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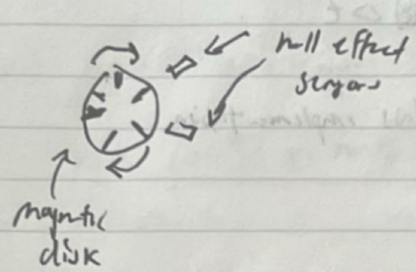
Homework 1

1) Encoders use magnets to track the rotations - there 6 magnets on a disk that rotate to create a step. these rotations are detected by hall effect sensors which measure one magnetic disk spin every 12 counts



2) our gear box is

1, $\frac{30}{12}$ $\frac{28}{16}$ $\frac{36}{9}$ $\frac{26}{8}$

$\Rightarrow G_1 \times G_2 \times G_3 \times G_4 = 48.75$

take revolution counts, multiply by gear ratio:

$12 \times 48.75 = 585$ counts for 1 wheel revolution

3) $v(T) = \omega r = 2\pi \frac{n}{N} \frac{r}{T}$

where n = number of counts measured
N = number of counts per wheel revolution = 585
r = radius of wheel
T = sampling window

This equation takes encoder counts and wheel dimensions measured across a sampling time to get a current velocity in m/s

4) $u(t) = K_p e(t) + K_i \int_0^t e(\tau)\,d\tau$

proportional gain

error

integral gain

$u(t) = K_p e(t) + K_i \sum_{j=0}^{k} e[j]\,\Delta t$

see PIcontroller.py for a class implementation

5)

a) I'd say it falls into both

→ Perceptual class: robot categorizes distances into either too close or too far

→ Action oriented perception: not building a 3D environments, using sensor data to make immediate decisions

b) @ a distance to reflecting object of 35 cm, the graph reads about 0.75V output

c) see isTooClose.py in folder

6) Every 20 encoder counts = 1/200 of a wheel rotation:

a)

→ one full wheel rotation = 4000 encoder counts

$1200/4000 = 0.3$ around wheel

$0.3(60\pi) = \underline{18\pi \text{ mm}}$

b) tangential velocity :

$$v_t = 2\pi \left(\frac{n}{N}\right)\left(\frac{1}{T}\right) r$$

given : $n = 600$ $N = 2000$ $T = 2.2$ $r = 80/2$

$$\Rightarrow v_t = 2\pi \left(\frac{600}{2000}\right)\left(\frac{1}{2.2}\right)\left(80/2\right)$$

$$\underline{v_t = 10.91\pi \text{ mm/s}}$$

7) a) $u = a \times \tau$, $a = 4\text{m/s}$ $0 \leq \tau \leq 1$

$$\Rightarrow \tau = K_p(u_t - u)$$

$$\tau = K_p(u_t - (a \times \tau))$$

$$\underline{\tau = K_p u_t / (1 + K_p a)}$$

b) $u = a \times \tau$

$$\Rightarrow \underline{u_{ss} = a\left(K_p u_t / (1 + K_p a)\right)}$$

when $u_{ss} = u_t$:

$$a K_p = 1 + K_p a$$

$0 = 1$ meaning impossible, actual speed will not reach target speed

c) $u_t = 3\ m/s \quad K_p = 0.2$

$$\Rightarrow u_{ss} = \left((4)(0.2)(3) / (1+(0.2)(4)) \right)$$

$$\therefore u_{ss} = 1.33\ m/s$$

this is lower than the target speed of 3 m/s which is still much lower

d) Yes, when you increase $K_p \to \infty$, theoretically you will reach target speed u_t. however raising K_p introduces errors, namely much more aggressive oscillatory behavior around the target speed.

e) $\tau = K_p e(t) + K_i \int e(t)\, dt$

$$\Rightarrow a\tau = K_p (u_t - u) + K_i \int (u_t - u)\, dt$$

$$a\tau + K_p u + K_i \int u\, dt = K_p u_t + K_i \int u_t\, dt$$

$$u + K_p/a\, u + K_i/a \int u\, dt = K_p/a\, u_t + K_i/a \int u\, dt$$

$$U(s)\left(1 + K_p/a + K_i/as\right) = K_p/a\, U_t(s) + K_i/as\, U_t(s)$$

$$u_{ss} = \lim_{s \to \infty} U(s) = u_t \left(\frac{K_p/a + K_i/as}{1 + K_p/a + K_i/as} \right)$$

as $s \to \infty$, the fraction approaches 1, so the target speed u_t is about equal to steady state u_{ss}