Exercise 1:

$$X_{t+1} = X_t + \delta t \cdot (\dot{x}_t \cos\varphi_t - \dot{y}_t \sin\varphi_t) + w_{x,t}$$

$$Y_{t+1} = Y_t \ \delta t \cdot (\dot{x}_t \cos\varphi_t + \dot{y}_t \sin\varphi_t) + w_{y,t}$$

$$\varphi_{t+1} = \varphi_t + \delta_t \cdot \dot{\varphi}_t + w_{\varphi,t}.$$

when position of vehicle, $p_t = [x_t, Y_t]^T$

then $m_j = [\, m_{j,x} \ \ m_{j,y} \,]^T$

$m_{j,x,t+1} = m_{j,x,t}$ $\quad m_{j,y,t+1} = m_{j,y,t}$

$$x_t = \begin{bmatrix} x_t \\ Y_t \\ \varphi_t \\ m_{x_1} \\ m_{y_1} \\ m_{x_2} \\ m_{y_2} \\ \vdots \\ m_{x_n} \\ m_{y_n} \end{bmatrix} \qquad f(x_t, u_t) = \begin{bmatrix} x_t + \delta t \cdot (\dot{x}_t \cos\varphi_t - \dot{y}_t \sin\varphi_t) \\ Y_t + \delta t \cdot (\dot{x}_t \cos\varphi_t + \dot{y}_t \sin\varphi_t) \\ \varphi_{t+1} = \varphi_t + \delta_t \cdot \dot{\varphi}_t + w_{\varphi,t}. \\ m_{x_1} \\ m_{y_1} \\ \vdots \\ m_{x_n} \\ m_{y_n} \end{bmatrix}$$

$$\frac{\partial x_{t+1}}{\partial x_t} = 1 \qquad \frac{\partial x_{t+1}}{\partial Y_t} = 0 \qquad \frac{\partial x_{t+1}}{\partial \varphi_t} = -\delta_t(\dot{x} \sin\varphi_t + \dot{y}_t \cos\varphi_t)$$

$$\frac{\partial Y_{t+1}}{\partial x_t} = 0 \qquad \frac{\partial Y_{t+1}}{\partial Y_t} = 1 \qquad \frac{\partial Y_{t+1}}{\partial \varphi_t} = \delta_t(\dot{x}_t \cos\varphi_t - \dot{y}_t \sin\varphi_t)$$

$$\frac{\partial \varphi_{t+1}}{\partial \varphi_t} = 1$$

$$\frac{\partial m_{x_j,t+1}}{\partial m_{x_j,t}} = 1 \qquad \frac{\partial m_{y_j,t+1}}{\partial m_{y_j,t}} = 1$$

$$\therefore F_t = \begin{bmatrix} 1 & 0 & -\delta_t(\dot{x}\sin\psi_t + \dot{y}\cos\psi_t) & 0 & 0 & \cdots & 0 \\ 0 & 1 & \delta_t(\dot{x}_t\cos\psi_t - \dot{y}_t\sin\psi_t) & 0 & 0 & \cdots & 0 \\ 0 & 0 & 1 & 0 & 0 & \cdots & 0 \\ 0 & 0 & 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & \vdots & \vdots & 1 & 0 \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & 0 & 1 \cdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & 0 & \ddots 0 & \vdots \\ 0 & 0 & 0 & 0 & 0 & \cdots & 1 \end{bmatrix}$$

$$y_{j,\ distance} = \sqrt{(m_{xj} - X_t)^2 + (m_{yj} + Y_t)^2}$$

$$\frac{\partial y_{j\,distance}}{\partial X_t} = \frac{(m_{xj} - X_t)}{\|m_j - p_t\|} \qquad \frac{\partial y_{j\,distance}}{\partial Y_t} = \frac{(m_{yj} - Y_t)}{\|m_j - p_t\|}$$

$$\frac{\partial y_{j\,distance}}{\partial m_{xj}} = \frac{(m_{xj} - X_t)}{\|m_j - p_t\|} \qquad \frac{\partial y_{j\,distance}}{\partial m_{yj}} = \frac{(m_{yj} - Y_t)}{\|m_j - p_t\|}$$

$$y_{j\,bearing} = \operatorname{atan2}(m_{yj} - Y_t, m_{xj} - X_t) - \psi_t$$

$$\frac{\partial y_{j\,bearing}}{\partial X_t} = \frac{m_{yj} - Y_t}{(m_{xj} - X_t)^2 + (m_{yj} - Y_t)^2} \qquad \frac{\partial y_{j\,bearing}}{\partial X_t} = \frac{m_{xj} - X_t}{(m_{xj} - X_t)^2 + (m_{yj} - Y_t)^2}$$

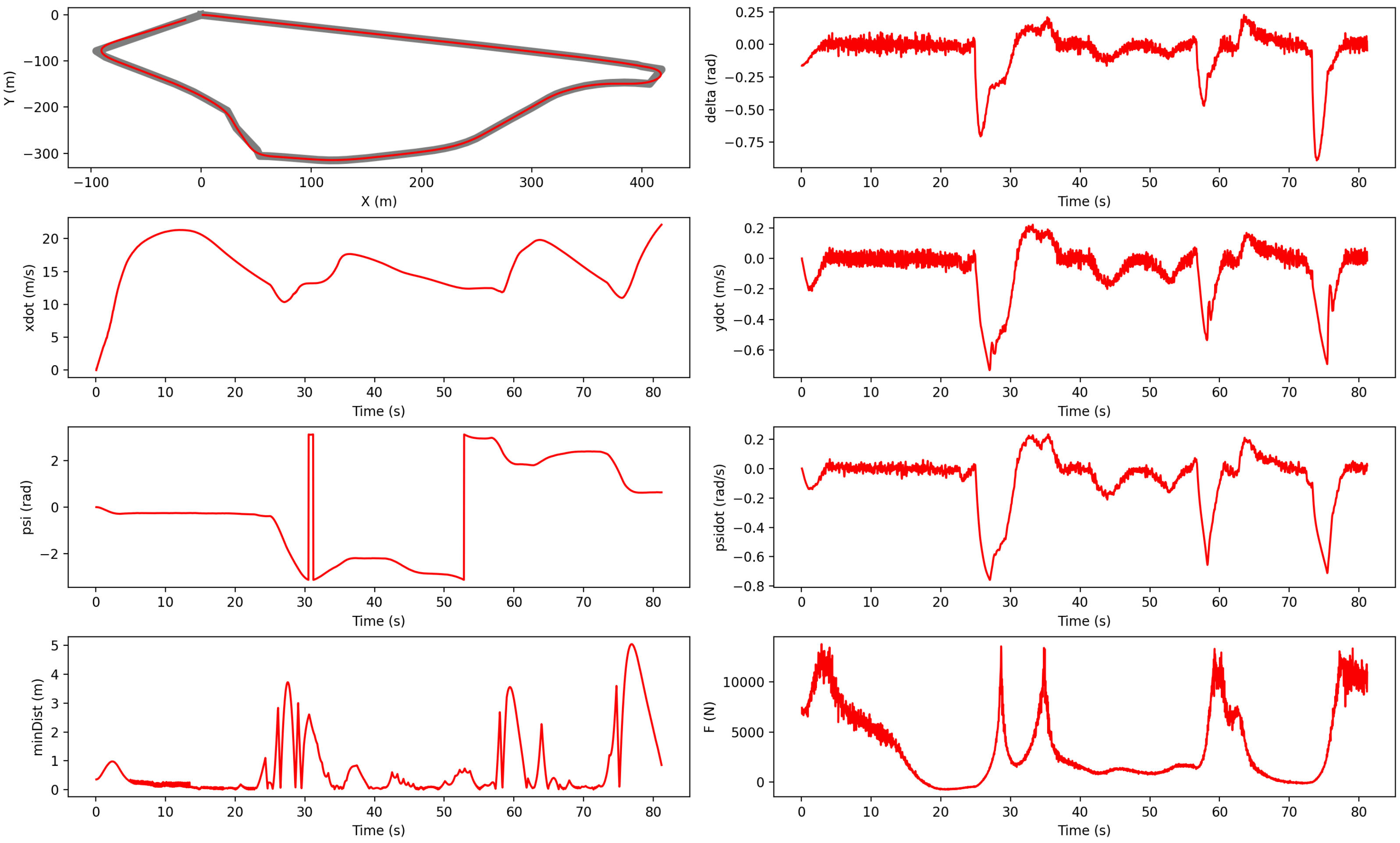
$$\frac{\partial y_{j\,bearing}}{\partial m_{xj}} = \frac{m_{yj} - Y_t}{(m_{xj} - X_t)^2 + (m_{yj} - Y_t)^2} \qquad \frac{\partial y_{j\,bearing}}{\partial m_{yj}} = \frac{m_{xj} - X_t}{(m_{xj} - X_t)^2 + (m_{yj} - Y_t)^2}$$

$$\frac{\partial y_{j\,bearing}}{\partial \psi_t} = -1.$$

$$H_t = \begin{bmatrix} H_{distance} \\ H_{bearing} \end{bmatrix}$$

$$
= \begin{bmatrix} -\frac{m_{xj}-x_t}{\|m_j-p_t\|} & -\frac{m_{yj}-y_t}{\|m_j-p_t\|} & 0 & \cdots & \frac{m_{xj}-x_t}{\|m_j-p_t\|} & \frac{m_{yj}-y_t}{\|m_j-p_t\|} \\ \frac{m_{yj}-y_t}{d_j^2} & -\frac{m_{xj}-x_t}{d_j^2} & -1 & \cdots & \frac{m_{yj}-y_t}{d_j^2} & \frac{m_{xj}-x_t}{d_j^2} \end{bmatrix}
$$

Exercise 2.



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 81.184
Your total score is : 100.0/100.0
total steps: 81184
maxMinDist: 5.04857264481053
avgMinDist: 0.749838878407121