Project Report

ALVN

Autonomous LiDAR and Vision based Navigator

By

Ciaran Maye

C00253212

Ollscoil Teicneolaíochta an Oirdheiscirt

South East Technological University

Table of Contents

Introduction

The main objective of this project was to develop an autonomous vehicle system capable of detecting a predefined path and scanning its surroundings to avoid obstacles while navigating through the path. I was successful in implementing an obstacle avoidance system using a polar histogram algorithm and a basic line following system. However, I was not able to complete the lane following program, the VFH based obstacle avoidance system or the integration of both systems to achieve the ultimate goal.

Problems Encountered and Resolutions

Lane/Path Following

During development of the path-following system, I encountered several problems.

Noise and false detections:
During development, the system occasionally detected irrelevant lines or objects in the image, leading to incorrect steering decisions. To address this issue, I applied image preprocessing techniques, such as Gaussian blur and morphological operations (e.g., erosion and dilation), to reduce noise and improve edge detection.

Camera angle:
The camera was mounted at a 30-degree angle, which resulted in the vehicle processing the steering angle slightly too early. To account for this, I adjusted the region of interest (ROI) in the image by extending the ROI further in the direction the camera was facing. This allowed the vehicle to process the steering angle more accurately.

Varying lighting conditions:
The system's performance was affected by changes in lighting conditions, such as shadows or glare. To mitigate this problem, I used the HSV color space, which separates color information from brightness. Additionally, I implemented dynamic thresholding and adaptive color filtering to better handle varying lighting conditions.

Computational resources:
Real-time processing of image data and control algorithms can be computationally demanding, potentially leading to latency issues or reduced performance. To overcome this challenge, I optimized the code as much as possible by tuning the Open CV hyperparameters and implemented multithreading.

Hyperparameter Tuning:
Lastly, I focused on tuning hyperparameters, as this proved to be the key to success in addressing the aforementioned issues. The performance of the system was sensitive to various parameters, such as the steering scaling factor, buffer size, and color thresholds. By carefully tuning these parameters, I was able to improve the overall performance and robustness of the systems.

Obstacle Avoidance

During development of the Obstacle Avoidance System, I encountered several problems.

Inaccurate Lidar data:
During the development process, I noticed that the data obtained from the Lidar sensor was noisy and inconsistent at times. This affected the system's ability to accurately detect and avoid obstacles. To resolve this issue, I applied filtering and averaging techniques through the histogram methods which significantly improved its reliability.

Computational complexity:
Real-time processing of Lidar data and the control of the vehicle proved to be computationally demanding. To optimize the system's performance, I made a conscious decision to implement efficient algorithms. This allowed the system to process the data and control the vehicle more efficiently.

Hyperparameter tuning:
Lastly, and similarly to the path/lane following, one of the keys to success in addressing these issues and achieving a usable Obstacle Avoidance System was the careful tuning of various hyperparameters. By adjusting hyperparameters such as the moving average window size, steering angle limits, and Lidar data thresholds, I was able to optimize the system's performance, ensuring accurate obstacle detection and smooth vehicle control. Fine-tuning these parameters played a crucial role in overcoming the challenges faced during the development process, ultimately leading to the successful implementation of the Obstacle Avoidance System.

Achievements

Successfully implemented an obstacle avoidance system using a polar histogram algorithm.
Successfully implemented a path following algorithm.

Unachieved Goals

I was not able to complete the lane following program.
I was not able to implement the VFH based obstacle avoidance system.
I was not able to integrate both systems to achieve the ultimate goal of detecting a predefined path and scanning its surroundings to avoid obstacles while navigating through the path.

Future Development/Reflections

Despite not being able to complete all of the planned objectives, the project has laid the foundation for future development and improvement. There are several areas where the current system can be improved to achieve the ultimate goal of an autonomous vehicle system:

1. Completing the lane following program to enable the vehicle to detect and follow a lane.
2. Improving the path following system to be fully functional.
3. Improving the obstacle avoidance system by incorporating the VFH algorithm to increase its efficiency and accuracy.
4. Integrating both the line following and obstacle avoidance systems to achieve the ultimate goal of detecting a predefined path and scanning its surroundings to avoid obstacles while navigating through the path.
5. Implementing additional features such as traffic sign recognition, traffic light recognition, and vehicle control to increase the overall functionality of the autonomous vehicle system.

These developments will bring the project closer to the goal of creating a fully functional autonomous vehicle system capable of safely navigating through complex environments.

Conclusion

In conclusion, this project aimed to develop an autonomous vehicle system that could detect a predefined path and scan its surroundings to avoid obstacles while navigating through the path. Although not all objectives were achieved, significant progress was made in implementing a basic path following algorithm and an obstacle avoidance system using a polar histogram algorithm. Challenges such as noise, camera angle, lighting conditions, computational resources, and hyperparameter tuning were addressed effectively, resulting in robust solutions for both systems.

Despite not completing the lane following program, the VFH-based obstacle avoidance system, or integrating both systems, the groundwork has been laid for future development. By focusing on completing the lane following program, improving the path following system, incorporating the VFH algorithm, integrating the systems, and adding additional features such as traffic sign and traffic light recognition, the ultimate goal of a fully functional autonomous vehicle system could be achieved.

The lessons learned from the challenges faced during this project and the successful implementation of key components serve as valuable experience for future endeavors in the development of autonomous vehicle systems and beyond. The hands-on experience gained from working on this project has allowed me to not only improve my problem-solving skills, but also to deepen my understanding of the intricacies involved in building complex systems. This invaluable experience has equipped me with the technical expertise and the ability to tackle real-world issues, which will undoubtedly benefit my future projects and contribute to my professional growth in the of software development.

I declare that all material in this submission, e.g. thesis/essay/project/assignment, is entirely my own work except where duly acknowledged.

I have cited the sources of all quotations, paraphrases, summaries of information, tables, diagrams, or other material, including software and other electronic media in which intellectual property rights may reside.

I have provided a complete bibliography of all works and sources used in the preparation of this submission.

I understand that failure to comply with the Institute's regulations governing plagiarism constitutes a serious offence.

Student Name : Ciaran Maye
Student Number: C00253212
Student Signature: