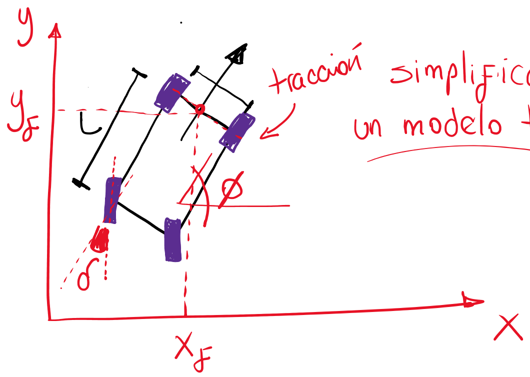
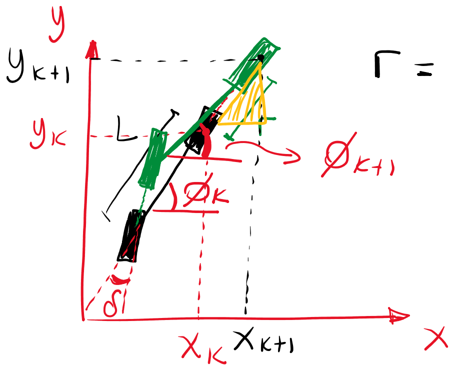
VEHÍCULO AUTÓNOMO TIPO CARRO

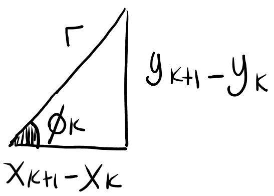
Velocidad : cte



simplificar a un modelo tipo bicicleta



$$r = V\cdot\Delta t$$



$$r\cdot sen(\phi_k) = y_{k+1}-y_k$$

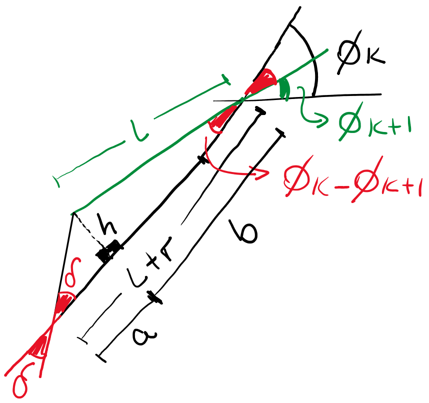
$$V\,sen(\phi_k) = \frac{y_{k+1}-y_k}{\Delta t}$$

$$\dot{y} = V\,sen(\phi)$$

$$r\cos(\phi_k) = x_{k+1}-x_k$$

$$V\cos(\phi_k) = \frac{x_{k+1}-x_k}{\Delta t}$$

$$\dot{x} = V\cos(\phi)$$



$$\rightarrow a+b = L+r$$

$$L\cos(\phi_k-\phi_{k+1}) = b$$

$$\left.\begin{aligned}\rightarrow L\,sen(\phi_k-\phi_{k+1}) &= h\\ tg(\delta) &= \frac{h}{a}\end{aligned}\right\}\ a = \frac{L\,sen(\phi_k-\phi_{k+1})}{tg(\delta)}$$

$(\phi_k-\phi_{k+1}) <<< 1$

$sen(\phi_k-\phi_{k+1}) \approx \phi_k-\phi_{k+1}$

$\cos(\phi_k-\phi_{k+1}) \approx 1$

$$L\frac{\cancel{sen}(\phi_k-\phi_{k+1})}{tg(\delta)} + \cancel{L}\cos(\cancel{\phi_k-\phi_{k+1}})^{1} = \cancel{L} + V\cdot\Delta t$$

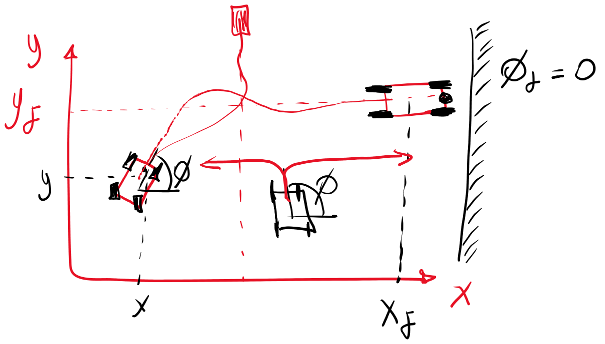
$$-L\frac{(\phi_{k+1}-\phi_k)}{tg(\delta)} = V\cdot\Delta t$$

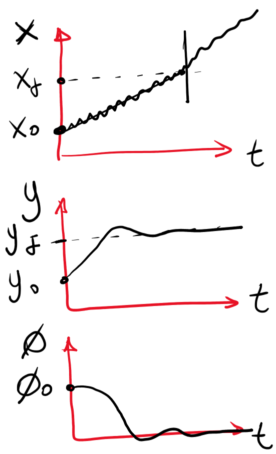
$$\frac{\phi_{k+1}-\phi_k}{\Delta t} = -\frac{V}{L}\,tg(\delta)$$

$$\dot{\phi} = -\frac{V}{L}\,\underbrace{tg(\delta)}_{u\,:\,control}$$

$$\left.\begin{aligned}\dot{x} &= V\cos(\phi)\\ \dot{y} &= V\,sen(\phi)\end{aligned}\right\}\ \text{sistema no-holonómico}$$

$\times\quad \dot{x} = V\cos(\phi)$ ⎫ Sistema
$\checkmark\quad \dot{y} = V\,\mathrm{sen}(\phi)$ ⎬ no-holonómico
$\checkmark\quad \dot{\phi} = -\frac{V}{L}\,tg(\delta)$





Modelo tipo carro

$$\dot{y} = V\,\mathrm{sen}(\phi)$$
$$\dot{\phi} = -\frac{V}{L}\,tg(\delta)$$

Linealización Aproximada

$\phi \ll 1$, $\mathrm{sen}\,\phi \approx \phi$ $\Big\}$ $\dot{y} = V\phi$, $\dot{\phi} = -\frac{V}{L}\,tg(\delta)$

$$X = \begin{bmatrix} y \\ \phi \end{bmatrix}$$

$$\underbrace{\begin{bmatrix} \dot{y} \\ \dot{\phi} \end{bmatrix}}_{\dot{X}} = \underbrace{\begin{bmatrix} 0 & V \\ 0 & 0 \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} y \\ \phi \end{bmatrix}}_{X} + \underbrace{\begin{bmatrix} 0 \\ -\frac{V}{L} \end{bmatrix}}_{B} \underbrace{tg(\delta)}_{u}$$

Riccatti $\rightarrow$ K

controlador

$$\underbrace{u}_{tg(\delta)} = -KX = -K_1(y-y^*) - K_2(\phi-\phi^*)$$

$$u = -K_1(y-y^*) - K_2(\phi-\phi^*)$$

$$(u-u^*) = -K_1(y-y^*) - K_2(\phi-\phi^*)$$

Linealización Exacta (Feedback Linealization)

$$\dot{y} = V\,\mathrm{sen}(\phi)$$
$$\dot{\phi} = -\frac{V}{L}\,\underbrace{tg(\delta)}_{u}$$

$$\dot{z} = Az + Bt$$

$z_1 = y$

$\rightarrow z_2 = \dot{y} = V\,\mathrm{sen}(\phi)$

$\rightarrow \dot{z}_1 = z_2$

$$\dot{z}_2 = V\cos(\phi)\cdot\dot{\phi} = -\frac{V^2}{L}\cos(\phi)\,tg(\delta) = t$$

$$\underbrace{\begin{bmatrix} \dot{z}_1 \\ \dot{z}_2 \end{bmatrix}}_{\dot{z}} = \underbrace{\begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} z_1 \\ z_2 \end{bmatrix}}_{z} + \underbrace{\begin{bmatrix} 0 \\ 1 \end{bmatrix}}_{B} \underbrace{t}_{t}$$

Riccatti $\rightarrow$ K

controlador

$$t = -Kz = -k_1 z_1 - k_2 z_2$$

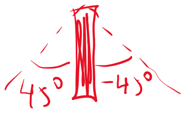
$$\cancel{-}\frac{V^2}{L}\cos(\phi)\,\underbrace{tg(\delta)}_{u} = \cancel{-}k_1 y \cancel{-} k_2 V\,\mathrm{sen}(\phi)$$

$$u = \frac{k_1 y + k_2 V\,\mathrm{sen}(\phi)}{\frac{V^2}{L}\cos(\phi)}$$

$$u = \frac{+k_1(y-y^*) + k_2 V\,\mathrm{sen}(\phi-\phi^*)}{\frac{V^2}{L}\cos(\phi-\phi^*)}$$

$$\frac{V^2}{2}\cos(\phi-\phi^*)$$

$u = tg(\delta)$



$-1 < tg(\delta) < 1$

$-45° < \delta < 45°$