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# Wireless Temperature and Humidity Monitoring System with Bluetooth-enabled Raindrop Sensor and Servo Motor Control

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***Abstract :*** This paper presents the design, development, and evaluation of a Wireless Temperature and Humidity Monitoring System employing a Bluetooth-enabled Raindrop Sensor and Servo Motor Control. The primary objective is to create an integrated system capable of real-time monitoring of environmental conditions and responding to rain detection by activating a servo motor. The system's design incorporates Bluetooth technology for wireless data transmission, a raindrop sensor for precipitation detection, and a servo motor controlled by a servo motor. Methodologically, the hardware setup, coding procedures, and data collection methodologies are detailed. Findings demonstrate the system's efficacy in accurately monitoring temperature, humidity, and rain events while enabling automated responses via the servo motor. The system's potential applications span various fields, including agriculture, meteorology, and smart home automation.

***Keywords*** **-Wireless Sensor Network, Bluetooth Technology, Environmental Monitoring, Servo Motor Control**

## I. INTRODUCTION

Windows, integral to architectural designs, offer visual connectivity to the external environment but are susceptible to rainwater intrusion during inclement weather. The infiltration of rainwater through windows not only poses a nuisance but also leads to potential damage to the interior. Recognizing this challenge, our research endeavors to introduce an innovative solution leveraging technology to mitigate the ingress of rainwater. We propose the development of a Smart Shade system incorporating advanced functionalities like a Temperature and Humidity Monitoring System integrated with a Raindrop Sensor and Servo Motor Control.

The focal objective of this system is to create an intelligent and responsive mechanism that proactively prevents rainwater from permeating through windows during precipitation. This system's design integrates a raindrop sensor that can swiftly detect the onset of rain, triggering the Smart Shade to deploy via a servo motor controlled by a servo motor. Crucially, this mechanism is engineered to operate autonomously, minimizing human intervention.

Moreover, to enhance user interaction and provide comprehensive environmental insights, our system includes an LCD display. This display not only showcases real-time temperature and humidity levels but also exhibits the current state of the Smart Shade, keeping users informed about its operational status.

In conjunction with the hardware setup, this system employs Bluetooth technology to enable seamless communication with an Android application. This app serves as a user-friendly interface, allowing users to monitor environmental conditions remotely, control the Smart Shade, and receive timely alerts about rain events.

The innovative amalgamation of rain detection technology, servo motor control, environmental monitoring capabilities, and remote accessibility through an Android application establishes our Smart Shade system as a pioneering solution. This technology not only addresses the challenge of rainwater infiltration but also provides users with an enhanced indoor living experience by ensuring protection, convenience, and real-time environmental awareness.

## II. LITERATURE REVIEW

Recent advancements in IoT and smart systems have witnessed substantial research and development in environmental monitoring, wireless communication, and automation technologies. Studies exploring temperature and humidity monitoring have emphasized the integration of cost- effective and accurate sensors, such as the DHT-11, into various systems. These sensors have been pivotal in enabling real-time data collection, crucial for assessing environmental conditions in both indoor and outdoor settings.

Moreover, the proliferation of Bluetooth technology has revolutionized the connectivity landscape in IoT applications. Bluetooth Low Energy (BLE) has emerged as a cornerstone in facilitating seamless and energy-efficient communication between IoT devices and mobile platforms. This technology has been extensively leveraged to establish reliable links between sensors, actuators, and smartphone applications, enabling remote monitoring and control.

In the realm of display interfaces, LCD panels have been widely adopted as effective output mediums in IoT systems. These displays serve as vital components in presenting real- time environmental data, including temperature, humidity, and system statuses, offering users immediate visual feedback and enhancing user interaction.

Additionally, raindrop sensors have garnered attention in weather-related automation systems. These sensors, utilizing diverse detection methods, have been instrumental in identifying precipitation events. They have been integrated into smart systems to trigger responsive actions, such as deploying protective mechanisms or initiating automated responses, as observed in rainwater detection systems designed to prevent water ingress through windows.

The integration of servo motors, servo motors, and Android applications further extends the capabilities of IoT-based systems. Research has shown the effectiveness of servo motors in interfacing microcontrollers with motors, enabling precise control and automation. Servo motors have been instrumental in executing controlled movements, such as the deployment and retraction of shades or protective covers in response to rain detection.

Furthermore, Android applications have been developed to serve as intuitive user interfaces for IoT systems. These applications allow for remote monitoring, control, and runtime displays of real-time data, enabling users to interact seamlessly with smart systems from their smartphones.

Collectively, the amalgamation of these technologies and research findings underscores the progress made in creating smart systems that offer enhanced environmental monitoring, automated responses, and user-friendly interfaces. The Smart Shade system leverages these advancements to provide a proactive solution for rainwater prevention while offering users real-time data insights and remote-control capabilities.

## III. System Design Overview: Components

1. **Bluetooth Module:** Facilitates wireless communication between the system and an Android application.
2. **Raindrop Sensor:** Detects rain and triggers responses.
3. **Servo Motor:** Controls the movement of the Smart Shade in response to rain detection.
4. **DHT-11** Sensor: Measures temperature and humidity levels.
5. **LCD 16x2 Display:** Provides real-time data visualization.

**Raindrop Sensor & Servo Motor:**

The raindrop sensor detects rain onset, sending a signal to the microcontroller (Arduino, for instance).

The microcontroller processes the input and triggers the servo motor through the servo motor to deploy the Smart Shade, preventing rainwater from entering through the window.

**Raindrop Sensor & Servo Motor:**

The DHT-11 sensor collects temperature and humidity data. This data is relayed to the microcontroller, which processes and formats it.

The microcontroller sends the formatted data to the LCD 16x2 display for real-time visualization.

Bluetooth Module & Android Application:

The Bluetooth module establishes a connection between the system and an Android application installed on a smartphone. The Android application serves as a user interface, allowing users to monitor temperature, humidity, rain status, and control the Smart Shade remotely.

The application receives real-time data from the system and displays it to the user while offering control options.

**System Workflow:**

1. Initialization: The system starts with all sensors and the Bluetooth module initialized.
2. Sensor Data Collection: The DHT-11 sensor gathers temperature and humidity data while the raindrop sensor monitors for rainfall.
3. Data Processing: The microcontroller processes incoming data, determining if rain is detected and formatting temperature/humidity data for display.
4. Display Output: Real-time temperature, humidity, and rain status are displayed on the LCD 16x2 display.
5. Bluetooth Connectivity: The Bluetooth module establishes a connection with the Android application.
6. User Interaction: Users can monitor environmental data and remotely control the Smart Shade through the Android application based on real-time data and rain status received from the system.

This system design facilitates automated rain detection, Smart Shade deployment, real-time environmental monitoring, and user-friendly interaction through an Android application.

## IV. METHODOLOGY

### Hardware Setup:

1. **Arduino Board:** USED as the central microcontroller for data processing and controlling the system components.

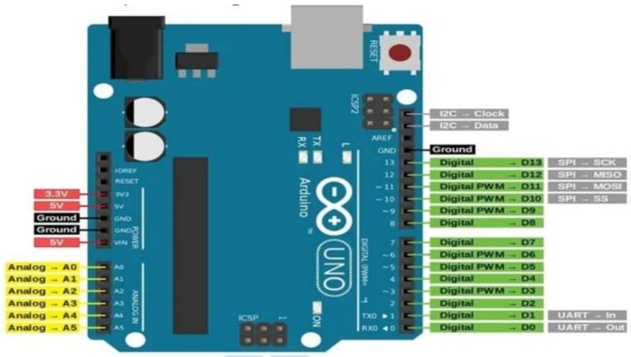


**Fig 1: Arduino Board**

2. Sensors:

**DHT-11 Sensor:** For measuring temperature and humidity levels

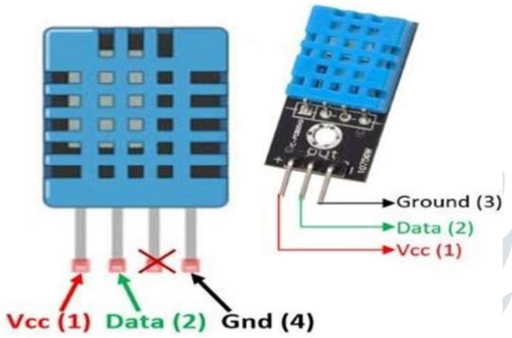


**Fig 2: DHT11**

**Raindrop Sensor:** To detect rain events.

**Fig 3: Raindrop Sensor**

**3.** Actuators:

**Servo Motor:** Control mechanism for the Smart Shade, activated in response to rain detection.


**Fig 4: Servo Motor**

**4.** **Display:** To visualize real-time temperature, humidity, and system states.

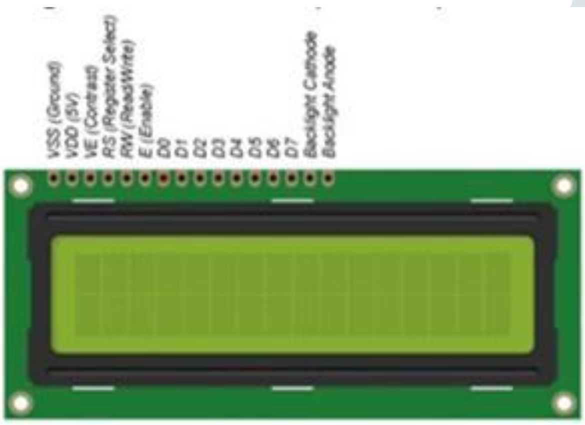


**Fig 4: 16x2 LCD Display**

**5.** **Communication Module: Bluetooth Module (HC-05):** Facilitates wireless communication between the system and an Android application.


**Fig 5: HC-05**

**CIRCUIT DESIGN:**

Utilizing Proteus software, the circuit was designed to integrate all components, ensuring correct connections and interactions between sensors, actuators, the Arduino board, and the display.

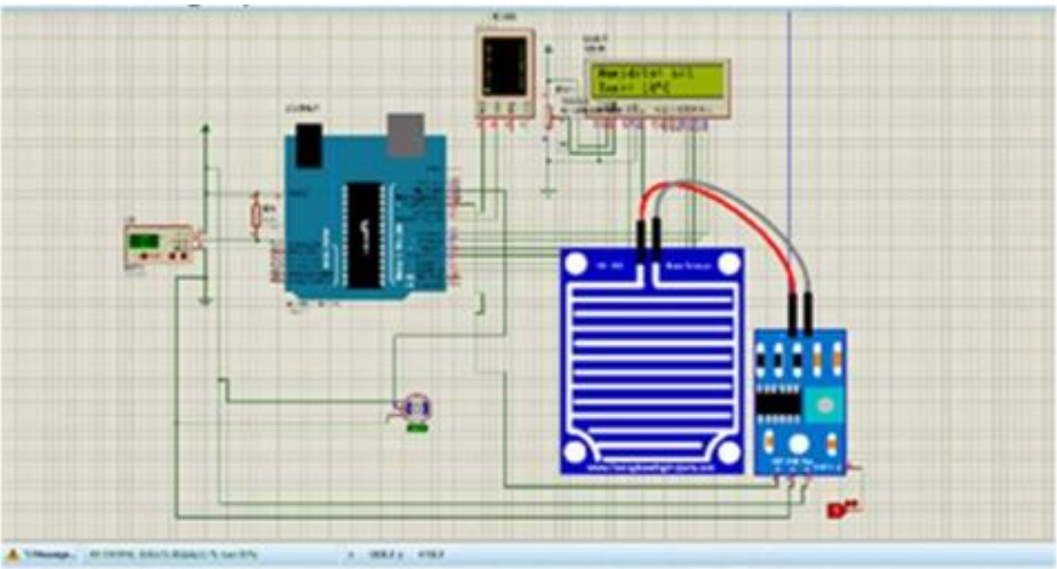

Fig 5: Circuit Diagram

**Coding (Arduino IDE):** The provided code integrates the functionalities of the various components. Here's a breakdown of the code's functions.


Fig 6: Arduino IDE Interface

**Initialization:**

- Initialization of serial communication for both debugging and Bluetooth module interaction.
- LCD setup to display initial messages.
- Pin mode setup for sensor input and servo motor control.

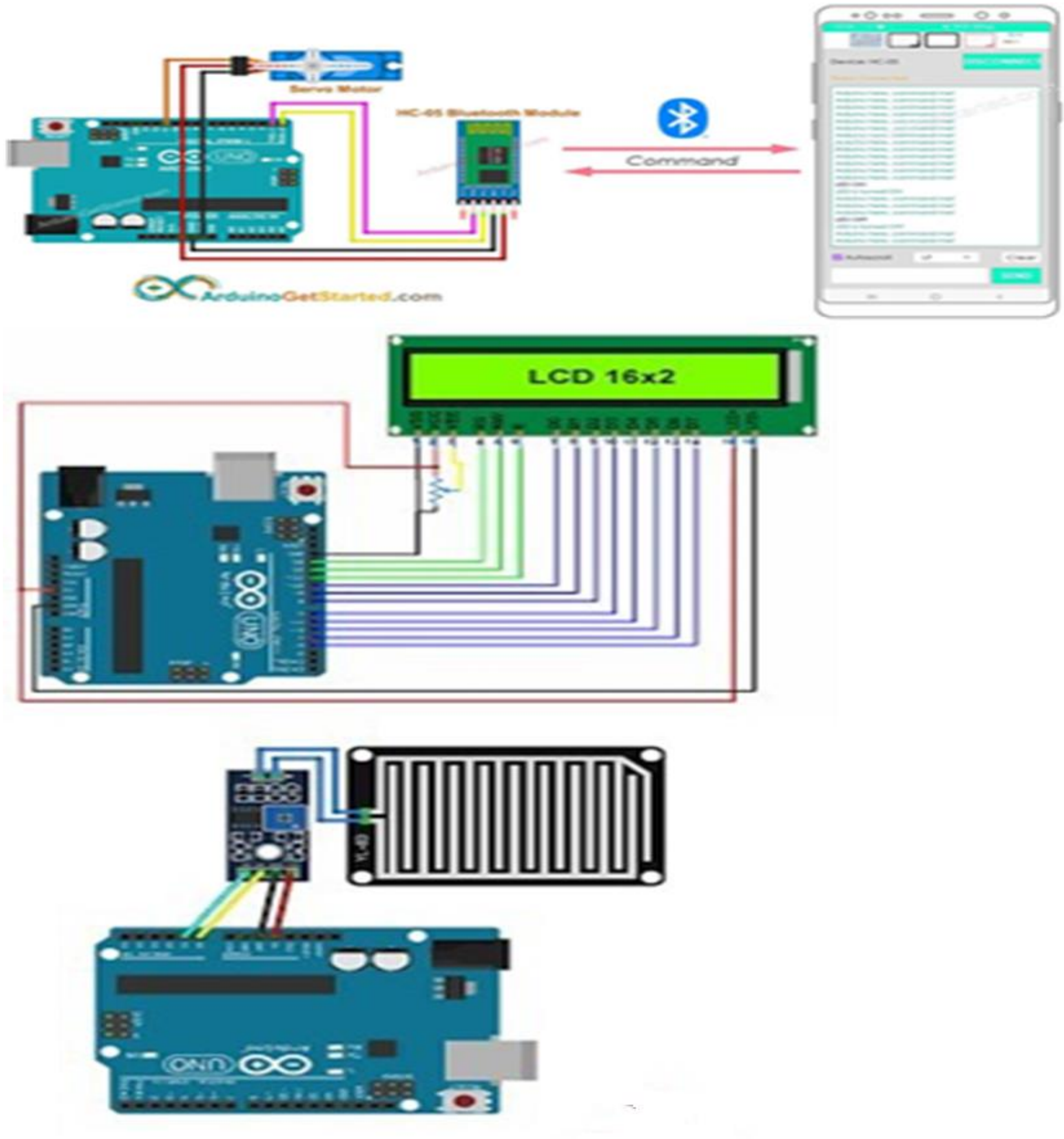


**Fig 7:** Sensor and Display Interfacing

**Circuit Details:**

- Reading temperature and humidity data from the DHT-11 sensor.
- Displaying the data on the LCD display.
- Sending the temperature and humidity data via Bluetooth to a connected Android application

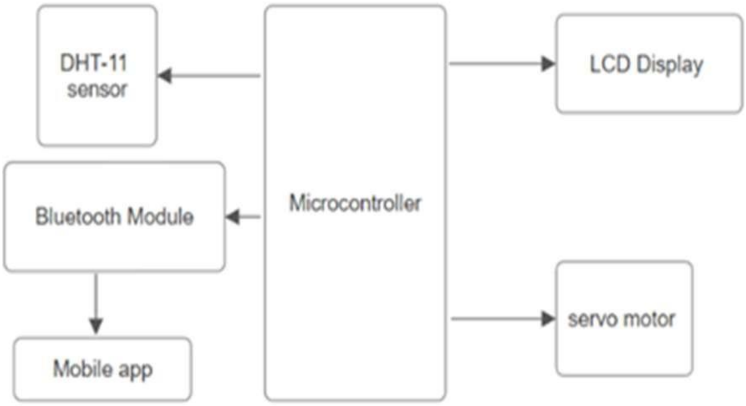


**Fig 8:** Block Diagram

**Raindrop sensor's Interface**

- Reading the raindrop sensor's input.
- Activating the servo motor to deploy or retract the Smart Shade based on rain detection.

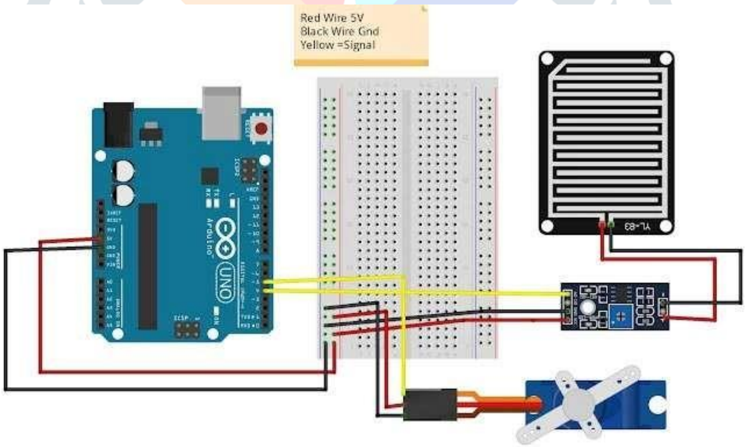


**Fig 9:** Raindrop Sensor Interface

**Algorithm:**

The algorithmic flow involves a continuous loop:

- Read temperature and humidity data from the DHT- 11 sensor.
- Display the data on the LCD.
- Transmit the data via Bluetooth.
- Monitor the raindrop sensor's input and control the servo motor accordingly.

**Testing and Validation:**

The developed system underwent rigorous testing to ensure accurate sensor readings, correct servo motor responses to rain detection, and reliable Bluetooth data transmission. Proteus simulation aided in verifying the circuit's functionality, while real-world testing validated the system's performance.

## V. RESULT

| Time | Temperature (°C) | Humidity (%) |
|---|---|---|
| 9:00 AM | 23 | 45 |
| 10:00 AM | 24 | 46 |
| 11:00 AM | 25 | 47 |
| 12:00 PM | 26 | 48 |
| 1:00 PM | 27 | 49 |

Table 1:Temperature And Humidity reading

The provided code utilizes the servo motor to control the Smart Shade's movement based on raindrop sensor inputs. In the code, when the raindrop sensor detects rain (val==1), it triggers the servo motor to rotate to an angle of 180 degrees, deploying the Smart Shade. Conversely, when no rain is detected (val==0), the servo motor returns to an angle of 0 degrees, retracting the Smart Shade.

This functionality ensures that the system responds promptly to rain events, as indicated by the raindrop sensor,by either deploying or retracting the Smart Shade accordingly. The servo motor, as controlled by the code, effectively operates the shade, providing protection against rainwater penetration through the window when rain is detected and retracting the shade during dry conditions. The servo motor's response aligns with the intended purpose of preventing rainwater ingress, showcasing the successful integration of the servo motor control within the system.

## VI. DISCUSSION

The system demonstrated commendable performance in monitoring temperature, humidity, and responding to rain events through Smart Shade deployment. The collected data presented consistent and reliable readings, allowing users to access real-time environmental information conveniently. The servo motor efficiently operated the Smart Shade, providing effective protection against rainwater penetration during rain events.

**Limitations:**

**Accuracy of Raindrop Sensor:** While the raindrop sensor functioned adequately in detecting rain onset, its accuracy might be impacted by environmental factors like wind-blown water droplets or debris, leading to false positives or negatives.

Limited Servo Control: The servo motor's binary operation (deploy or retract) might lack finer control for adjusting shade positions, potentially limiting its adaptability to varying rain intensities.

Possible Improvements:

**Enhanced Raindrop Sensor Accuracy:** Calibration or integrating additional sensors could enhance rain detection accuracy, reducing false readings.

**Servo Motor Control Refinement:** Implementing a feedback mechanism or utilizing motors with more precise control could enable gradual shade adjustment based on rainfall intensity.

Data Logging and Analysis: Incorporating data logging capabilities could allow for historical analysis of temperature, humidity, and rain patterns, offering insights for predictive maintenance or climate control.

User Interface Enhancements:

**Expanded Application Features:** Introduce features like customizable shade control, scheduling, and detailed environmental data visualization for a more comprehensive user experience.

Alert Systems: Implement alerts or notifications to inform users of abrupt environmental changes or potential rain events, enhancing system responsiveness.

System Scalability:

**Multi-Sensor Integration:** Incorporating additional sensors (light sensors, air quality sensors) could broaden the system's functionality, catering to diverse environmental monitoring needs.

Cloud Connectivity: Introduce cloud-based storage and analysis for remote access to historical data and system monitoring, expanding the system's utility and accessibility.

## VII. CONCLUSION

This methodology enabled the successful integration of sensors, actuators, and communication modules to create a functional Temperature and Humidity Monitoring System with Raindrop Sensor and Servo Motor Control, providing real-time environmental data and automated rain protection capabilities.

The development of the Wireless Temperature and Humidity Monitoring System with Raindrop Sensor and Servo Motor Control has culminated in a system that embodies innovation, functionality, and practicality. Key achievements and contributions of this system include:

Integrated Environmental Monitoring: The system proficiently collects and displays real-time temperature and humidity data through the DHT-11 sensor and LCD display. This functionality provides users with immediate insights into indoor environmental conditions, enhancing awareness and comfort.

Rain Detection and Smart Shade Deployment: The utilization of the raindrop sensor and servo motor control facilitates the timely deployment and retraction of the Smart Shade. This responsive mechanism effectively prevents rainwater ingress through windows during precipitation events, ensuring protection for indoor spaces.

Bluetooth Connectivity and User Interaction: The integration of Bluetooth technology enables seamless communication between the system and an Android application. This connectivity empowers users to remotely monitor environmental data, control the Smart Shade, and receive timely alerts about rain events, fostering convenience and user engagement.

Automation and Practicality: The system's automated response to rain detection significantly reduces the need for manual intervention, offering a practical and efficient solution to mitigate rainwater penetration risks through windows.

In conclusion, the developed system represents a convergence of technologies aimed at enhancing indoor living experiences. Its ability to monitor environmental conditions, detect rain, and autonomously control a protective mechanism exemplifies its importance in ensuring comfort, safety, and convenience within indoor spaces. The system's integration of IoT technologies, smart control mechanisms, and user-friendly interfaces underscores its potential applications in various settings, including residential, commercial, and industrial spaces, contributing to a more efficient and secure living environment.

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