Feedback Control

Brian Zhu

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1 Open Loop (holistic) Control

- Let loose and allow it to purely go off of the enviorment. "set it and forget it"
- Does not take in feedback

2 Feedback Control

- Objective: Drive $\vec{e}$ to zero at all times
- $\vec{e}$ is a vector
- The higher rate of control, the better the performance

2.1 Proportional Control

- $u = k_p(\vec{x_d} - \vec{x})$
  - k_p is a gain value (fraction)
  - We could have gains for y and theta seperately
  - We want the best gain so that it reaches where it wants to go and dosent undershoot(too low gain) and that it dosent overshoot(too high gain)

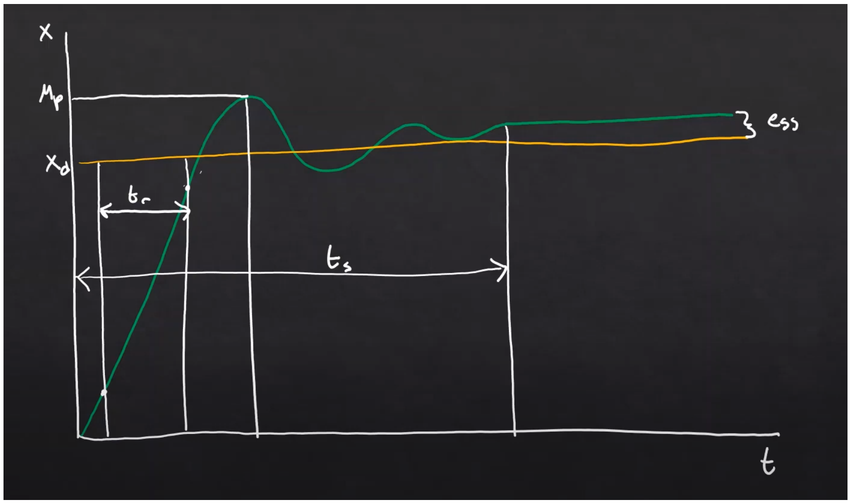
2.1.1 Parameters for characterizing controller performance

- Rise time (t_r)
  - Time to go from .1 to .9 $\vec{x_t}$
  - Faster rise time, more likely that you will overshoot. Then will have to bounce around which means longer settle time
  - Longer rise time, Longer settle time but may not have M_p or e_{ss}
- overshoot (M_p)

- Largest magnitude in excess of x_d

- Settle time (t_s)
  - Time when absolute value of error is less than or equal to .01 of a desried value $\vec{x_t}$

- Steady state error (e_{ss})
  - Error remaining after plant is not changing $\vec{x}_{k+1}$



2.2 Proportional Derivative Controller (PD)

- Real systems have momentum, so P controller isnt enough for real systems. Can overshoot due to momentum

- PD controller adds derivative term
  - $\vec{u} = k_p e + k_d \dot{e}$
  - When rate of change of error is changing error very little, then error will add a little to the equation. When changing alot, will add alot

- helps dampen oscillations, reduce overshoot and settle time

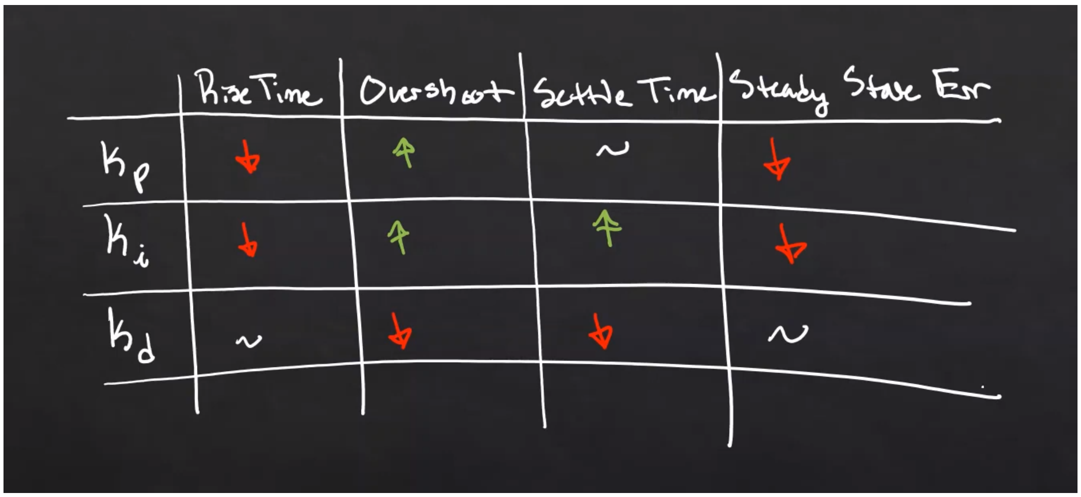
2.3 Proportional Integral Derivative Controller (PID)

- Adds the integral term to correct the steady state error

- $u = k_p e + k_d \dot{e} + k_i \int_0^t edt$
  - Starts when controller Starts

  - If there is still a steady state error, then the integral term will dominate other terms in equation and adjust

- ”itegral windup”
  - Can cause overshoot
  - Solved by putting a limit on the I term. So dont integrate whole time



	Rise Time	Overshoot	Settle Time	Steady State Err
K_p	↓	↑	~	↓
K_i	↓	↑	↑	↓
K_d	~	↓	↓	~