Design of a Predictive Method for Obstacle Detection and Safe Operation of Autonomous Vehicles

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Abstract

- Although the use of autonomous vehicles to transport people and objects from one location to another is a very interesting concept, the operation of autonomous vehicles opens doors to various safety issues and security vulnerabilities.
- This is especially evident during the presence of traffic and unidentified obstacles on the road. In addition, the cost of the sensors used in autonomous vehicles is very high and the sensor hardware itself is very prone to malfunction and failure.
- Accurate operation of these sensors is extremely important to the overall safety of the passengers inside the vehicle because they can determine whether an accident will be avoided.

Introduction

- This research is focused on designing a predictive obstacle detection and avoidance method that would be optimal for avoiding objects on a road that an autonomous vehicle operates on.
- The research explores Model Predictive Control (MPC) to optimize future time slots based on the outputs of the current time steps under a set of multiple constraints, giving an advantage over other methods.
- This research also makes use of Matlab-Simulink to test various outcomes of object avoidance based on several factors such as velocity and object detection distance.

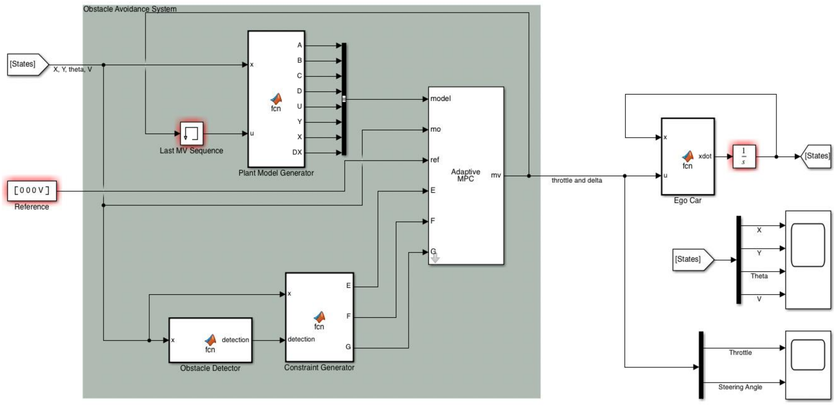

Figure 1: Design of the Predictive Method for Obstacle Detection

Methodology

- The aim of the Model Predictive control code that this research is based on is to accurately detect and avoid any object that is in the autonomous vehicles path.
- The algorithm is based on a set of initial control variables such as velocity, object detection distance, and object location.
- These variables determine how the vehicle will interact with the object and whether it will be able to avoid it.

Table 1: Experimental Testing of Variables

	V	Obstacle length	Obstacle width	Obstacle X	Obstacle Y	Detection distance
Control Trial	20	5	2	35	0	30
Trial 1	**60**	5	2	35	0	30
Trial2	**10**	5	2	35	0	30
Trial 3	20	5	2	35	0	**10**
Trial 4	20	5	2	35	0	**50**
Trial 5	20	**10**	**4**	35	0	30
Trial 6	20	**2**	**1**	35	0	30
Trial 7	20	5	2	**15**	0	30
Trial 8	20	5	2	**55**	0	30
Trial 9	20	5	2	35	**10**	30
Trial 10	20	5	2	35	**-5**	30

Experiment

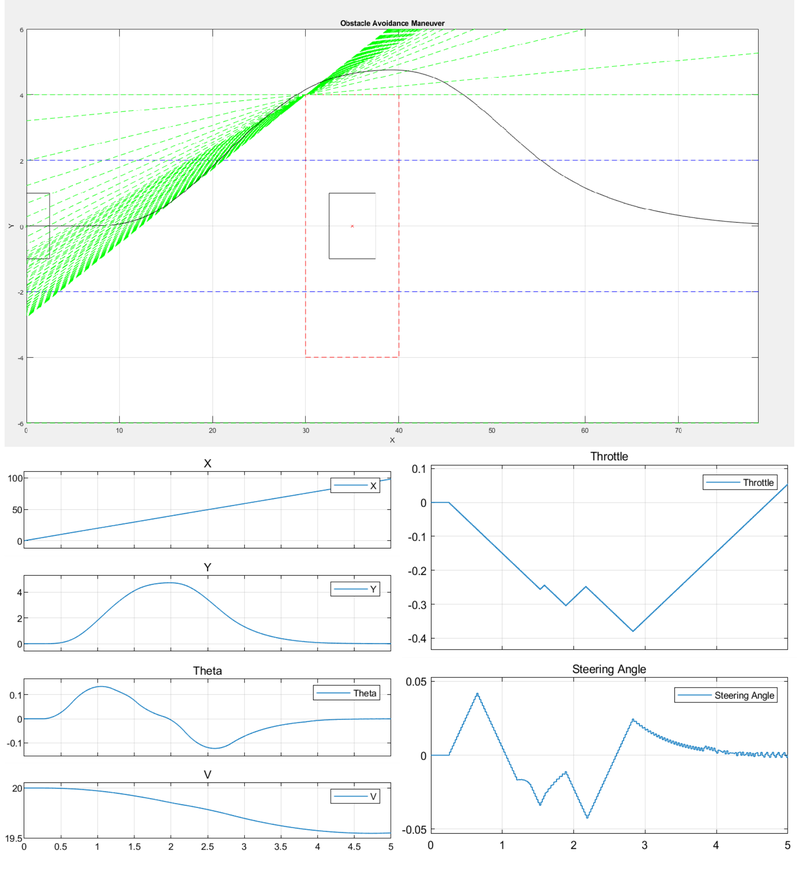

Figure 2: Output of the Control Trial of Experiment

Results and Conclusion

- This results indicated ways that an autonomous vehicle may interact with its environment and how that can affect the safety of the vehicle.
- One area for improvement is in the sensing and reaction of the vehicle to the object. In experiment number 9, although the shorter and safer route around the object was to go below it, the vehicle went above the object.
- This issue is due to the original code and shows that this is a possible area for improvement in the future.
- Future work could lead to an overall safer experience for both the passengers of the autonomous vehicle and the people driving alongside the vehicle.

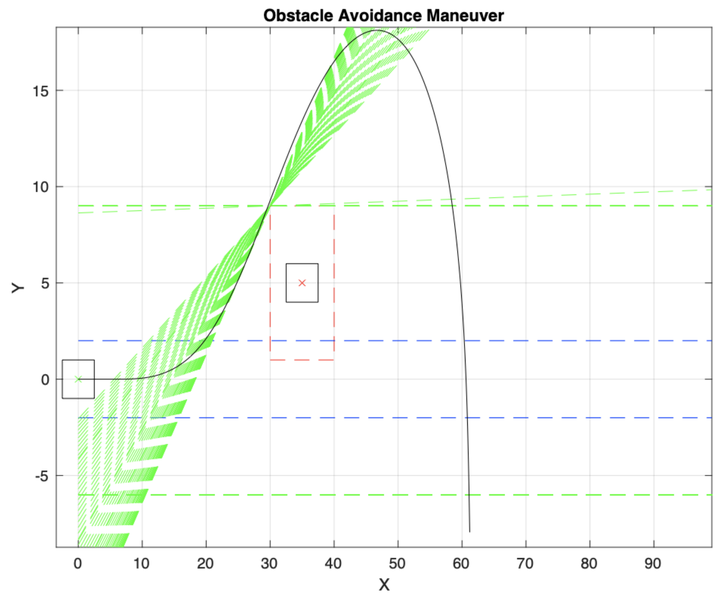

Figure 3: Output of the Experiment 9

References

1. B. W. Abegaz and N. Shah, "Sensors based Lane Keeping and Cruise Control of Self Driving Vehicles," 2020 11th IEEE Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON), New York, NY, USA, 2020, pp. 0486-0491, doi: 10.1109/UEMCON51285.2020.9298141.
2. Mathworks, "Obstacle Avoidance Using Adaptive Model Predictive Control," [Online]. Available: https://www.mathworks.com/help/mpc/ug/obstacle-avoidance-using-adaptive-model-predictive-control.html. [Accessed: 18-Mar-2023].