ROB 535 Project Report - Yifan Wang

Task Summary:

- **Task 1:** Design a control input to make the car complete the track as quickly as possible. Completion is defined as the center of mass passing the red line and not leaving the track at any point.
- **Task 2:** Design control inputs to get you across the track as quickly as possible. However, now obstacles will be randomly distributed on the track. To emulate a real scenario, the positions of all obstacles are known beforehand. Completion is defined as before: the center of mass passes the red line and does not leave the track or hit obstacles at any point.

My Contributions:

- **Explored RL:** For part 2, I researched and explored the reinforcement learning approach to solve this problem. Reinforcement learning (RL) is a type of machine learning that involves an agent interacting with an environment to learn a policy that maximizes a reward signal. In this case, the agent would be the vehicle, and the environment would be the track and space outside the track. In my imagination, the vehicle can take actions (e.g., moving forward, turning left or right) that change the state of the environment. The goal is to learn a policy that maximizes the reward (i.e., reaching the finish line) while minimizing the punishment (leaving the track or hitting the obstacle). However, it is very difficult to formulate an unbiased policy because of several reasons:
    - The vehicle model is too complicated to be model as the simple "actions"
    - It is hard to generate reward signals along the track (before it reaches the finish line).
    - It is also non-trivial to model the state since the track is fairly complex.

  In addition, training an agent to perform well will require thousands of iterations and huge computational power, which we could not afford for this project. All these factors made our team abandon the RL approach and work on PID for part 1 & MPC for part 2.
- **Worked on PID:** I also worked on task 1 using the PID method with Siyuan. we needed to choose the reference signal, which in this case was the position of the vehicle on the track. We measured the output variable, the position of the vehicle on the track, and used it to calculate the error between the desired reference signal and the actual output. We then used this error to calculate the control input (car's forward velocity and steering angle) using the PID controller. Overall, using the PID controller allowed us to complete task 1 successfully.

Teammates' Work

- **Ziqin Han:** Implemented MPC for Task 2.
- **Siyun Ying:** Explored fmincon for Task 1; Implemented PID for Task 1 with me.
- **Qilin He:** Explored fmincon for Task 1; Implemented MPC for Task 2.
- **Yuzhou Chen:** Explored PID for part 2.