Project Proposal: Global and Local Motion Planning for Self-driving Car using Carla Simulator

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Summary:

In this project, our aim is to create a local motion planner that is able to handle real-world scenarios that are consistently encountered by autonomous vehicles every day. We will write Python code to interact with the CARLA simulator, navigate a prepared scenario, and avoid collisions with several dynamic obstacles. The controller of the car and the sensing and image processing methods will be provided by Coursera course: Self-Driving Cars Specialization.

Objectives:

- **Global Motion Planning:** The global trajectory of the vehicle will be computed with a global planner, which will be implemented by ourselves during this project.
- **Local Motion Planning:** The local trajectory of the vehicle will be computed with a local motion planner, which will be implemented by ourselves during this project.
- **Navigating:** The car will be following a set of way-points which will be generated with the global planner until it reaches a goal.
- **Static Obstacle Avoiding:** There will be a static parked obstacle blocking the current lane. The discrete samples of the footprint of the obstacle will be given, and we will need to use circles to approximate the footprint of the ego vehicle along each planned path in order to quickly compute whether or not the path is in collision with the obstacle. By removing the paths in collision with this obstacle from our planning process, we will be able to avoid the obstacle entirely.
- **Dynamic Obstacle Avoiding:** A lead vehicle and several pedestrians will be encountered during the navigation. This vehicle will be moving below the speed limit, and as such we will have to regulate the velocity profile accordingly to prevent a collision.
- **State Machine Design:** The car will reach a stop-sign controlled intersection. A state machine that can handle the stop sign will be developed, which means it must have the ability to decelerate to a stop, briefly weight once stopped, and then proceed through the intersection.

Methodology:

- **Literature Review:** Review the relevant literature and the content from the course to understand the principle of different algorithms.

- **Environment Setup:** Set up CARLA Simulator for scenario visualization in Windows/Linux and interact with Python.
- **Path Planning:** Compare several global planning and local planning algorithms and implement the most suitable ones to navigate the car with the concepts of shortest path search on graphs in order to find a sequence of road segments in a driving map that will navigate a vehicle from a current location to a destination. (Alternative options: Smooth local planning, …, etc.)
- **Behaviour Planning:** Understand how to create occupancy grid maps to identify static obstacles in the environment, how to assess the time to collision of dynamic obstacles in the environment and how to apply swath-based and circle-based collision checking.
- **State Machine:** Develop a basic rule-based behaviour planning system, which performs high level decision making of driving behaviours such as lane changes, passing of parked cars and progress through intersections.

Relevant literature links:

A. Kelly and B. Nagy, "Reactive Nonholonomic Trajectory Generation via Parametric Optimal Control," The International Journal of Robotics Research, vol. 22, no. 7, pp. 583–601, 2003. This paper discusses the math behind generating spirals to desired terminal states.

A. Piazzi and C. G. L. Bianco, "Quintic G/sup 2/-splines for trajectory planning of autonomous vehicles," Proceedings of the IEEE Intelligent Vehicles Symposium 2000 (Cat. No.00TH8511). This paper discusses the math behind generating quintic splines to desired terminal states.

M. Mcnaughton, C. Urmson, J. M. Dolan, and J.-W. Lee, "Motion planning for autonomous driving with a conformal spatiotemporal lattice," 2011 IEEE International Conference on Robotics and Automation, 2011. This paper introduces the concepts behind generating a conformal spatiotemporal lattice for on-road motion planning.

Freya Fleckenstein, Wera Winterhalter, Christian Dornhege, Cedric Pradalier, Wolfram Burgard. "Smooth Local Planning Incorporating Steering Constraints". 12th Conference Field and Service Robotics, Aug 2019, Tokyo, Japan.

Villagra, J., Milanés, V., Pérez, J., & Godoy, J. (2012). "Smooth path and speed planning for an automated public transport vehicle." Robotics and Autonomous Systems, 60(2), 252–265. https://doi.org/10.1016/j.robot.2011.11.001