OuterSense

Automated Driving Using External Perception

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1. Individual Progress

1.1 MRSD Project: Team OuterSense

Currently my focus is on building a python implementation of MPC and move away from MATLAB Simulink. We feel we have extracted sufficient data points at the moment from MPC simulation in Simulink (discussed in ILR02) and moving to python implementation will help in project development.
High level flow of python MPC implementation:

- A reference path is defined using desired waypoints
- The RC car is given initial state(x position, y position, velocity, orientation), control inputs(acceleration, steering)
- As the vehicle moves its state is estimated every time step
- A linearized model is defined using Ackermann model based on current state and control inputs in robot frame
- The deviation of current state from the desired states on the path is calculated. This is done by finding a closest point from the current state of the vehicle on the path, and error between current state and this state is calculated. Now from this closest point N points on the path are considered where N is prediction horizon and deviation of current state from all these N desired states on the path are computed and converted to robot frame.
- The obtained data from above point is given to the MPC which minimized the error between the current and desired state such that the constraint conditions are satisfied.
- MPC generates the set of acceleration and steering inputs which will minimize the error. The first value of acceleration and steering is sent to the vehicle.
- Using ODE and kinematic model the next state of the vehicle is computed and plotted for simulation.

Figure 1.1 shows the plot of trajectory and control inputs over time.

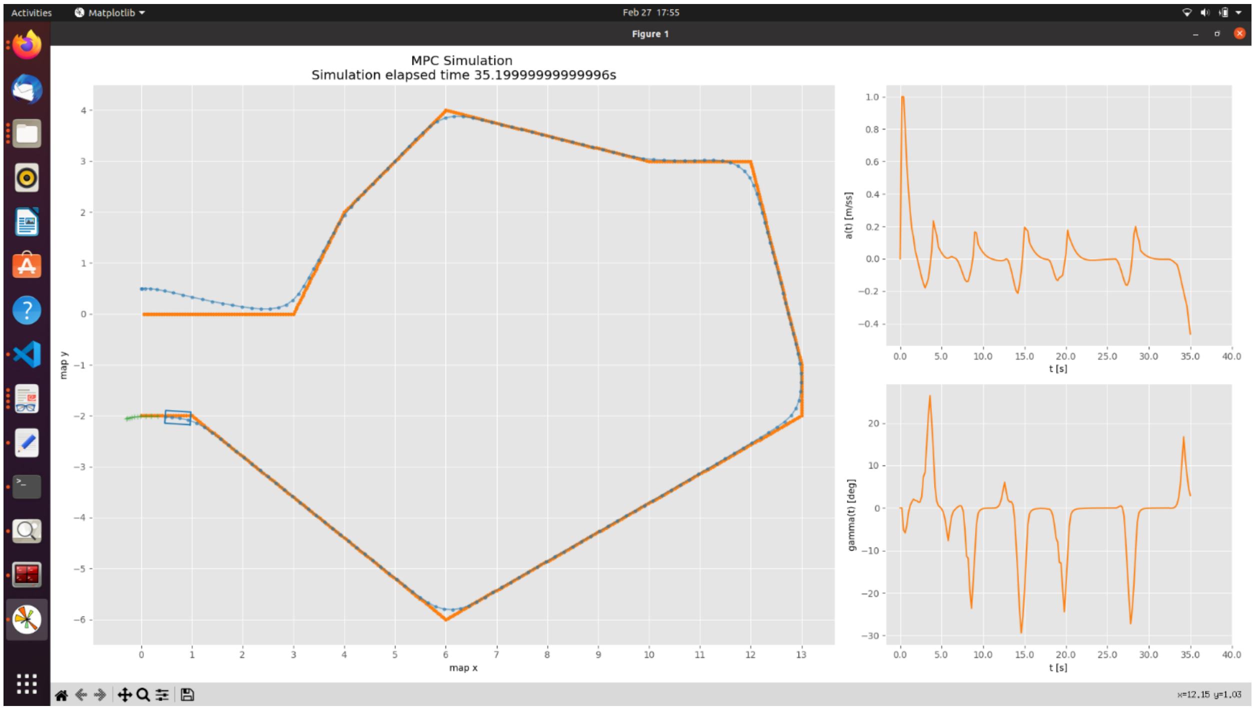

Figure 1.1 : Simulation plot

The next objective is:

- Simulate lateral offset and observe MPC performance.
- Simulate latency in communication of control inputs and delay in receiving sensor data.

Lateral offset is added because in the project our goal is to use external perception and external perception measurement will have some error. However, in this code we are not using any external sensor to estimate state but using the control inputs generated by MPC to find the next state. This code assumes that the state is updated instantly and accurately based on control outputs given by MPC. To simulate our objectives, in every time step when the state is updated based in the control inputs I create a copy of this state and add some random offset value to get a state with offset. The state with offset is given as new input to MPC but the original state is used for plotting. In this way MPC works on states with errors.

I conducted tests for different ranges of x offset and plot for each is given below:

Refer figure 1.1.1 for results when **additional x offset** between -0.1 to 0.1 m is given. The steering output is still smooth, and the vehicle does not leave the path. This is acceptable.

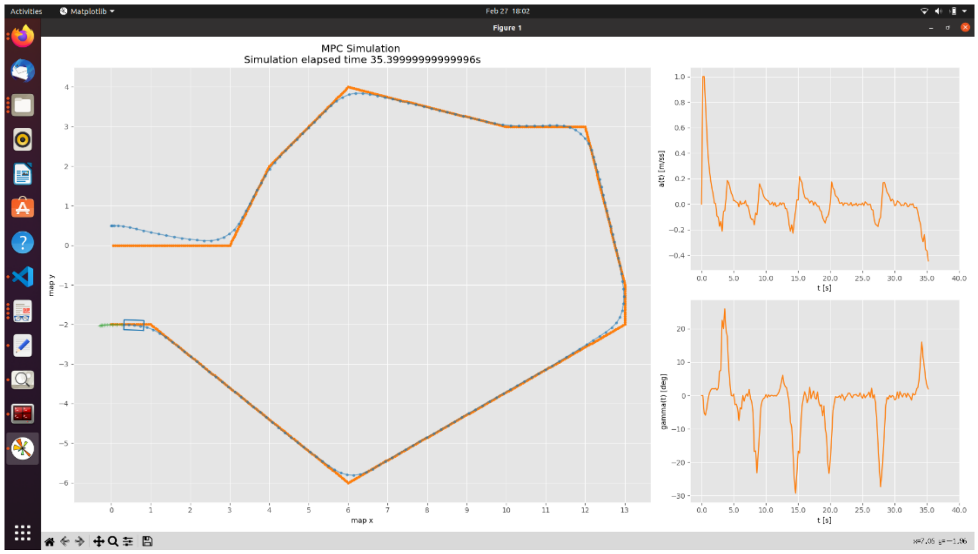

Figure 1.1.1 : x offset between -0.1 m and 0.1 m offset

Refer figure 1.1.2 for results when **additional x offset** between -0.2 to 0.2 m is given. The steering output is still smooth, and the vehicle does not leave the path. This is acceptable.

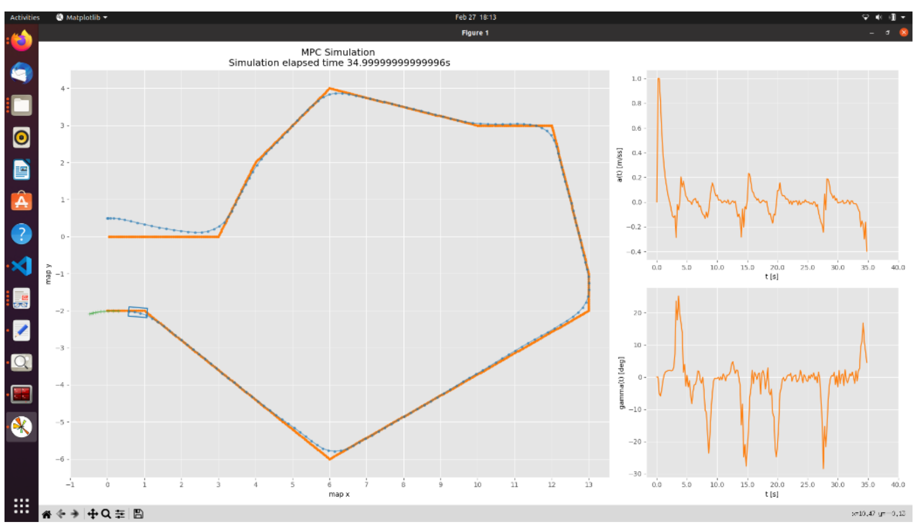

Figure 1.1.2 : x offset between -0.2m and 0.2 m

Refer figure 1.1.3 for results when **additional x offset** between -0.5 to 0.5 m is given. The steering output is **jerky**; however, the vehicle does not leave the path. This is not acceptable because the steering is not smooth.

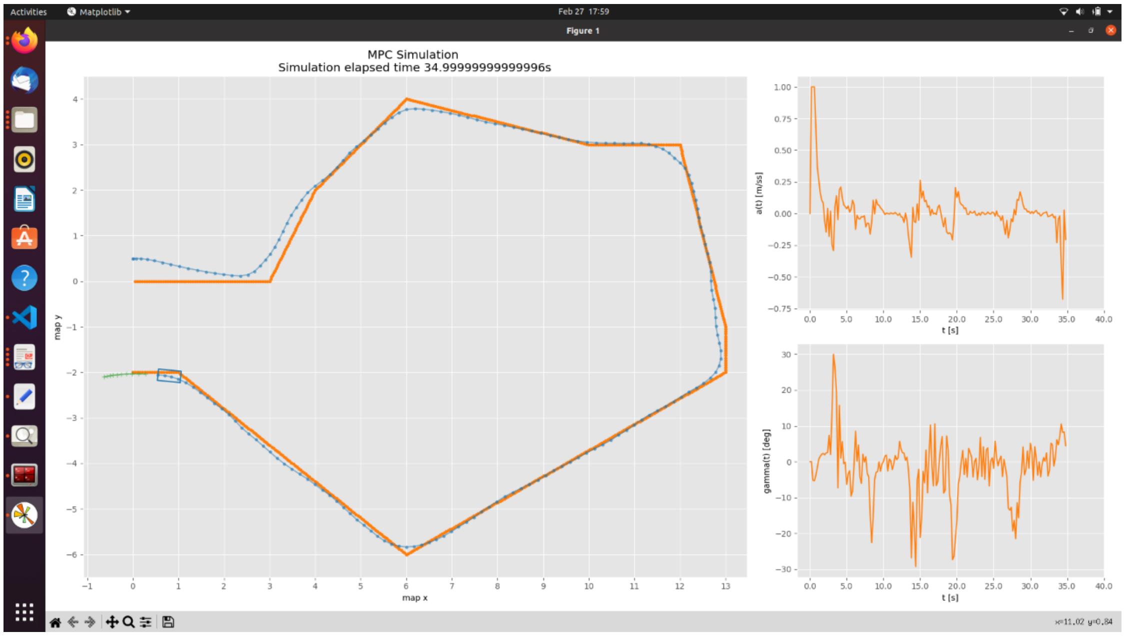

Figure 1..1.3: x offset between -0.5m to 0.5m

Refer figure 1.1.4 for results when **additional x offset** between -1m to 1 m is given. The steering output is a lot **jerky**, the vehicle does leave the path slightly. This is not acceptable.

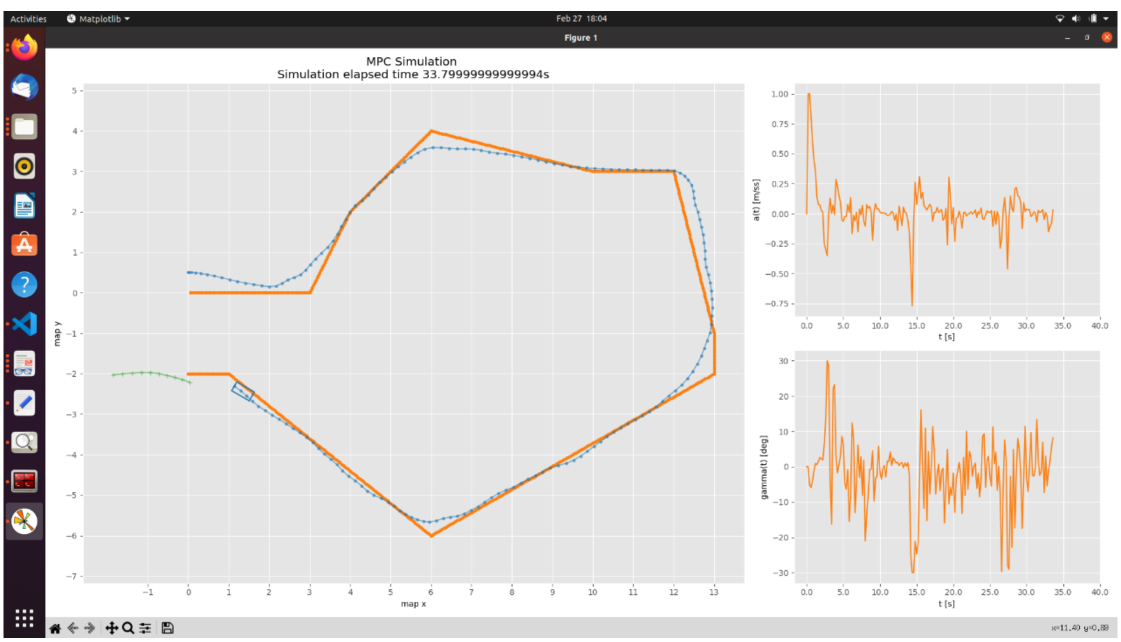

Figure 1.1.4: x offset between -1m to 1 m

My other task was to work on the building the power distribution board for our project. I have developed the conceptual design for the board and the first draft of schematic. Refer 1.1.5 for schematic.

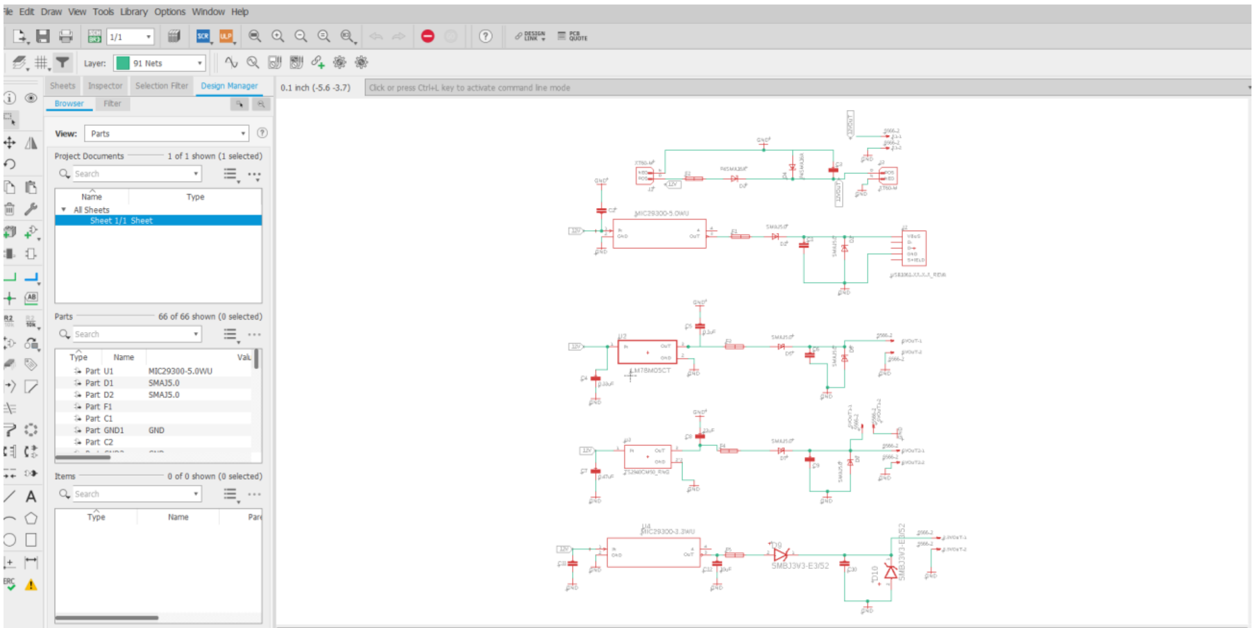

Figure 1.1.4: PDB Schematic

We are mounting this PDB on the RC vehicle. The battery on the RC car is of 12V and the components to power are Raspberry Pi (5V, 3A) , IMU sensor (5V,0.5A), servo motor (5V, 1A), BLDC motor (12V 10A). A PDB is required to distribute power to all these subsystems.

2. Challenges

2.1 MRSD project

- The main challenge is to simulate latency in sensor measurement and sending MPC output. I am struggling to incorporate latency in the given code. Currently to simulate latency in sending MPC output to vehicle I am updating my state with MPC output after every certain timestep (latency), otherwise old state is used for computation. Not sure if this is the right approach and I am exploring more options/ ways to implement this.
- All the results obtained are on simulation and on actual scale values. The challenge will be to make it work on hardware and scaled down model.

3. Team work

Ronit Hire: Ronit is working on implementing another control approach where he is developing PID control to solve the problem.

Shreyas Jha: Shreyas is working on building the RC car and teleoperate it using laptop. He has developed a ROS architecture to send and receive data between RC car and laptop.

Dhanesh Pamnani: He is handling the manufacturing side of the track and is working in the machine shop to build the infrastructure units. He is also working on the perception front with Jash and has developed a program for calibration of real sense camera.

Jash Shah: He is working on the perception front and has completed table tests for detecting objects and finding their orientations. He has also completed Aruco detection and calibration of real sense camera.

4. Future Plan

- The next step for me is to transfer the MPC implementation on ROS and simulate latency.
- Develop the PCB layout for our power distribution board
- I also plan to help in testing components of RC car and assemble it.