Autonomous Vehicle

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Abstract

This project focuses on developing an autonomous, lane-following, and obstacle-avoiding vehicle using both simulation and hardware. A scaled car was modified by hacking its actuators, designing PCBs, integrating sensors, and mounting processors—all within the chassis. The vehicle navigates a racing track at constant speed while switching lanes to avoid collisions. The complete system was tested under various scenarios, demonstrating reliable performance in both simulated and real-world environments. This work highlights the effectiveness of a modular ROS-based approach for small-scale autonomous driving platforms.

Methodology

This approach integrates Gazebo simulation with hardware deployment using a Raspberry Pi and Arduino. The system is designed to achieve autonomous lane following and obstacle avoidance through localization, control, and planning modules.

System Components:

- **Localization:** A Kalman Filter processes sensor data to estimate position and orientation.
- **Control:** The speed is regulated using a PID controller, while lateral control is achieved using a Pure Pursuit algorithm to steer the vehicle along the center of the lane.
- **Planning:** Generates lane and speed profiles for the vehicle's movement.
- **Hardware:** The sensors and actuators are positioned in their designated places for smooth operation.

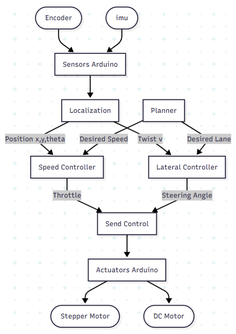

Figure 1. Flow Chart

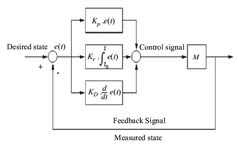

Figure 2. PID Speed Control

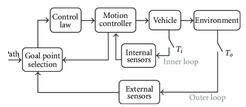

Figure 3. Lateral Control

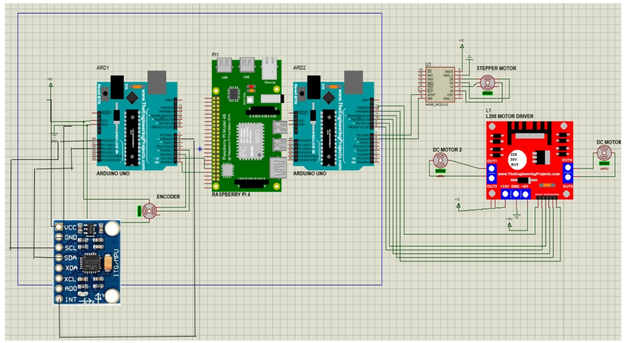

Figure 4. Flow Chart

Figure 5. Hardware model

Figure 6. Hardware model

Figure 7. Hardware model

Results

The vehicle was tested in both simulation and hardware environments.

Test Case 1 – Lane Following: The vehicle followed the lane with a track completion time of 6.7 seconds. The deviation from the center was kept below 3 cm, showing stable lane tracking.

Test Case 2 – Lane Switching: The vehicle successfully switched lanes while avoiding obstacles, with a lane change time of around 1.1 seconds. It maintained a clear path without collisions.

Overall, the vehicle showed reliable performance in lane following and switching. Both simulation and hardware tests confirmed its effectiveness in real-world applications.

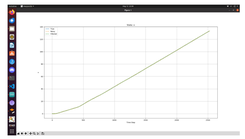

Figure 8. States Plot 1

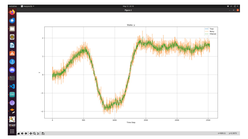

Figure 9. States Plot 2

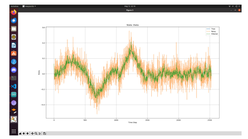

Figure 10. States Plot 3

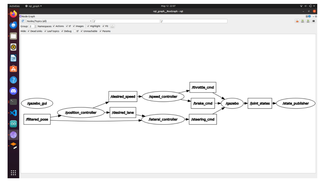

Figure 11. RQT Graph

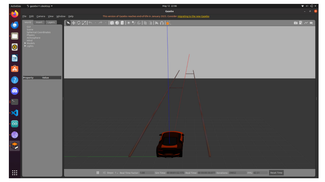

Figure 12. Gazebo Simulation

Videos

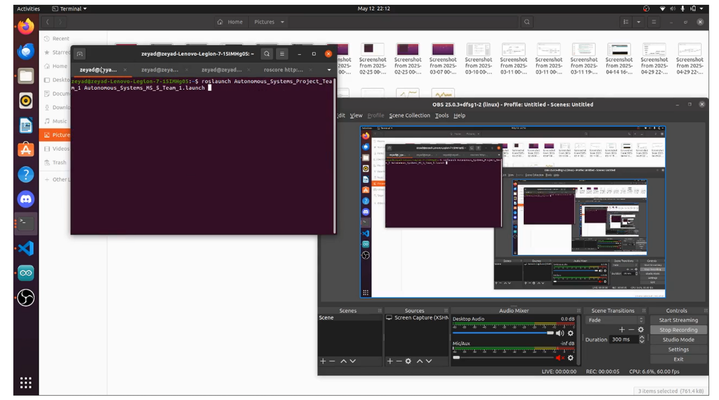

Figure 13. makan ll video

Conclusion

The autonomous vehicle successfully integrated key functionalities for lane following and obstacle avoidance, as demonstrated through both simulation and physical testing. The system performed well under various test conditions, with accurate lane tracking and effective lane switching. The results show that the vehicle can navigate a predefined track while maintaining safety and efficiency.