State Prediction (Odometry)

$$\hat{\mathbf{x}}_k = f(\mathbf{x}_{k-1}, \mathbf{u}_k)$$

$$\hat{C}_k = F_x\, C_k\, F_x^T + F_u\, U_k\, F_u^T$$

Control u_k : wheel displacements s_l , s_r

$$\mathbf{u}_k = (s_l\ s_r)^T$$

$$U_k = \begin{bmatrix} \sigma_l^2 & 0 \\ 0 & \sigma_r^2 \end{bmatrix}$$

Error model: linear growth

$$\sigma_l = k_l\, |s_l|$$

$$\sigma_r = k_r\, |s_r|$$

Nonlinear process model f :

$$\mathbf{x}_k = \begin{bmatrix} x_{k-1} \\ y_{k-1} \\ \theta_{k-1} \end{bmatrix} + \begin{bmatrix} \frac{b}{2}\, \frac{s_l+s_r}{s_r-s_l}\, (-\sin\, \theta_{k-1} + \sin(\theta_{k-1} + \frac{s_r-s_l}{b})) \\ \frac{b}{2}\, \frac{s_l+s_r}{s_r-s_l}\, (\ \ \cos\, \theta_{k-1} - \cos(\theta_{k-1} + \frac{s_r-s_l}{b})) \\ \frac{s_r-s_l}{b} \end{bmatrix}$$

Hessian line model

$$x\ cos(\alpha) + y\ sin(\alpha) - r = 0$$

$$\mathbf{z}_k = \begin{bmatrix} \alpha \\ r \end{bmatrix}$$

$$R_k = \begin{bmatrix} \sigma_\alpha^2 & \sigma_{\alpha r} \\ \sigma_{r\alpha} & \sigma_r^2 \end{bmatrix}$$

- Kalman gain

$$K_k = \hat{C}_k\, H^T S_k^{-1}$$

- State update (robot pose)

$$\mathbf{x}_k = \hat{\mathbf{x}}_k + K_k\, \nu_k$$

- State covariance update

$$C_k = (I - K_k\, H)\, \hat{C}_k$$