**Group – 13**

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**CAR - MPC**

**Introduction –**

In robot motion planning, a sequence of valid configurations of the robot is found that moves the robot from initial position to final position. An example of a robot can be an autonomous car performing a parking manoeuvre on its own.

In this project, motion planning of an autonomous car is performed for moving obstacle avoidance using model predictive control. MPC solves a sequence of finite-time trajectory optimization problems in a recursive manner and takes into consideration updating of the environment states during its planning course. The main advantages of MPC are:

* Constraints are included in the design
* Online path planning is required as the environment is dynamic
* Optimisation is done in a recursive manner so that updating of environment is taken into account.
* Solves finite time trajectory instead of complete trajectory.

However, an accurate model of the car (in this case) is needed and online computation takes time. For this case, a basic half car model is selected, therefore the drawbacks are not significant.

**Kinematics and Equations of Motion**

A following model of the car was selected for minimizing the computation time and simplicity. The car can be defined using the following variable

X = global position of the x coordinate of the car

Y = global position of the y coordinate of the car

Theta = global orientation of the car

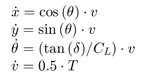
V = velocity of the COG of the car

The input given to the car are

T = acceleration of the car

Delta = steering input to the car

The following set of equation defines the dynamics of the car



The following constraints can be applied to the car

 this defines the Euclidean distance which the car should avoid

-6<y<6 This defines the lane boundary of the road which the car should not leave

We also define constraints on the maximum acceleration and the maximum steering angle input which can be given.

**Planner / Controller –**

The planner being used is model predictive control to predict the vehicle motion and position depending on its environment. With MPC, it is possible to vary the scenario and the controller adapts accordingly.

**Planned Simulation Environment –**

The car was modelled in MATLAB and simulated in MATLAB, Simulink and/or V-REP. To optimise the motion using MPC, Gurobi / Casadi is used.

**Planned Scenarios –**

The car motion planning is demonstrated for a moving obstacle avoidance such as a pedestrian.

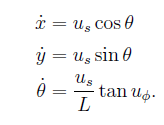
In obstacle avoidance, the car has to avoid a moving obstacle such as a pedestrian while moving. A cost function for each of the cases is defined.

References –

1. C. Liu, S. Lee, S. Varnhagen and H. E. Tseng, "Path planning for autonomous vehicles using model predictive control," 2017 IEEE Intelligent Vehicles Symposium (IV), Los Angeles, CA, 2017, pp. 174-179.
2. M. Obayashi, G. Takano, *Real-Time Autonomous Car Motion Planning using NMPC with Approximated Problem Considering Traffic Environment*, IFAC-PapersOnLine, Volume 51, Issue 20, 2018, Pages 279-286, ISSN 2405-8963, <https://doi.org/10.1016/j.ifacol.2018.11.026>.

Feedback:

* Define Workspace and configuration space
  + Configuration space is R2xS1
  + Workspace is R2xS1
* Change the model of the car to bicycle model and find the equations
* The equations of motion for a simple car



Constraints on the system include -

* Steering angle u\_phi varies from -90 to 90
* Constraint on steering angle abs (u\_phi) <= abs (phi\_max) < 90
* -1 <= Speed <= 1
* Turning radius rho\_min = L/tanphimax
* Since we do not travel higher than 50km/hr (target) we do not worry of steering angle effect on speed.
* Pedestrian Model – constant velocity predefined trajectory
* MPC Controller
* Cost function
* Constraints