Pre-planning Intersection Traversal for Autonomous Vehicles

Master's Thesis in Computer Engineering

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Preface

This master thesis is titled “Pre-planning Intersection Traversal for Autonomous Vehicles” and is devised by Ian Dahl Oliver. The author is a student at Aarhus University, Department of Electrical and Computer Engineering, enrolled in the Computer Engineering Master’s programme. The author has completed a Bachelor’s degree in Computer Engineering under the same conditions.

The thesis has been conducted in the period from 27-01-2025 to 05-06-2024, and supervised by Associate Professor Lukas Esterle. I would like to express my gratitudes to my supervisor for his support and advice throughout the project.

An additional thanks goes to...

All software developed in this thesis is released under the MIT license, and is provided as is without any warranty.

Enjoy reading,
Ian Dahl Oliver

Abstract

hello Robot Operating System 2 (ROS2)

Nomenclature

Some terminology and type setting used in this thesis may not be familiar to the reader, and are explained here for clarity.

Hello › World

Acronyms Index

Acronym	Definition
AIM	Autonomous Intersection Management
API	Application Programming Interface
AV	Autonomous Vehicle
CNN	Convolutional Neural Network
CPU	Central Processing Unit
CV	Computer Vision
DL	Deep Learning
DOF	Degrees of Freedom
GNN	Graph Neural Network
GUI	Graphical User Interface
ID	Identifier
JSON	JavaScript Object Notation
MLP	Multilayer Perceptron
PNG	Portable Network Graphics
PRNG	Pseudo-Random Number Generator
RMSE	Root Mean Squared Error
RNG	Random Number Generator
ROS2	Robot Operating System 2
TOML	Tom's Obvious Minimal Language
UI	User Interface
UX	User Experience
YAML	YAML Ain't Markup Language

Contents

1 Introduction

The introduction to the thesis will be structured as follows...

1.1 Motivation

1.2 Problem Statement

Advancements in Autonomous Vehicle (AV) technologies have been at the forefront of tech innovations in the 21st century. A key challenge in the development of fully autonomous vehicles, is their ability to handle intersections. Intersections pose a wide variety of challenges to AVs: from those posed by complex structures, to those posed by the unpredictability of human drivers, to faded lines that make it difficult for on-board computer vision system to clearly identify lanes or paths. All of these hinder AVs from reaching their full potential and being able to navigate intersections safely and efficiently.

Current existing solutions are very infrastructure-dependent. The Car2X system by Volkswagen, for example, relies on a network of sensors and communication devices installed in the infrastructure to spread information to vehicles on the road [1]. Autonomous Intersection Management (AIM) also relies on infrastructure to provide vehicles with information regarding intersections, with an orchestrator monitoring and managing individual intersections [2], [3], [4], with active development moving towards a more decentralized and distributed approach [5]. Furthermore, reliance on camera-based vision is susceptible to environmental limitations, such as adverse weather, that reduce system reliability.

The challenges posed by intersections cause major problems for AV developers who want to push fully autonomous driving. AVs' inability to properly react to and handle intersections, leads to significant delays in real-world deployment as a consequence of the unreliability experienced by regulators and the general public. If AVs want to enter the market with full self-driving capabilities, full autonomy is a key challenge to be tackled, as it is an essential task experienced when driving.

This projects aims to develop a solution that will help AVs to better handle intersections. With the use of Deep Learning (DL) and Computer Vision (CV) technologies, trained on and utilizing satellite imagery, this project aims to train a model that can accurately identify the proper path for an AV to travel through an intersection. The system is not meant to

replace current systems deployed in AVs, but rather assist the existing systems make better decisions when in self-driving mode and approaching an arbitrary intersection.

2 Related Works

3 Background

This section outlines the theory relevant to the thesis. It begins with...

3.1 Section 1

4 Methodology

This section covers the methodology and work produced as part of the thesis...

4.1 Section 1

5 Results

This section details the experiments conducted

6 Discussion

In this section...

7 Conclusion

References

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Appendix

A: Appendix 1