Project 4 MPC part

1 Model Predictive Control

Consider the linearized model of an aircraft at altitude of $5000m$ and speed $128.2m/s$:

$$\dot{x} = \begin{bmatrix} -1.28 & 0 & 0.98 & 0 \\ 0 & 0 & 1 & 0 \\ -5.43 & 0 & -1.84 & 0 \\ -128.2 & -128.2 & 0 & 0 \end{bmatrix} x + \begin{bmatrix} -0.3 \\ 0 \\ -17 \\ 0 \end{bmatrix} u, \qquad y = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} x$$

where $x = [x_1\ x_2\ x_3\ x_4]$ with $x_1[rad]$ is the angle of attack, $x_2[rad]$ is the pitch angle, $x_3[rad/s]$ is the pitch rate, and $x_4[m]$ is the altitude. In addition, $u[rad]$ is the elevator angle as shown in the Figure 8. Perform the following tasks:

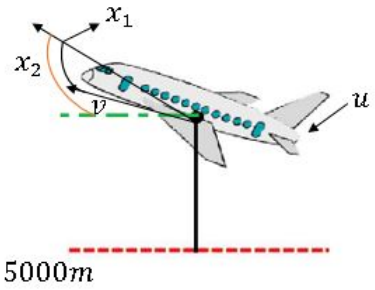

Figure 1: Aircraft control problem

Part A: Unconstrained MPC

For the aircraft control problem, you will first design an unconstrained MPC for a simulation time of 10 s with a sampling time of 0.25 s. Consider the initial conditions to be $x(0) = [0,\ 10,\ 0,\ 100]$, $y(0) = [0\ 0\ 0\ 5000]$ and the state and input penalty matrices are $Q = diag(0,\ 1,\ 0,\ 1)$ and $R = 10$, respectively. Comment on the results based on the following conditions:

1. What happens to the states and control action when the prediction horizon $N = 10$ and $N = 5$?
2. What happens to the states and control action if the initial conditions are $x(0) = [10\ 0\ 100\ 0]$

Part B: Constrained MPC

For the aircraft control problem, you will now design a constrained MPC for a simulation time of 30 s with a sampling time of 0.25 s. Consider the initial conditions to be $x(0) = [0,\ 10,\ 0,\ 100]$, $y(0) = [0,\ 0,\ 0,\ 5000]$ output input constraints are $-0.262\,rad \leq u \leq 0.262\,rad$, and the state and input penalty matrices are $Q = diag(0,\ 1,\ 0,\ 1)$ and $R = 10$, respectively. Comment on the results based on the following conditions:

1. What happens to the states and control action when the prediction horizon $N = 10$ and $N = 5$?

2. What happens to the states and control action if the initial conditions are $x(0) = [10\ 0\ 100\ 0]$

NOTE: You can set the values of Q and R to get the better response. Therefore, for this project, you are allowed to use any value of Q and R. For both the parts, you are required to write a single page report or a section in the code to comment your understanding from this project.