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IoT Based Weather Monitoring System

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Abstract*: The system proposed in this paper is an advanced solution for monitoring the weather conditions at a particular place and make the information visible anywhere in the world. The technology behind this is the internet of things (IoT), which is an advanced and efficient solution for connecting the things to the internet and to connect the entire world of things in a network. Here things might be whatever like electronics gadgets. sensors, automotive electronic equipment. The required hardware includes an Arduino development board, I2C module with LCD, DHT11, MQ 135, BMP 180, ESP 8266/01 Wi-Fi module, raindrop sensor and a 12 core adapter. The system deals with monitoring and controlling environmental conditions such as temperature, relative humidity, barometric pressure, air quality, rainfall and sends the information to the web page and then plot the sensor data as graphical statistics using Thing-Speak software. The data updated from the implemented system can be accessible on the internet from anywhere in the world.*

Keywords: I2C, IoT, Arduino, Sensors

I. INTRODUCTION

The Internet of Things (IoT) has revolutionized the way we interact with the world around us offering unprecedented oppurtunities for data collection and analysis. One of its most impactful applications lies in environmental monitoring, particularly in the realm of the weather observation. An IoT based weather monitoring system harnesses interconnected devices to gather real-time meterological data, providing accurate insights into atmospheric conditions. The system not only enhances our understanding of weather patterns but also facilitates timely responses to climate related challenges. By integrating sensors, cloud computing, data analytics, this innovative approach aims to improve local weather forecasting, support agricultural practices and contribute to disaster management efforts. This paper explores the components, functionality, potential applications of an Iot based weather monitoring system

II. EXISTING SYSTEM AND LIMITATIONS

IoT, or the internet of things, refers to the network of the interconnected devices that can collect, exchang, analye data. In the context of weather monitoring system, IoT enables the development of sensor equipped devices to gather real time environmental data and transmit it to cloud platforms for centralized processing and analysis.

LIMITATIONS:

1. It requires a well structured hardware.
2. Data on the online platform cannot be stored for future use.
3. Maintaining and updating the IoT hardware and software can be a significant challenge, especially in remote and harsh environments.

III. PROBLEM STATEMENT

The development of a real-time IoT-based weather monitoring system faces significant challenges, including inaccurate and delayed forecasting, limited spatial coverage, high energy consumption, security vulnerabilities, and inadequate alert systems. To address these issues, an efficient system must be designed to collect and transmit real-time weather data from remote locations, leveraging machine learning algorithms and sensor data fusion for accurate forecasting. The

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system should prioritize energy efficiency, security, and scalability, while providing timely alerts and warnings to stakeholders, including farmers, emergency responders, urban planners, and the general public, ultimately enhancing decision-making capabilities, reducing costs, and ensuring public safety and awareness.

IV. LITERATURE SURVEY

IoT-based weather monitoring systems leverage Internet of Things technology to collect and disseminate real-time weather data, enhancing decision-making in various sectors such as agriculture, disaster management, urban planning, and health. These systems utilize wireless sensor networks, GSM, and cloud platforms to collect data from diverse sensors. The systems employ various sensors, including temperature, humidity, pressure, rain, and wind sensors, to gather accurate weather data. IoT-based architectures, such as device-to- device, device-to-cloud, and fog computing, enable efficient data processing and transmission. This enables real-time monitoring and analysis of weather patterns. However, challenges persist, including energy efficiency, data accuracy, security, and scalability. Ongoing research focuses on addressing these issues, optimizing sensor power consumption, improving data validation, ensuring secure transmission, and developing modular architectures to create robust and reliable weather monitoring systems. By overcoming these challenges, IoT-based weather monitoring systems can provide more accurate and reliable data, supporting informed decision-making. Applications span agriculture, where real-time data aids precision farming (Sinha et al., 2021), to disaster management, providing early warnings for natural disasters (Ali & Xu, 2019), and urban climate monitoring to inform city planning (Zhang et al., 2021). Future directions suggest a growing integration of AI for predictive modelling and the potential of 5G technology to enhance connectivity, ultimately improving the effectiveness of these systems across various sectors

V. SCOPE OF PROJECT

The system aims to collect and analyze real-time weather data, including temperature, humidity, wind speed, and rainfall. This data will be accessible remotely via a mobile app or web dashboard. The system will consist of sensors, a microcontroller for data processing, communication modules for data transmission, and cloud storage for secure data management. A user-friendly interface will allow individuals to visualize data and receive timely alerts.

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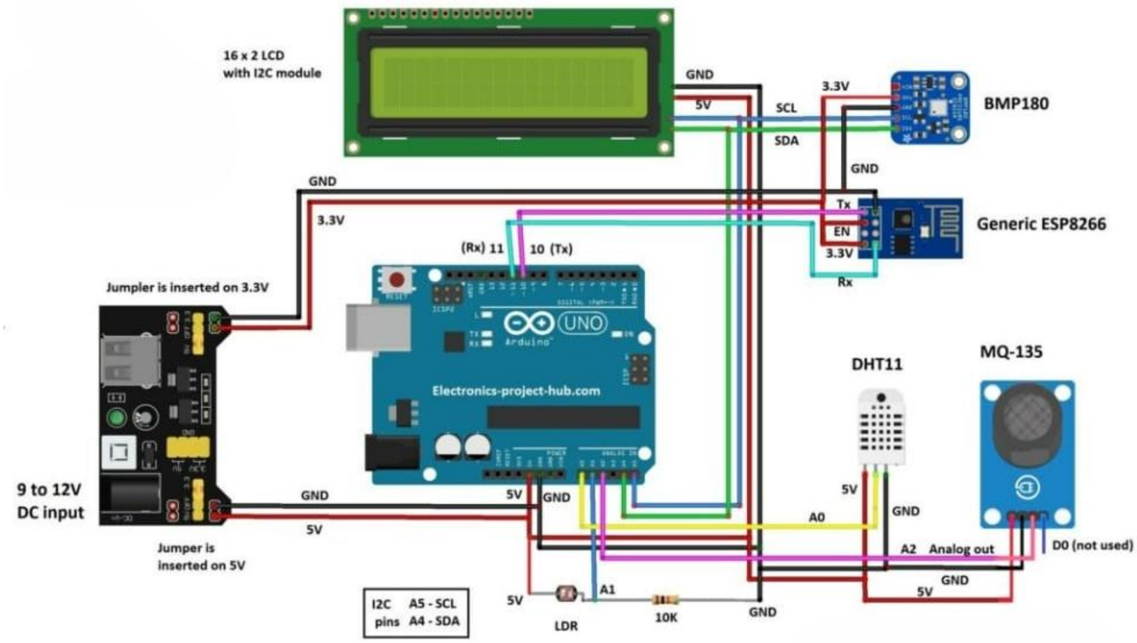
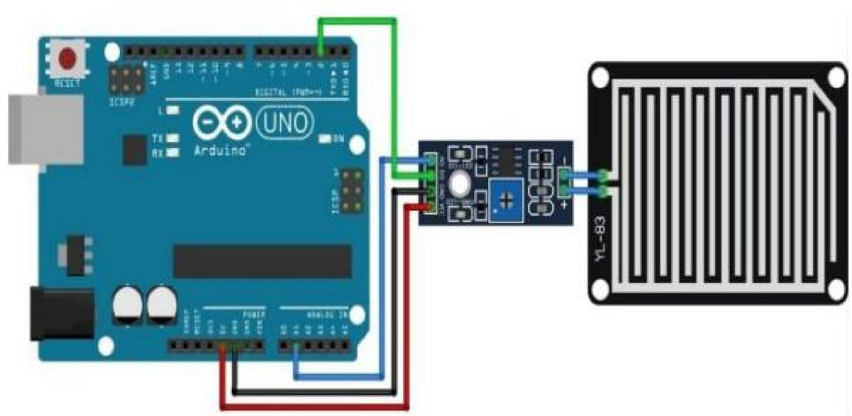
VI. SCHEMATIC DIAGRAM



As there is no rain sensor in the schematic, we have added the interfacing of the raindrop sensor with the Arduino board.



WORKING

After setting up the weather monitoring system and making all the necessary connections, upload the code to Arduino and provide 5V and 3.3V power supply to the circuit. Once the system is powered ON, the sensors keep monitoring the weather conditions.

When the DHT11 senses any changes in the temperature and humidity it will send the signal to Arduino, and the amount of temperature or humidity will be displayed on the 16x2 LCD. With the help of Thingspeak software and the ESP82666 these parameters will be displayed graphically. The BMP180 barometric sensor which is capable of measuring atmospheric data; it can give out data like, atmospheric pressure at ground level, atmospheric pressure at sea level and altitude. Just like the DHT11 it will sense the atmospheric pressure and the values will be displayed on the LCD and the online cloud.

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MQ-135 is an analog air quality sensor which takes air samples from your surroundings and gives out an analog voltage at its output terminal. When it monitors the air quality ,the LCD will display the air quality in percentage and whether the air is clean or toxic.

LDR is responsible for collecting data about the intensity of light at your surroundings and it is a passive analog sensor. The LDR is essentially a resistor that is sensitive to the light, when higher intensity light falls on the photosensitive surface its resistance drops and when less light is received its resistance increases. In other words, the resistance is inversely proportional to the intensity of the light on the photosensitive surface of LDR.

The ESP01/8266 Wi-Fi module sends the measured parameters to the online cloud for the graphical display.

A raindrop sensor detects precipitation using a photodiode or infrared sensor. When a raindrop falls on the sensor's surface, it blocks or scatters the emitted light. This change in light intensity is detected by the sensor, triggering an electrical signal that indicates the presence of rain. When water droplets are put on the plate of the rain sensor, the value decreases. This is because this sensor emits light and due to the water droplets the intensity of the light decreases indicating that rainfall is present. This results in lower output voltage. The value will be high when the sensor is in the dry state.

The Arduino board is the heart of this system. It controls the overall operation of the system. Once the program code is uploaded onto the microcontroller of the Arduino, the entire operation begins.

VII. HARDWARE COMPONENTS DESCRIPTION

Arduino UNO

The Arduino Uno is a widely-used microcontroller board designed for building digital devices and interactive projects. Powered by the ATmega328P microcontroller, it features 14 digital input/output pins, 6 analog inputs, and a USB connection for programming. It also includes a power jack and a reset button. The Arduino Uno can be programmed using the Arduino IDE, which supports a variety of coding libraries, making it ideal for both beginners and experienced developers looking to prototype and bring their ideas to life

Specifications:

- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limit): 6-20V
- Digital I/O pins: 14 (6 PWM outputs)
- Analog Input pins: 6
- DC current per I/O pin: 20mA
- Clock Speed: 16 MHz
- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)

16x2 LCD (Liquid Crystal Display)

A 16x2 LCD is a display module that shows 16 characters across 2 lines. It uses an HD44780 controller and typically communicates with a microcontroller via a parallel interface. It supports ASCII characters and some custom ones, with an LED backlight for visibility. Commonly used in DIY projects, it's perfect for displaying text and basic graphics.

Specifications:

- Display Type: 16 characters wide by 2 lines.
- Controller: HD44780 or compatible
- Voltage: Typically operates at 5V
- Interface: Parallel

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- Backlight: LED backlight, often with adjustable brightness
- Character Size: Approximately 5x8 pixels per character.
- Dimensions: Around 80mm x 36mm.
- Operating Temperature: -20°C to +70°C.
- Storage Temperature: -30°C to +80°C.

ESP 01/8266 Wi-Fi Module

The ESP-01/ESP8266 is a small, low-cost Wi-Fi module that adds Internet connectivity to microcontroller projects. It features a 32-bit processor, integrated TCP/IP stack, and supports multiple communication protocols, making it ideal for IoT applications.

Specifications:

- Microcontroller: 32-bit Tensilica Xtensa LX106 CPU running at 80 MHz (overclockable to 160 MHz)
- Flash Memory: 512 KB
- External Flash**:** 8 Mbit (1 MB) external QSPI flash memory
- Wi-Fi: 802.11 b/g/n (2.4 GHz), supporting WPA/WPA2
- Interfaces: UART, SPI, I²C, GPIO, PWM
- Power Supply: 3.3V
- Current Consumption: 100 mA (spikes up to 300 mA depending on mode)

DHT11 (Temperature and Humidity Sensor)

The DHT11 is a widely-used sensor module designed for measuring temperature and humidity. It features a digital output, making it simple to interface with microcontrollers like the Arduino. The DHT11 offers fairly accurate readings, with a temperature range of 0-50°C and a humidity range of 20-90%.

Specifications:

- Operating Voltage: 3.5V to 5.5V
- Operating Current: 0.3 mA (measuring), 60 µA (standby)
- Temperature Range: 0°C to 50°C
- Humidity Range: 20% to 90%
- Resolution: 16-bit for both temperature and humidity
- Accuracy: ±1°C for temperature, ±1% for humidity
- Output: Serial data

MQ 135 (Air Quality Sensor)

The MQ-135 is an air quality sensor used to detect and measure various harmful gases such as ammonia, nitrogen oxides, benzene, smoke, and carbon dioxide. It operates at 5V and provides both analog and digital outputs. The sensor requires a preheating time of about 20 seconds for accurate readings. It's widely used in air quality monitoring systems due to its sensitivity, low power consumption, and affordability.

Specifications:

- Operating Voltage: 5V
- Power Consumption: 150 mA
- Detectable Gases: Ammonia (NH3), Nitrogen Oxides (NOx), Benzene, Smoke, Carbon Dioxide (CO2), and other harmful gases
- Output: Analog (0-5V) and Digital (TTL Logic: 0V or 5V)
- Sensitivity: High sensitivity to the target gases

BMP 180 (Pressure Sensor)

The BMP180 is a high-precision barometric pressure sensor designed for consumer applications. It measures atmospheric pressure and temperature, providing accurate data for applications like altitude measurement, weather forecasting, and environmental monitoring2. The sensor operates on a low voltage (1.3V to 3.6V) and communicates via I2C interface, making it suitable for battery-powered devices.

Specifications:

- Operating Voltage: 1.3V to 3.6V
- Input Voltage: 3.3V to 5.5V
- Pressure Range: 300 to 1100 hPa
- Temperature Range: -40°C to +80°C
- Pressure Accuracy: ±0.12 hPa
- Temperature Accuracy: ±1°C
- Current Consumption: 3 µA (standby), 5 mA (active)
- Communication Interface: I2C

Raindrop Sensor

A raindrop sensor is a compact electronic device designed to detect and measure the presence of raindrops or water on its surface. It typically consists of a sensing pad and a control module2. The sensing pad detects rain, and the control module processes this information, providing both analog and digital outputs. This sensor is commonly used in weather monitoring systems, smart irrigation solutions, and automotive applications to automatically control windshield wipers or detect roof leaks.

Specifications:

- Operating Voltage: 3.3V to 5V
- Current Consumption: 15 mA
- Sensing Pad Size: 5cm x 4cm with a nickel plate
- Output: Analog (AO) and Digital (DO)
- Comparator Chip: LM393

I2C (Inter-Intergrated Circuit Bus)

I2C (Inter-Integrated Circuit) is a serial communication protocol commonly used for connecting low-speed peripherals to microcontrollers and microprocessors. It uses two wires: SDA (data line) and SCL (clock line) to facilitate communication between devices. I2C supports multiple masters and slaves on the same bus, allowing for efficient and straightforward communication. It's widely used in sensors, EEPROMs, and other integrated circuits due to its simplicity and versatility.

Specifications:

- Wires: 2 (SDA for data, SCL for clock)
- Speed Modes: Standard Mode (100 kbps), Fast Mode (400 kbps), Fast Mode Plus (1 Mbps), High-Speed Mode (3.4 Mbps)
- Addressing: 7-bit or 10-bit addresses
- Communication: Half-duplex
- Number of Devices: Supports multiple masters and up to 128 devices on the bus
- Clock Stretching: Supported, allowing slave devices to control the clock speed
- Voltage Levels: Typically operates at 3.3V or 5V

Jumper Wires

This is a set of 10 rainbow colour male to male jumper wires. They can be used for interconnecting electronic components on breadboard Or berg strips. The wires are 20 cm long. Both the side of the wire has female pins. The colour of all four wires will be different but the exact colour might vary from that of the picture. These male-to-male jumper wires are of good quality, reusable and has an approximate length of 20cm.

Specifications:

- 1 x 20cmmale to female breadboard connecting wires
- Easy to plug in
- Multiple Colours
- Jumper wire size: 26 AWG
- Current Rating: up to 1 A
- Insulation Type: PVC

12 Core Adapter

A 12V DC Adapter, also known as a power adapter, converts AC power from a wall outlet into 12V DC power for various electronic devices. Commonly used for laptops, routers, LED lights, and DIY projects, these adapters come in different current ratings such as 1A, 2A, and 5A. Designed for reliability, safety, and energy efficiency, they often include built-in protection against overvoltage, overcurrent, and short circuits.

Specifications:

- Input Voltage: 100-240V AC, 50/60Hz
- Output Voltage: 12V DC
- Output Current: 1A, 2A, 5A (varies by model)
- Power Output: 12V x 2A = 24W (example for 2A adapter)
- Efficiency: Typically above 80%
- Protection: Overvoltage, overcurrent, and short-circuit protection
- Connector Type: 5.5mm x 2.1mm barrel plug (centre positive)
- Cable Length: Often around 1 meter (varies by model)

Breadboard

A breadboard is a versatile and reusable platform used for prototyping and testing electronic circuits. It allows you to quickly and easily build and modify circuits without soldering, making it ideal for experiments and educational purposes.

Specifications:

- Dimensions: Varies, common sizes include 170 tie-points (small), 400 tie-points (medium), and 830 tie-points (large).
- Tie-Points: The number of connection points. For example, a medium breadboard has around 400 tie-points.
- Bus Strips: Usually two power rails on each side for power supply connections
- Terminal Strips: The main area where components are inserted. Typically divided into two sections with a centre gap.
- Material: Usually made from ABS plastic.
- Contact Material: Phosphor bronze with nickel plating or other conductive metal.
- Pitch**:** 0.1 inches (2.54 mm) between holes, compatible with standard DIP (Dual In-line Package) components.
- Current Rating: Typically around 1A.
- Voltage Rating: Typically up to 300V.

- Durability: Reusable, withstands multiple insertions and removals.

VIII. CONCLUSION

By keeping the weather monitoring system in the environment for monitoring enables self- protection (i.e., smart environment) to the environment. To implement this need to use the sensor devices in the environment for collecting the data and analysis. By using sensor devices in the environment, we can bring the environment into real life. Then the collected data and analysis results will be available to the user through the Wi-Fi. The smart way to monitor the environment an efficient, low-cost embedded system is presented in this paper. It also sent the sensor parameters to the cloud. This data will be helpful for future analysis and it can be easily shared to other users also. This model can be expanded to monitor the developing cities and industrial zones for pollution monitoring. To protect the public health from pollution, this model provides an efficient and low-cost solution for continuous monitoring of environment.

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