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AUTOMATIC RAIN AND FOG SENSING WIND SHIELD WIPER

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ABSTRACT

A windscreen wiper or windshield wiper is a device used to remove rain and debris from a windscreen. Almost all motor vehicles, in clouding trains, aircraft and watercraft, are equipped with such wipers, which are usually an essential requirement. A wiper generally consists of an arm, pivoting at one end and with a long rubber blade attached to the other. The blade is swung back and forth over the glass, pushing water from its surface. The speed is normally adjustable, with several continuous speeds and often one or more “intermittent “settings. Most automobiles use two synchronized radial-type arms. It takes a lot of force to accelerate the wiper blades back and forth across the windshield so quickly. In order to generate this type of force, a worm gear is used on the output of a small electric motor. The worm gear reduction can multiply the torque of the motor by about 50 times, while slowing the output speed of the electric motor by 50 times as well. The output of the gear reduction operates a linkage that moves the wipers back and forth. Inside the motor/gear assembly is an electronic circuit that senses when the wipers are in their down position, they are parked at the bottom of the windshield and then cuts the power to the motor. This circuit also parks the wipers between wipes when they are on their intermittent setting. With drivers exposed to an ever-increasing number of distractions, an automatic rain-sensing wiper. Systems become an even more appealing feature, as they work to minimise the time the driver must take his/her hands off the wheel. These systems detect droplets of rain on the wind shield and automatically turn on and adjust the wiper system in accordance to the level of precipitation.

KEYWORDS: Windshield Wiper, Arduino, Rain Sensing, Fog Sensing, Automation and Vehicle Safety

INTRODUCION

Automatic windshield wiper systems represent a critical safety and convenience feature in modern automobiles, evolving significantly from simple switch-operated mechanisms. The core problem this technology addresses is the delay and distraction caused when a driver must manually adjust wiper speed as weather conditions change. The solution lies primarily in optical sensing technology, which came into widespread automotive use starting in the late 20th century. These systems typically use an infrared (IR) light source and a photodiode detector mounted inside the windshield near the rearview mirror. When the windshield is dry, the infrared light emitted by the sensor is almost entirely reflected back to the detector through a phenomenon known as Total Internal Reflection. However, when rain droplets strike the glass, they scatter and refract the infrared light, causing a sharp reduction in the light detected by the photodiode. This measurable drop in detected light signals a microprocessor (or microcontroller) to activate the wipers. The faster the reflection signal drops, the heavier the rain is perceived to be, and the faster the

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wiper speed is automatically set (intermittent, low, or high). For the related function of fog sensing, while the optical rain sensor can sometimes detect the fine mist of fog, advanced systems typically rely on integrating information from the rain sensor with other vehicular inputs, such as ambient temperature and humidity sensors, or even forward-facing cameras, to determine true lowvisibility conditions and trigger systems like fog lights and continuous low-speed wiping, offering a comprehensive and distraction-free driving environment.

LITERATURE SURVEY

[1] The Arefin, M.S et.al (2021) A Dynamic Rain Detecting Car Wiper In this paper, it explains about the crucial advancement in automotive technology, enhancing safety and convenience by automatically adjusting to varying rainfall intensities. These systems typically use optical, infrared, or capacitive sensors to detect raindrops on the windshield and dynamically control the wiper speed. Current research highlights the integration of machine learning algorithms, IoT connectivity, and predictive analytics to improve system accuracy and responsiveness. However, challenges persist, such as inconsistent performance in light drizzle, delays in sudden heavy rain, and high costs of implementation. Emerging trends focus on integrating these systems with Advanced Driver Assistance Systems (ADAS) and weather forecasting technologies for a more proactive approach. Despite these innovations, research gaps exist in universal adaptability, energy efficiency, and cost reduction, indicating significant scope for further development. [2] Awodugba, O. A. et.al (2022) Development and Implementation of a Prototype Automatic Rain-Sensor Car Wiper System In his paper, it explains about the wiper system has garnered significant attention in recent years, driven by the need for enhanced driving safety and convenience. A variety of sensor technologies, including capacitive, optical, and piezoelectric sensors, have been explored for detecting rainfall intensity and activating wipers accordingly.

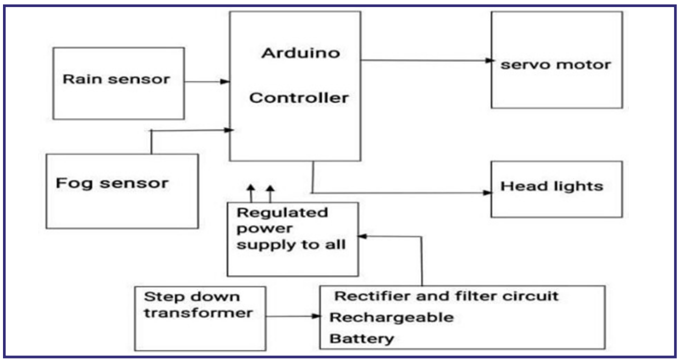
Studies indicate that the integration of these sensors with microcontroller-based systems can automate the wiper's operation, adjusting speed in response to the severity of the rain. Additionally, advances in machine learning and signal processing have been employed to improve the accuracy and responsiveness of these systems, minimizing false triggers and enhancing reliability. The concept of the automatic wiper system aligns with the broader trend of integrating intelligent, sensor-driven technologies in vehicles, aiming to optimize performance and reduce manual interventions. Various prototypes have been designed and tested, demonstrating the potential to improve driver comfort while contributing to road safety by ensuring better visibility during adverse weather conditions. [3] Reddy et.al Microcontroller Automatic Rain Sensing Car Wiper System Using AT89C51 Microcontroller In this paper, it describes the design and implementation of reconfigurable automatic rain- sensitive windshield wipers have become a focal point for enhancing vehicle safety and convenience by adapting wiper functionality to varying environmental conditions. Recent studies have focused on creating systems that not only detect the presence and intensity of rain through sensors such as capacitive, optical, and piezoelectric types, but also offer the ability to adjust wiper behaviour based on factors like the type of rain, vehicle speed, or user preferences. The integration of reconfigurability allows the system to switch between different operating modes, such as intermittent, continuous, or variable speed wiping, based on real-time inputs from the sensors and environmental conditions. Researchers have also explored the use of microcontrollers and advanced signal processing techniques to improve system responsiveness, accuracy, and adaptability, ensuring that wipers function optimally in different weather patterns. Additionally, the ability to reconfigure these systems helps improve the user experience by allowing drivers to fine-tune wiper settings or adapt them to unique driving scenarios, ultimately enhancing safety, comfort, and efficiency. [4] Mukul Joshi et al. (2022) recommended a new system based on a resistive-type rain sensor that uses a PIC microcontroller. In their work, they calculated rainfall by measuring the change in resistance across the sensor surface due to raindrops. The incorporation of a linear zing circuit was made to enhance system performance which dealt with sensor non- linearity. Furthermore, they had implemented fuzzy logic into the system so that the algorithm could better autonomously interpret the raw output from the signal conditioning hardware. Their system improved wiper speed adjustment with rain to a more sophisticated and intelligent control. Nonetheless, Joshi's design contained additional complexity because of the use of fuzzy logic and PIC microcontrollers which increase the design and code complexity of the system. [5] Lubna Alazzawi and Avik Chakravarty (2021) explained a reconfigurable wiper system that would be variable for different cars without changing the hardware. Fuzzy logic employed in their work also made it variable and easy to be changed. The intelligent algorithm made the wiper system automatically react to changing weather conditions. But as in the previous work, it relied on more sophisticated microcontrollers and was not designed for less complex, cheaper platforms like the 8052 microcontroller (Alazzawi & Chakravarty, 2021). [6] Sourish Mitra et al. (2020). They designed a wiper system controlled by Bluetooth that can be operated with an Android smartphone. With an HC-05 Bluetooth module and Arduino, users could turn the wipers on and off with commands sent from their phone. As novel as this method was, it does include the driver manually sending commands, which takes away from the idea of having a completely automated system (Mitra et al., 2020).

OBJECTIVES

- To design an automatic wiper system using rain and fog sensors for enhanced driver visibility.
- To minimize driver distraction by automatically controlling the wiper and headlight functions.
- To improve vehicle safety and comfort during rainy and foggy conditions.
- To develop a cost-effective and reliable automation system using Arduino microcontroller.
- To ensure continuous and efficient windshield cleaning based on real-time weather conditions.

METHODOLOGY

Fig. 1: Block Diagram



Block Diagram Working

1. Power Supply: Provides a stable voltage to all components such as sensors, Arduino, and motor driver circuit.
2. Rain Sensor: Detects raindrops on the windshield and sends an electrical signal proportional to rain intensity.
3. Fog Sensor: Monitors atmospheric humidity and visibility to detect the presence of fog.
4. Arduino Microcontroller: Receives sensor signals, processes them, and decides when to activate the wiper system.
5. Motor Driver Circuit: Acts as an interface between the Arduino and the DC wiper motor, amplifying control signals.
6. DC Wiper Motor: Operates the wiper blades automatically when activated by the motor driver.
7. Automatic Control: The Arduino adjusts the wiper's speed based on the detected rain or fog intensity.
8. System Response: Once rain or fog stops, the sensors send low or no signal, and the wiper motor automatically turns off.

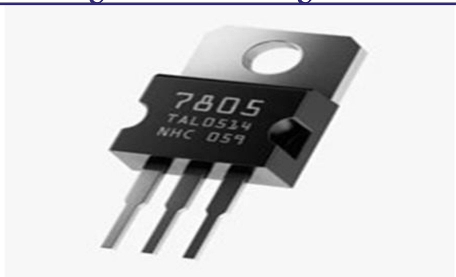
DESCRIPTION OF COMPONENTS

1.Rain sensor module: The Rain Sensor Module is a dual component device consisting of a sensing pad (the flat board with nickel-coated traces) and a control module (the small blue PCB). It functions as a variable resistor that changes its resistance based on the amount of water present on the sensing pad.

Fig. 2: Rain sensor module

2.7805 IC Regulator: The 7805 IC regulator is a highly popular, three-terminal linear voltage regulator that provides a fixed, positive output voltage of +5V. It belongs to the 78xx series, where "78" denotes a positive regulator and "05" indicates the 5volt output. Its primary function is to maintain a stable 5V output, regardless of fluctuations in the unregulated DC input voltage or changes in the load current.

Fig. 3: 7805 IC Regulator



3.LDR'S: An LDR (Light Dependent Resistor) is a variable resistor whose resistance changes based on light intensity. It operates on photoconductivity, where the electrical conductivity of the material increases with light exposure. Typically made from semiconductor materials like cadmium sulfide (CDs), the resistance decreases in brighter light, allowing more current to flow. In low light, resistance increases, reducing current flow. LDRs are ideal for light detection and light-sensitive switching applications.

Fig. 4: LDR'S

4. Servo Motor: A servo motor is a motor designed for precise position, velocity, and acceleration control. It moves to a specific position and holds it with high accuracy, unlike ordinary motors. Servo motors operate in closed-loop control systems with feedback mechanisms for precision. They are commonly used in robotics, CNC machinery, conveyor systems, and radar antenna positioning.

Fig. 5: Servo Motor

5.Step down Transformer: A step-down transformer reduces voltage from a higher value to a lower value while maintaining the same frequency. It works on electromagnetic induction, with the primary coil having more turns than the secondary coil, reducing voltage and increasing current. Step-down transformers are essential in power distribution, making high voltage safer for use in homes, industries, and other low-voltage applications.

Fig. 6: Step down Transformer

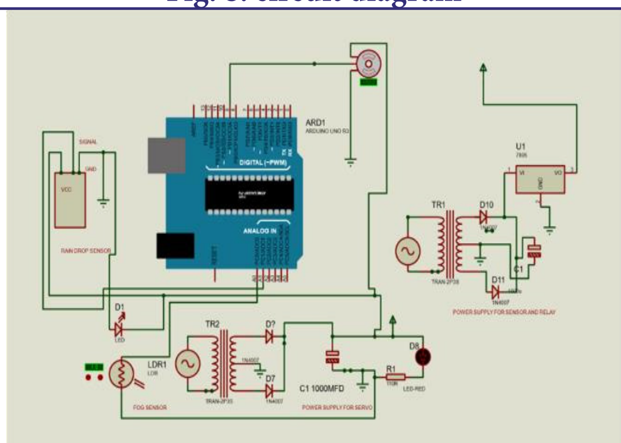
6. Arduino UNO R3: The Arduino UNO R3 is an 8-bit microcontroller from Atmel (now Microchip Technology), commonly used in electronics and embedded systems. It features the ATMega328P as the central processing unit, making it suitable for tasks like data processing, control systems, and communication. The R3 version refers to the third revision of the Arduino board.

Fig. 7: Arduino uno

IMPLEMENTATION AND DESIGN

Circuit Diagram:

Fig. 8: circuit diagram



The design focuses on integrating raindrop and fog detection sensors with an Arduino UNO to automate windshield maintenance for vehicle safety. The implementation utilizes a smart control unit that monitors the windshield environment through specialized sensors to determine necessary wiper actions. By processing analog variations from the sensing modules, the system regulates a Servo Motor via pulse width modulation (PWM), ensuring optimal visibility without manual driver intervention during rainy or foggy conditions

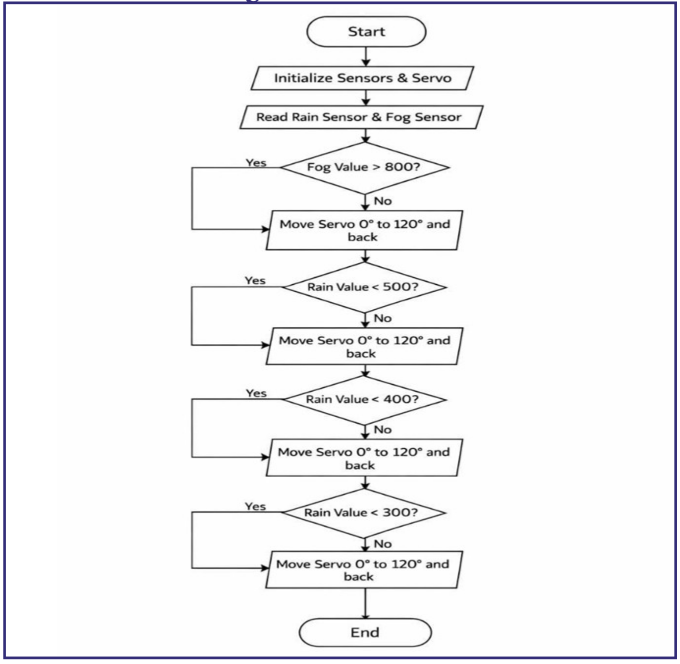
Working of Circuit

The system operates by continuously monitoring the windshield's condition through two primary sensing inputs connected to the Arduino UNO. The raindrop detection sensor is linked to the analog A1 pin, where it monitors the presence and quantity of water falling on the glass. Simultaneously, the fog detection sensor, composed of a high-power LED and LDR module, is connected to the A0 pin. When fog accumulates, the light intensity falling on the LDR decreases, creating analog signal variations that the microcontroller interprets. Based on these inputs, the Arduino generates PWM pulses through pin 9 to control the rotation and speed of a Servo Motor, which serves as the wiper actuator. The entire electronic setup is powered by a robust regulation circuit starting with a 9V step-down transformer. This AC input is converted to DC using a full-wave rectifier and smoothed by a 1000µF filter capacitor to eliminate ripples. Finally, a 7805-voltage regulator IC reduces and maintains a constant 5V output, providing the stable power required for the Arduino and the sensitive monitoring modules.

Flow Chart

The flowchart represents the working of an automatic rain and fog sensing windshield wiper using an Arduino. The system starts by initializing the servo motor and sensors. It continuously reads data from the rain and fog sensors. If the fog value exceeds 800, the servo activates the wiper movement between 0° and 120°. Similarly, if the rain sensor value drops below 500, 400, or 300, the servo operates at increasing speeds to clear the windshield more effectively. After each operation, the system loops back to read sensor values again, ensuring automatic and adaptive wiper control based on weather conditions.

Fig. 9: Flow Chart



RESULTS AND DISCUSSION

Results

The Automatic Rain and Fog Sensing Windshield system successfully demonstrates an intelligent vehicle safety solution by automating windshield clearing under adverse weather conditions. By integrating a Raindrop Detection Sensor and a custom Fog Detection module with an Arduino UNO controller, the system eliminates the need for manual driver attention to wiper controls. The results show that the system accurately identifies environmental changes such as the presence and quantity of raindrops and the density of fog and translates these into precise mechanical actions through a Servo Motor. This automation significantly reduces driver distraction during heavy rain or fog, directly addressing major safety requirements for four-wheelers.

Fig. 10: Prototype

System Performance Analysis

The performance of the system was evaluated based on sensing accuracy, processing speed, and power stability. The Raindrop Sensor, connected to the Analog A1 pin, provided continuous monitoring of moisture on the windshield glass. The Arduino UNO demonstrated high efficiency in processing these analog signals to determine the exact speed and on/off status of the Servo Motor via PWM pin 9.

For fog detection, the LDR and LED module, mounted on the windshield and connected to the Analog A0 pin, effectively triggered the wipers as light intensity decreased due to fog accumulation. From a hardware perspective, the power supply system maintained high reliability; the step-down transformer and full-wave rectifier successfully converted AC to DC, while the 1000 microfarad capacitor and 7805 regulators ensured a ripple free 5V DC supply for the microcontroller and sensors.

Challenges and solutions Signal Instability and Power Ripples

- Challenge: The secondary output of the step-down transformer is AC, which, even after rectification, contains ripples that can cause erratic sensor readings and microcontroller instability.
- Solution: A 1000 microfarad, 25V filter capacitor was implemented to remove AC ripples and provide pure DC, while a 7805-voltage regulator was used to lock the output at a steady 5V required for the Arduino and sensors.
- Wiper Speed and Position Control
- Challenge: Traditional motors often lack the precision to vary speed based on the intensity of rain or return to a specific home position when turned off.
- Solution: A Servo Motor was utilized and connected to a PWM (Pulse Width Modulation) pin on the Arduino.
- This allows the program to dynamically control the motor's speed based on the quantity of raindrops detected, as well as manage the specific on/off angles.
- Fog Detection Accuracy
- Challenge: Detecting fog on glass requires a method that differentiates between simple darkness and actual obstruction on the windshield surface.
- Solution: A custom sensor was designed using a high power LED and LDR placed opposite each other on the windshield glass. When fog affects the glass, it specifically interrupts the light path between the LED and LDR, providing an accurate analog signal to the A0 pin to trigger the wipers automatically.

CONCLUSION

The Automatic Rain and Fog Sensing Windshield Wiper system successfully achieves its objective of providing an intelligent, responsive, and reliable safety solution for modern vehicles. By integrating raindrop and fog detection sensors with an Arduino UNO microcontroller, the system ensures that visibility is maintained automatically, even in challenging weather conditions. The automated approach minimizes the driver's need to manually adjust wiper speeds, thereby reducing distraction and enhancing overall road safety. The inclusion of a custom-designed fog sensor utilizing LED and LDR technology adds a significant layer of protection, addressing a major cause of accidents during the rainy season. Furthermore, the implementation of a stable power supply featuring a 7805 regulator and 1000 microfarad capacitor ensures that the electronic components operate with high precision and minimal signal noise. This project offers a scalable and effective model for automotive safety, demonstrating how simple yet powerful sensor-based automation can transform the driving experience and contribute to the prevention of weather-related collisions.

FUTURE SCOPE

Automated windshield management systems have a promising future as vehicles transition toward higher levels of autonomy and smarter driver-assistance technologies.

AI and Predictive Analysis: Future iterations could use machine learning to predict rainfall patterns based on humidity and atmospheric pressure, adjusting wiper preparation before the first drop hits the glass.

Advanced Optical Sensing: Replacing standard LDRs with high resolution optical cameras could allow the system to detect not just fog, but also mud, dust, or ice, providing a more comprehensive cleaning solution.

V2X Communication: Integrating the sensing data with Vehicle to-Everything (V2X) networks could allow a vehicle detecting heavy rain to warn nearby cars about slippery road conditions.

Energy Efficiency: Future designs may incorporate low-power sleep modes similar to IoT energy management systems, ensuring the sensors consume negligible power when the vehicle is parked or the weather is clear.

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