1 Introduction

During this reporting period, the team encountered a major setback caused by a burned MOSFET on the power board. If the power board is not repaired by 3 February, a custom replacement board will be developed.

Despite this issue, the team designed a system architecture and maintained consistency with it throughout development. The Brain currently follows the defined architectural pipeline. At this stage, traffic sign detection is implemented, and further tuning is planned to enable reliable semaphore recognition.

2 Planned activities

Research:
This month, research focused on implementing lane detection, traffic sign recognition, and semaphore recognition, as well as understanding how perception outputs are transformed into actuator commands. The main objective was to study how recognition results can be converted into reliable control actions.

Environment-Preparation:
Due to the power board malfunction, the board was sent for repair, and development continued using only the Raspberry Pi and the NUCLEO. As a result, this report mainly presents terminal outputs and software-level validation. Nevertheless, the team is confident in the correctness of the implemented code and expects full system testing to resume once the power board is functional.

Development:
Because of the hardware setback, most development activities were focused on theoretical design and software validation. Commands for speed and steering based on lane detection and traffic sign recognition were successfully transmitted from the Raspberry Pi to the NUCLEO. The positive response from the NUCLEO confirmed that the command generation and communication pipeline is operational.

3 Status of planned activities

System Architecture and Control Pipeline
Status: Partially completed

Implementation:

A modular control and perception architecture was developed, consisting of interconnected components responsible for data validation, decision processing, and motion control. The perception and context module integrates multiple camera-based inputs into a unified environmental representation. Lane detection was calibrated and incorporated into this module, enabling reliable lane perception.

Perception outputs are first validated by the Safety Guard to ensure consistency and physical plausibility. Verified data is then processed by the Control Unit, which determines appropriate vehicle actions and forwards commands to the Command Shaper. The Command Shaper

generates smooth actuator signals by gradually adjusting speed and steering, improving vehicle stability and reducing mechanical stress.

This layered pipeline (Perception → Safety Guard → Control Unit → Command Shaper → Actuators) ensures clear separation of responsibilities and supports scalable system integration. Future extensions include adaptive speed control for ramps and slopes.

Lane Keeping
Status: Completed

Implementation:
After completing lane detection in the previous reporting period, the algorithm was calibrated and integrated into the perception and context module.

Traffic Sign Detection
Status: Completed

Implementation:
A YOLOv8 model was trained for traffic sign recognition and integrated into the perception and context module.

Difficulties:
Integrating traffic sign detection with lane detection proved challenging.

Solutions:
A dedicated perception integration module was developed to manage and synchronize multiple perception sources.

Semaphore Perception
Status: Ongoing

Implementation:
Although a V2X server is expected to provide semaphore information, a camera-based fallback system was developed. This system detects semaphore colors using image processing techniques.

Difficulties:
The algorithm currently reacts to any occurrence of red, yellow, or green light in the camera view, which can lead to false detections.

Solutions:
A unified detection approach is planned, where a trained model will first identify the semaphore object and then determine its active signal color.

4 General status of the project

At the current stage, the system is capable of performing lane keeping and traffic sign recognition and integrating both into the perception pipeline. However, semaphore detection remains unreliable and requires further development.

Due to hardware limitations caused by the power board failure, full system validation has been delayed. Once hardware functionality is restored, comprehensive testing and tuning will be conducted to improve system robustness and integration.

5 Upcoming activities

- Integrate semaphore and traffic sign recognition into a unified detection model
- Define and implement path planning algorithms
- Develop intersection and roundabout navigation
- Implement a parking sequence
- Implement obstacle detection
- Integrate turn signal control