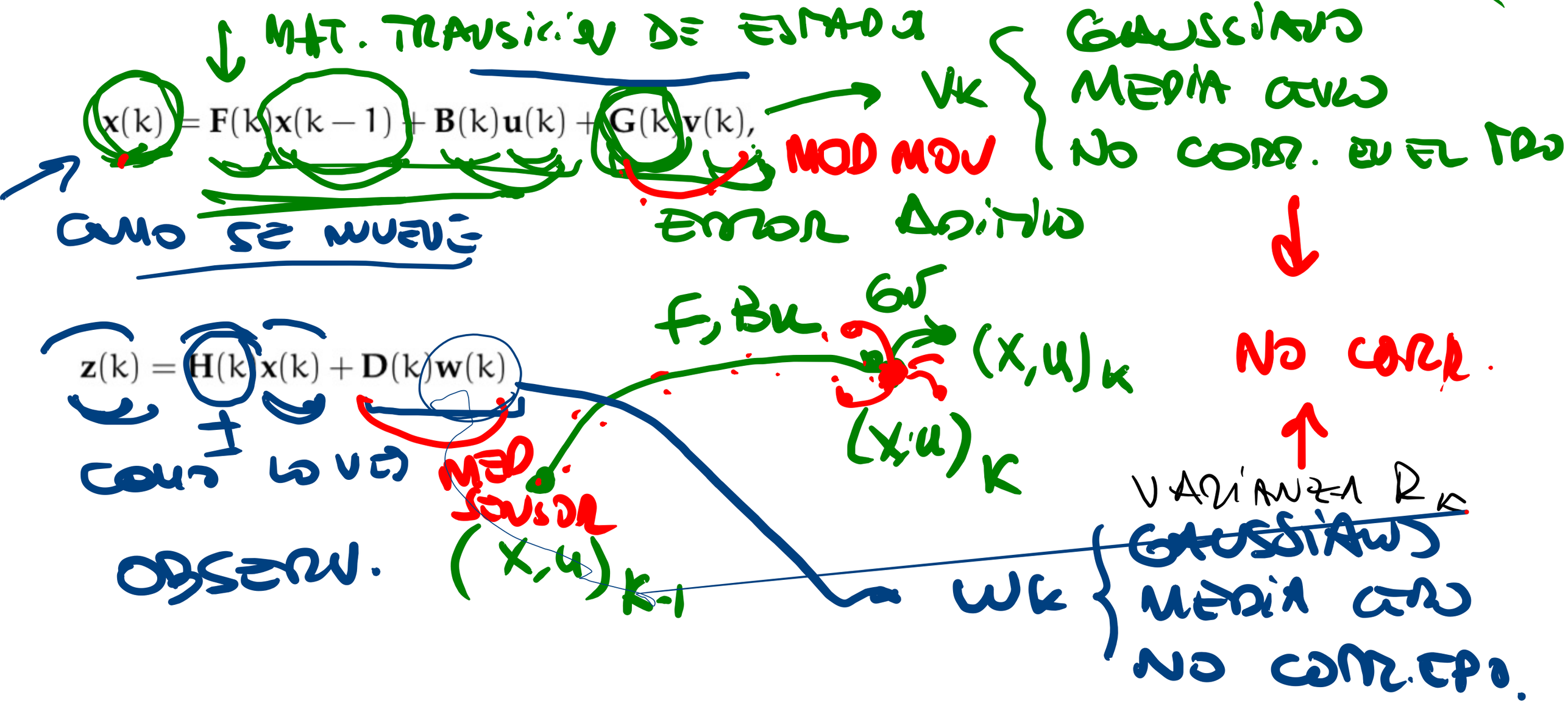
Estimación Probabilística - Sistema Lineal

$$\mathbf{x}(k) = \mathbf{F}(k)\mathbf{x}(k-1) + \mathbf{B}(k)\mathbf{u}(k) + \mathbf{G}(k)\mathbf{v}(k),$$

$$\mathbf{z}(k) = \mathbf{H}(k)\mathbf{x}(k) + \mathbf{D}(k)\mathbf{w}(k)$$



SPEARMAN RANK

POS MAC

AP_1

POS MAC

AP_2

IP

P

MAC P_{12}

MAC POS

FIRMA

$(X,Y)_D$ MAC P_{12}

GPS MAC P_{32}

MAC AP_3 P_{32}

FIRMA BD

$(X,Y)_1$ (GPS)

MAC AP_1, P_1

MAC AP_2, P_2

MA AP_3, P_3

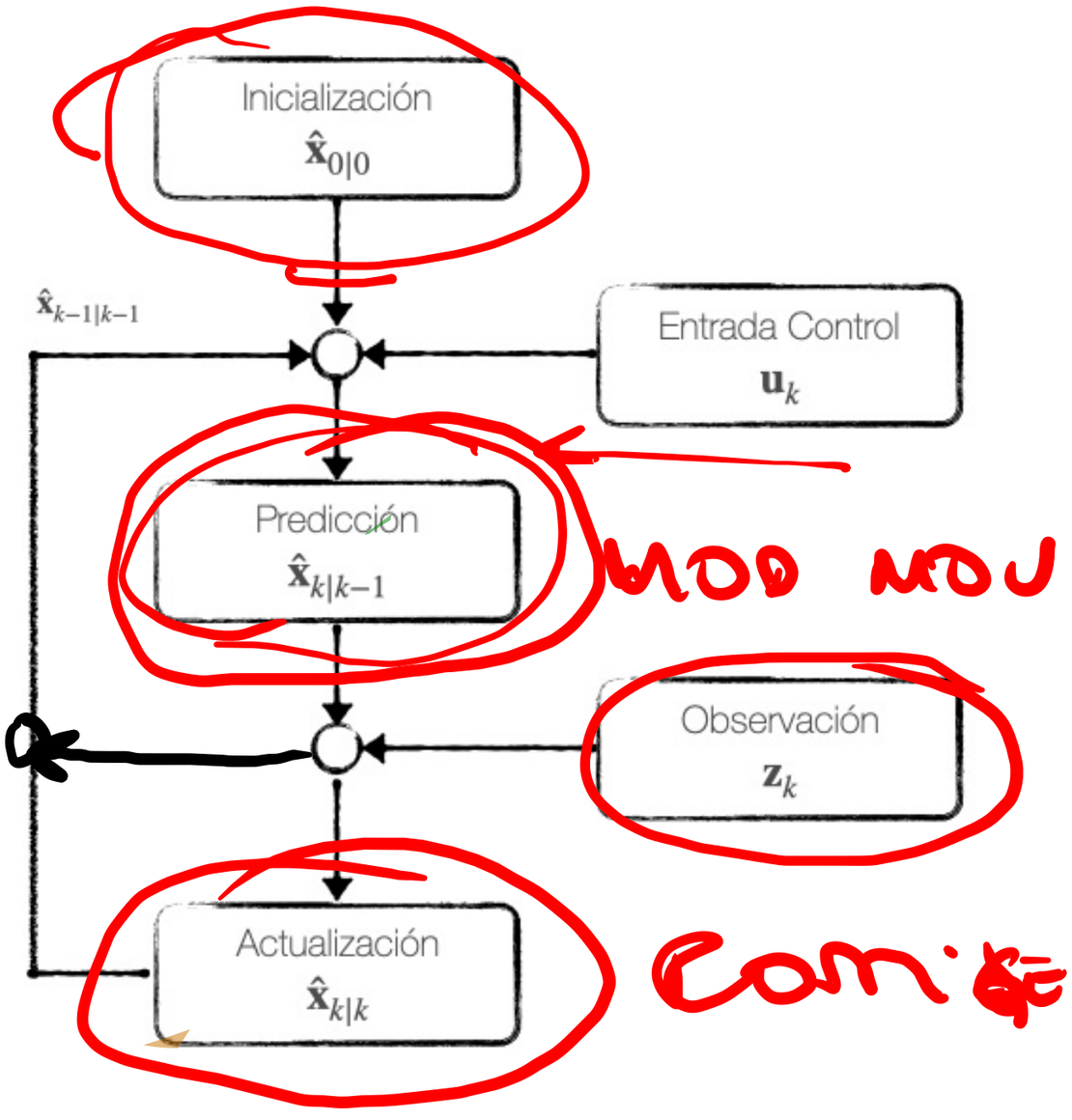
1 recondo BD

2 recondo BD

3 recondo

~~GPS~~ MAC, IP

Filtro de Kalman (lineal)



Filtro de Kalman (lineal)

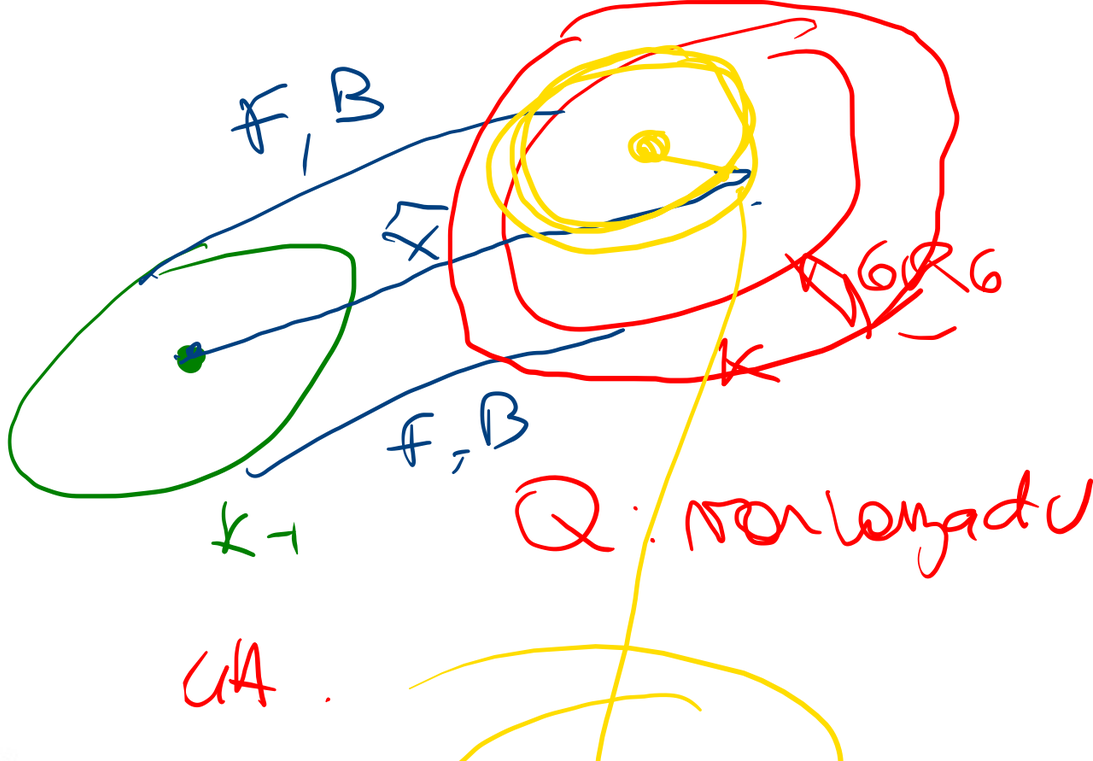
Predicción del estado y la varianza

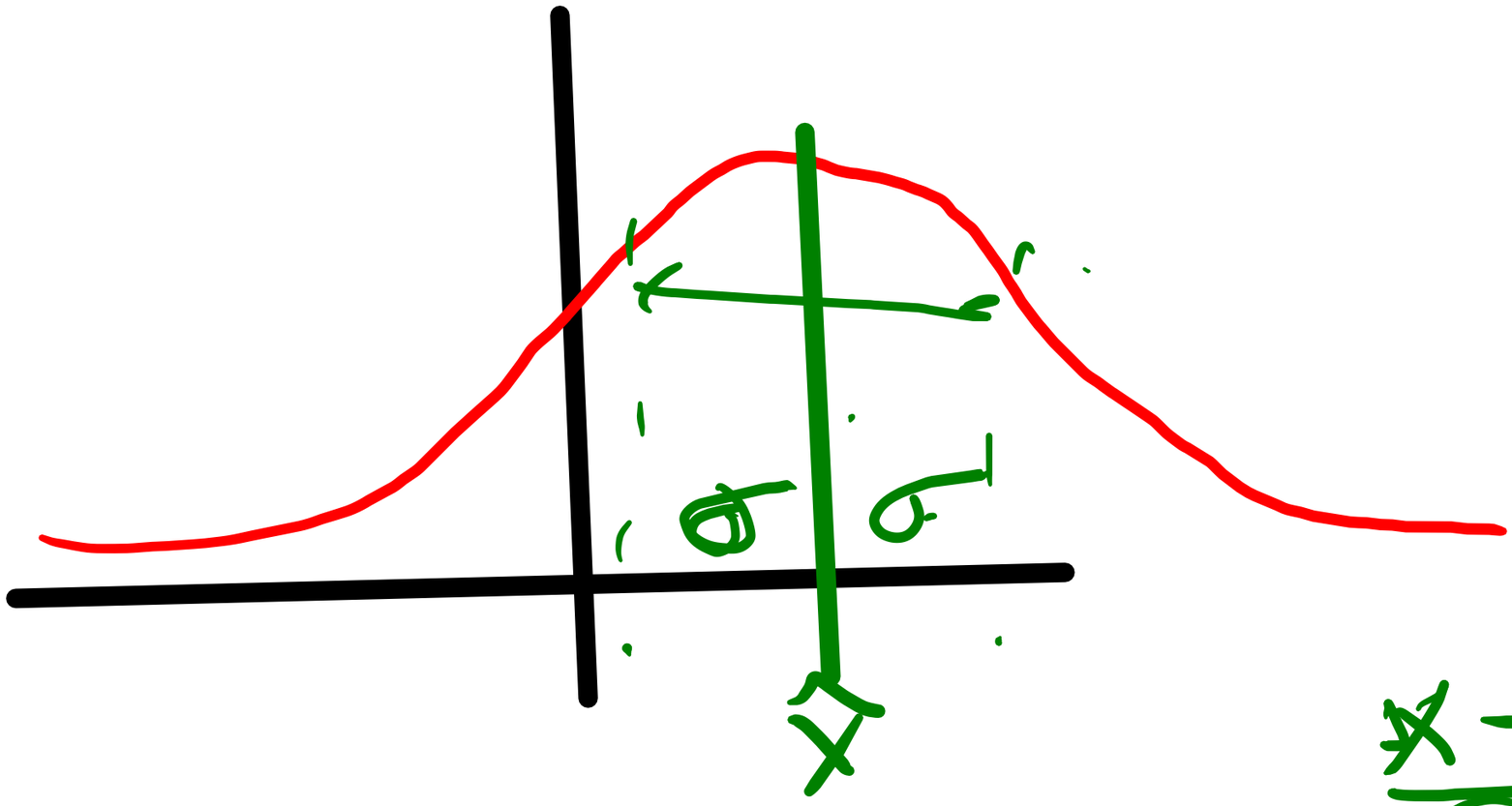
$$\hat{\mathbf{x}}_{k|k-1} = \mathbf{F}_k \hat{\mathbf{x}}_{k-1|k-1} + \mathbf{B}_k \mathbf{u}_k$$
$$\mathbf{P}_{k|k-1} = \mathbf{F}_k \mathbf{P}_{k-1|k-1} \mathbf{F}_k^{\mathsf{T}} + \mathbf{G}_k \mathbf{Q}_k \mathbf{G}_k^{\mathsf{T}}$$

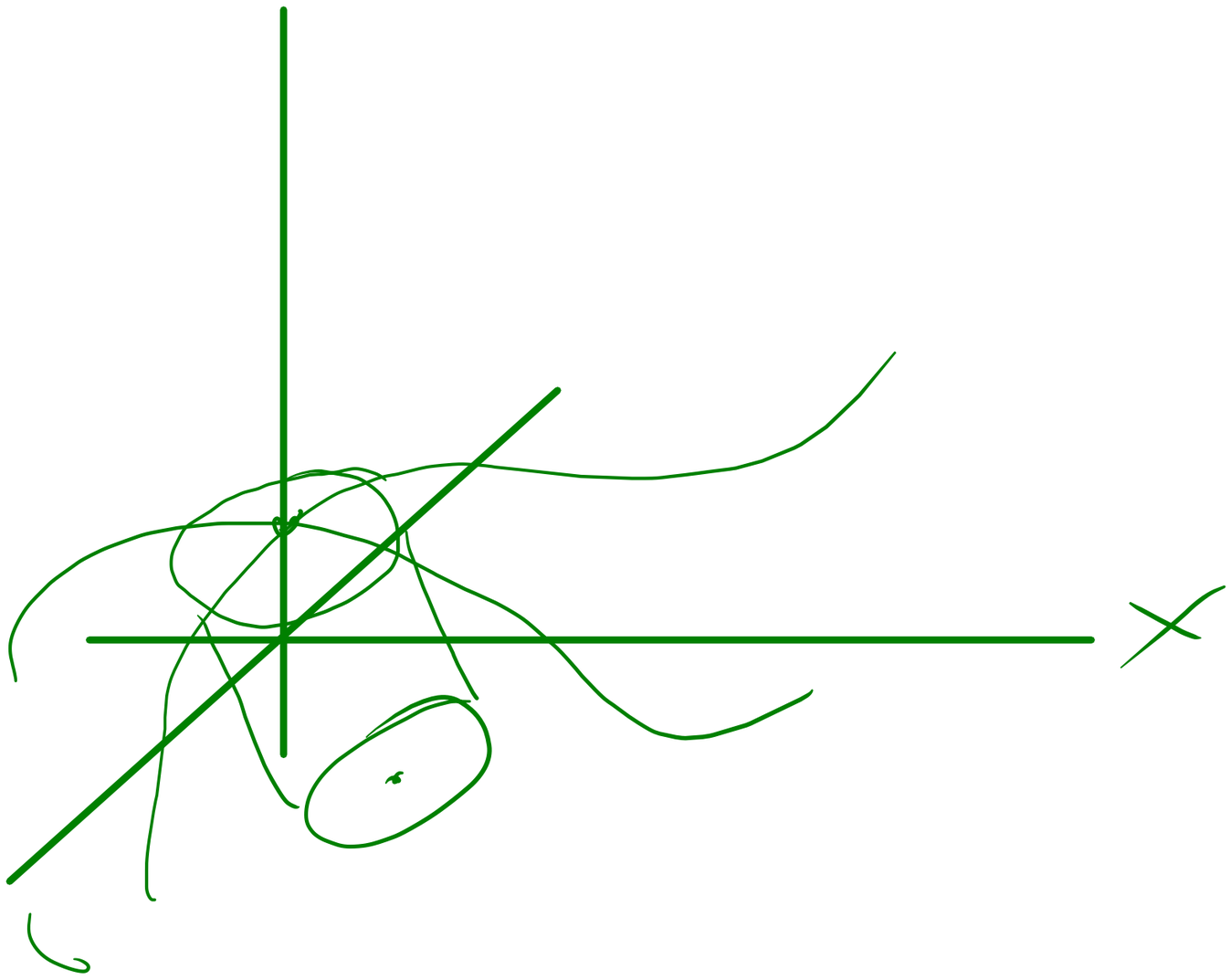
Actualización del estado y la varianza

$$\hat{\mathbf{x}}_{k|k} = \hat{\mathbf{x}}_{k|k-1} + \mathbf{W}_k \left(\mathbf{z}_k - \mathbf{H}_k \hat{\mathbf{x}}_{k|k-1}\right)$$
$$\mathbf{P}_{k|k} = (\mathbf{I} - \mathbf{W}_k \mathbf{H}_k) \mathbf{P}_{k|k-1} (\mathbf{I} - \mathbf{W}_k \mathbf{H}_k)^{\mathsf{T}} + \mathbf{W}_k \mathbf{R}_k \mathbf{W}_k^{\mathsf{T}}$$

$$\mathbf{W}_k = \mathbf{P}_{k|k-1} \mathbf{H}_k^{\mathsf{T}} \left[\mathbf{H}_k \mathbf{P}_{k|k-1} \mathbf{H}_k^{\mathsf{T}} + \mathbf{R}_k\right]^{-1}$$




$\bar{x}$
$p(x) = k e^{\frac{(x-\bar{x})^2}{\sigma^2}}$


x

Innovación

$$\nu_k = \mathbf{z}_k - \mathbf{H}_k \hat{\mathbf{x}}_{k|\,k-1}$$

$$\mathrm{E}\{\nu_k | \mathbf{Z}^{k-1}\} = 0 \qquad \mathrm{E}\{\nu_i \nu_j^T\} = \mathbf{S}_i \delta_{ij}$$

$$\mathbf{S}_k = \mathbf{R}_k + \mathbf{H}_k \mathbf{P}_{k|\,k-1} \mathbf{H}_k$$

incerteza de wk

incerteza de la pred.

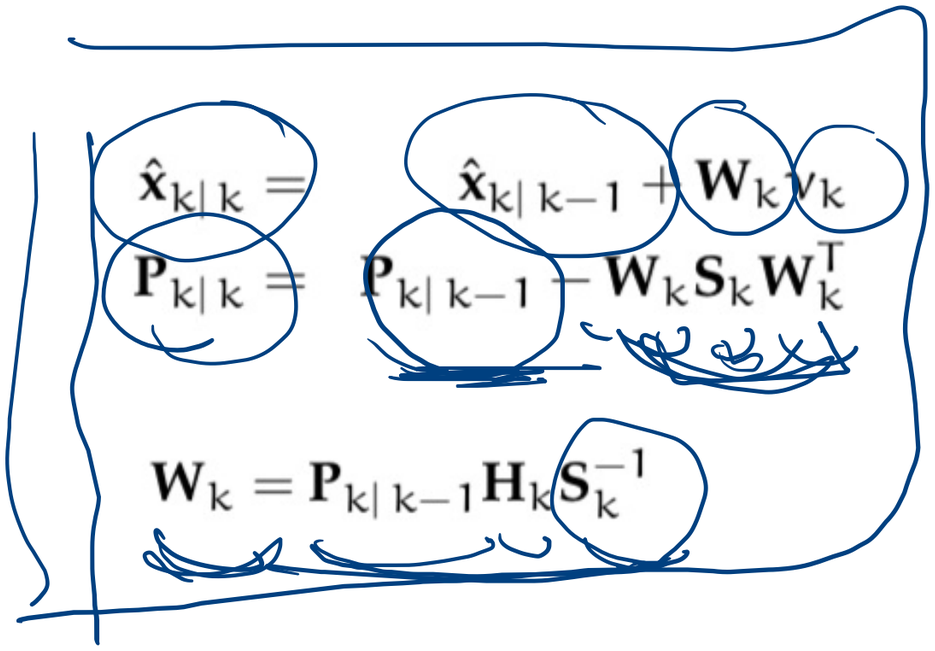
Filtro de Kalman (lineal)

Actualización del estado y la varianza

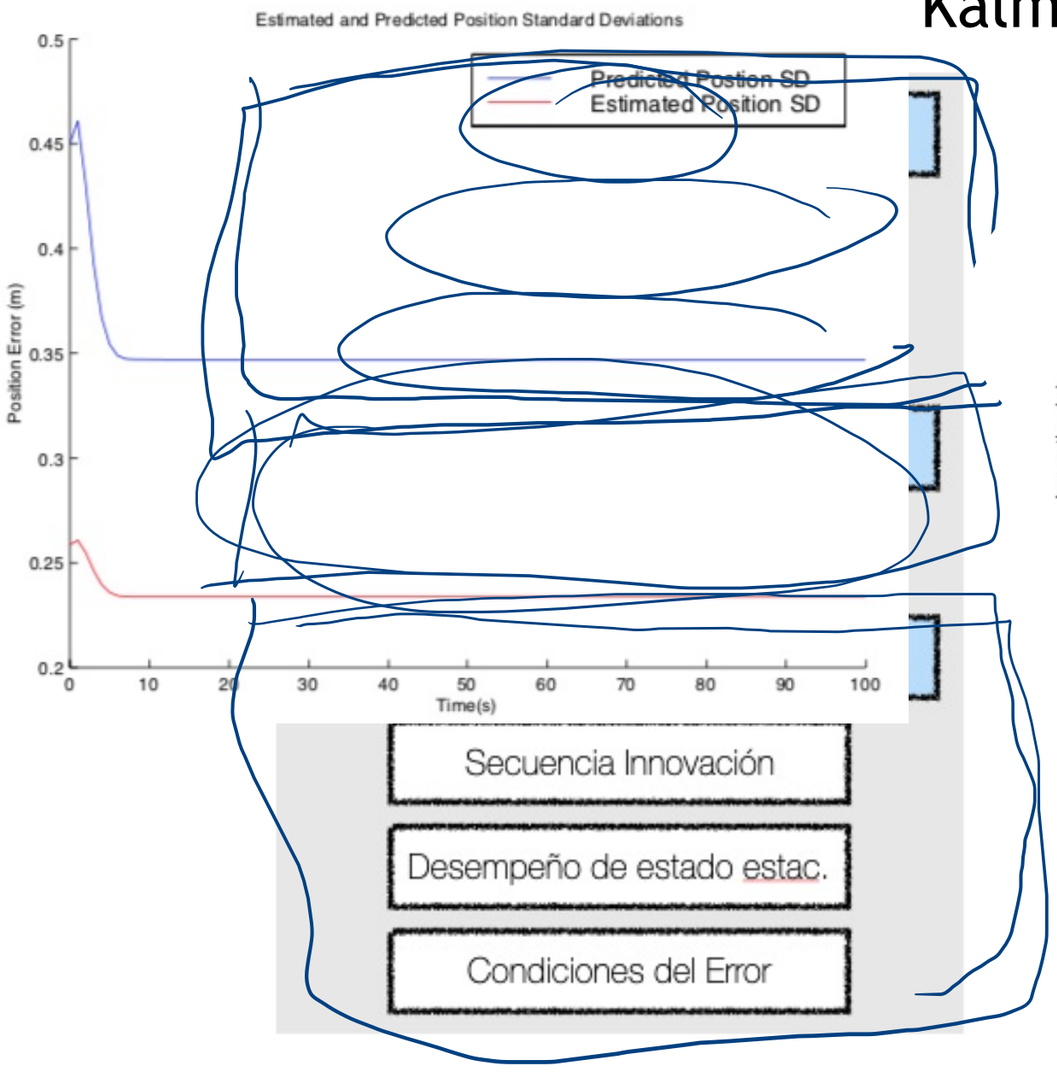
$$\hat{\mathbf{x}}_{k|k} = \hat{\mathbf{x}}_{k|k-1} + \mathbf{W}_k \left(\mathbf{z}_k - \mathbf{H}_k \hat{\mathbf{x}}_{k|k-1}\right)$$

$$\mathbf{P}_{k|k} = (\mathbf{I} - \mathbf{W}_k \mathbf{H}_k)\mathbf{P}_{k|k-1}(\mathbf{I} - \mathbf{W}_k \mathbf{H}_k)^{\mathsf{T}} + \mathbf{W}_k \mathbf{R}_k \mathbf{W}_k^{\mathsf{T}}$$

$$\mathbf{W}_k = \mathbf{P}_{k|k-1}\mathbf{H}_k^{\mathsf{T}}\left[\mathbf{H}_k \mathbf{P}_{k|k-1}\mathbf{H}_k^{\mathsf{T}} + \mathbf{R}_k\right]^{-1}$$



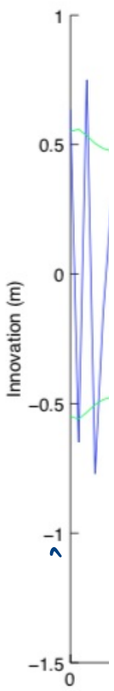
Kalman

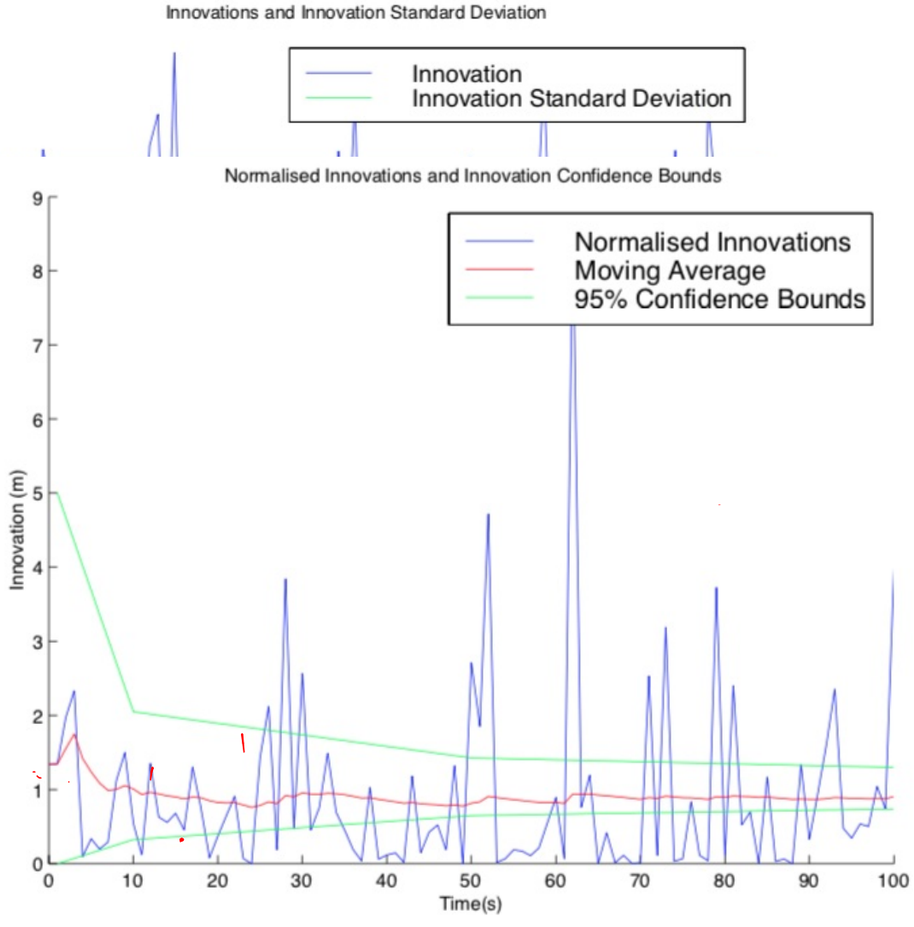


Secuencia Innovación

Desempeño de estado estac.

Condiciones del Error





$\frac{V_0^2}{S_0}$

$\frac{V_0}{S_0} / 1$

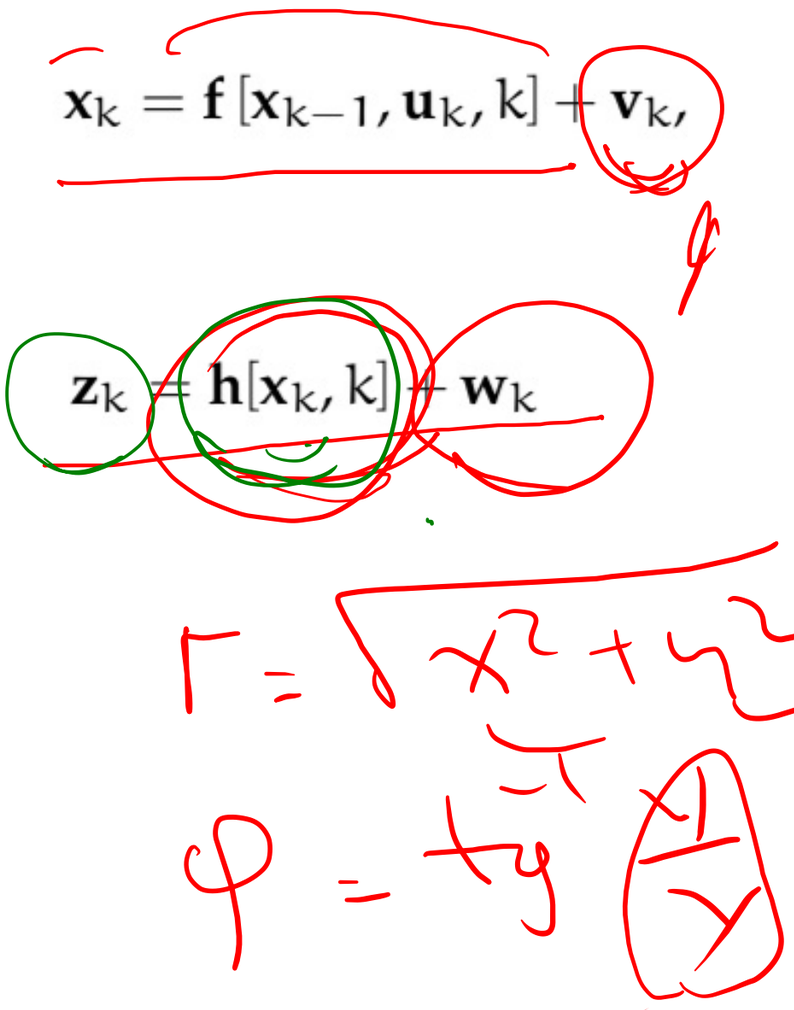
$\frac{V_0 + U_1}{S_0} / 2$

$\frac{U_0}{S_0} + \frac{U_1 + U_2}{S_1}$

Sistema No lineal

$$\mathbf{x}_k = \mathbf{f}[\mathbf{x}_{k-1}, \mathbf{u}_k, k] + \mathbf{v}_k,$$

$$\mathbf{z}_k = \mathbf{h}[\mathbf{x}_k, k] + \mathbf{w}_k$$



$$f = \begin{bmatrix} A & 0 & B & 0 \\ 0 & 1 & C & 0 \\ 0 & \cdots & & \end{bmatrix}$$

$$f = \begin{bmatrix} f_1(x, u) \\ f_2(x, u) \\ \vdots \end{bmatrix}$$

EKF: Filtro extendido de Kalman (no lineal)

Predicción del estado y la varianza

$$\hat{\mathbf{x}}_{k|k-1} = \mathbf{f}[\hat{\mathbf{x}}_{k-1|k-1}, \mathbf{u}_k]$$

$$\mathbf{P}_{k|k-1} = \nabla\mathbf{f}_x \mathbf{P}_{k-1|k-1} \nabla\mathbf{f}_x^T + \mathbf{Q}_k$$

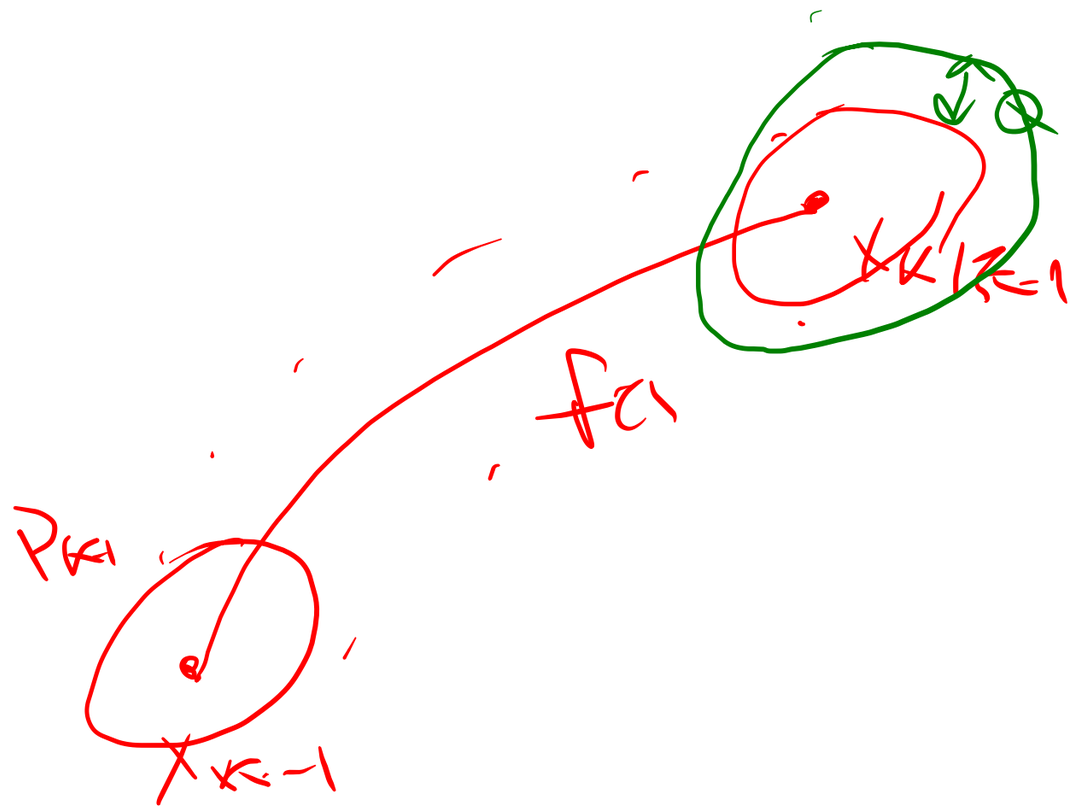
Actualización del estado y la varianza

$$\hat{\mathbf{x}}_{k|k} = \hat{\mathbf{x}}_{k|k-1} + \mathbf{W}_k \left(\dot{\mathbf{z}}_k - \mathbf{h}[\hat{\mathbf{x}}_{k|k-1}]\right)$$

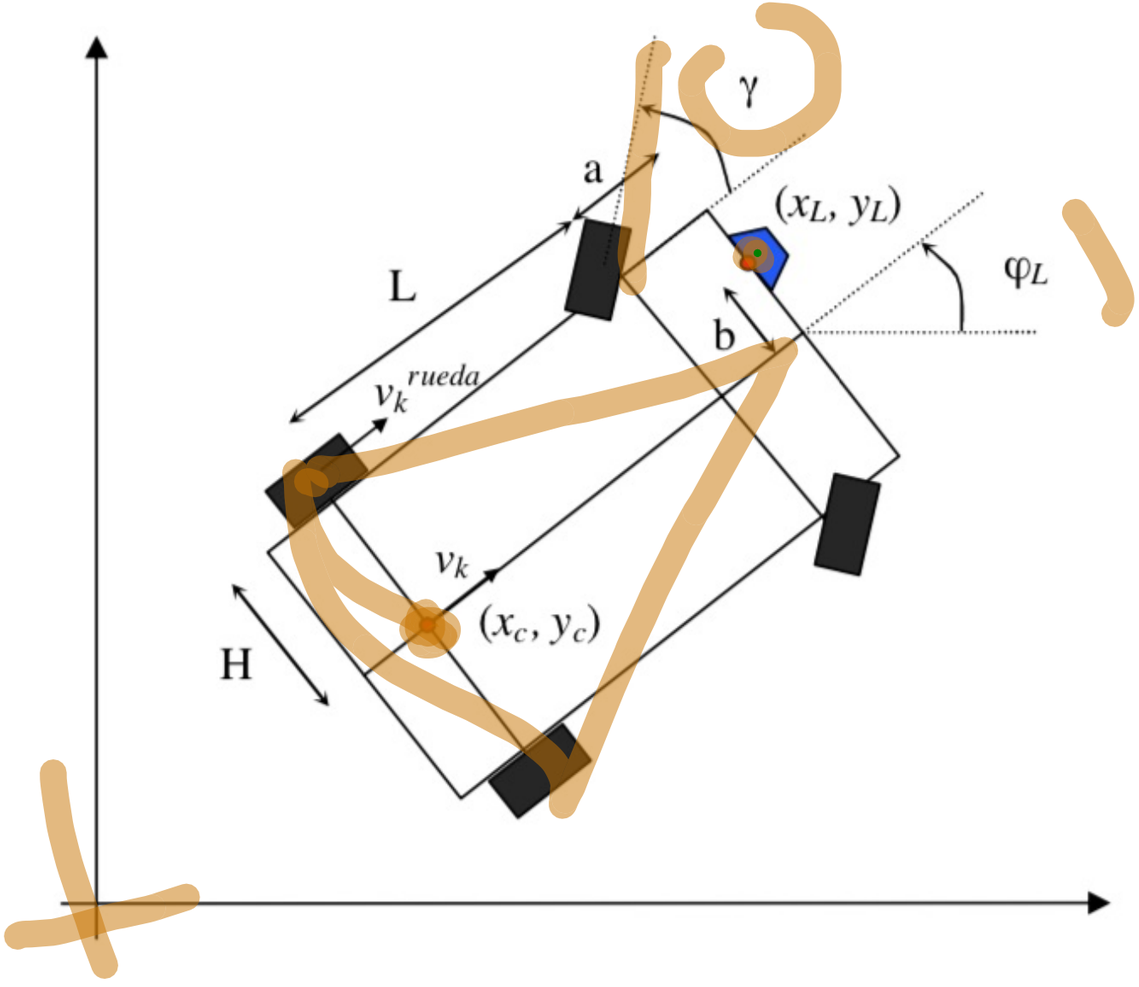
$$\mathbf{P}_{k|k} = \mathbf{P}_{k|k-1} - \mathbf{W}_k \mathbf{S}_k \mathbf{W}_k^T$$

$$\mathbf{W}_k = \mathbf{P}_{k|k-1} \nabla\mathbf{h}_x^T \mathbf{S}_k^{-1}$$

$$\mathbf{S}_k = \nabla\mathbf{h}_x \mathbf{P}_{k|k-1} \nabla\mathbf{h}_x^T + \mathbf{R}_k$$



Modelo de un Vehículo Terrestre



Modelo de un Vehículo Terrestre

$$\begin{bmatrix} x_{Lk} \\ y_{Lk} \\ \varphi_{Lk} \end{bmatrix} = \begin{bmatrix} x_{Lk-1} + \triangle t \cdot v_k \cdot [\mathbb{G} \cos(\varphi_{Lk-1}) - \mathbb{H} \operatorname{sen}(\varphi_{Lk-1})] \\ y_{Lk-1} + \triangle t \cdot v_k \cdot [\mathbb{G} \operatorname{sen}(\varphi_{Lk-1}) + \mathbb{H} \cos(\varphi_{Lk-1})] \\ \varphi_{Lk-1} + \triangle t \cdot \frac{v_k}{L} \cdot \tan(\gamma_k) \end{bmatrix}$$

- $L = 2{,}38\text{m}$
- $a = 0{,}95\text{m}$
- $b = 0{,}5\text{m}$
- $H = 0{,}75\text{m}$

$$\mathbb{G} = \left(1 - \frac{b \tan(\gamma_k)}{L}\right)$$

$$\mathbb{H} = \frac{(L + a) \tan(\gamma_k)}{L}$$

$$v = \frac{v_r}{1 - \frac{H}{L} \tan(\alpha)}$$