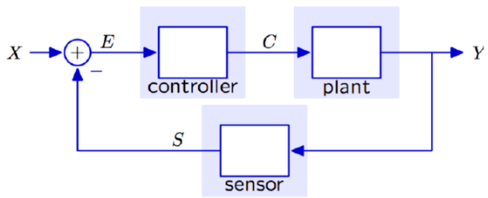
VE216 Lecture 10

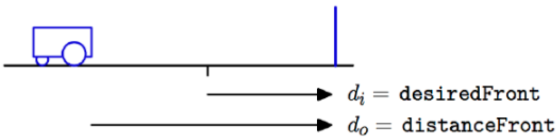
> Feedback and Control

Structure of a Control Problem



- plant: the system to be controlled
- sensor: measures the output of plant
- controller: specify a command C to plant based on difference between X and S

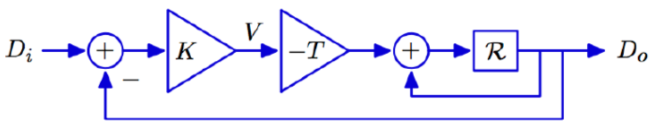
Analysis of Wall Finder System



Controller: $v[n] = K(d_i[n] - d_s[n])$

Sensor with no delay: $d_s[n] = d_o[n]$

Locomotion: $d_0[n] = d_o[n-1] - Tv[n-1]$

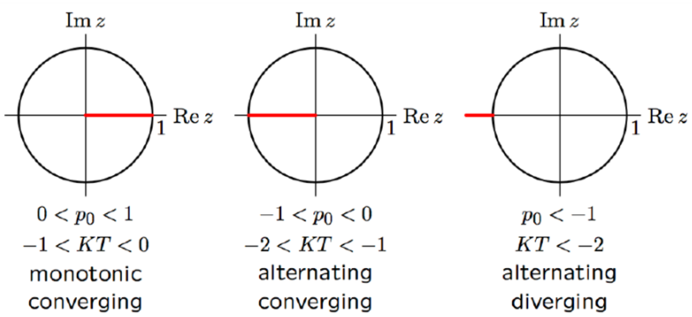


So we get $\frac{D_o}{D_i} = \frac{-KTR}{1-(1+KT)R}$

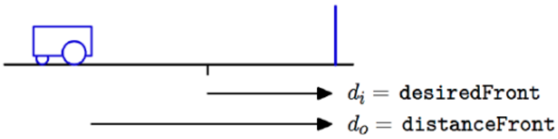
The single pole is $z = 1 + kT$

Pole Analysis

$\frac{D_o}{D_i} = \frac{-KTR}{1-(1+KT)R} = \frac{(1-p_0)R}{1-p_0R}$ and $p_0 = 1 + KT$



Analysis of Wall Finder System: Adding Sensor Delay



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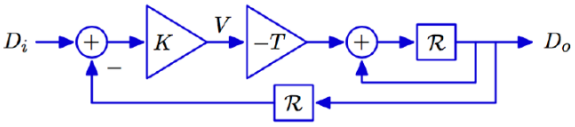
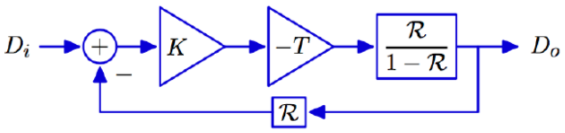


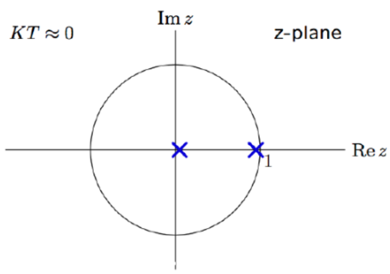
Or we get



$\frac{D_o}{D_i} = \frac{-KTR}{1-R-KTR^2}$ with the poles $z = \frac{1}{2} \pm \sqrt{(\frac{1}{2})^2 + KT}$

Poles Analysis

$z = 1 + KT, -KT$ when KT is small:



- pole near 0 fast response
- pole near 1 slow response
- slow response, slow mode dominates the response.

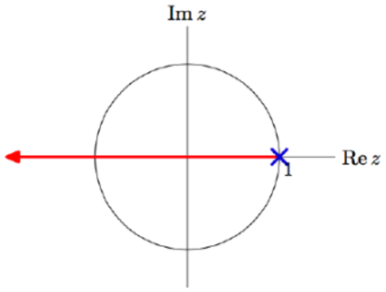
When KT become negative, $z = \frac{1}{2}$ with $KT = -\frac{1}{4}$

- The system is stable.
- Persistent responses (from pole > 1) decay.

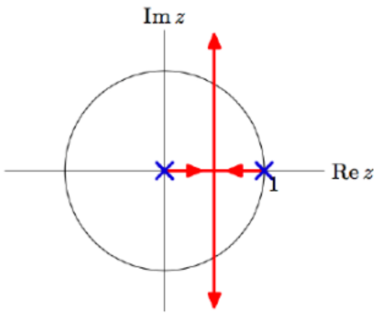
When $KT < -\frac{1}{4}$, then the poles become complex.

- Oscillation.
- $KT = -1$ the period of oscillation is 6 since $p_0 = e^{\pm j\pi/3}$.

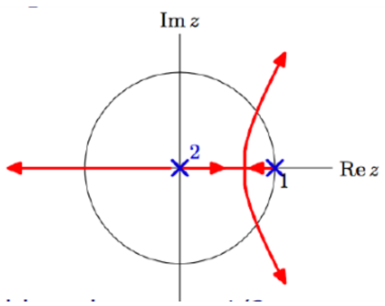
Destabilizing Effect of Delay

- no delay: 

  $z = 0$ is the fastest response with 0 delay.

- one delay: 

  $z = \frac{1}{2}$ is the fastest response with 1 delay.

- more delay: 

  $z = 0.682$ is the fastest response with 2 delay. Even slower.

Summary

- Stability of feedback system is determined by dominant pole.
- Delay tend to decrease the stability of the system.