paper presents the design and implementation of a low-cost, IoT-enabled weather monitoring station using the ESP8266 microcontroller. The system integrates multiple sensors to measure wind speed, wind direction, rainfall, temperature, and humidity in real time. The collected data is displayed locally on an LCD screen and transmitted to the Blynk cloud platform for remote access via mobile devices. Alert mechanisms using buzzers are implemented to notify users of strong wind conditions and heavy rainfall. Experimental results demonstrate the effectiveness of the proposed system for real-time weather monitoring applications such as agriculture, disaster prediction, and smart city deployments.

Keywords

IoT, ESP8266, Weather Station, Blynk, Sensors, Real-Time Monitoring

Figure 1 group of the project

Introduction

Weather plays a crucial role in human activities ranging from agriculture and transportation to disaster preparedness and environmental studies. Conventional weather stations are capable of delivering accurate data but are often costly and not accessible to small-scale users such as farmers, schools, or individual researchers. The emergence of the Internet of Things (IoT) has created opportunities to develop affordable, scalable, and real-time monitoring systems using low-cost microcontrollers and sensors. In this context, the integration of wireless communication technologies with environmental sensing enables users to access weather data remotely and take timely actions.

The primary objective of this research is to design and implement a low-cost weather monitoring station that measures multiple weather parameters including temperature, humidity, wind speed, wind direction, and rainfall. Unlike traditional monitoring systems that require significant infrastructure, the proposed solution is compact, energy-efficient, and capable of transmitting real-time data to a mobile platform. In addition, the system incorporates alert mechanisms such as buzzers to provide immediate notifications of hazardous conditions, making it useful for agricultural decision-making, early disaster warnings, and smart city applications.

Literature Review

A wide range of research has been conducted on IoT-based weather monitoring systems. Previous studies have demonstrated the use of microcontrollers such as Arduino, ESP8266, and ESP32 for environmental sensing and cloud integration. Many of these systems focus primarily on temperature and humidity monitoring, using sensors such as the DHT11 and DHT22, with data transmitted via Wi-Fi or GSM modules to cloud platforms for visualization. Some implementations include rainfall or wind speed measurements, but the integration of multiple weather parameters into a single compact and cost-effective system remains limited. In addition, communication technologies such as GSM and LoRa have been explored to transmit weather data over long distances, particularly in rural or remote areas. While these approaches extend the coverage, they often increase system cost and complexity. Existing literature also highlights challenges in sensor calibration, accuracy under different environmental conditions, and data visualization for end users. The present work addresses these gaps by integrating wind speed, wind direction, rainfall detection, temperature, and humidity sensing into a single IoT-based platform, while ensuring low cost and ease of deployment.

System Design and Methodology

The proposed weather monitoring station is designed around the ESP8266 NodeMCU microcontroller, which provides both processing capabilities and built-in Wi-Fi connectivity. Several sensors are connected to the microcontroller to capture different weather parameters. A DHT11 sensor is used for temperature and humidity measurement, while a Hall effect sensor coupled with an anemometer captures wind speed by detecting the rotation frequency of the blades. Wind direction is determined using a set of infrared sensors placed in the cardinal directions, enabling the system to identify both primary and intermediate wind directions such as north, south, east, west, northeast, northwest, southeast, and southwest. Rainfall intensity is measured using an analog rain sensor, which outputs different resistance values depending on water presence.

The system also includes two buzzers, one dedicated to rainfall alerts and the other to high wind speed alerts. These ensure that critical weather events are not only displayed on the monitoring interfaces but also signaled locally in real time. A 16x2 liquid crystal display (LCD) with I²C communication is incorporated to show weather data locally. The system is programmed using the Arduino IDE, and the data is transmitted to the Blynk cloud platform where users can visualize parameters remotely on their smartphones. The overall workflow follows a sequence of data acquisition from sensors, data processing by the ESP8266, real-time display on the LCD, conditional activation of buzzers, and transmission of results to the Blynk platform for remote access.

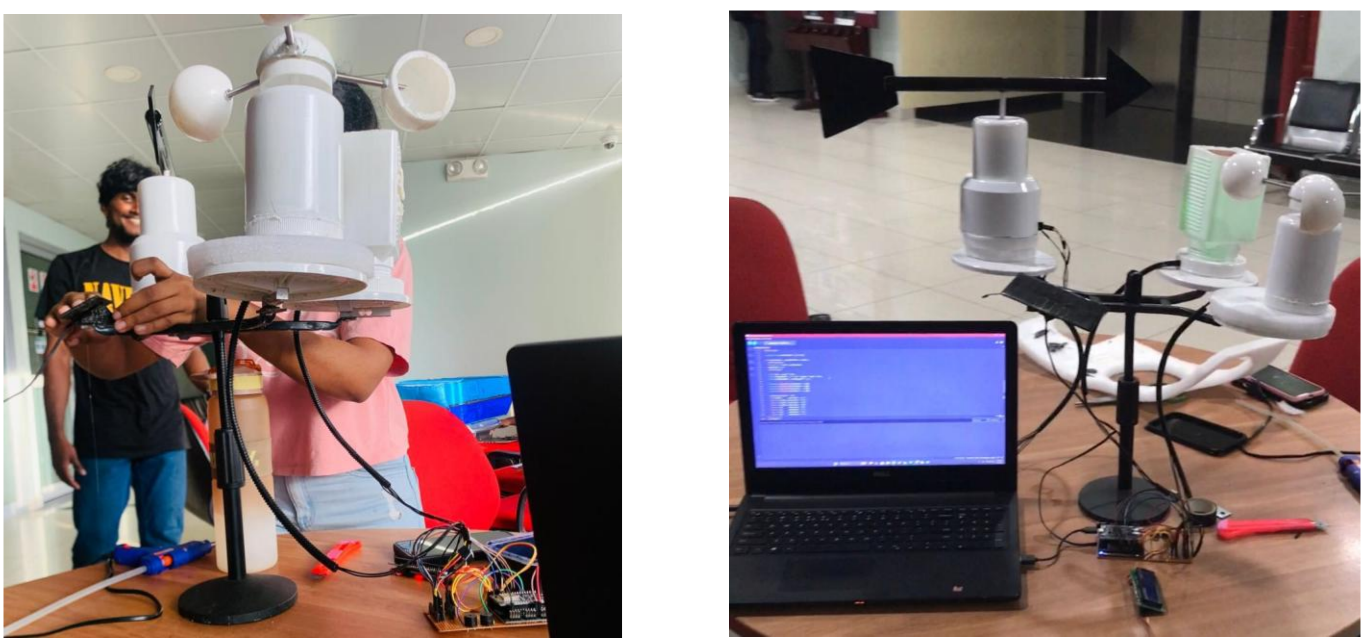

Figure 2 Design of the project

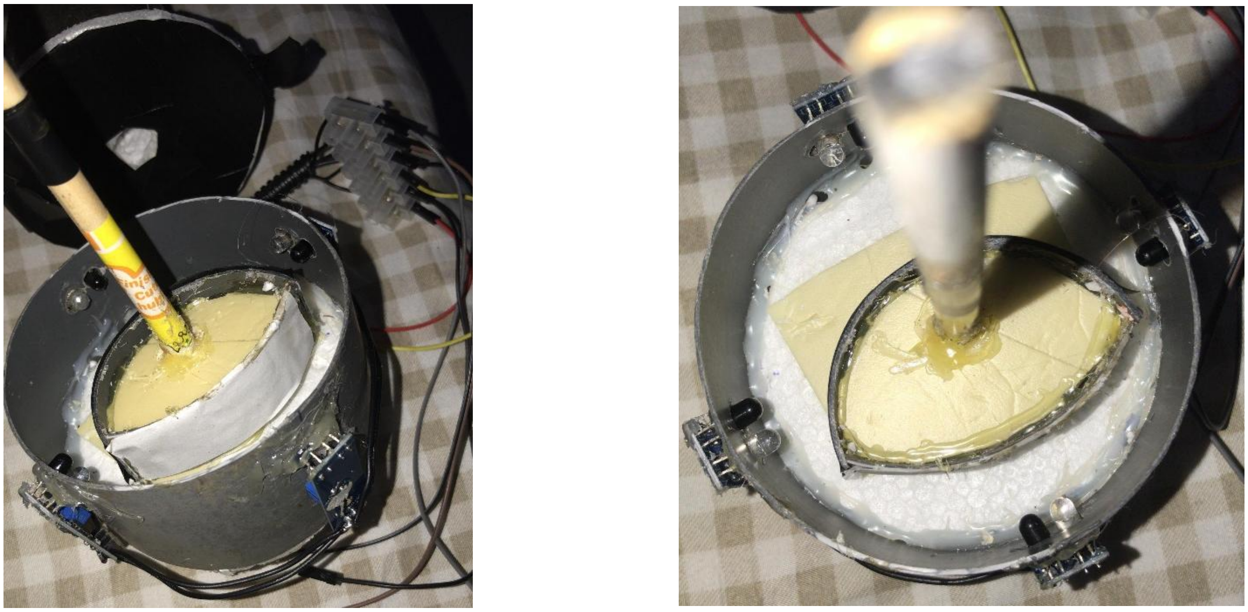

Figure 3 Inner mechanical Appearance of wind wane

Implementation

The hardware implementation involved assembling the ESP8266 NodeMCU with the DHT11 sensor, rain sensor, Hall effect sensor, IR modules, buzzers, and LCD display. The pin configuration was selected to optimize interrupting handling for the Hall sensor and to maintain compatibility with the ESP8266's input-output limitations. Software development was carried out in the Arduino IDE, with libraries such as Blynk, DHT, and LiquidCrystal_I2C facilitating sensor interfacing and communication.

The code was structured to periodically calculate wind speed by counting pulses from the Hall sensor, while simultaneously acquiring temperature, humidity, rainfall, and wind direction data. These values were displayed on the LCD in a compact two-line format. Data was also uploaded to the Blynk cloud using virtual pins, which allowed mobile users to visualize the weather conditions in real time. The Blynk interface was customized to include graphs, numeric displays, and status indicators for rainfall and wind alerts. During testing, the system successfully transmitted real-time data over Wi-Fi and triggered buzzer alerts when defined thresholds were exceeded.

Results and Discussion

Experimental evaluation of the system was carried out under varying weather conditions. The DHT11 sensor provided reasonable readings of temperature and humidity, although with limited accuracy compared to professional instruments. The Hall effect sensor and anemometer combination successfully measured wind speed, with calculated values showing close agreement with a reference weather application within a ±5% margin. Wind direction detection using IR sensors functioned effectively, though occasional interference required recalibration. Rainfall detection was sensitive to water presence, classifying conditions as dry, light rain, or heavy rain depending on sensor output values.

The results were displayed both on the local LCD and the Blynk application, where users could remotely track conditions in real time. The system reliably triggered buzzer alerts when wind speed exceeded 40 km/h or when heavy rainfall was detected. However, some limitations were observed. The DHT11 sensor exhibited delays and lower accuracy at higher humidity levels, and the analog rain sensor was influenced by surface dirt or inconsistent wetting. The dependency on Wi-Fi connectivity also limited deployment in areas with poor coverage. Despite these challenges, the overall system performance was robust for low-cost weather monitoring.

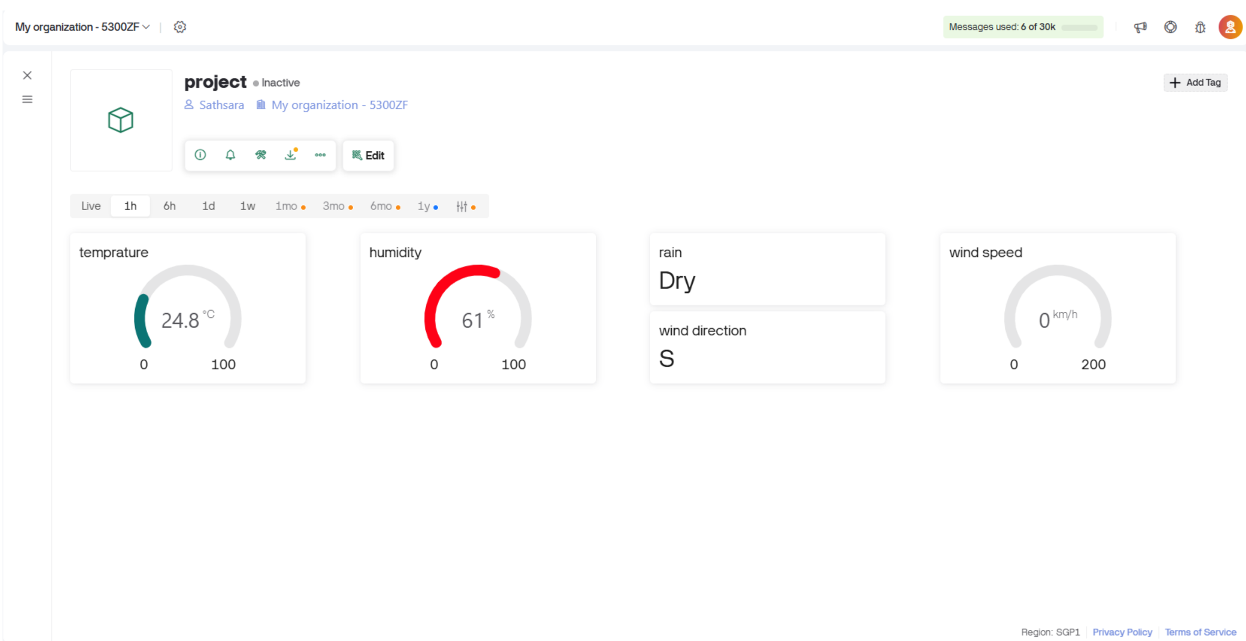

Figure 4 Web Dashboard

Applications

The developed weather monitoring system has a range of practical applications. In agriculture, it can assist farmers by providing real-time data on rainfall and humidity, enabling informed decisions regarding irrigation and crop protection. In disaster management, the system can serve as an early warning tool for floods and strong winds, helping to reduce potential damage and loss of life. For smart cities, deploying multiple such stations can create a localized network of weather data collection points, enhancing urban planning and safety. The low cost and compact design also make it suitable as an educational tool for students learning about IoT and environmental monitoring.

Conclusion and Future Work

This work has presented the design and implementation of a multi-sensor, IoT-based weather monitoring station using the ESP8266 NodeMCU and the Blynk cloud platform. The system successfully measured and displayed wind speed, wind direction, temperature, humidity, and rainfall, while also providing real-time alerts through buzzers. Results demonstrated that the system is effective as a low-cost solution for localized weather monitoring.

Future work will focus on enhancing sensor accuracy by replacing the DHT11 with more precise sensors such as the DHT22 or SHT31. Power autonomy can be improved through solar panel integration, making the system suitable for rural or remote areas. Data analytics and machine learning techniques can also be incorporated to predict weather patterns based on collected data. Furthermore, alternative communication technologies such as LoRa or 5G can be explored to extend coverage beyond the limitations of Wi-Fi.

References

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