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I hereby declare that the work entitled **"Smart Weather Station"** is my work, conducted under the supervision of **Dr. Shobha Mishra , Assistant Professor ,** during the session Jan-May 2024. The report submitted by me is a record of bonafide work carried out by me.
I further declare that the work reported in this report has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

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ABSTRACT

This project presents the development of an IoT-based smart weather station using the NodeMCU ESP8266 microcontroller. The weather station connects a combination of DHT11 sensor for temperature and humidity measurements together with rain sensors and LDR (Light Dependent Resistor) to monitor light intensity levels. Real-time data monitoring happens through a 16x2 LCD screen that displays all recorded information to users in the local area. The NodeMCU uses its WiFi capabilities to send sensor data to Adafruit IO cloud platform providing users with constant environmental condition tracking through their internet devices.

IFTTT (If This Then That) enables automated alerts that improve user safety as a core functionality within the system. The system uses IFTTT as a protocol to send emails alerting users about threatening weather conditions when specified thresholds such as high temperature or heavy rainfall or low sun exposure occur. Through its proactive warning capabilities the weather station proves itself to be informative and warning delivering at the same time. The weather monitoring solution provides an affordable system which operates in real-time and scales effectively so it fits well for agricultural use alongside home automation and distant environmental site inspection programs.

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ACRONYMS

1. **IoT** – *Internet of Things*
2. **LCD** – *Liquid Crystal Display*
3. **LDR** – *Light Dependent Resistor*
4. **IFTTT** – *If This Then That*
5. **GPIO** – *General Purpose Input/Output*
6. **ESP** – *Espressif Systems Platform* (in NodeMCU ESP8266)

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CHAPTER 1: INTRODUCTION

Weather monitoring has become increasingly important in today's world, where climate conditions directly impact agriculture, transportation, daily planning, disaster preparedness, and overall public safety. Weather information delivered in real time enables organizations and individuals to minimize losses and boost performance and create better analytical choices for their personal and business needs. Standard weather stations remain costly as well as technically advanced while maintaining barriers for individuals aside from students and users working with small-scale operations. The systems feature restricted versatility combined with limitations in remote data access in real time. The fast development of Internet of Things (IoT) technology allowed researchers to build small affordable weather monitoring systems which provide real-time data access from distant sites. Through its framework the IoT establishes effortless communication among sensors systems and microcontrollers and cloud storage which enables ceaseless data information gathering and pattern analysis along with warning capabilities [1][3].

This project proposes the development of a smart weather station utilizing the NodeMCU ESP8266 microcontroller, known for its low power consumption and integrated Wi-Fi capability. The core sensing components include a DHT11 sensor for measuring temperature and humidity, a rain sensor to detect precipitation levels, and an LDR (Light Dependent Resistor) to monitor ambient light intensity. These sensors continuously collect environmental data, which is simultaneously displayed on a 16x2 LCD module for local real-time viewing. Moreover, the data is wirelessly transmitted to the Adafruit IO cloud dashboard, enabling users to remotely monitor current weather conditions through a user-friendly interface. To enhance responsiveness and user safety, the system integrates IFTTT (If This Then That) automation. When specific thresholds are crossed—such as high humidity, the presence of rain, or significantly low light levels—IFTTT services trigger automatic email alerts to notify users of potentially unfavorable or dangerous weather conditions. This real-time alert mechanism allows users to take preventive or responsive action quickly. Overall, this project presents a reliable, scalable, and energy-efficient weather monitoring solution that supports a wide range of applications, including academic experimentation, smart agriculture, remote weather surveillance, and home automation systems. It showcases the practical application of IoT in creating intelligent systems that are affordable, accessible, and impactful [4][5].

CHAPTER 2: LITERATURE SURVEY

The growing demand for real-time and remote weather monitoring has led researchers and developers to explore IoT-based weather stations using various microcontrollers and sensors. Numerous studies have built weather monitoring systems through Arduino and Raspberry Pi platforms while using DHT11 temperature and humidity sensors and rain sensors and light sensors. Although environmentally tracked data could be shown from these systems they did not have internet capabilities or live warning systems [8]. Developers have achieved compact and affordable weather station development with wireless data transmission to Adafruit IO cloud services through the NodeMCU ESP8266 which features integrated Wi-Fi capabilities. Cloud dashboards offer successful visualizations of weather trends as demonstrated by previous artwork but automatic alerts and automation are absent in these deployments [6].

The proposed project takes the standard weather station blueprint into a new direction through the combination of real-time data visualization with enlightened alert automation capabilities. The combination of NodeMCU technology with DHT11 sensor and rain sensor and LDR provides the project with multi-dimensional capability to monitor diverse weather parameters. Data from the system becomes visible on a local LCD screen and at the same time gets transferred to the Adafruit IO dashboard for remote cloud viewing [9]. IFTTT services function in this project to generate email notifications for specific threshold events such as high humidity and rain detection and low light conditions. The automated notification capability enhances user awareness while quickening response times to weather changes thus making this system appropriate for agricultural and educational purposes together with remote environmental monitoring tasks [10].

CHAPTER 3: COMPONENTS USED

The components used in this smart weather monitoring system were carefully selected based on their affordability, ease of use, and seamless compatibility with the NodeMCU ESP8266 microcontroller, which acts as the central control unit of the setup. The NodeMCU, with its built-in Wi-Fi capabilities, facilitates smooth communication between the sensors and the cloud platform, making it ideal for IoT-based applications. The DHT11 sensor offers reliable temperature and humidity readings, while the rain sensor detects the presence of rainfall, and the LDR measures light intensity to assess surrounding brightness or darkness. These sensors collectively ensure comprehensive environmental data collection. To provide immediate on-site feedback, a 16x2 LCD display is integrated for real-time local data visualization. Simultaneously, all sensor data is uploaded to the Adafruit IO dashboard, enabling remote monitoring via any internet-connected device. The inclusion of IFTTT further enhances system functionality by triggering automated email alerts when specific weather thresholds are met. This dual approach of local and remote access makes the system versatile, user-friendly, and suitable for various applications such as education, smart agriculture, and personal weather tracking [11][14].

1. NodeMCU ESP8266

The NodeMCU ESP8266 in Fig. 1 comes with Wi-Fi features while being based on the ESP8266 microcontroller chip yet remains affordable to most users. As the central processor of the weather station it obtains data from sensors before processing it while maintaining communication with the cloud platform (Adafruit IO). The NodeMCU ESP8266 consists of Wi-Fi hardware integrated into its design which enables it to transfer data directly to the internet so it serves as an excellent IoT solution [15].

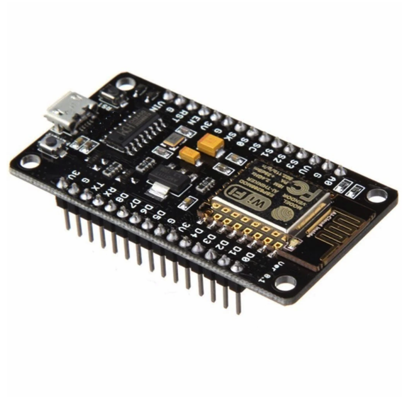

Fig. 1: NodeMCU ESP8266 Board

2. DHT11 Temperature and Humidity Sensor

The DHT11 operates as an economical environmental sensor which detects both temperature conditions and surrounding humidity values. Reliable climate condition data is available through its operational system. The DHT11 sends digital data to the NodeMCU enabling the microcontroller to receive temperature and humidity readings needed for weather monitoring operations [16].

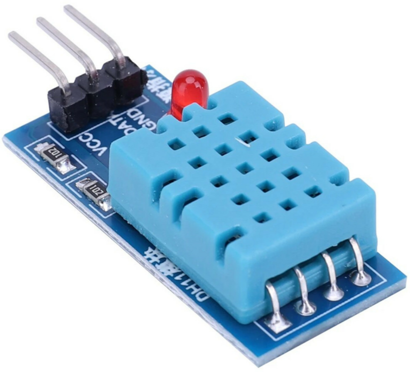

Fig. 2 : DHT11 Temperature and Humidity Sensor

3. Rain Sensor

The sensor uses its surface to detect rain through identifying moisture accumulation. A basic digital signal from the sensor delivers rain detection information to the NodeMCU because it generates either HIGH or LOW_output signals. Real-time precipitation monitoring becomes possible through the weather station because the rain sensor sends immediate alerts or initiates programmed responses upon detection of precipitation [17].

Fig. 3 : Rain Sensor

4. LDR (Light Dependent Resistor)

The variable resistor LDR decreases its resistance value as light intensity in its environment rises. Using an LDR enables the system to detect the surrounding light intensity which corresponds to daytime progression or cloud cover intensity. Light conditions monitored through the LDR analog output become detectable to the NodeMCU so that the system produces weather-related information [18].

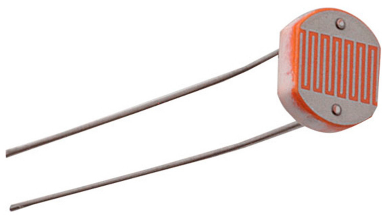

Fig. 4 : LDR Sensor

5. 16x2 LCD Display (I2C)

Real-time measurements of temperature together with humidity values and lighting conditions display through the 16x2 LCD interface. The I2C communication protocol installed on the LCD reduces wiring complexity because it provides seamless display updates. Users can easily view present environmental conditions using the local display instead of logging into the cloud dashboard [19].

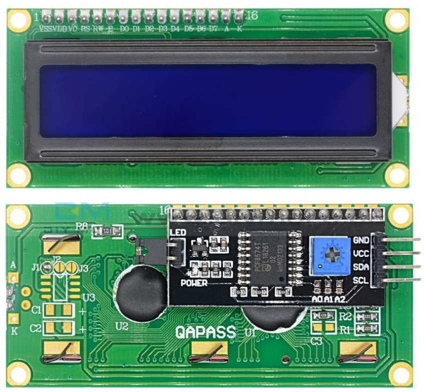

Fig. 5 : 16x2 LCD Display (I2C)

Sensor	Parameter	Range	Accuracy
DHT11	Temperature Humidity	0 – 100 °C 20 – 90% RH	±2 °C ±5%
Rain Sensor	Rain Detection	Wet/Dry	Approximate 100 %
LDR	Light Intensity	Low to High(LUX)	±10 LUX

Table 1 : Sensor Specifications Table

6. Breadboard and Jumper Wires

The breadboard connects all components through wires which eliminates the requirement of soldering. The circuit testing process becomes simpler through the use of breadboards. NodeMCU uses jumper wires to connect with the different sensors and LCD display for data transmission throughout the system .

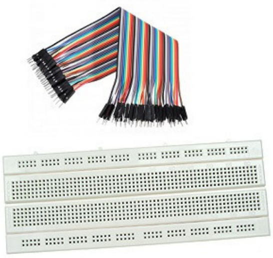

Fig. 6 : Breadboard and Jumper Wires

7. Adafruit IO Dashboard

Users benefit from using Adafruit IO as a cloud-based data visualization platform that processes information from their weather station. Weather data is accessible anytime on a web dashboard through internet connection because of this system. The NodeMCU ESP8266 transfers weather station sensor data to the Adafruit IO platform by using Wi-Fi. The interface displays real-time updates of temperature and humidity measurements alongside light intensity and precipitation data using a user-friendly format. Additionally, Adafruit IO stores historical data, providing users with insights into long-term environmental trends [20].

8. IFTTT (If This Then That)

IFTTT serves as an advanced automation system which enables users to make applets that activate sequences based on particular circumstances. The project employs IFTTT to activate automated email alerts through predefined conditions which include weather readings revealing high humidity together with rainfall content or reduced light measurements that indicate reduced visibility. The NodeMCU transmits data to Adafruit IO for IFTTT to monitor and initiate user-defined actions that include sending email advisories about unfavorable weather conditions. By integrating these elements the system obtains immediate warning capabilities alongside user protection benefits [21].

Component/Sensor	Measured Parameter	Function
DHT11	Temperature and Humidity	Detects ambient temperature and humidity levels
Rain Sensor	Rainfall Detection	Senses presence of rain
LDR	Light Intensity	Measures ambient light levels
NodeMCU ESP8266	Data Processing & Transmission	Collects sensor data and handles communication
Adafruit IO	Cloud Dashboard	Visualizes live weather data online
IFTTT	Event Trigger and Notification	Sends automated email alerts based on conditions

Table 2 : Sensors Functionality

CHAPTER 4: SYSTEM ARCHITECTURE

The system follows a basic modular framework which enables simple deployment along with straightforward future scaling.

1. Overview of System Architecture

I. NodeMCU ESP8266 microcontroller functions as the central controller to incorporate diverse sensors within its system architecture which operates the complete system. The system has three main operational areas called Data Acquisition alongside Data Processing and Data Visualization/Alerting.

II. The data acquisition stage uses three environmental sensors including DHT11 for temperature and humidity readings as well as rain detection through the rain sensor and light measurement with the LDR. The NodeMCU collects signals that either come as analog or digital from the sensors.

III. The NodeMCU operates on sensor input to generate weather parameters as well as structure the data before additional procedures begin. Through Wi-Fi transmission the NodeMCU transmits data to Adafruit IO platform and displays updates on its local LCD screen.

IV. The 16x2 LCD screen serves to show processed data that users can monitor locally. At the same time the processed data travels to Adafruit IO before it gets displayed on their web-based dashboard. When the IFTTT service detects any weather condition surpassing established thresholds it generates an automated email notification for the user.

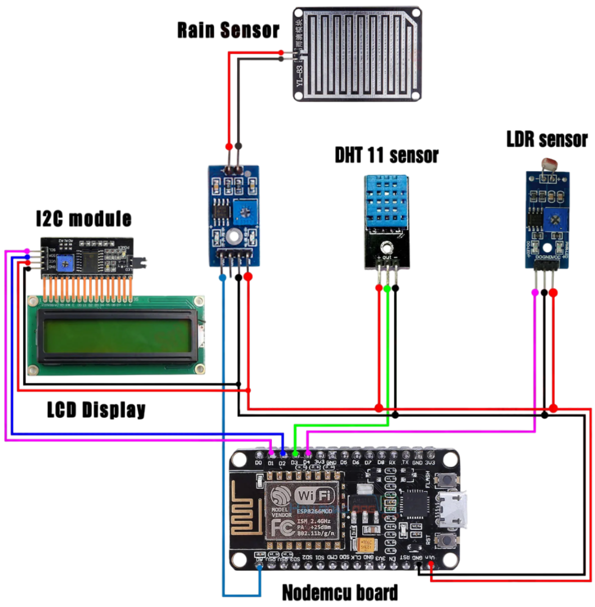

Fig. 7 : Architecture Based On Sensors And IOT Devices

2. Detailed Architecture Flow

I. The NodeMCU connects the DHT11 sensor with the Rain Sensor and LDR through GPIO pins for communication. The NodeMCU receives digital sensor readings from the DHT11 regarding temperature and humidity measurement on a continuous basis. The Rain Sensor uses digital communication to detect rainfall through HIGH/LOW signals. The LDR produces light intensity measurements through analog signal output.

II. The core processing unit of the system functions through the NodeMCU ESP8266 microcontroller. The NodeMCU performs sensor input data collection before transitioning it to data processing then manages Wifi connectivity. The NodeMCU receives instructions through the Arduino IDE to handle sensor interactions and data processing which enables it to transmit the information to both the LCD display and Adafruit IO dashboard. The microcontroller uses IFTTT to send emails when particular conditions detect high humidity or rainfall.

III. The 16x2 LCD connected through I2C communicates weather data monitoring real-time including temperature alongside humidity counts and rainfall conditions and illumination measurements. The LCD acts as a local output display for quick monitoring of environmental conditions.

IV. The NodeMCU transmits sensor data through the Wi-Fi network to Adafruit IO within the Cloud Communication platform. The cloud platform delivers real-time and historical monitoring of weather data by allowing users to view dashboards through an internet-based interface [15]. The system displays complete weather trend and condition data for users to observe on their dashboard interfaces.

V. IFTTT (If This Then That) enables email notifications by detecting particular weather patterns such as high humidity, heavy rainfall and low light values. When data becomes available from Adafruit IO the IFTTT applet begins its function which delivers notifications instantly through email [21].

CHAPTER 5: WORKING METHODOLOGY

The smart weather monitoring system executes its functions using a stepwise process starting from sensor data acquisition up to local visualization before moving to cloud-based monitoring and ending with intelligent alert generation. The major component of the system is the NodeMCU ESP8266 microcontroller that directs the entire operational sequence. Through its programming the NodeMCU ESP8266 microcontroller reads continuous sensor data from the DHT11 sensor for temperature and humidity while simultaneously reading the Rain Sensor for precipitation detection and the LDR (Light Dependent Resistor) for lighting conditions. Each sensor utilizes specific GPIO pins for connection before the system collects data periodically to maintain current environmental monitoring status [16].

The 16x2 LCD display accepts processed sensor readings in real-time to show the current weather conditions in the local area. The NodeMCU utilizes its Wi-Fi module to send this data through the built-in Wi-Fi connection to the Adafruit IO dashboard where real-time sensor information appears as dynamic widgets including graphs as well as gauges and indicators. The remote monitoring function with internet connectivity enables users to access and track information from any spot where an internet connection exists.

Condition	Sensor Involved	Min Threshold	Max Threshold	Action Triggered
Abnormal Temperature	DHT11 (Temperature)	Below 15 °C	Above 35 °C	Email alert via IFTTT
Abnormal Humidity	DHT11 (Humidity)	Below 15 %	Above 40%	Email alert via IFTTT
Rainfall Detected	Rain Sensor	N/A	Detected (Wet)	Email alert via IFTTT
Poor Visibility (Low Light)	LDR	Below 100 (LUX)	N/A	Email alert via IFTTT

Table 2 : Alert Threshold Configuration Table

The proposed solution uses IFTTT (If This Then That) automation services to boost system speed. The defined system parameters establish specific environmental criteria like high humidity and rainfall together with reduced light levels to signal upcoming harsh weather [7]. It activates a particular Adafruit IO event after detecting the predefined threshold conditions which automatically launches the IFTTT applet to create email alerts. Real-time weather notifications through this mechanism enable automatic alerts to users about unsafe weather conditions without their having to monitor the environment manually thus creating a reliable interactive warning system [21].

Chapter 6: Results

All targets for the smart weather monitoring system generated quick and precise data throughout its intended platforms. The NodeMCU program upload led to verification through the Serial Monitor feature in Arduino IDE for sensor and data acquisition responses as shown in Fig. 9. The Serial Monitor gave ongoing access to temperature results along with humidity readings and light measurement values and results for rain detection. The values from the NodeMCU and its connected sensors were updated at consistent time intervals thereby validating their correct operational connection. The testing phase needed this step because it helped to establish correct sensor precision levels and maintain system responsiveness.

Fig.9 : Output of Serial Monitor

The data transmission process operated simultaneously between the electronic sensors and the Adafruit IO Dashboard. Every sensor provided its data through interactive visualization tools which included gauges , Bar Graphs and Indicators as shown in Fig.10. The displayed dashboard automatically refreshed with the newest environmental data that sensors scanned at that point in time. Through the display gauges showed temperature and humidity readings but the rain sensor status used a binary ON/OFF indicator and LDR data printed an ambient light chart across elapsed time. The visualization proved the flawless connection between NodeMCU and the Adafruit IO platform which enabled real-time monitoring through web and mobile interfaces.

The project automation system used IFTTT triggers to send automatic alert emails when multiple critical parameters such as humidity increase and rain plus bad visibility occurred simultaneously. The system sent out rapid alerts to the registered email immediately for providing safety notifications to users. The functional output of our system is shown in the screenshots that include Serial Monitor logs and Adafruit IO dashboard with sample IFTTT email notifications.

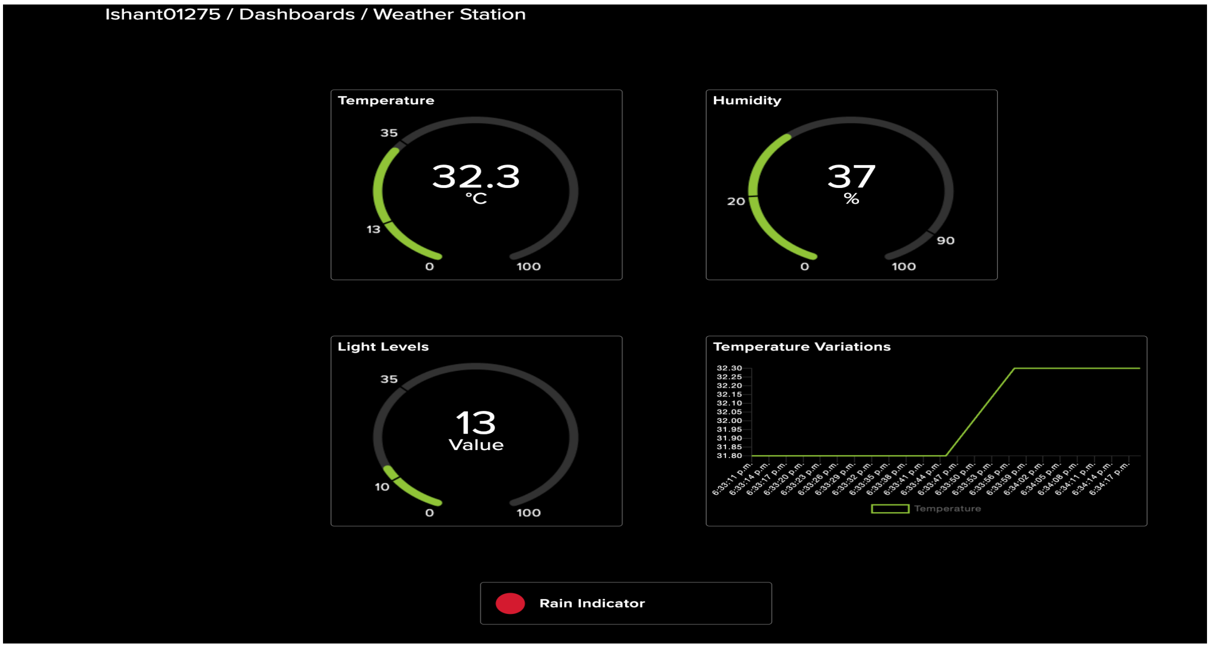

Fig. 10 : Dashboard of Weather Station

CHAPTER 7: CONCLUSION

The development and implementation of the smart weather station using the NodeMCU ESP8266 microcontroller, along with sensors such as the DHT11, Rain Sensor, and LDR, has demonstrated the effectiveness of IoT-based systems in environmental monitoring. By leveraging low-cost and easily accessible components, the project successfully collected, processed, and displayed real-time weather data on both a local LCD display and a remote cloud dashboard using Adafruit IO. The integration of Wi-Fi functionality provided seamless data transmission, ensuring that users could monitor weather conditions from any location with internet access.

Additionally, the use of **IFTTT automation** enhanced the system's responsiveness by providing **automated email alerts** based on critical weather conditions. This feature added a significant layer of usability, enabling proactive measures to be taken in scenarios such as high humidity, rainfall, or poor visibility. The project proves to be highly applicable for use in smart farming, educational environments, and remote weather surveillance, offering a scalable and efficient solution. Overall, this system represents a practical and valuable application of IoT in weather monitoring, promoting accessibility, automation, and real-time awareness.

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