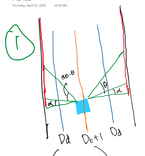
PID lab

Thursday, April 23, 2020 12:30 PM

1



desired distance

projected distance from wall

positive error → steer right

$D_{t+1} < D_d$

steering angle ↓

∴ right error = $D_d - D_{t+1}$

negative error → steer left

$D_{t+1} > D_d$

steering angle ↑

∴ left error = $D_{t+1} - D_d$

∴ center error = (left error + right error)/2

2 Lookahead distance

i) For followLeft, followRight = 1.5m (as maximum speed is 1.5 m/s) [This also worked best]

ii) For follow Center = 2.5m

In center following, I found the robot behavior quite unstable.

So I chose a liberal error threshold of 2.5m. This was also chosen based on experiments.

3 PID Gains

i) For followLeft, followRight, I chose $K_P = 0.6$, $K_D = 0.01$

Kp

i) $K_P > 0.6$ → the turns were quite sharp, robot crashes, erratic movement, quick response

ii) $K_P < 0.6$ [0.1 - 0.5] → sluggish response. The robot is slow at turning, will complete turns partially.

Kd

i) $K_D > 0.01$ → The robot becomes slow in response. Will take a long time to move forward

ii) $K_D \approx 0.01$ → It stabilizes the robot's movement, turns are much closer and stable

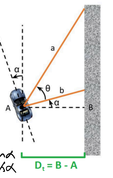
ii) For followCenter : $K_P = 0.6$, $K_D = 0.2$

K_P → reasoning is same as above

K_D → I had to increase $K_D = 0.2$, because at $K_D = 0.01$ the robot was still unstable at turns for center following.

$K_D > 0.2$ → the response is super sluggish and robot will make very small movements.

4 Deriving α.



$AB = a\cos(\theta + \alpha)$

also

$AB = b\cos(\alpha)$

$b\cos(\alpha) = a\cos(\theta + \alpha)$

$b\cos\alpha = a\cos\theta\cos\alpha - a\sin\theta\sin\alpha$

$\tan\alpha = \dfrac{a\cos\theta - b}{a\sin\theta}$

$$\boxed{\alpha = \tan^{-1}\left(\frac{a\cos\theta - b}{a\sin\theta}\right)}$$

Hence proven.

LAPLACE TRANSFORM

1 $f: \mathbb{R} \to \mathbb{R}$, $f(t) = 0 \ \forall t < 0$

$F(s) = \mathcal{L}(f)$

$\mathcal{L}(d^2f/dt^2) = s^2F(s) - sf(0) - f'(0)$

we know,

$$\mathcal{L}(f) := \int_0^\infty f(t)e^{-st}dt := F(s)$$

$$\mathcal{L}\left(\frac{d^2f}{dt^2}\right) = \int_0^\infty \frac{d^2f(t)}{dt^2} e^{-st}dt$$

$$= e^{-st}f'(t)\Big|_0^\infty + \int_0^\infty se^{-st}f'(t)dt$$

$$= s(sF(s) - f(0)) + \lim_{t\to\infty} e^{-st}f'(t) - e^{-s(0)}f'(0)$$

$$\boxed{= s^2F(s) - sf(0) - f'(0)}$$

Hence proved.

2 $x'' + 3x' + 2x = 0$, $x(0) = a$, $x'(0) = b$

Laplace transform

$x'' = s^2x(s) - sx(0) - x'(0)$

$3x' = 3sx(s) - 3x(0)$

$2x = 2x(s)$

$\Rightarrow s^2x(s) - sx(0) - x'(0) + 3sx(s) - 3x(0) + 2x(s)$

$\Rightarrow s^2x(s) + 3sx(s) + 2x(s) - sa - b - 3a = 0$

$x(s)(s^2 + 3s + 2) = 3a + sa + b$

$$x(s) = \frac{3a + sa + b}{s^2 + 3s + 2}$$

$$= \frac{3a + sa + b}{(s+1)(s+2)}$$

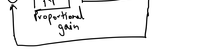
$$\frac{2a+b}{s+1} - \frac{a+b}{s+2}$$

$\mathcal{L}^{-1}\left(\frac{1}{s+1}\right) = e^{-t}$ $\quad$ $\mathcal{L}^{-1}\left(\frac{1}{s+2}\right) = e^{-2t}$

$$\boxed{\therefore x(t) = (2a+b)e^{-t} - (a+b)e^{-2t}}$$

3 Inertia load = $(Js^2)^{-1}$

Transfer function $H(s) = \dfrac{X(s)}{R(s)}$



$$H(s) = \frac{X(s)}{R(s)} = \frac{K_P}{Js^2 + K_P}$$