IEEE Micromouse DeCal

Week 5: PID

Applications

A Weird Formula

$$u = K_p e + K_i \int_0^t e\,dt + K_d \frac{d}{dt} e$$

Problem

- Motors move at different speeds
  - Difficult to drive straight

Proportional Control (<u>P</u>ID)

For our Micromouse

- Goal: Left velocity = Right velocity (going straight)

- Sensor: Encoder
- Metric: Velocity
- Correction mechanism:
  - Case 1: Skewing left:
    - Apply more power to Left wheel
  - Case 2: Skewing right:
    - Apply more power to Right wheel

Proportional Control

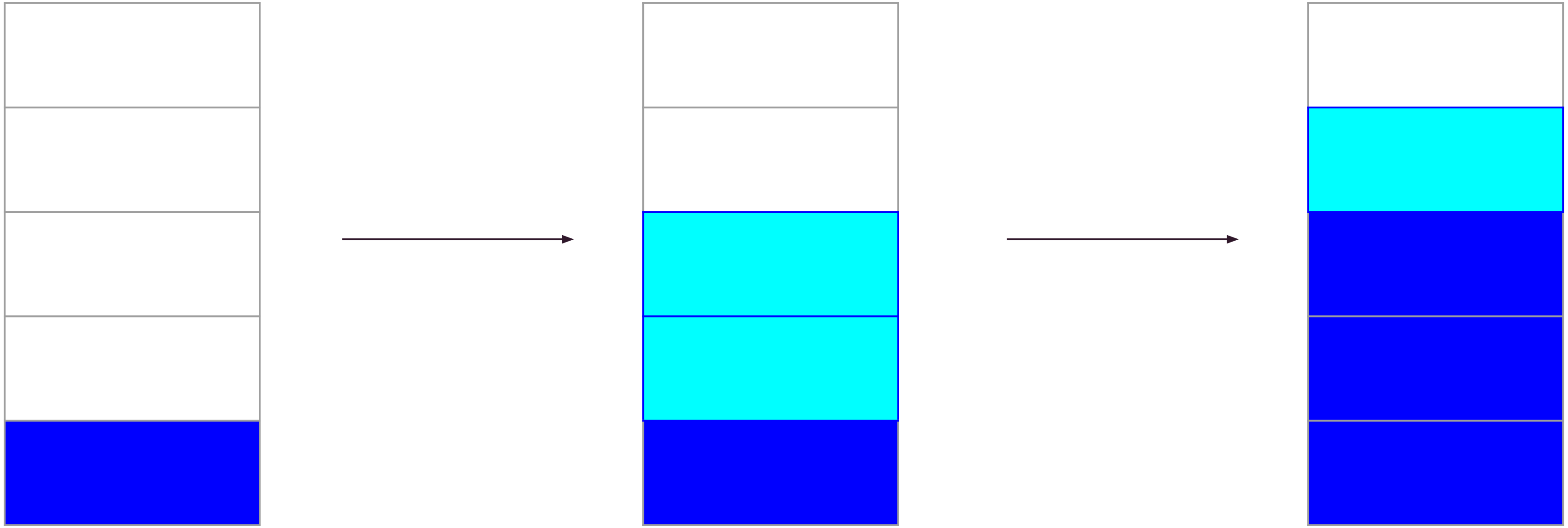
- Goal: Left velocity = Right velocity
  - Left velocity = constant + correction
  - Right velocity = constant + correction
  - K_p intuition: how quickly we ramp up to the goal state
- Math
  - Error = e_p = **(left_velocity -- right_velocity)**
  - **PROPORTIONAL CORRECTION = K_p(left_velocity -- right_velocity)**
  - **PROPORTIONAL CORRECTION = $K_p e_p$**

Control Example

Goal:
Fill up a cup of BOBA!

Fill up a cup of BOBA! (Kp = 0.5)

$e_p = 4$ $e_p = 2$ $e_p = 1$



Problems with P-control

- Overshoot/Never reach
- Take too long/never reach target path
- Not smooth
- Persistent Small steady state error
    - What if the cup keep leaking out

Integral Control (P<u>I</u>D)

- Accounts for errors over time
- Sum past errors → correct it
  - Ex. Sleep debt

DAY	SLEEP AMT	ERROR
Monday	1 hr	--8 hr
Tuesday	9 hr	0 hr
Wednesday	8 hr	--1 hr
Thursday	10 hr	+1 hr

I'm getting good sleep!!

No, you need to make up for those 8 hours.

Integral Control (P<u>I</u>D)

$$CORRECTION = K_i[\Sigma(left_{velocity} - right_{velocity})]$$

$$CORRECTION = K_i(\Sigma \mathrm{e}(\mathrm{t}))$$

$$CORRECTION = K_i \int_0^t e(t)dt$$

- CORRECT for past cumulative sum of errors

Derivative Control

- Prevents proportional from overshooting
  - Derivative measures error RATE: (left_velocity -- right_velocity) / time
- Math
  - Error Rate = d/dt (e(t))
  - Derivative = Kd (Error Rate) = Kd d/dt (e(t))
  - CORRECTION TERM = P Correction + D Correction
  - **CORRECTION TERM = $K_p e + K_d \, d/dt\,(e(t))$**

PID Control

- Error = left_velocity - right_velocity
- Account for present (proportional), past (integral), future (derivative)

$$u = \underbrace{K_p e}_{\text{Proportional Term}} + \underbrace{K_i \int_0^t e\,dt}_{\text{Integral Term}} + \underbrace{K_d \frac{d}{dt} e}_{\text{Differential Term}}$$

PID Video

https://www.youtube.com/watch?v=4Y7zG48uHRo

https://www.youtube.com/watch?v=fusr9eTceEo