A research on path planning module based on rule based method

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Abstract—Path planning is a very important part of self driving car. Maybe path planning is the hardest part of all module. Path planning should cover search problem, behavior planning, trajectory generation and so on. There are many way to construct path planning algorithm. In this research, a easy way of path planning algorithm is implemented. A rule based algorithm is implemented.The algorithm is validated by using the simulator which is provided. It can be found that, there are no warnings happened in whole highway road about 5 miles.

Index Terms—Self driving car, Path planning, Decision making, Udacity, LaTeX, Spline fitting, rule based control.

1 Introduction

Path planning is a very important part of self driving car. Maybe path planning is the hardest part of all module. There are 3 main modules in path planning problem.

1.0.1 Search algorithm

1) Search problem. Search algorithm provides optimal path for vehicle to follow. It receives the collision area and other constraints, then output a path. The classic algorithm in search module is famous A* algorithm. This algorithm has completeness and optimize path characters. However, A* algorithm is a discrete algorithm. It divides environment in cells, then using these cells to generate path. But the cell is discrete. Vehicle can't follow a discrete path. So usually, A* algorithm needs other algorithms to make it works in continuous.
2) Hybrid A*. Hybrid A* is a improve version of A* algorithm. As above mentioned, A* is discrete. So Hybrid A* is based on A*, then combines vehicle model to make a small step prediction. Then discrete cells can be turned into continuous curve. If the cells small enough, then the curve can be smooth enough.

1.0.2 Prediction module

Prediction module is important in dynamic environment. Since surrounding items moving all the time, self driving car needs to judge where will the surrounding cars will be. Then search module generates the path which considering the prediction results. Usually, in simple case, kinematic model is used for predicting other vehicles' future position.

1.0.3 Behavior planning

Behavior module is try to make decision like man does. When we are driving, we try to go goal position as fast as possible. So we need to assess the environment and take lane change behavior or keep lane behavior. Behavior module just works in this way. In order, behavior planning has higher order to search module.

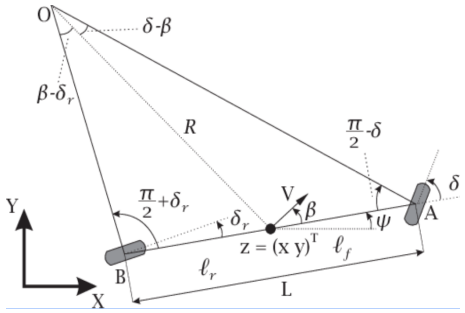

Fig. 1. Prediction with bicycle model

1.0.4 Trajectory generation

Now, the vehicle should generate the way points based on previous module. However, vehicle can't move in uncomfortable way since there are passengers. So the jerk shouldn't happens. In other words, vehicle should generates the trajectory points with some constraints. Usually the constraints are acceleration in longitudinal and lateral, speed limit, time to goal, distance to other vehicles and so on. These parameters effect passengers feeling and comfort.

2 Evaluation based on simulator

In this research, a drivable trajectory and resonable behavior should be implemented. The evaluation of the proposed algorithm is done by simulator which is provided from udacity. It occurs warning when vehicle runs in uncomfortable and unreasonable way.

3 Path planning logic

With the given data and simulator, we don't need to do search. Because a ground truth frenet coordinate is given. The only thing we need to do is generating trajectory points and change lane in reasonable way.

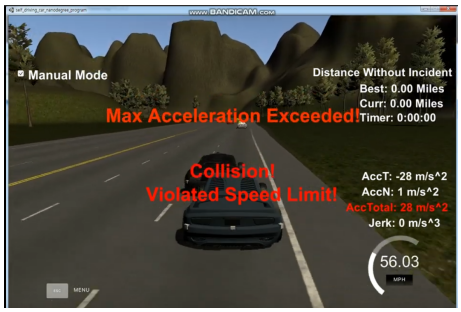

Fig. 2. Warning shows up when break the rule

Fig. 3. Total path planning module logic

3.0.1 *Decision making*

There are There is cost function based method and rule based method. I choose rule based method. Ego vehicle uses the surround vehicles position to judge whether to change lane. The ROI of lane change is set. Once vehicle in ROI, then vehicle shouldn't change lane. If not, then change lane and run with max velocity.Parameter which is named ROI-offset make vehicle can change lane more aggressive.

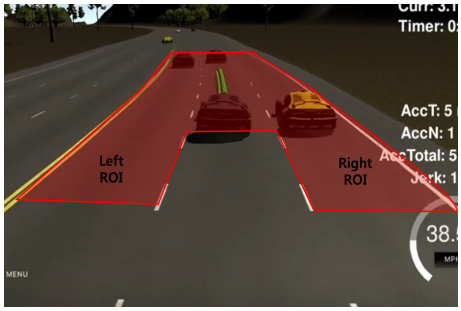

Fig. 4. ROI setting for lane change behavior

3.0.2 *Way points generation*

There are two kinds of way points. One is lane level way points. It gives a rough path. Vehicle should follow this rough path with continuous control. However, in this project , we don't need to control the steering. We just move a very little just like control effect. So how to generate the little move is important. Spline fitting is used for generating these little move.

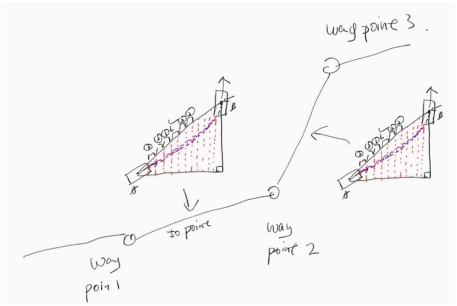

Fig. 5. Spline fitting for generate little move

4 Results

Below is the result of the simulation results. The first figure below is the success figure capture. From the right up side of the figure, it can be found that vehicle doesn't collide with other vehicles and no any warning shows up. From this result, it can be found the algorithm which is developed can meet the rubric.

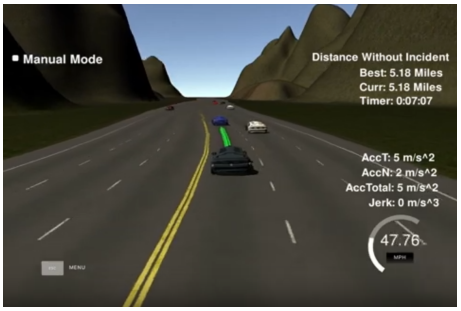

Fig. 6. Success run without any warnings in 5 miles

With the ROI and ROI-offset parameter, vehicle performs more aggressive lane change behavior without any warning happens. It means ego vehicle not only go faster but also follow the constraints. Even in below figure situation, vehicle decides to change lane. Everybody wants to reach goal as fast as possible!

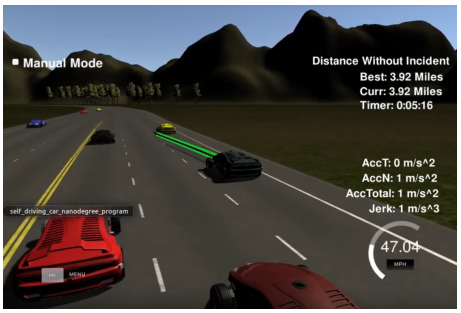

Fig. 7. Aggressive lane change behavior

5 Future Work

In this research, because we use perfect controller and pre-known map data, so that we don't need to concern about that. But in reality, the controller and perception is also important to vehicle safety and comfort. In the future, the

controller and perception combined algorithm should be implemented to car. Then search problem such as A* should be used to search the path.

6 Reference

References:

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2.https://darienmt.com/CarND-Path-Planning-Project-P1/