IOT-Based Interoperable Platform for Real-Time Weather Data Acquisition and Visualization

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Abstract –
Weather monitoring plays an important role in agriculture, environmental studies, and disaster management. Traditional weather monitoring systems are often expensive, complex, and lack real-time accessibility. This paper presents an **IoT-Based Interoperable Platform for Real-Time Weather Data Acquisition and Visualization** that measures important atmospheric parameters such as wind speed, wind direction, and rainfall. The system utilizes sensors including an **anemometer, wind vane, and rain gauge**, which collect environmental data in real time. The collected data is processed using an **STM32 microcontroller based on ARM Cortex-M4 architecture** and displayed on a **16×2 LCD** for immediate visualization. Through IoT integration, the data can also be transmitted to cloud platforms for remote monitoring and analysis. The proposed system provides a **low-cost, energy-efficient, and scalable solution** for continuous environmental monitoring and can be applied in agriculture, meteorology, and smart city applications.

Key Words: IoT, Weather Monitoring System, STM32 Microcontroller, Anemometer, Wind Vane, Rain Gauge, Real-Time Monitoring.

1.INTRODUCTION

Accurate weather monitoring is essential for agriculture, disaster prediction, environmental research, and climate analysis. Conventional weather stations are often expensive and require large infrastructure, making them difficult to deploy in remote areas.

With the advancement of **Internet of Things (IoT)** technology, it has become possible to design compact and cost-effective weather monitoring systems that provide real-time data acquisition and remote accessibility.

The proposed system introduces an **IoT-based interoperable weather monitoring platform** capable of collecting and processing weather parameters such as wind speed, wind direction, and rainfall. Sensors installed in the environment collect atmospheric data and send it to the **STM32 microcontroller**, which processes and displays the information on a local LCD display.

The system is designed to be **scalable and interoperable**, allowing additional sensors such as temperature, humidity, and air quality sensors to be integrated in the future. This flexibility makes the platform suitable for a wide range of environmental monitoring applications.

2. Body of Paper

2.1 Literature Review / Related Work

Several research studies have focused on developing weather monitoring systems using embedded systems and IoT technology. Traditional meteorological stations provide accurate data but are expensive and difficult to deploy in large numbers.

Recent studies have introduced IoT-based weather monitoring systems that use microcontrollers such as Arduino, Raspberry Pi, and ESP32 to collect environmental data. These systems allow remote monitoring through cloud platforms and mobile applications.

However, many existing systems lack interoperability and scalability, making it difficult to integrate multiple sensors and communication protocols. The proposed system addresses these limitations by designing a flexible platform using the STM32 microcontroller, which provides high processing capability and advanced peripherals for efficient sensor integration.

2.2 Problem Statement

Traditional weather monitoring systems suffer from several limitations such as high cost, limited accessibility, and lack of real-time data availability. These systems are difficult to deploy in remote or rural areas and often lack flexibility for expansion.

The main problem is to design a **low-cost, scalable, and real-time weather monitoring system** that can collect environmental data accurately and transmit it for remote monitoring.

The system should:

1. Acquire real-time weather parameters such as wind speed, wind direction, and rainfall.
2. Process sensor data efficiently using a microcontroller.

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3. Display weather information locally and allow remote monitoring through IoT.
4. Provide an interoperable platform that supports integration of additional sensors.

2.3 Objectives

- To design an **IoT-based weather monitoring system** for real-time environmental data acquisition.
- To measure atmospheric parameters such as **wind speed, wind direction, and rainfall** using appropriate sensors.
- To process and display sensor data using the **STM32 microcontroller and LCD display**.
- To enable remote monitoring through **IoT-based communication platforms**.
- To develop a **scalable and interoperable system** that can integrate additional sensors in the future.

2.4 Methodology

The proposed system consists of the following main components:

Sensors:
- Anemometer for measuring wind speed
- Wind vane for detecting wind direction
- Rain gauge for measuring rainfall

Microcontroller:
- STM32 microcontroller based on ARM Cortex-M4 architecture.

Display Unit:
- 16×2 LCD used to display real-time weather parameters.

IoT Connectivity:
- Data can be transmitted to cloud platforms for remote monitoring and analysis.

Data Processing:
- Sensor signals are read using ADC and digital input pins.
- Wind speed is calculated by counting pulses generated by the anemometer.
- Wind direction is determined by measuring analog voltage from the wind vane.

2.5 Implementation

The system hardware consists of sensors interfaced with the **STM32 microcontroller**. The **anemometer** generates pulses proportional to wind speed, which are counted using external interrupt pins of the microcontroller.

The **wind vane** produces analog voltage corresponding to wind direction, which is converted into digital values using the microcontroller's **ADC module**.

The **rain gauge** measures rainfall by generating pulses when water fills and tips the bucket mechanism.

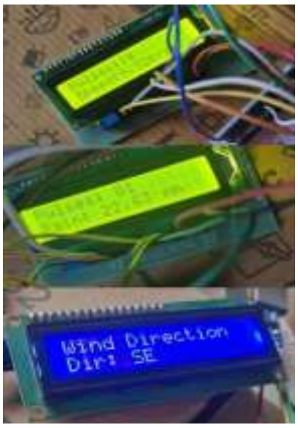
All sensor data is processed by the STM32 microcontroller and displayed on a **16×2 LCD screen**. The system can also transmit the collected data to an IoT platform for remote monitoring and long-term data storage.

2.6 Results and Discussion

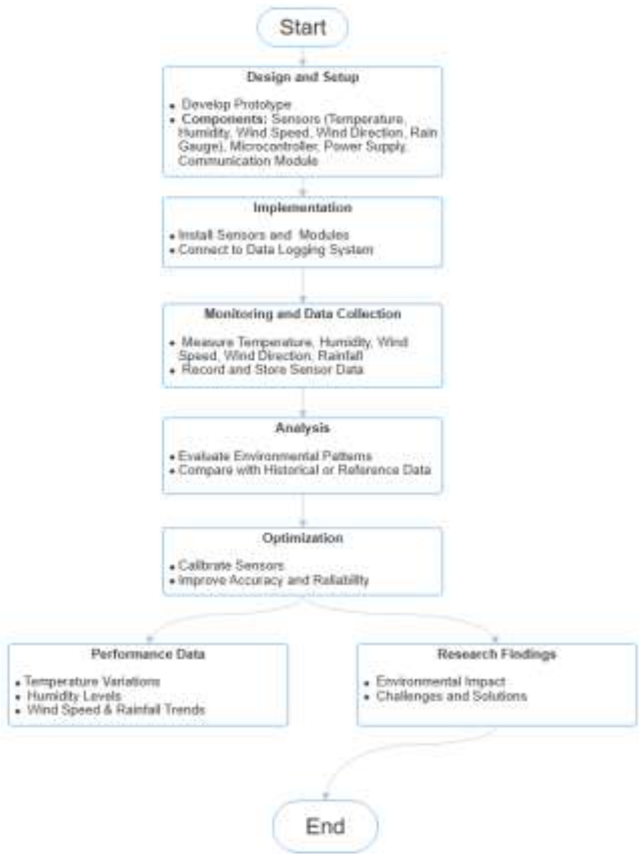
The implemented system successfully measured weather parameters including wind speed, wind direction, and rainfall in real time.

Experimental testing demonstrated that the system provides:

- Accurate measurement of environmental parameters.
- Fast response time for sensor data acquisition.
- Reliable display of weather information on LCD.



2.7 System Architecture



2.8 Limitations

- Sensor accuracy may vary depending on environmental conditions.
- Continuous internet connectivity is required for IoT data transmission.
- The system currently measures limited weather parameters.
- Calibration of sensors is required for accurate measurements.

2.9 Future Scope

Future improvements can include integrating additional environmental sensors such as:

- Temperature sensor
- Humidity sensor
- Atmospheric pressure sensor
- Air quality monitoring sensor

The system can also be integrated with **mobile applications and cloud analytics** for advanced data visualization and predictive weather analysis

3. CONCLUSIONS

The proposed **IoT-Based Interoperable Platform for Real-Time Weather Data Acquisition and Visualization** provides an efficient and cost-effective solution for environmental monitoring. By integrating sensors with the **STM32 microcontroller and IoT technology**, the system enables real-time weather data collection and visualization.

The developed platform demonstrates reliable performance, scalability, and low power consumption. It can be widely used in agriculture, meteorology, environmental research, and smart city applications.

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