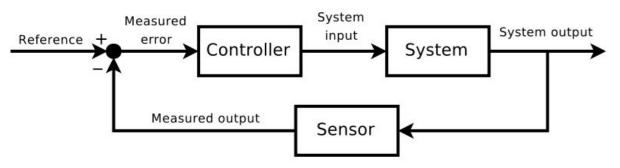
Feedback Control (Basic) Cheat Sheet (source: Brian Douglas) V2021.01.27

(Dr Yan Xu)

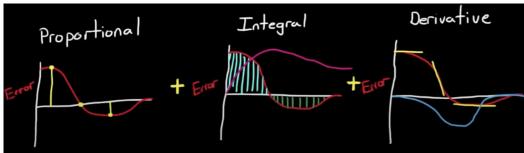
Basic Concepts



- → Reference: Target KPI
- → Measured Error(s): Signal
- → Controller: we will focus on PID controller

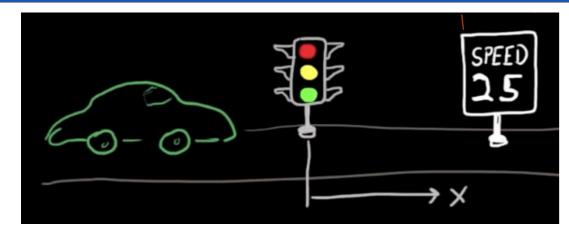
PID Controller

$$u(t) = K_\mathrm{p} e(t) + K_\mathrm{i} \int_0^t e(t') \, dt' + K_\mathrm{d} rac{de(t)}{dt}$$



1: We may not use all P, I and D in a solution. It depends on the relationship between system input and output.

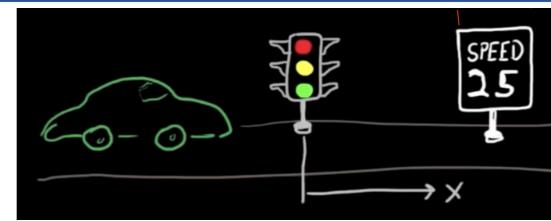
Proportional Control Example



- → Reference: 25 MPH
- → System Input: speed pedal angle change (+/-)
- → Signal: Reference Measured Speed
- → Controller: P-Controller

1: It is important to tune K_p to avoid unstable system

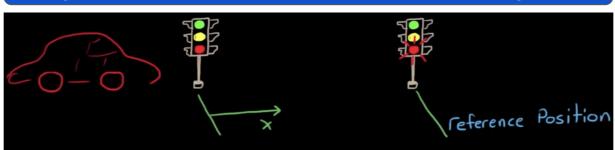
Proportional-Integral Control Example



- → Reference: 25 MPH
- → System Input: speed pedal angle (20 degree)
- → Signal: Reference Measured Speed
- → Controller: PI-Controller

If using P-Controller, the car will slow down once arrive the target speed 25 MPH, since speed pedal angle become 0.
It is important to tune K_p and K_i to achieve desired behavior.
Integral signals captures the desired angle for a stable speed. However, this design is not as simple/efficient as the previous section. So, choosing the right system input is critical.

Proportional-Derivative Control Example



- → Reference: destination location
- → System Input: speed pedal angle
- → Signal: distance to destination
- → Controller: PD-Controller
 - o derivative signal slows down the car before destination

1: It is important to tune K_p and K_d to achieve desired behavior

PID Controller Tuning

- → Simulation-based Tuning
- → Grid Search
- → Desired Overshooting
- May have different parameters for different scenarios

Time Delay

- → It is extremely difficult to deal with
- → Idea 1: Model-based Prediction
 - delay -> exponential distribution
- → Idea 2: Reduce Control Frequency

Reference Reset

- → Consider to have a delay to response to reference reset, to avoid system unstable due to human error.
- → Reference reset typically requires to reset system status.
- → Reference reset typically requires to reset integral signal if used.

Control System (a broader view)

