ME131 Lab 6 Deliverables
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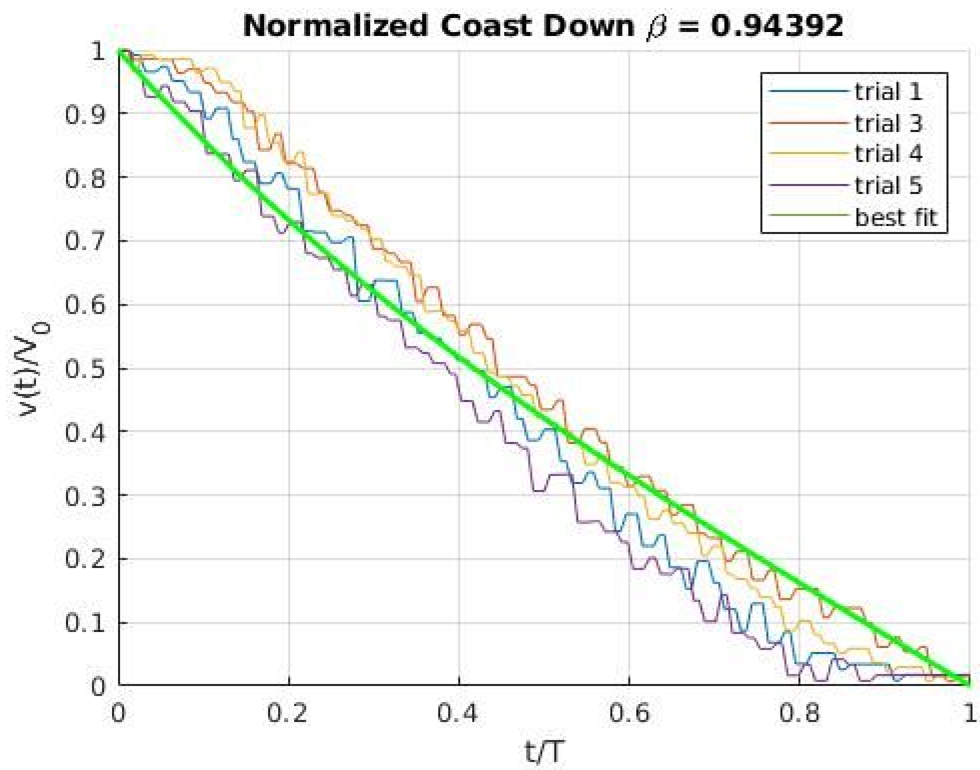
1.1



1.2

The nonlinear squares resulted in the following quantities:
Beta = 0.9439
Cd = 24.9727
Rx = 3.0344

Cd is two orders of magnitude greater than we'd expect for a real vehicle because it has no aerodynamic surfacing, it is not "streamlined". It is also possible that back EMF from the electric motor caused a negative torque when no torque command was sent since the drivetrain cannot be completely disengaged from the wheels on the BARC. This nonconservative force could have caused Cd to be inflated in our estimate.

1.3

$$F_{x,d} = R_x + mg\sin(\theta) + \frac{1}{2}\rho C_d A_F (v_d)^2$$

1.4

syms Fx Rx theta m g F_aero p Cd Af vd
dvdt = (Fx - Rx - m*g*sin(theta) - 1/2*p*Cd*Af*vd^2)/m;
jacobian(dvdt,[vd,Fx])

A = -Af*Cd*p*vd/m where vd = 0.5 in this case
B = 1/m

1.5

K = lqr(A,B,1,1)
K = 0.6092 when Q=R =1

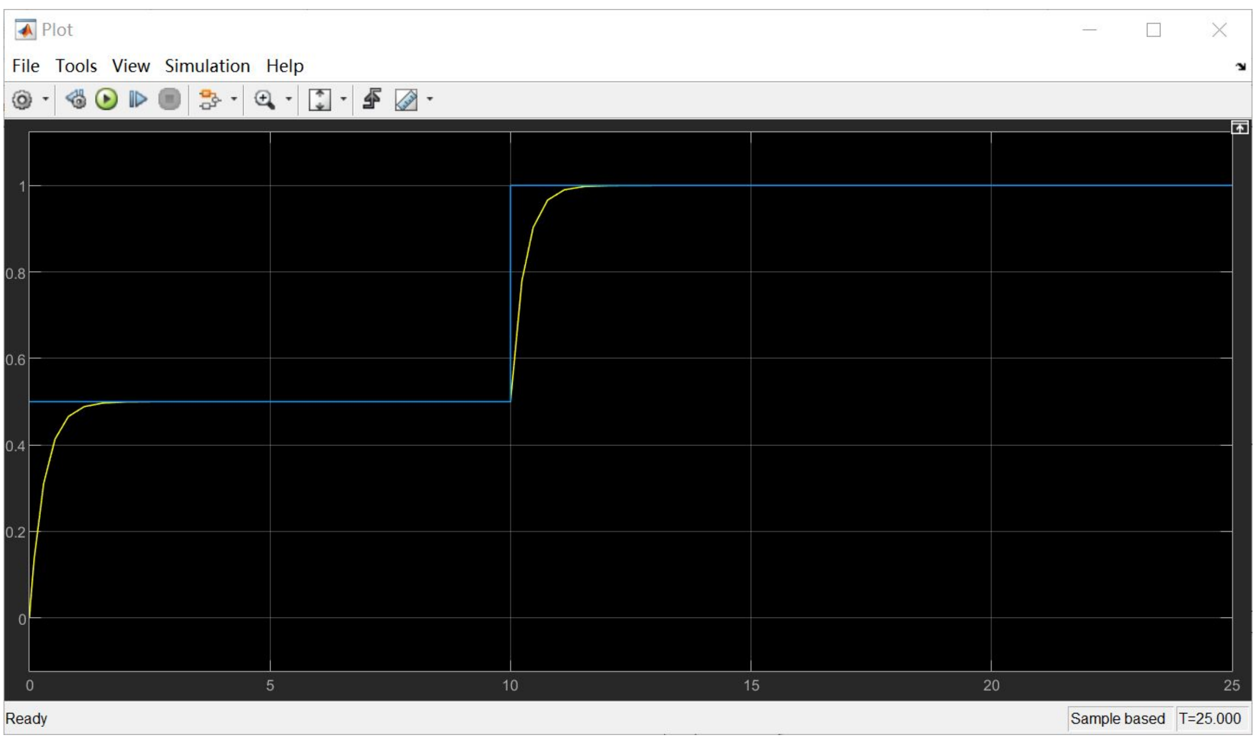
1.6

We make Q = 100 to get faster response
K = lqr(A,B,100,1)
K = 9.4971 when Q=100 R=1

The simulink file is attached.
RUN LAB6.m before

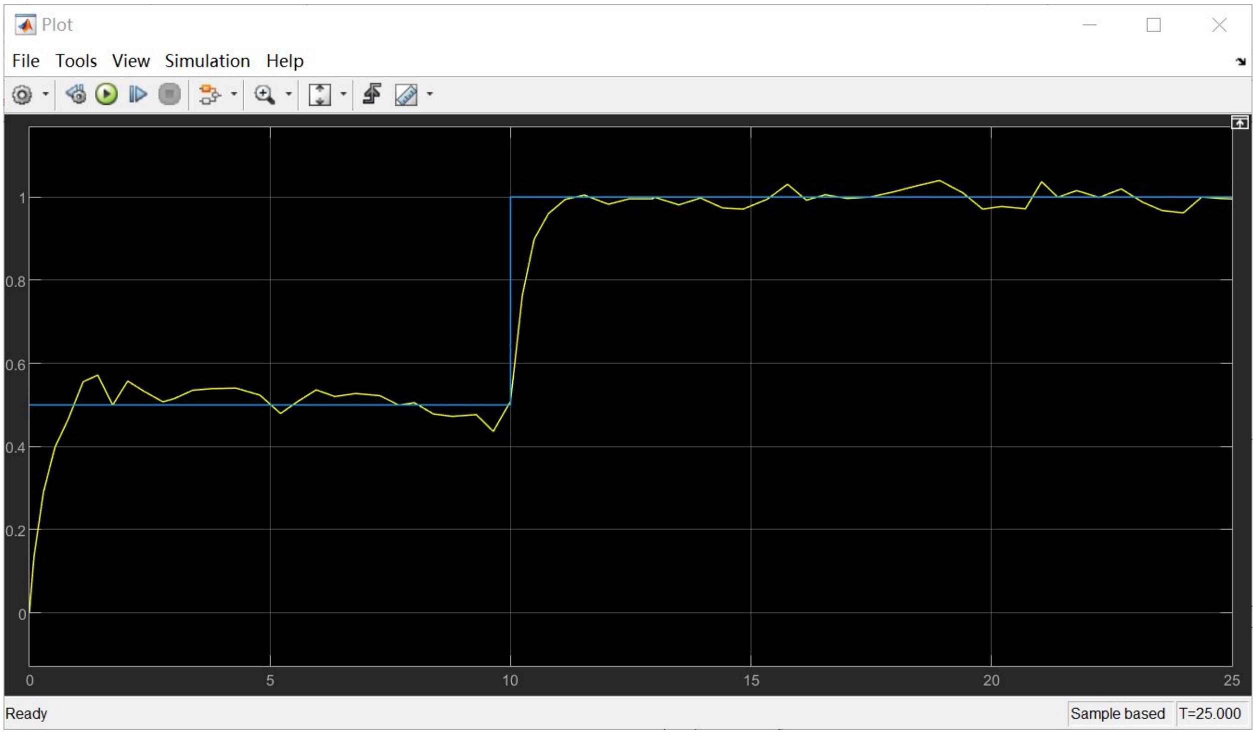
1.7

Without noise, the controller tracks well even with incline and decline.



1.8

We still use Q=100, R=1, which shows good result even when noise exists.



1.9

When we use LQR to get the feedback law, the cost is minimized in infinite time length. In addition that Q and R are positive definite in this case, the cost will have a finite value, which means error goes to 0 as time reaches infinity. Therefore, even without I controller, LQR can make error asymptotically reach 0.

As for disturbance, continuous time LQR is robust with a phase margin at least 60 degree (conclusion from ME233). So, the system can still works on well even with some disturbance.