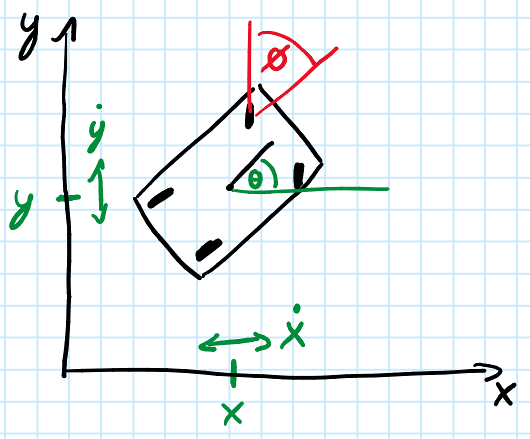
EKF for a car

Mittwoch, 3. Juli 2019 10:39

$$\vec{X} = \begin{pmatrix} x \\ y \\ \theta \\ \phi \\ \dot{x} \\ \dot{y} \end{pmatrix} \begin{matrix} : \text{x-Position} \\ : \text{y-Position} \\ : \text{yaw} \\ : \text{Steering angle} \\ : \text{x-Velocity} \\ : \text{y-Velocity} \end{matrix}$$



$$\vec{u} = \begin{pmatrix} v_c \\ \phi_c \end{pmatrix} \begin{matrix} : \text{command velocity} \\ : \text{command steering} \end{matrix}$$

Predict

$$\tilde{x}_{\ell|\ell-1} = f(x_{\ell-1|\ell-1}, u_\ell)$$
$$\tilde{P}_{\ell|\ell-1} = F_\ell \cdot P_{\ell-1|\ell-1} \cdot F_\ell^T + W_\ell \cdot \tilde{Q}_\ell \cdot W_\ell^T$$

$$\vec{f} = \begin{pmatrix} \Delta t \cdot \dot{x} + x \\ \Delta t \cdot \dot{y} + y \\ \Delta t \cdot \frac{1}{L} \cdot \tan(\phi_c) \cdot v_c + \theta \\ \phi_c \\ \cos(\theta) \cdot v_c \\ \sin(\theta) \cdot v_c \end{pmatrix} \quad F_\ell = \left[\frac{\partial f_i}{\partial x_j}\right] = \begin{pmatrix} 1 & 0 & 0 & 0 & \Delta t & 0 \\ 0 & 1 & 0 & 0 & 0 & \Delta t \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\sin(\theta) \cdot v_c & 0 & 0 & 0 \\ 0 & 0 & \cos(\theta) \cdot v_c & 0 & 0 & 0 \end{pmatrix}$$

$$W_\ell = \left[\frac{\partial f_i}{\partial w_j}\right] = \begin{pmatrix} 0 & 0 \\ 0 & 0 \\ \frac{\Delta t}{L} \tan \phi_c & \frac{\Delta t}{L} \sec^2 \phi_c \cdot v \\ 0 & 1 \\ \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{pmatrix} \quad \tilde{Q}_\ell = \begin{pmatrix} \sigma_v^2 & \sigma_{\phi v} \\ \sigma_{v\phi} & \sigma_\phi^2 \end{pmatrix}$$

Update

Seperated for every sensor

$$y_\ell = z_\ell - h(\tilde{x}_{\ell|\ell-1})$$
$$S_\ell = H_\ell \cdot \tilde{P}_{\ell|\ell-1} \cdot H_\ell^T + R_\ell$$
$$K_\ell = \tilde{P}_{\ell|\ell-1} \cdot H_\ell^T \cdot S_\ell^{-1}$$
$$x_{\ell|\ell} = x_{\ell|\ell} + K_\ell \cdot y_\ell$$
$$P_{\ell|\ell} = (I - K_\ell \cdot H_\ell) \cdot P_{\ell|\ell-1}$$

LIDAR Update

$$z_\ell = \begin{pmatrix} x_L \\ y_L \\ \theta_L \end{pmatrix} \quad h(x) = \begin{pmatrix} x \\ y \\ \theta \end{pmatrix}$$

$$H_\ell = \left[\frac{\partial h_i}{\partial x_j}\right] = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \end{pmatrix}$$

$$R_\ell \in \mathbb{R}^{3\times3}$$
$$R_\ell = \begin{pmatrix} \sigma_x^2 & 0 & 0 \\ 0 & \sigma_y^2 & 0 \\ 0 & 0 & \sigma_\theta^2 \end{pmatrix}$$

IMU Update

$$z_\ell = \theta_{IMU} \quad h(x) = \theta$$

$$H_\ell = (0 \quad 0 \quad 1 \quad 0 \quad 0 \quad 0)$$

$$R_\ell \in \mathbb{R} \qquad R_\ell = \sigma_\theta^2$$

actual Velocity update

$$z_\ell = v_A \quad h(x) = \sqrt{\dot{x}^2 + \dot{y}^2}$$

$$H_\ell = \left(0 \quad 0 \quad 0 \quad 0 \quad \frac{\dot{x}}{\sqrt{\dot{x}^2+\dot{y}^2}} \quad \frac{\dot{y}}{\sqrt{\dot{x}^2+\dot{y}^2}}\right)$$

$$R_\ell \in \mathbb{R} \qquad R_\ell = \sigma_v^2$$