

Tracking the states w/ UUV

1. Data Sync.
2. Bias initialization
3. eskf model

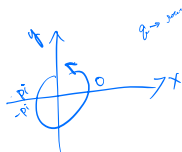
ESKF model

$$x_t = \begin{bmatrix} p_t \\ v_t \\ R_t \\ b_{gt} \\ b_{at} \\ g_t \end{bmatrix} \quad \tilde{x} \quad \checkmark \quad IMU$$

$$\begin{aligned} \hat{p}_t &= p_t \\ \hat{v}_t &= R_t (\tilde{x} - b_{gt} - \eta_{gt}) + \dot{p} \\ \hat{R}_t &= R_t (\tilde{x} - b_{gt} - \eta_{gt})^A \\ b_{gt} &= q_{bg} \\ b_{at} &= q_{ba} \\ \dot{g} &= 0 \end{aligned}$$

Schubkraft $\dot{p} := \text{true state}$

$$\begin{aligned} p_t &= p + \delta p \\ v_t &= v + \delta v \\ R_t &= R \delta R \\ b_{gt} &= b_g + \delta b_g \\ b_{at} &= b_a + \delta b_a \\ g_t &= g + \delta g \end{aligned} \quad \left\{ \begin{aligned} \hat{p}_t &= p_t \\ \hat{p}_t + \delta \hat{p} &= v + \delta v \\ \therefore \delta \hat{p} &= \delta v - \dot{p} \\ b_{gt} &= \eta_{bg} \\ \hat{p}_t + \delta \hat{p} &= \eta_{bg} \dot{p} \\ b_{at} &= \eta_{ba} \\ \hat{p}_t + \delta \hat{p} &= \eta_{ba} \dot{p} \\ g_t &= 0 \\ \delta g &= 0 \end{aligned} \right.$$



$$\begin{cases} \hat{R}_t = R_t (\tilde{x} - b_{gt} - \eta_{gt})^A - \dot{p} \\ R_t = R \cdot \text{Exp}(\delta R) \end{cases} \quad \text{--- ①}$$

$$\begin{aligned} \text{Jacobian ①} \\ \hat{R}_t &= \hat{R} \cdot \text{Exp}(\delta \theta) + R \cdot \text{Exp}(\delta \theta) \\ &= R (\tilde{x} - b_{gt} - \eta_{gt})^A \text{Exp}(\delta \theta) \\ &\quad + R \cdot \text{Exp}(\delta \theta) \delta \theta^A \end{aligned}$$

$$\begin{aligned} \text{Jacobian ② \& ③} \\ R_t (\tilde{x} - b_{gt} - \eta_{gt})^A \\ = R \cdot \text{Exp}(\delta \theta) (\tilde{x} - b_{gt} - \eta_{gt})^A \end{aligned}$$

$$\Rightarrow \int^R$$

→ IMU is
→ GPS is
→ ESKF

$$\tilde{z} = h(x)$$

$$x = \begin{bmatrix} p \\ v \\ R \end{bmatrix}$$

$$p_{\text{prev}} = \delta \theta$$

	x, y, z	Q, R	Jacobian	Remark
1330	20N	$\begin{bmatrix} 280 & 1 \\ 280 & 1 \end{bmatrix}$	0.02	
1350	20N	$\begin{bmatrix} 280 & 10 \\ 280 & 10 \end{bmatrix}$	0.05	
1400	20N	$\begin{bmatrix} 280 & 10 \\ 480 & 10 \end{bmatrix}$	0.03	
1410	20N	$\begin{bmatrix} 280 & 15 \\ 480 & 15 \end{bmatrix}$	0.03	
1430	20N	$\begin{bmatrix} 280 & 1 \\ 380 & 1 \end{bmatrix}$	0.03	
1440	20N	$\begin{bmatrix} 280 & 1 \\ 480 & 1 \end{bmatrix}$	0.03	
1450	40N	$\begin{bmatrix} 300 & 1 \\ 480 & 1 \end{bmatrix}$	0.03	
1545	40N	$\begin{bmatrix} 300 & 1 \\ 480 & 1 \end{bmatrix}$	0.05 (Signed)	
1550	40N	$\begin{bmatrix} 300 & 1 \\ 380 & 1 \end{bmatrix}$	0.03	
1600	20N	$\begin{bmatrix} 300 & 10 \\ 320 & 10 \end{bmatrix}$	0.03	
1600	40	$\begin{bmatrix} 300 & 1 \\ 480 & 1 \end{bmatrix}$	0.06	
1700	40	$\begin{bmatrix} 300 & 1 \\ 280 & 1 \end{bmatrix}$	0.06 (cancel)	(cancel in MP)
1710	40	$\begin{bmatrix} 300 & 1 \\ 300 & 480 \end{bmatrix}$	0.05	(cancel in MP)

EKF Subiding proof

$$\Delta E[w_k w_k^T] = Q_k$$

$$E[v_k v_k^T] = R_k$$

$$\Delta x_{k+1} = f(x_k) + w_k$$

$$z_k = h(x_k) + v_k$$

① predict

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

$$\hat{P}_k = F_k \hat{P}_{k-1} F_k^T + Q_k$$

$$F_k = \left[\frac{\partial f}{\partial x} \right]_{x=\hat{x}_{k-1}}$$

② update

$$y_k = z_k - h(\hat{x}_k)$$

$$K_k = \hat{P}_k H_k^T (H_k \hat{P}_k H_k^T + R_k)^{-1}$$

$$H_k = \left[\frac{\partial h}{\partial x} \right]_{x=\hat{x}_k}$$

$$\hat{x}_k = \hat{x}_k + K_k y_k$$

$$\hat{P}_k = (I - K_k H_k) \hat{P}_k$$

证明收敛性

△ \hat{P}_k is non-singular $\forall k \geq 0$

△ \hat{P}_k are bounded from below

$$\text{where } \bar{I} \succeq R_k \quad \forall k \geq 0$$

$$\bar{I} \succeq Q_k$$

$$\Delta \hat{x}_k = x_k - \hat{x}_k$$

$$\hat{e}_k = x_k - \hat{x}_k$$