System Theory
project: Model Predictive Control Using FPGA

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1 Introduction

This journal paper (**Model Predictive Control Using FPGA**) is trying to use MPC for motor speed control. In addition, they also deploy their method into FPGA. So they will varify their algorithm and model parameters by MATLAB and then convert the code to C program. Afterwards, they will use the SDK provided by FPGA manufacturer to export program into FPGA board.
In this report, I will implement the MPC algorithm to simulate the system provided by this paper.

1.1 Model Predictive Control

Give a state-space model as

$$x(k+1) = A_m x(k) + B_m u(k) \tag{1}$$
$$y(k) = C_m x(k) \tag{2}$$

then we can further create augmeted model

$$x(k+1) = Ax(k) + Bu(k) \tag{3}$$
$$y(k) = Cx(k) \tag{4}$$

For each time of iteration, we will use Quadratic Programming to solve an non-linear system

$$\min_{\Delta U} \frac{1}{2}\Delta U^T H \Delta U + \Delta U^T f \tag{5}$$
$$A\Delta U \leq b \tag{6}$$

In **Receding Horizon Control**, we will only use the first element of ΔU and re-compute the QP for next iteration.

2 Simulation Result

2.1 System Model

In this paper, the state-space model is

$$A_m = \begin{bmatrix} -0.0001 & 0 \\ 3.3864 & 0.9974 \end{bmatrix} \tag{7}$$
$$B_m = \begin{bmatrix} 0.0025 \\ 0.2594 \end{bmatrix} \tag{8}$$
$$C_m = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \tag{9}$$
$$N_c = 3 \tag{10}$$
$$N_p = 10 \tag{11}$$

However, in this paper they say the weight matrix Q and R need to be finetune but they didn't give me the exact value. So the matrix H is unknown and I directly use the matrix provided in class book with

$$H = \Phi^T \Phi + \bar{R} \tag{12}$$
$$f = -2\Phi^T (R_s - Fx(k_i)) \tag{13}$$

2.2 Result

Fig. 1 and 2 is the predicted control sigal from the paper and my implementation, respectively.

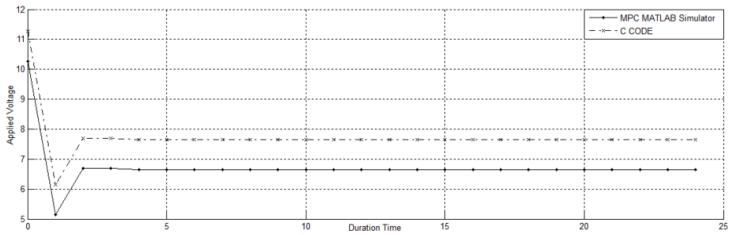

Figure 1: The predicted control value u in the paper.

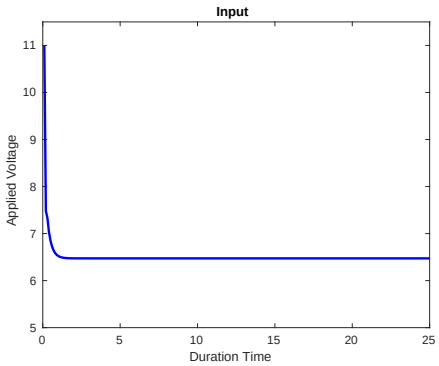

Figure 2: The predicted control value u with my implementation.

Fig. 3 and 4 is the output sigal from the paper and my implementation, respectively.

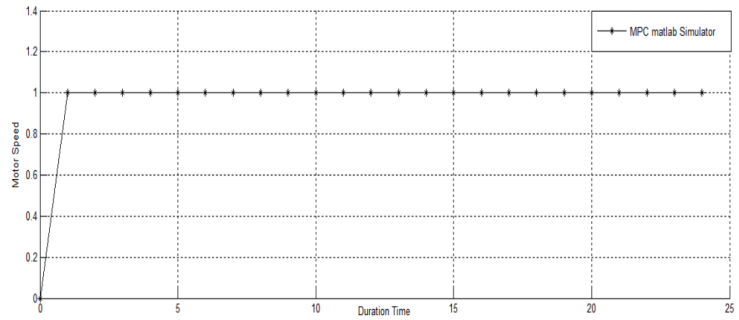

Figure 3: The output signal y in the paper.

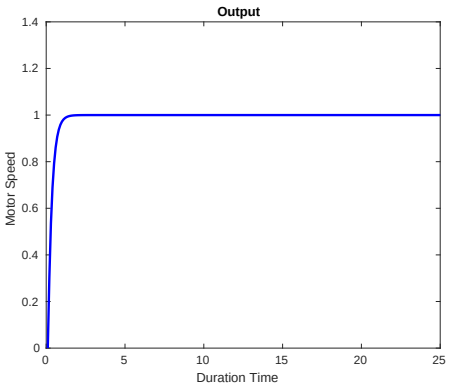

Figure 4: The output signal y with my implementation.