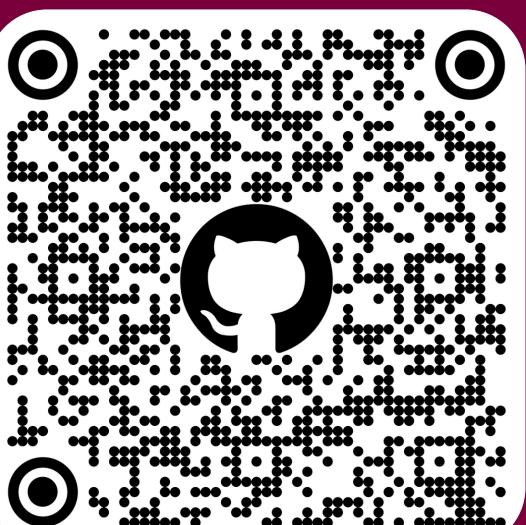




WEATHER AUTOMATED RESPONSE SYSTEM

A Smart Windshield Solution

Viktor Veljanovski, David Sagalovitch, Cole Cadera, Jackson Bell



Objective

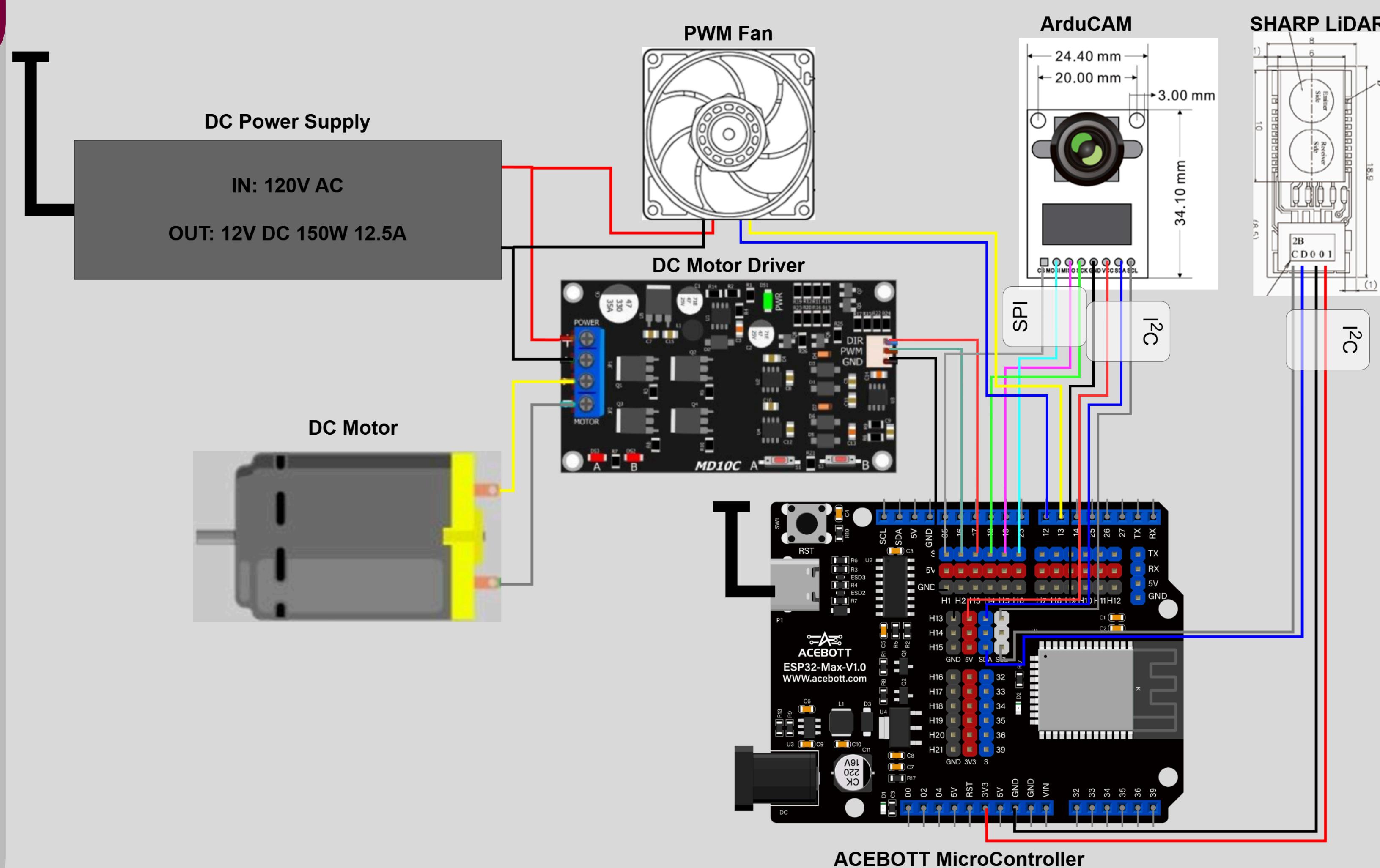
Our Capstone develops an automatic windshield wiper system using ESP-32, a camera, and LiDAR. It detects rain, fog, and debris in real time. The system adjusts wiper speed and activates defogging automatically. This reduces driver distraction, improves visibility, and extends wiper lifespan. It also optimizes energy use and supports vehicle automation.

Challenges

- Camera integration with ESP-32 required firmware changes.
- No existing neural networks for rain detection; opted for OpenCV-based analysis.
- Limited processing power on ESP-32; offloaded tasks to an external PC via WiFi.
- LiDAR only provided distance data, requiring a custom rain detection algorithm.
- Motor torque limitations led to using a rear-window wiper for the demo.

Components

- Microcontroller: ESP-32 handles communication and control between sensors & motors.
- HD Camera & LiDAR: Captures images & measures distance data to determine rain intensity.
- DC Motor: Speed adjusts based on detected rain intensity.
- Python: Implementation of Neural Network and OpenCV image processing algorithms such as edge detection, blob detection, filtering, etc.
- Arduino Code: Controls decision-making, SPI & I²C communication, and motor actuation (PWM).



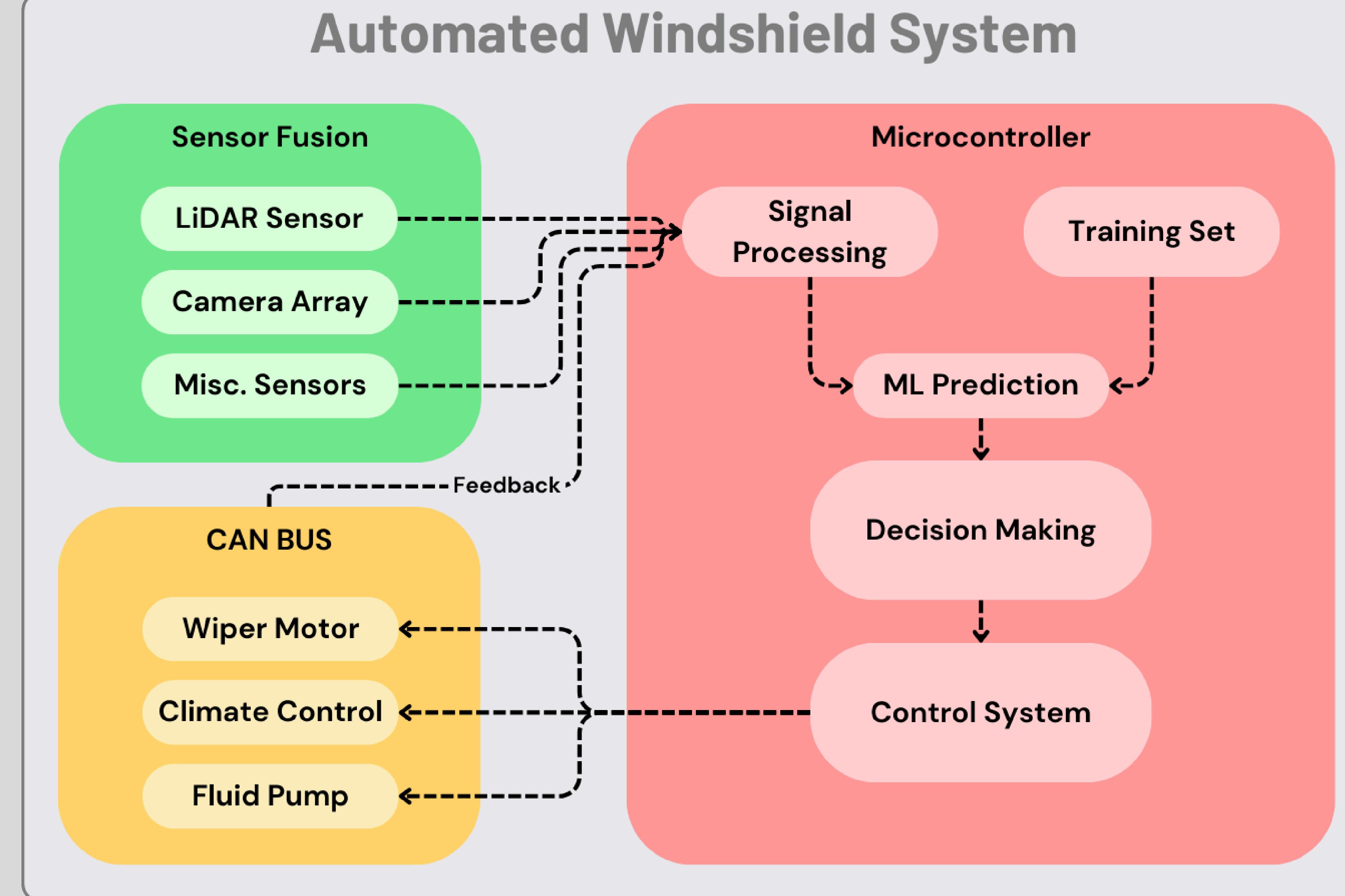
Next Steps

- Implement PID control for smoother and more precise wiper motor operation.
- Continue collecting raindrop data to train a better machine learning model.
- Expand detection to include dirt, snow, ice, and debris.
- Optimize power efficiency to improve performance on low-power hardware.
- Enhance real-time processing for faster and more accurate weather response.
- Develop a compact, standalone module for easy installation in any vehicle.

CAN BUS

We considered the OBD-II port to integrate our system with older cars, controlling wipers and climate systems via CAN BUS. However, manufacturer-specific protocols and the need for real vehicle testing made implementation too complex, so we paused this feature to focus on a functional prototype. ECU communication remains a goal.

System Overview



How it Works



1. Camera and LiDAR Sensor capture windshield conditions.
2. Neural Network and OpenCV processes images to detect raindrops.
3. ESP-32 receives rain intensity data from a Python-based server.
4. Wiper speed is adjusted dynamically based on detected rain.
5. Fog detection triggers a PWM fan to defog the windshield.

Rain Intensity: 51