1 Introduction

During this period, we focused on enhancing both the hardware and software aspects of our project. To integrate the new mainboard and vehicle structure, we designed components using a 3D-printed framework for the Jetson Orin Nano.

On the algorithmic side, we explored and validated multiple path tracking methods, including PID control, Stanley, and Pure Pursuit. Additionally, we implemented and tested the UKF localization algorithm in the F1tenth simulator, ensuring reliable positioning accuracy.

For perception improvements, we trained a YOLOv8 model for traffic sign detection. The model demonstrated strong performance, achieving high accuracy on test datasets and successfully detecting signs in real world environments. Furthermore, we integrated our previously developed lane detection algorithm into the BFMC simulation environment, where it consistently exhibited stable performance.

2 Planned activities

(1) Geunwoo Kim
- a. Hardware improvement
- b. Localization algorithm development

(2) Hyoseok Bang
- a. Lane tracking implementation and testing

(3) Minhyek Choi
- a. Hardware improvement

(4) Myungeun Cho
- a. YOLO model training
- b. Path tracking algorithm development

3 Status of planned activities

(1) Hardware

a. Mainboard replacement with Jetson Nano (completed)

To replace the Raspberry Pi with the Jetson Nano, we redesigned the existing frame to fit the new board. The design is complete, and we only need to 3D-print it for the final replacement.

b. Implement embedded code and brain code (40%)

The provided Brain code needs to be transferred to the Jetson Nano. However, this process is still in progress and requires further adjustments for proper functionality.

(2) Algorithms

a. Localization algorithm (completed)

Initially, we used laser odometry alone because the vehicle did not have an encoder, so we collected odometry data using the laserscan. However, the performance was unsatisfactory. By applying the Unscented Kalman Filter (UKF) to fuse IMU and odometry data, we achieved 95% localization accuracy in the F1tenth simulation.

b. Traffic sign detection (completed)

Using a dataset of over 4,000 images, we trained a YOLOv8n model, achieving 98% accuracy with a fast processing speed of 28ms. The model was tested on both a test dataset and real-world environments, confirming its robust performance.

c. Path tracking algolithm (completed)
We implemented PID, Stanley, and Pure Pursuit algorithms for path tracking. PID is suitable for simple control but suffers from overshoot, Stanley performs well on sharp curves, and Pure Pursuit offers stable trajectory tracking with smooth steering. The final selection will be determined through real-world testing.

d. Apply algorithms to the BFMC simulation (50%)
We successfully transferred and tested the previously developed lane detection algorithm in the BFMC simulation environment. The algorithm performed well, and further integration of other algorithms will follow.

4 General status of the project

(1) Hardware (80%)

- The design for the 3D-printed frame to fit the Jetson Orin Nano is complete. We only need to print it to proceed with the replacement.
- The Brain code still needs to be fully transferred to the Jetson Nano. Once completed, full hardware integration will be achieved.

(2) Algorithms (100%)

- The UKF-based localization algorithm has been successfully implemented and acheived 95% localization accuracy in the F1tenth simulator, significantly improving localization accuracy.
- Multiple path tracking algorithms (PID, Stanley, Pure Pursuit) have been developed and validated in the F1tenth simulator. The final selection will be determined after testing on an actual vehicle.
- The YOLOv8n model for traffic sign detection has been trained with over 4,000 images, achieving 98% accuracy with a fast processing speed of 28ms. It has been verified on both test datasets and real-world scenarios.

5 Upcoming activities

(1) Finalize the mainboard transition

- Complete the transfer of Brain and embedded code to Jetson Orin Nano and verify stable operation.

(2) Implement algorithms on the actual vehicle

- The developed algorithms, including lane detection, localization (UKF), path tracking (PID, Stanley, Pure Pursuit), and traffic sign detection (YOLOv8), will be transferred to the actual vehicle.

(3) Prepare for mission execution (parking & obstacle avoidance)

- Develop and test parking and obstacle avoidance functions for the demo.