Report 1
Establishing Foundational Control Architecture

Team Autopilot
22/12/2025

I. Executive Summary

This inaugural report highlights the progress of our team AUTOPILOT, enunciating on our current progress and initial activities. Over the reporting period, our primary focus has been on setting up the hardware for perception and control along with core software components' development and testing. We have successfully defined the foundational architecture for the autonomous driving solution and identified the core functional modules critical for success in the challenge, in which we have integrated our own preliminary autonomous algorithm for longitudinal movement of the prototype as well as our basic object detection module.

II. Key Areas of Focus and Planned Activities

Based on the requirements of the challenge, the following modules have been prioritized for efficient autonomous vehicle control:

- **Architecture and Planning:** Determination of additional features and functionalities for both software, hardware and their integration
- **Object Detection and Tracking:** Connecting the hardware and software together for efficient vehicle manipulation and control
- **Behavioral Logic - Stop Sign Detection & Response:** Development and integration of algorithms that allow the vehicle to detect lanes and enable smooth transitions during lane changes
- **Lateral control:** To enhance state estimation and localisation for efficient lateral control and autonomous steering changes
- **Path planning algorithms:** To stimulate and test best possible path planning algorithms to make intelligent decisions autonomously
- **State estimation and Localization:** To understand the vehicle's surroundings through real-time feedback from the IMU, reducing latency in real-time predictions

III. General Status of the Project

Architecture and Planning

Status: Completed
Implementation: Our team has successfully identified the key areas to be focusing on for smooth software-hardware integration to test and evaluate perception and control.
Key Challenges: Due to certain dependency errors we had to re-flash the raspberry pi kit which obligated us to start the setup from scratch, hence leading to flash the Nucleo module and integrating both to achieve the required and functional firmware setup.

Object Detection and Tracking

Status: Implemented and refining
Implementation: Deployed a YOLOv8 deep learning framework to efficiently detect objects and label them as classes along with confidence scores.
Key Challenges: Iterative testing of the model to perform and generalise well to images captured under different illumination and lighting variations.

Behavioral Logic: Stop Sign Detection & Response

Status: Implemented and refining
Implementation: The vehicle currently maintains a steady speed of 25 centimeters per second and has demonstrated the ability to detect and physically respond to stop signs
Key Challenges: Integrating the detection logic with the control layer to ensure a smooth halt upon detection was a key technical milestone.

Lateral Control

Status: Future implementation
Implementation: To estimate the right steering angle and look ahead distance and arrive at the most suitable algorithm by iterative refinement. Taking feedback from the steering servo actuator and correct implementation of the algorithm, real time monitoring and establishing a feedback loop based on both state estimation and perception.
Key Challenges: Understanding the actual translation of actuator effort to vehicle physical positioning, establishing a feedback look system to understand the physical or mechanical state of the vehicle.

Path Planning

Status: Future implementation
Implementation: To simulate the vehicle in the provided track to efficiently identify

and dynamically adjust the path traversed, involving real-time intelligent decision making and compute an optimal trajectory using benchmark algorithms such as A*, Dijkstra's, etc. to ensure smooth vehicle operations and increased passenger comfort.
Key Challenges: Accurately adapting the planned path in real time when faced with dynamic and out-of-the-box situations such as moving obstacles, unexpected track deviations and environmental uncertainties.

State Estimation and Localization

Status: Future implementation
Implementation: Accurately determine the position and orientation of the vehicle within the track environment from the sensor data perceived from its surroundings, ensuring that the planned trajectory of motion is being executed with high accuracy.
Key Challenges: To enhance robustness of the localisation even in the presence of noise in the observed sensor data or any other dynamic uncertainties that the vehicle might face over the course of its autonomous driving.

IV. Conclusion and Next Steps

The AUTOPILOT team is on schedule, having completed the foundational architectural design and detailed planning. The next steps will focus on the parallel development and implementation of the core Perception modules (Lane Detection, Object Detection) and the initial Motor Control Actuation interface, followed by iterative integration and testing. The next step we will be looking at is lateral control and path planning, implementing planning algorithms. The team is looking forward to working on a strong fundamental and performing iterative refinements to mimic a human-like driving pattern.