Automatic Window Control System Using Rain and Temperature Sensors With Manual Override

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Abstract. The essential role of automated systems in modern vehicles establishes their function as protective technologies which also enhance passenger entertainment. The drivers of traditional vehicles must operate window controls through manual procedures which creates distractions during critical moments of unexpected weather conditions. The driving experience becomes more demanding because the situation presents drivers with challenges which cause them physical discomfort and pose potential damage risks to the vehicle's internal systems. This research presents an automatic window control system which utilizes rain and temperature sensors that function through a microcontroller connection. The system automatically closes windows during rainfall detection to prevent water from entering the vehicle. The system uses temperature monitoring to determine appropriate window openings which create a comfortable environment for people inside the vehicle. Users can manually control the system through an override function which allows them to operate the system while still meeting safety requirements. The system operates its functions through a priority framework which establishes rain detection as the primary task while managing temperature control and manual operation. The proposed system provides an effective smart automotive solution which combines simplicity with dependable performance and affordable costs for future intelligent vehicle development.

Keywords: Embedded Systems, Arduino Uno, Automotive Automation, Smart Window Control,

1 Introduction

The development of intelligent automotive systems has been greatly affected by the fast progress of embedded systems and sensor technologies. Automotive manufacturers today develop vehicles that use automation to create better passenger experiences through improved safety features and increased comfort and operational convenience. Manual window control through traditional methods becomes difficult and dangerous when sudden environmental changes happen like unexpected rain or fast temperature increases. Rainfall creates conditions that let water enter the vehicle, which leads to damage of both electronic parts and fabric materials. High cabin temperature leads to passenger discomfort because parked vehicles face direct sunlight exposure. Environmental sensor systems must operate in real time to enable intelligent automation which protects window operating processes. The vehicle window control system uses rain and temperature sensors to work together with microcontrollers for its automated window operation and adaptive window control functions. The system design uses safety rules which give priority to rain detection because it stops users from using temperature-based operations and manual control to protect the system from damage while improving safety. The development of intelligent automotive systems has been greatly affected by embedded system technologies and sensor system technologies which show fast progress. Automotive manufacturers today develop vehicles that use automation to create better passenger experiences through improved safety features and increased comfort and operational convenience. The automation of car window control operates as an interest area because it replaces traditional window operation which drivers handle through manual control. Manual window operation through traditional methods becomes problematic and dangerous for drivers because sudden changes in weather conditions like rain and temperature lead to unpredictable situations. Drivers fail to close windows during rain because they lack proper timing skills while they need to adjust window positions repeatedly for thermal comfort which leads to driving distractions and vehicle interior damage. The safety of the vehicle and passenger comfort depend on environmental conditions. Rainfall creates conditions that let water enter the vehicle if windows are left open, which results in damage to electronic parts and upholstery material and interior surfaces. In addition, high ambient temperatures create discomfort because ventilation becomes insufficient, especially when the vehicle is parked or travels at low speeds. The situation creates a requirement for a smart window control system which needs to operate automatically based on changing environmental conditions without needing driver control at all times.

2 Related Work

Automatic environmental sensing and control systems have been widely explored in automotive and smart window applications. The study demonstrated how rain sensors work with microcontrollers and motor mechanisms to close windows automatically during rain events which stops water from entering the vehicle and protects its interior parts [1].The system detects rain intensity through its raindrop sensors which provide real-time environmental monitoring and system status information to both automated operations and user monitoring capacity [2].Research has investigated rain-sensing technologies for cars through sensor selection decision-making and signal processing methods and fail-safe mechanisms which help ensure dependable function across different weather conditions [3].

Temperature-based control systems have been proposed to enhance passenger comfort by continuously monitoring cabin temperature and activating ventilation or adjusting window positions when predefined temperature limits are exceeded [4]. The advanced systems combine rain detection and temperature measurement which creates a safety-comfort balance. In such systems, rain detection receives greater importance because windows need to close during rain regardless of existing temperature conditions [5].Weather-responsive window control systems use environmental sensor data and control systems to achieve better performance through accurate sensor calibration which stops unnecessary system changes that result from minimal environmental changes [6].Environmental monitoring and sensor integration with intelligent control strategies serve as essential elements for building efficient smart window automation systems which operate reliably.

2.1 Problem statement

The indoor spaces of vehicles experience quick temperature increases because of sunlight exposure, which results in passenger discomfort and damages to their interior parts. The unexpected rain allows water to enter the vehicle through open windows, which results in damage to electronic components and upholstery materials and the interior parts of the vehicle. Manual window operation constitutes the only function of conventional window systems, which create two operational problems because they lack rapid window response during sudden weather changes and they generate driver distraction. The development of an affordable yet dependable embedded monitoring system is necessary to assess temperature and rain conditions, which will control window operation through automatic adjustments and allow for manual window control while maintaining safety through rain-priority window operation.

2.2 Objectives

- To design and develop an automatic car window control system using embedded technology.
- To implement automatic window operation based on environmental conditions.
- To provide manual override control for driver convenience.
- To implement rain-priority safety logic that overrides manual and temperature control during heavy rain.
- To develop a low-cost, reliable, and real-time embedded solution for smart automotive applications.

3 Proposed System Architecture

The system architecture has been constructed through two different elements which include a layered embedded system model and its four essential modules for sensing processing actuation and user interface operations. The architecture enables automatic vehicle window control by continuously monitoring environmental conditions and executing real-time control decisions.

The system includes a DS18B20 digital temperature sensor and a rain sensor module as its sensing unit. The temperature sensor measures the cabin temperature and provides digital output using the One-Wire protocol. The rain sensor detects rainfall presence and intensity through conductivity changes on the sensing plate while it produces an analog output which corresponds to rain intensity. The sensors keep sending environmental information to the controller at all times.

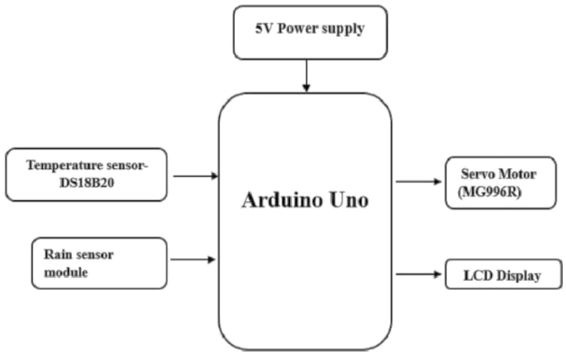

Fig 1: Block diagram of the automatic window control system

The processing unit is built around an Arduino Uno microcontroller system which functions as its central control system. The microcontroller reads sensor data and processes it using a priority-based decision algorithm. The system operates in three modes which include automatic temperature-based window control and rain safety override control and manual driver override mode. The rain detection condition is given highest priority to ensure immediate window closure during rainfall, regardless of temperature or manual input.The actuation unit consists of a servo motor that simulates the window mechanism. The servo motor receives Pulse Width Modulation (PWM) signals from the microcontroller and adjusts the window position accordingly. Different window positions which include closed partially open and fully open correspond to certain servo angles.The user interface unit includes a 16×2 LCD display with an I2C communication module. The display provides real-time information which includes the temperature value and rain detection status and operating mode and window position. This function enhances system transparency while allowing users to interact with the system.The proposed system architecture delivers dependable environmental monitoring together with intelligent decision-making and safety-based operations and effective window control. The modular design enables straightforward system expansion which allows for system integration with actual automotive components.

4 System Implementation

The automatic window control system was developed through system implementation which combined hardware components with embedded software development. The implementation process required the team to establish connections with sensors while they created control algorithms to operate actuators and display system status in real time for dependable and effective system performance.

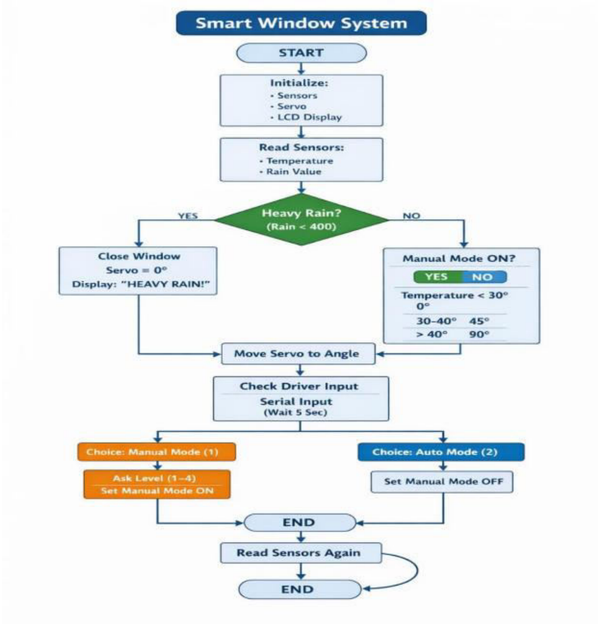

Fig 2: Flowchart

The hardware implementation required the DS18B20 temperature sensor and rain sensor module and servo motor and LCD display to connect with the Arduino Uno microcontroller through their respective interfaces. The DS18B20 temperature sensor needed to connect its digital input pin through One-Wire communication protocol together with a 4.7 kΩ pull-up resistor for proper data transmission. The rain sensor module established its connection with an analog input pin to provide continuous rain intensity measurements. The servo motor used a PWM-enabled digital pin to receive microcontroller output signals which controlled the window position. The 16×2 LCD display with I2C module was connected using SDA and SCL communication lines to reduce wiring complexity. The system components received power from the common Arduino 5V supply while all parts shared a ground connection for reliable operation throughout the system. The team built the software system with Arduino IDE using Embedded C programming language for development. The program included libraries which provided One Wire and Dallas Temperature and Servo and Wire and

LiquidCrystal_I2C functionalities to assist in hardware communication with control functions. The system operates as a continuous temperature reading system which monitors temperature data from DS18B20 sensor while also tracking rain intensity through the rain sensor module. The system uses a priority-based control algorithm to identify the optimal window position by analyzing these data inputs. The control logic system functions through three operational modes. The automatic mode enables the system to control window movement according to its established temperature limits which protect passenger comfort. The system enters rain safety mode when it detects heavy rain which activates window closure and system control shutdown for both automatic and manual operation modes. The driver can choose fixed window opening heights in manual mode when no rain is occurring. The Arduino generates PWM signals which the servo motor uses to obtain accurate window position control. The LCD display provides current system status through temperature readings and rain detection status together with information about operating mode and window position. The system underwent testing with various temperature settings and simulated rain conditions to evaluate its operational capabilities along with response speed and system dependability. The system successfully combines environmental sensing with embedded control logic and actuator operation and user interface display to deliver intelligent automatic window control for automotive applications.

5 Result Discussion

The automatic window control system which we developed was tested through multiple simulated environments to assess its operational performance and its ability to maintain reliable window control. The system operated with stability while all three parts of the system which included sensing and processing and actuation worked together effectively. The DS18B20 temperature sensor delivered precise temperature measurements which remained constant throughout all testing phases. The system used automatic mode to control window movement according to specific temperature limits which had been established.

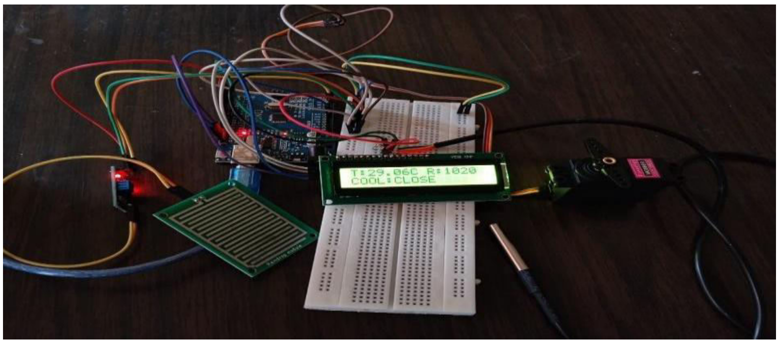

Fig 3: Prototype Setup

The window stayed closed during low temperature periods to support indoor comfort. The window opened halfway at moderate temperatures to create a flow of fresh air into the room while maintaining indoor comfort. The system opened the window completely during higher temperatures to create better airflow which decreased the heat accumulation inside the cabin. The servo motor executed window control commands by reaching all designated window positions with precise movement.The rain sensor module detected both the presence of rain and its intensity level. The system activated its safety mechanism to close the window completely when it simulated heavy rain conditions. The control logic which used priority rules achieved accurate implementation according to the test results. The system blocked all manual controls and temperature controls during heavy rain to prevent water from entering the vehicle interior. The system maintained automatic and manual functions during dry weather and light rain conditions without any interruptions to its operations.

The manual control mode enabled drivers to choose between different window heights which enhanced system flexibility. The level-based manual control system made it easier for users to operate the system because it required less effort than using direct control of angles. The system successfully switched between manual and automatic modes based on user input which confirmed its ability to transition between operating modes.

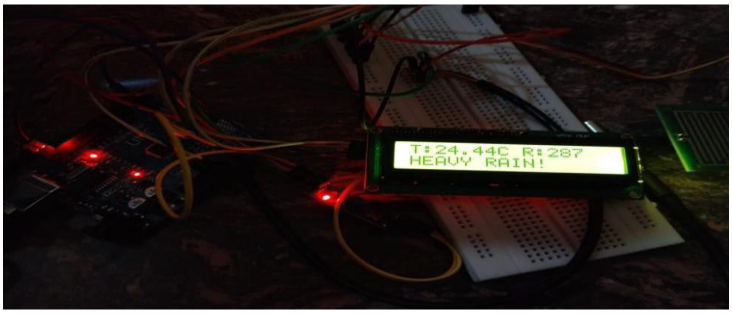

Fig 4: During working conditions

The 16×2 LCD display showed continuous updates about temperature and rain status and operating mode and window position. This improvement in user knowledge about system functions helped users understand their current system status during operation.

6 Conclusion

The engineers developed an automatic window control system which uses rain and temperature sensors to operate windows through embedded system technology. The system uses cabin temperature and rainfall detection to manage window opening which enhances passenger comfort and vehicle security. The system established real-time sensing capabilities through DS18B20 temperature sensor and rain sensor module and Arduino Uno microcontroller and servo motor and LCD display system components.

The installation of priority-based control logic designed to protect the vehicle interior from water entering through rain detection system which stops all other functions. The manual override feature enables drivers to operate the system according to their needs which protects safety requirements. The experimental results showed that the system functioned properly because it responded to sensors with accurate measurements and operated actuators smoothly while the display interface showed real-time monitoring results. The system achieves intelligent automotive window control through a solution which costs low and delivers dependable performance and uses minimal energy. The study proves how embedded systems and environmental sensors work together to create advanced vehicle comfort systems and safety features. The system demonstrates that modern automotive systems can successfully use automated environmental control systems for climate management purposes.

7 Future Work

The system requires real vehicle power window mechanisms for direct automotive implementation. The system needs additional environmental sensors which include humidity sensors and sunlight intensity sensors and air quality sensors to achieve better monitoring accuracy. The system implements remote monitoring and control through wireless communication modules which include Bluetooth and Wi-Fi and GSM. The development team creates a mobile application-based window control system to provide users with convenient window control access. The system enables window operation through automatic weather prediction-based weather forecast which connects to IoT cloud platforms. The system uses advanced rain sensing technologies which include capacitive sensors and optical rain sensors to achieve higher reliability. The system needs vehicle CAN bus system integration to support modern smart vehicle technology.

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