Automatic Rain Sensing Wiper

Seamless Wiper Control: A Smarter Solution for Every Drive

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1. Problem Statement

Driving in adverse weather conditions, especially during rain, presents several challenges to drivers. The inability to adjust the wiper speed automatically in response to varying rain intensity causes multiple issues. As rain intensity increases, the driver needs to manually adjust the wiper speed to maintain visibility, which can be dangerous. The continuous manual adjustment of wiper speeds becomes distracting, as it diverts the driver's attention away from the road. This situation, combined with reduced visibility during heavy rain, significantly increases the risk of accidents.

According to the National Highway Traffic Safety Administration (NHTSA), rain-related accidents account for around 46% of weather-related crashes, contributing to over 5,000 fatalities annually in the U.S. alone. Additionally, distractions caused by adjusting the wiper speeds manually are a major factor in accidents. The National Safety Council reports that distracted driving accounts for nearly 9 deaths per day in the U.S.

Our project aims to address these issues by introducing an intelligent, automatic wiper control system that adjusts the wiper speed based on rain intensity. This system will ensure that the driver's focus remains on the road, improving visibility during rain, reducing distraction, and enhancing safety for both the driver and other road users.

2. Aim of the Project

The primary aim of this project is to develop an automated rain-sensitive wiper control system that eliminates the need for manual adjustment of wiper speeds while driving in rainy conditions. By integrating a rain sensor, the system automatically adjusts the wiper speed based on the detected rain intensity, ensuring optimal visibility for the driver at all times. This will significantly reduce the driver's need to manually adjust the wiper speed, minimizing distractions and enhancing road safety.

In addition to improving safety, the project aims to enhance the overall driving experience by providing seamless, efficient, and effective wiper functionality. By automating the process of adjusting wiper speeds, the system ensures that the wipers respond promptly to changes in rain intensity, avoiding situations where the wipers are too slow in heavy rain or too fast in light rain.

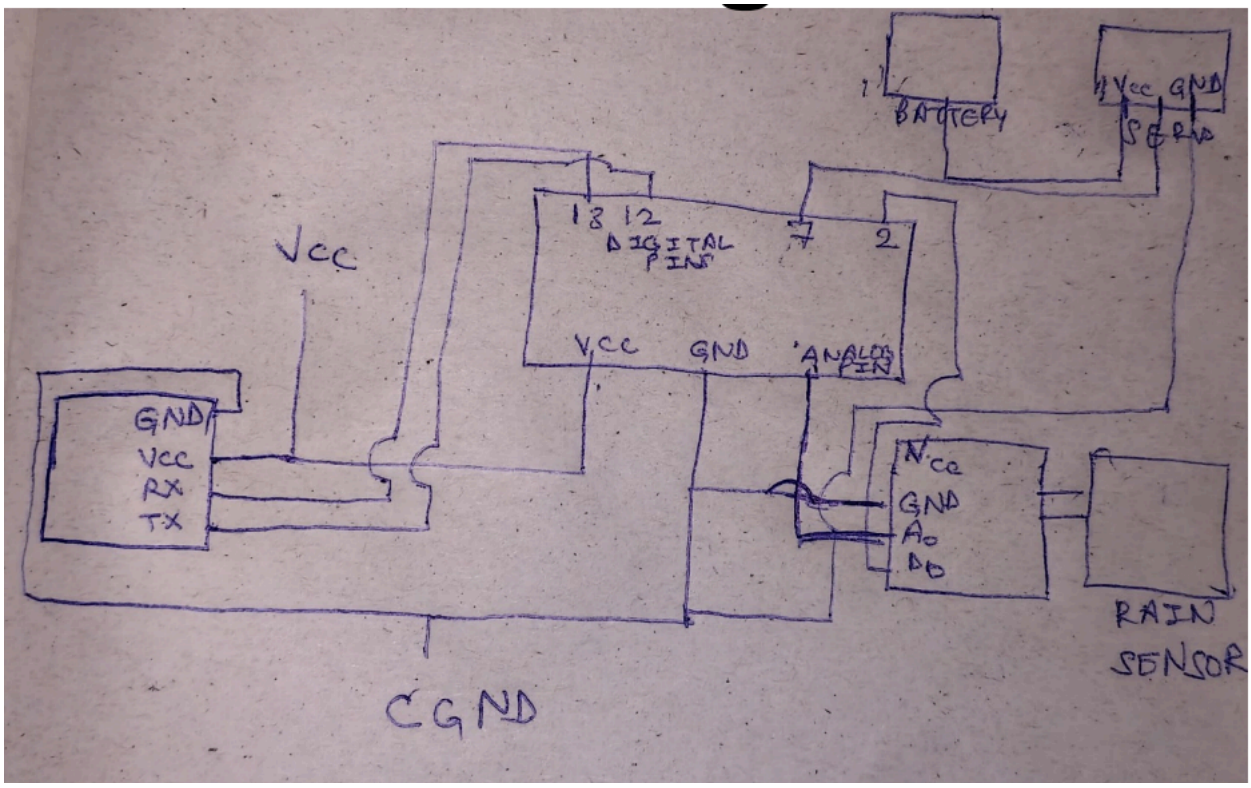
Ultimately, the project seeks to address both the technical challenges of effective wiper control and the human factors associated with manual adjustments, creating a safer and more comfortable driving environment.

3. Electronic Components Used

1. Arduino (Microcontroller):
    - Role: The Arduino acts as the central control unit of the system. It processes the input from the rain sensor to determine the rain intensity and sends control signals to the servo motor and Bluetooth module. It ensures that the wiper speed is adjusted automatically based on rain conditions and handles communication with the mobile app for manual control.
2. Rain Sensor:
    - Role: The rain sensor detects the presence and intensity of rain on the windshield. It measures the amount of water on the sensor's surface by utilizing the electrical conductivity of water droplets. The sensor sends an analog signal to the Arduino, which uses this data to adjust the wiper speed accordingly.
3. Servo Motor:
    - Role: The servo motor controls the wiper's movement on the windshield. Based on the rain intensity received from the sensor, the servo adjusts the speed and angle of the wiper to ensure the windshield is cleared effectively. It moves the wiper at various speeds, depending on the rain conditions, for optimal visibility.
4. Bluetooth Module (HC-05):
    - Role: The Bluetooth module enables wireless communication between the mobile app (MIT App Inventor) and the Arduino. It receives commands such as "Manual Mode," "Speed Level," and "Wipe Once" from the app, and sends them to the Arduino, which processes these instructions and controls the servo motor accordingly.
5. Power Supply (External Power for Servo):
    - Role: The servo motor requires more current than the Arduino can provide directly, so an external power supply is used to power the servo motor. This ensures that the servo operates efficiently and without draining the Arduino's power.
6. Connecting Wires:
    - Role: Connecting wires establish the necessary electrical connections between all the components in the circuit, allowing signals to flow between the Arduino, rain sensor, servo motor, and Bluetooth module.

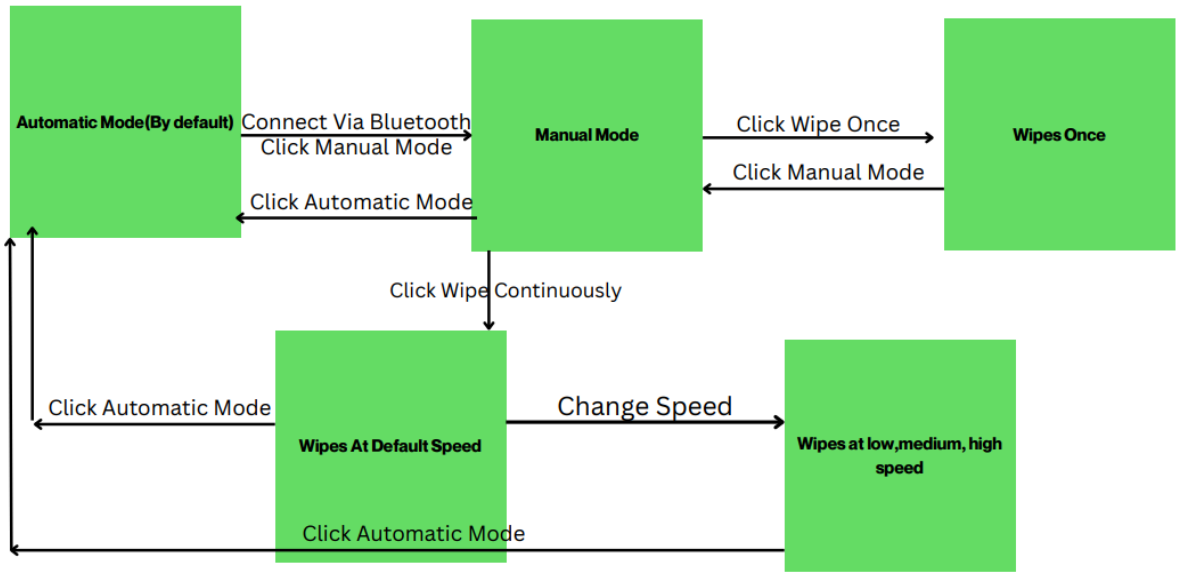
4. Circuit Schematic

The following components are connected as follows



1. **Arduino Microcontroller:**
    a. The **Arduino** is connected to the power supply. The **VCC** and **GND** are connected to the battery's power lines.
    b. The **TX** pin is connected to the Bluetooth module (to communicate wirelessly with the mobile app).
    c. The **RX** pin can be connected for communication with other components, but it's not required for this basic schematic.
2. **Bluetooth Module (HC-05):**
    a. The **VCC** and **GND** are connected to the power.
    b. The **TX** pin is connected to the Arduino **RX** pin for communication.
    c. The **RX** pin is connected to Arduino **TX** for feedback.
3. **Rain Sensor:**
    a. The **VCC** pin is connected to the power supply.
    b. The **GND** pin is connected to the common ground.
    c. The **Analog pin (A0)** is connected to the sensor output to read the intensity of rain.
4. **External Power Supply for Servo Motor:**
    a. The **VCC** and **GND** of the servo motor are connected to the power source.
    b. The control pin of the servo motor is connected to one of the PWM pins on the Arduino (for example, Pin 9).
5. **Battery:**

a. The **battery** is connected to the circuit to power the system. It's connected to the **VCC** of the Arduino and the **VCC** of the Bluetooth module.



1. **Automatic Mode (Default)**:
    a. When the system is powered on, the system defaults to **Automatic Mode**.
    b. The rain sensor and Bluetooth module are enabled to detect rain intensity and respond accordingly.
2. **Manual Mode**:
    a. User can switch to **Manual Mode** through the app.
    b. Wiper control can be adjusted manually by the user via app options (wiping speed control).
3. **Wiping Once**:
    a. In manual mode, if the user clicks the “Wipe Once” option, the wiper performs a single wipe action.
4. **Wipe Continuously**:
    a. User can change the wiping mode to continuous wiping and adjust speed (low, medium, high) via the app.
    b. The speed control operates via Bluetooth communication with the Arduino, which will adjust the servo motor position and speed accordingly.

6. Description of the Project

a) Approach

The system uses a combination of a **rain sensor**, **Arduino microcontroller**, and **servo motor** to automate the wiper's functionality. The rain sensor detects the intensity of the rainfall, which is then processed by the Arduino to adjust the speed of the wiper accordingly. Bluetooth communication is established between the system and a mobile app, allowing the user to switch between **automatic mode** (controlled by the rain sensor) and **manual mode** (controlled by the user through the app). The wiper speed can be adjusted in **low, medium, and high speeds**, depending on the rain intensity or user preference.

b) Methodology

1. **Rain Sensor Integration**: The rain sensor measures the presence and intensity of rainfall. When the sensor detects rain, it sends an analog signal to the Arduino. The Arduino processes this signal to adjust the wiper speed accordingly.
2. **Automatic Mode**: In automatic mode, the system continuously monitors the rain intensity. Based on predefined thresholds, the system adjusts the wiper speed to ensure maximum visibility for the driver.
3. **Manual Mode**: The app allows users to switch to manual mode, where they can control the wiper speed themselves. The user can adjust the speed to **low**, **medium**, or **high** as needed.
4. **Bluetooth Communication**: The system uses an HC-05 Bluetooth module to communicate with a mobile app (developed using MIT App Inventor). The app enables users to toggle between modes, initiate wiping, and change speed settings.
5. **Wiper Control via Servo Motor**: The servo motor adjusts the wiper arm's movement based on the received input from the rain sensor or the app. It operates within specific positions that correspond to low, medium, or high wiping speeds.

c) Steps Involved

1. **Design and Assembly**:
    - Choose appropriate components, including Arduino, Bluetooth module (HC-05), rain sensor, servo motor, and other electrical components.
    - Assemble the components on a breadboard or PCB to ensure correct wiring.
    - Establish communication between the Bluetooth module and the Arduino to allow for real-time control through the app.
2. **Rain Sensor Calibration**:
    - Calibrated the rain sensor to detect different levels of rain intensity. The sensor's output is fed to the Arduino's analog input pin, which processes the data.
    - Developed the logic to adjust the wiper speed based on the intensity of rain detected.
3. **Mobile App Development**:

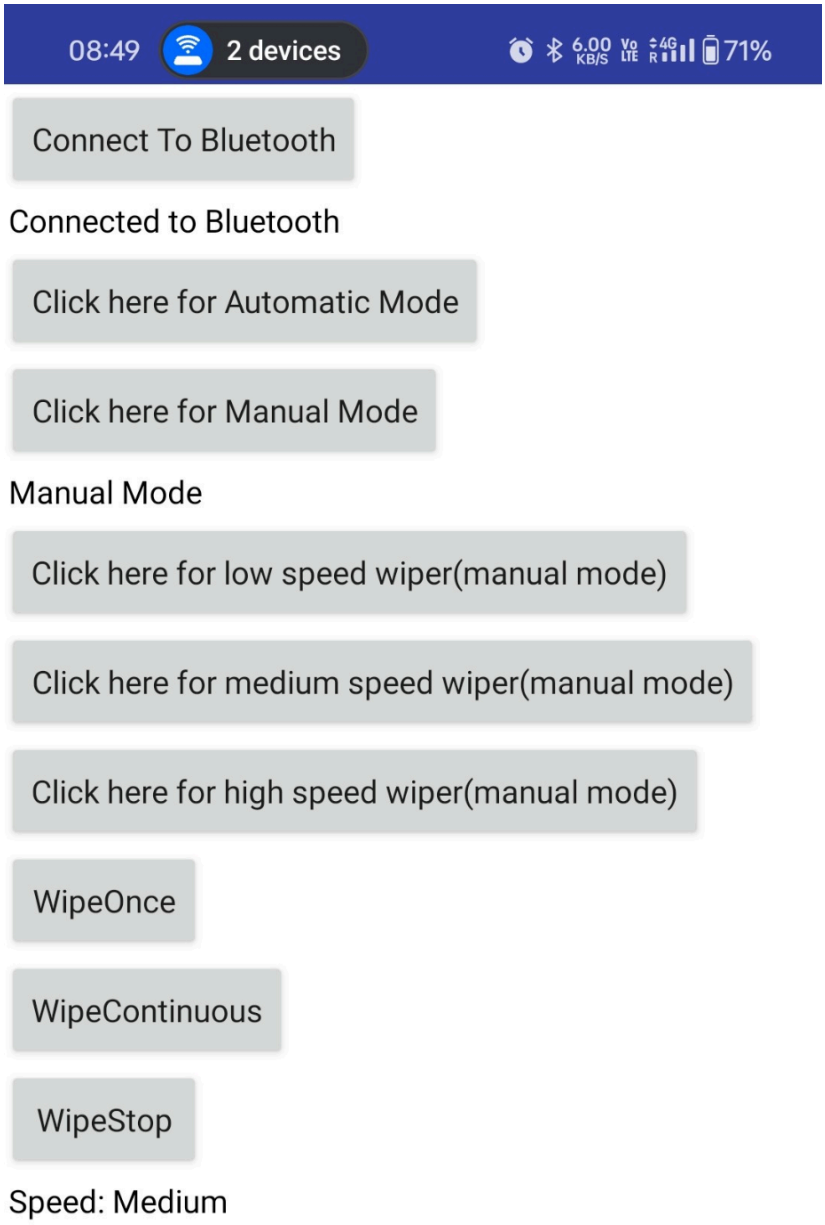
    - Using MIT App Inventor, created a user-friendly interface that allows the driver to toggle between **automatic mode** and **manual mode**, control the wiping speed, and view the current wiper status.
    - Implemented Bluetooth communication protocols to send control signals to the Arduino.
4. **System Integration and Testing**:
    - Integrated all components and test the system under different rainfall conditions and varying speeds to ensure smooth operation.
    - Ensured that the system responds correctly to inputs, both from the rain sensor and the manual control via the app.

7. Results

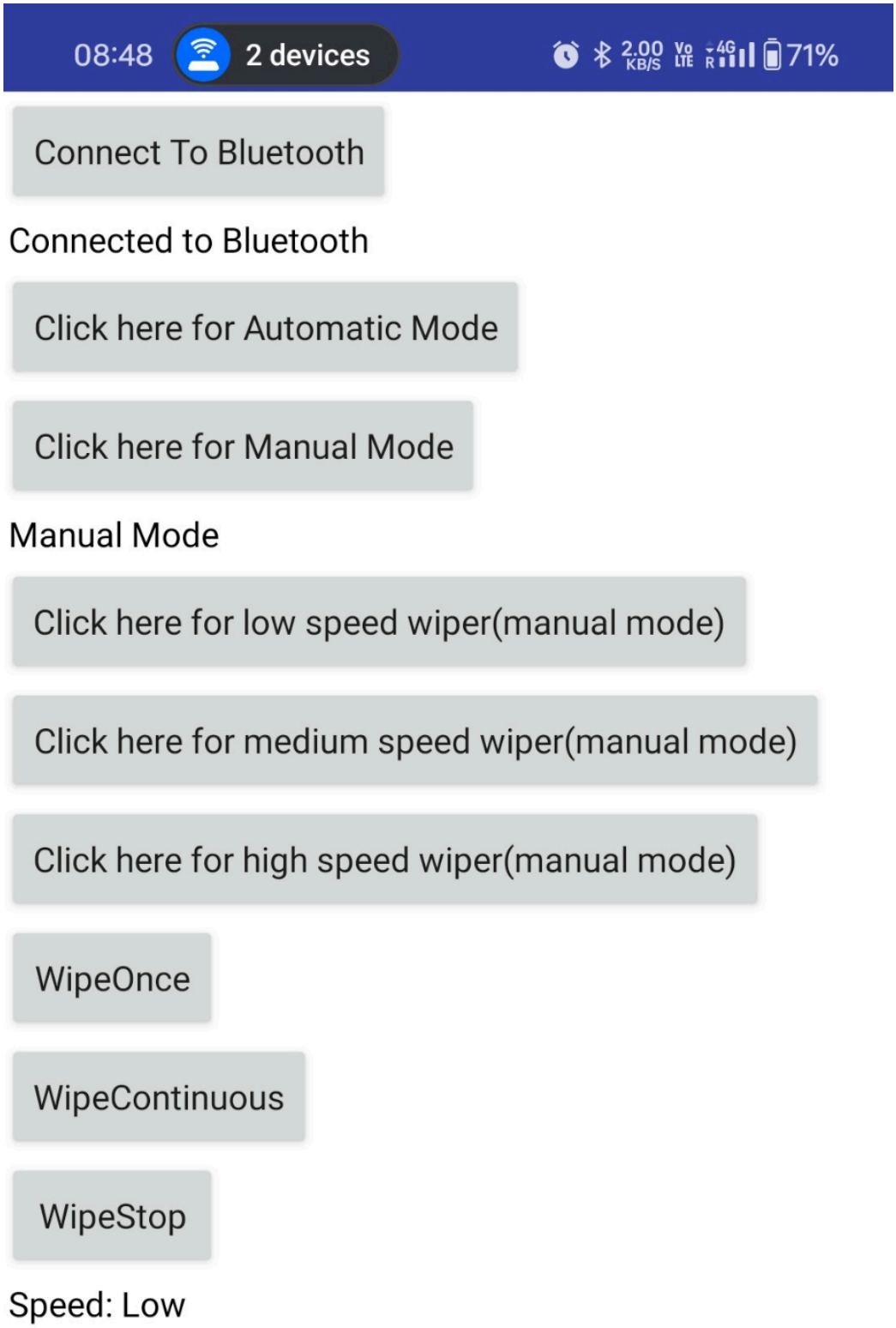
The automated rain-sensing wiper control system was successfully implemented, and several key results were observed during testing:

1. **System Performance**:
    - The rain sensor effectively detected the presence of rain, and the wiper speed adjusted according to the rain intensity, as anticipated.
    - In **automatic mode**, the wiper speed was adjusted dynamically based on the rain intensity readings. For light rain, the wiper speed was set to low, while moderate rain triggered a medium speed, and heavy rain resulted in high-speed wiping.
    - In **manual mode**, users were able to control the wiper speed using the mobile app, with feedback on the speed displayed in real-time.
2. **Bluetooth Communication**:
    - The Bluetooth module (HC-05) functioned as expected, facilitating smooth communication between the mobile app and the Arduino controller.
    - The app effectively sent commands (e.g., change wiper speed, switch modes) to the microcontroller, and the system responded promptly, adjusting the wiper motor accordingly.
3. **Wiper Motor Functionality**:
    - The servo motor responded accurately to the control signals received from the microcontroller, adjusting the wiper's angle in a manner that aligned with the set wiper speed.
    - The wiper motion was smooth, with the speed matching the rain conditions or manual settings from the app.
4. **Testing and Validation**:
    - **Rain sensor testing**: The sensor was placed under different rain conditions (light, moderate, and heavy), and the wiper speed changed as expected, confirming the correct operation of the rain-detection mechanism.
    - **App functionality**: The mobile app was tested for speed control and mode switching (automatic and manual). The interface was responsive, and changes made in the app were immediately reflected on the wiper system.

5. **Challenges Faced**:
    - There were occasional issues with Bluetooth disconnection, especially when adding delays in the Arduino code, which sometimes affected the system's response time.
    - Initially, there was a problem with the servo motor drawing too much power, causing interference with the Bluetooth communication. This was resolved by powering the servo separately.
6. **Conclusion**:
    - Overall, the project met its primary objectives of automating wiper speed adjustment and providing a manual override option via the mobile app. The system demonstrated high reliability and efficiency in adjusting wiper speeds based on varying rain conditions, improving safety by reducing driver distraction and improving visibility during rain.



Wiper speed set to Medium in Manual Mode under Wipe Continuous Mode



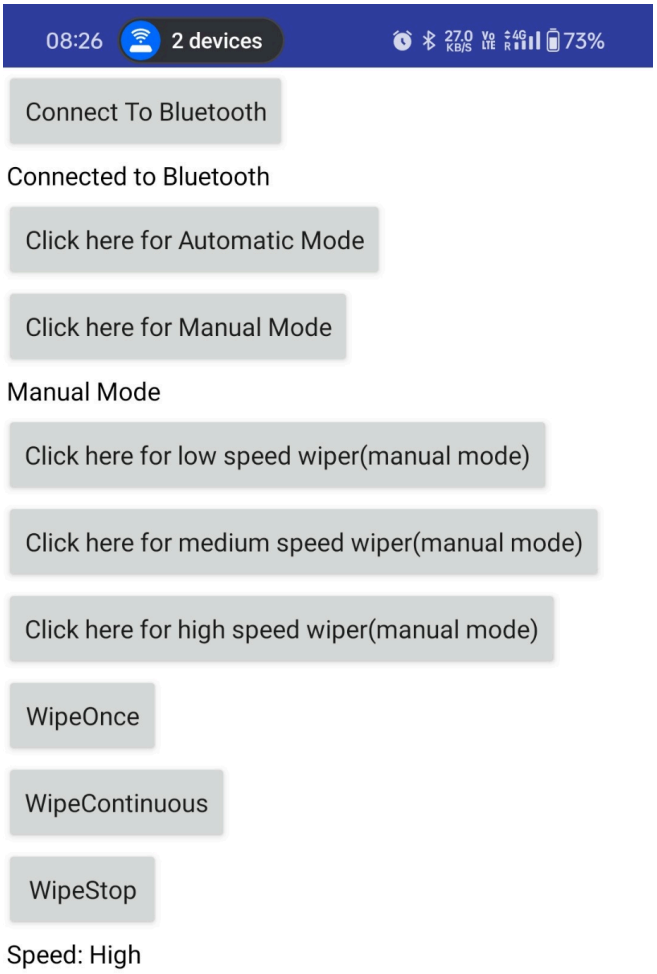
Wiper speed set to Low in Manual Mode under Wipe Continuous Mode

```
No rain detected. Wipers off.
No rain detected. Wipers off.
No rain detected. Wipers off.
No rain detected. Wipers off.
No rain detected. Wipers off.
No rain detected. Wipers off.
Switched to Manual Mode
Continuous wiping started.
Wiping stopped.
Continuous wiping started.
Wiper speed set to: Slow
Wiper speed set to: Medium
Wiper speed set to: Fast
```

Serial Monitor Output for Automatic and manual modes

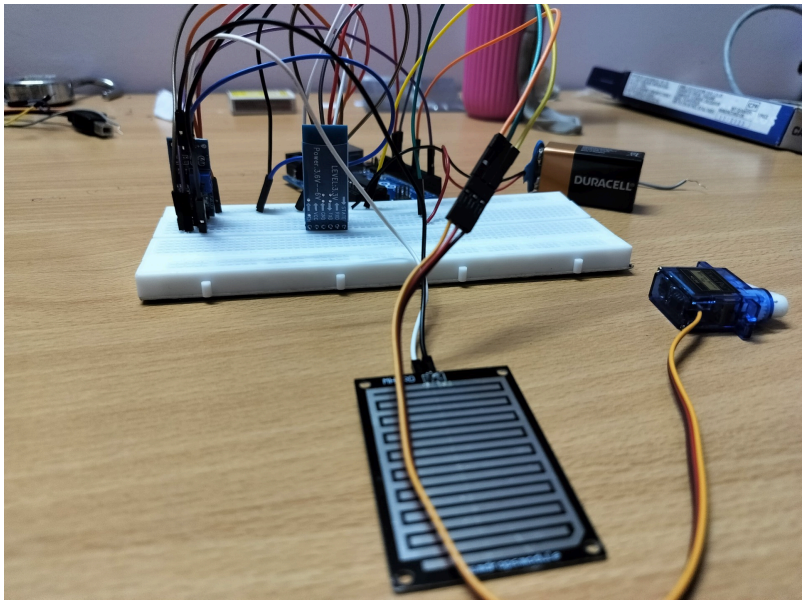
8. Simulation and Short Video Demonstration

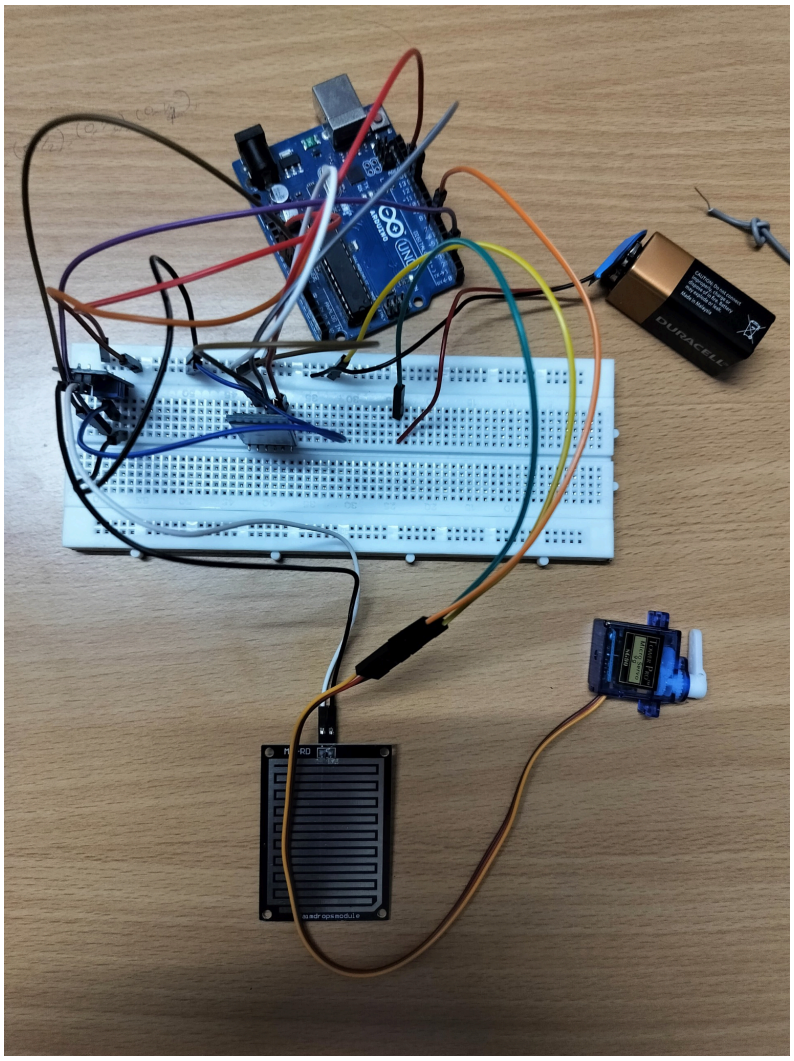
- Demonstration Video: https://drive.google.com/file/d/1QIFQOikV-6hKcCsYBDYr8lm1WI_OrsaL/view?usp=sharing



9. Photos

Photo of the MIT App Inventor APP





Photos of the Assembled Circuit

10. Bibliography and References

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