

Name: Barathkrishna Satheshkumar

## Exercise 1

$$x_t = \begin{bmatrix} x_t \\ y_t \\ \psi_t \\ m_x^i \\ m_y^i \\ m_x^a \\ m_y^a \end{bmatrix}, \quad y_t = \underbrace{\begin{bmatrix} \|m^i - p_t\| \\ \|m^a - p_t\| \\ \text{atan2}(m_y^i - y_t, m_x^i - x_t) - \psi_t \\ \vdots \\ \text{atan2}(m_y^a - y_t, m_x^a - x_t) - \psi_t \end{bmatrix}}_{h(x_t)} + \begin{bmatrix} v_t^i, \text{distance} \\ v_t^a, \text{distance} \\ v_t^i, \text{bearing} \\ \vdots \\ v_t^a, \text{bearing} \end{bmatrix}$$

also,  $x_{t+1} = x_t + \delta t \dot{x}_t + \omega_t^x$ ;  $y_{t+1} = y_t + \delta t \dot{y}_t + \omega_t^y$ ;  $\psi_{t+1} = \psi_t + \delta t \dot{\psi}_t + \omega_t^\psi$

where  $\dot{x}_t = \dot{x}_t \cos \psi_t - \dot{y}_t \sin \psi_t$ ;  $\dot{y}_t = \dot{x}_t \sin \psi_t + \dot{y}_t \cos \psi_t$

$$F_t = \begin{bmatrix} \frac{\partial f_1}{\partial n_1} & \frac{\partial f_1}{\partial n_2} & \dots & \frac{\partial f_1}{\partial n_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial f_n}{\partial n_1} & \frac{\partial f_n}{\partial n_2} & \dots & \frac{\partial f_n}{\partial n_n} \end{bmatrix}$$

$$\Rightarrow F_x = \begin{bmatrix} 1 & 0 & \delta t(-\dot{x}_t \sin \psi_t - \dot{y}_t \cos \psi_t) & 0 & \dots & 0 \\ 0 & 1 & \delta t(\dot{x}_t \cos \psi_t - \dot{y}_t \sin \psi_t) & 0 & \dots & 0 \\ 0 & 0 & 1 & 0 & \dots & 0 \\ 0 & 0 & 0 & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & 0 & \dots & 1 \end{bmatrix}$$

$$h(x_t) = \begin{bmatrix} \|m^i - p_t\| \\ \|m^a - p_t\| \\ \text{atan2}(m_y^i - y_t, m_x^i - x_t) - \psi_t \\ \vdots \\ \text{atan2}(m_y^a - y_t, m_x^a - x_t) - \psi_t \end{bmatrix} = \begin{bmatrix} [(m_x^i - x_t)^2 + (m_y^i - y_t)^2]^{\frac{1}{2}} \\ \vdots \\ [(m_x^a - x_t)^2 + (m_y^a - y_t)^2]^{\frac{1}{2}} \\ \text{atan2}(m_y^i - y_t, m_x^i - x_t) - \psi_t \\ \vdots \\ \text{atan2}(m_y^a - y_t, m_x^a - x_t) - \psi_t \end{bmatrix}$$

$$H_t = \frac{\partial h}{\partial n}$$

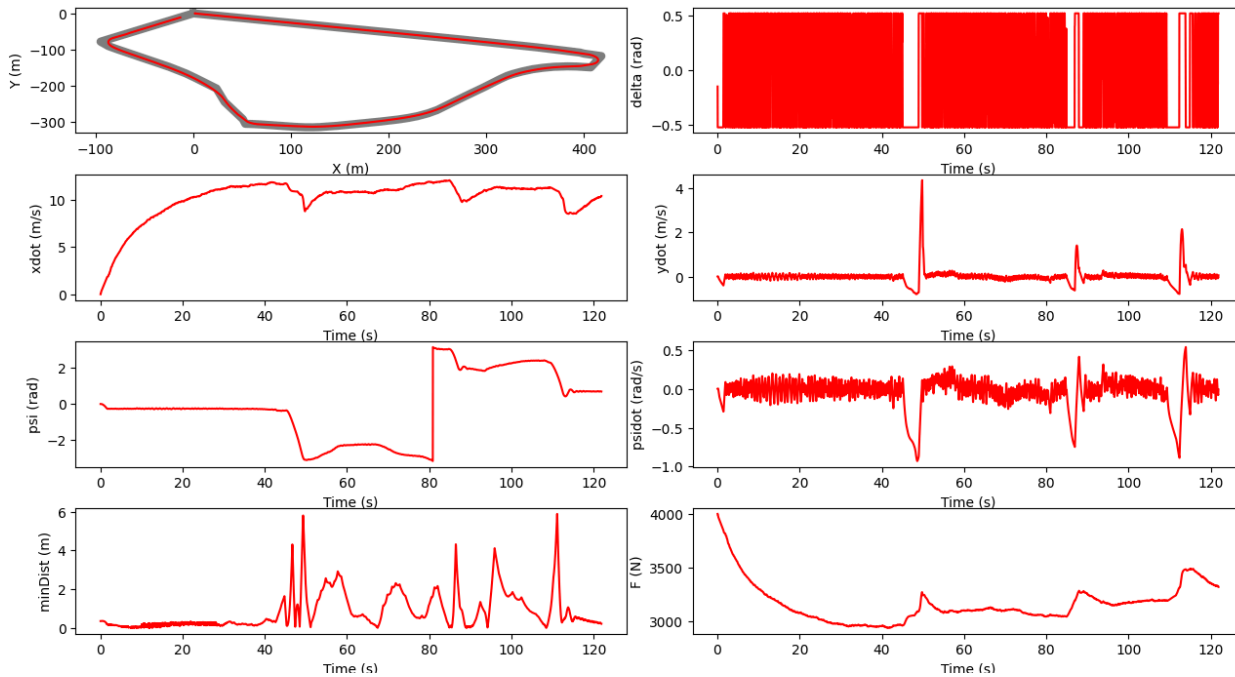
$$\Rightarrow H_t = \begin{bmatrix} \frac{-(m_x^i - x_t)}{[(m_x^i - x_t)^2 + (m_y^i - y_t)^2]^{\frac{1}{2}}} & \frac{-(m_y^i - y_t)}{[(m_x^i - x_t)^2 + (m_y^i - y_t)^2]^{\frac{1}{2}}} & 0 & \frac{(m_x^i - x_t)}{[(m_x^i - x_t)^2 + (m_y^i - y_t)^2]^{\frac{1}{2}}} & \frac{(m_y^i - y_t)}{[(m_x^i - x_t)^2 + (m_y^i - y_t)^2]^{\frac{1}{2}}} & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ \frac{-(m_x^a - x_t)}{[(m_x^a - x_t)^2 + (m_y^a - y_t)^2]^{\frac{1}{2}}} & \frac{-(m_y^a - y_t)}{[(m_x^a - x_t)^2 + (m_y^a - y_t)^2]^{\frac{1}{2}}} & 0 & 0 & 0 & \dots & \frac{(m_x^a - x_t)}{[(m_x^a - x_t)^2 + (m_y^a - y_t)^2]^{\frac{1}{2}}} & \frac{(m_y^a - y_t)}{[(m_x^a - x_t)^2 + (m_y^a - y_t)^2]^{\frac{1}{2}}} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ \frac{(m_y^i - y_t)}{(m_x^i - x_t)^2 + (m_y^i - y_t)^2} & \frac{-(m_x^i - x_t)}{(m_x^i - x_t)^2 + (m_y^i - y_t)^2} & -1 & \frac{-(m_y^i - y_t)}{(m_x^i - x_t)^2 + (m_y^i - y_t)^2} & \frac{(m_x^i - x_t)}{(m_x^i - x_t)^2 + (m_y^i - y_t)^2} & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ \frac{(m_y^a - y_t)}{(m_x^a - x_t)^2 + (m_y^a - y_t)^2} & \frac{-(m_x^a - x_t)}{(m_x^a - x_t)^2 + (m_y^a - y_t)^2} & -1 & 0 & 0 & \dots & \frac{-(m_y^a - y_t)}{(m_x^a - x_t)^2 + (m_y^a - y_t)^2} & \frac{(m_x^a - x_t)}{(m_x^a - x_t)^2 + (m_y^a - y_t)^2} \end{bmatrix}$$

Name: Barathkrishna Satheeshkumar

Andrew ID: bsathees

### Performance Plots

Time for loop completion: **121.856s**



### Evaluation

Evaluating...

Score for completing the loop: 30.0/30.0

Score for average distance: 30.0/30.0

Score for maximum distance: 30.0/30.0

Your time is 121.85600000000001

Your total score is : 100.0/100.0

total steps: 121856

maxMinDist: 5.885423199039033

avgMinDist: 0.8594179216798032

Figures from ekf\_slam.py

