1 Introduction

This report outlines the key activities carried out by **TEAM COSS** during the preparation for **the Bosch Future Mobility Challenge**, including team collaboration efforts, changes encountered during the project, and the progress made.

Particular Activities

Brain Code Analysis: Mapped the data flow from input to output (Speed & Steer).
YOLOv5-Based Object Detection and AEB Integration: Developed and integrated pedestrian detection with Autonomous Emergency Braking (AEB).
Lane Detection Development: Tested and developed lane detection algorithms.
RealSense Camera Integration: Connected and utilized depth data from the RealSense camera for distance measurement.

Team Spirit

All team members actively participated in the process and successfully fulfilled their roles.
Collaborative Problem-Solving: The team quickly resolved unexpected issues.

Changes

- Due to the unavailability of the Jetson Orin Nano, the team switched to Raspberry Pi for developing AEB and Lane Detection logic.

These activities and the spirit of collaboration played a crucial role in achieving the initial project goals. The team responded to challenges with flexibility and a proactive approach.

2 Planned activities

1) YOLOv5-Based Object Detection and AEB Integration
Details Task:

- **Data Preparation:** Created a custom dataset of approximately 100 images using a doll similar to BFMC's pedestrian model. YOLOv5 object detection results were used to send AEB signals to the NUCLEO board when specific conditions were met.

Outcome: Developed a simple logic where the car stops when detecting the doll and automatically resumes when the doll is no longer detected.

2) Lane Detection Testing and Development
Details Task:

- **OpenCV-Based Lane Detection:**
  - **Image Transformation:** Applied **bird's-eye view transformation** using a transformation matrix to the camera image.
  - **Edge Detection:** Used Sobel values for edge detection and enhanced contrast using **Lightness (HSL color space)**.
  - **Lane Modeling:** Recognized left and right lanes using the **sliding window technique**, generating a polynomial model based on pixel count.
- **AI Model (LaneNet)-Based Lane Detection:**
  - **Model Info:** 445K Parameters (light), 53.69 GFLOPs, 2.4GB memory usage
  - **Optimization:** Required further optimization due to high memory usage.

Outcome:

- Successfully recognized lanes using OpenCV.
- LaneNet achieved lane recognition but requires optimization for embedded boards.
- Verified the code's correct execution and the system's expected functionality.

3) RealSense Camera Integration with Depth Data

Details Task:

- Extracted depth data from RealSense using the bounding box center points of objects detected by YOLOv5 in real environments.

Outcome:

- Successfully detected specific objects and extracted accurate distance data during real-world testing.

4) Simulator Environment Setup and Algorithm Testing

Details Task:

- Validated algorithms in the simulator using ROS topics:
    - Lane and object detection and Traffic light-based vehicle control.

3 Status of planned activities

Activity	Status	Description	Difficulties
YOLOv5 and AEB Integration	Completed☑	1. Select AI Model 2. Collecting Custom Dataset 3. Connect Detection Result To Speed Output	Difficult to make the model recognize only the specific doll, as it also detected humans, likely due to the visual similarities between the doll and
Lane Detection	In Progress (60%)	1. Lane Detection with OpenCV (Completed) 2. Lane Detection with LaneNet (In Progress)	Difficult to make camera in good position
RealSense Camera	Completed☑	Integrated depth data with YOLOv5 to calculate object distances	Depth values were sometimes noisy
Simulator Testing	Completed☑	Tested lane and object detection, as well as traffic light-based vehicle control algorithms, using ROS topics in the simulator.	The simulator's graphical and configuration issues

4 General status of the project

The project has successfully advanced to the implementation phase, achieving key milestones in pedestrian detection, lane detection, and simulator-based algorithm testing, with initial objectives met and preparations for the next phase underway.

YOLOv5 and AEB Integration: Trained a pedestrian detection model and integrated the AEB function into the Brain framework seamlessly.

Lane Detection: Developed and compared methods using OpenCV and LaneNet

RealSense Camera: Implemented object distance calculation using depth data integrated with YOLOv5 and proposed improvements.

Simulator Testing: Tested the developed algorithms, using ROS topics in the simulator.

The project has met its initial objectives successfully and is ready for the next phase.

5 Upcoming activities

For the next reporting period, the main objectives are data preparation, sensor data integration, motor control optimization, and the development of a robust lane-keeping system. Each task focuses on enhancing system stability and autonomous driving functionality.

1) Development of a Robust Lane-Keeping Algorithm

Objective: Develop a robust lane-keeping algorithm, including lane detection

Detailed Tasks:

- Adjust camera alignment for optimal lane detection and Optimize motor control

2) Global Path Planning

Objective: Prepare global path planning for the competition environment.

Detailed Tasks:

- Develop global path planning logic based on competition missions and courses.
- Utilize IMU data to verify the vehicle's current state.

3) Traffic Sign Detection

Objective: Detect various traffic signs and signals used in the competition.

Detailed Tasks:

- Collect datasets for traffic signs and signals and optimize the model.