PE Course: Classical Control

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MM4: System Poles and Feedback Characteristics

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1 Reading

- Section 3.3 (response & pole locations, p.118-126);
- Section 4.1 (basic properties of feedback, p.167-179)
- Extra readings (Chapter 2 from Goodwin et al's lecture notes), it can be downloaded from the course webpage.

2 Content

- System poles vs time responses
- Feedback control characteristics
- Block diagram decomposition (Simulink)

3 Exercise

Continue to think about the pendulum system defined in Exercise MM1, where a linear model can be obtained as

$$T_c - mgl\theta = I\ddot{\theta}, \quad (1)$$

where T_c is the applied external torque, θ is the pendulum's deviated angle from the vertical position, I is the moment of initial of the pendulum, and it can be estimated as $I = ml^2$. Suppose the system parameters are $m = 0.2kg$, $l = 0.5m$.

- Regard T_c as the system input and θ as the system output, derive the transfer function of the considered system and determine system poles;
- Plot out the system poles (and zeros if there are) in the s-plane (could use *pzmap() function* in Matlab. How about the system's damping ratio ε and natural frequency ω_n? what's kind of damped status is this system under (undamped, underdamped, critically damped, overdamped)?
- Plot the unit step response (could use *step() function* in Matlab). Analyze the link of this time response to system pole locations;
- Plot the impulse response (could use *imp() function* in Matlab). Analyze the link of this time response to system pole locations;
- Plot the initial response regarding the initial condition $\theta(0) = 0.2rad$ and $\dot{(\theta)}(0) = 0$, using *ode23* or *ode45* or *lsim()* or simulink model. Make a comparison with the impulse response;
- Suppose the wind disturbance can be modeled as $T_f = K_f\dot{\theta}$, where K_f is some constant value determined by the fiction coefficient, then, system (1) can be updated. suppose $K_f = 0.2$, plot out the system poles (and zeros if there are) in the s-plane. How about the system's damping ratio ε and natural frequency ω_n of this updated system?
- Can you determine the ranges of K_f value if the updated system is under underdamped, critically damped, and overdamped status, respectively?
- How about the pole locations of your inverted pendulum or crane system based on the linearized model? Check its features using *ltiview() function*, What would you conclude about your system?