Project 4

Exercise 1

$$X_t = \begin{bmatrix} X_t \\ Y_t \\ \Psi_t \\ m_x^1 \\ m_y^1 \\ \vdots \\ m_x^n \\ m_y^n \end{bmatrix} = \begin{bmatrix} X_{t-1} + \delta t\left(\dot{X}_{t-1}\cos\Psi_{t-1} - \dot{y}_{t-1}\sin\Psi_{t-1}\right) \\ Y_{t-1} + \delta t\left(\dot{X}_{t-1}\sin\Psi_{t-1} + \dot{y}_{t-1}\cos\Psi_{t-1}\right) \\ \Psi_{t-1} + \delta t\,\dot{\Psi}_{t-1} \\ m_x^1 \\ m_y^1 \\ \vdots \\ m_x^n \\ m_y^n \end{bmatrix} + \begin{bmatrix} W_{t-1}^{x} \\ W_{t-1}^{y} \\ W_{t-1}^{\Psi} \\ W_{t-1}^{m_x^1} \\ W_{t-1}^{m_y^1} \\ \vdots \\ W_{t-1}^{m_x^n} \\ W_{t-1}^{m_y^n} \end{bmatrix}$$

$$y_t = \begin{bmatrix} \sqrt{(m_x^1 - X_t)^2 + (m_y^1 - y_t)^2} \\ \sqrt{(m_x^2 - X_t)^2 + (m_y^2 - y_t)^2} \\ \vdots \\ \sqrt{(m_x^n - X_t)^2 + (m_y^n - y_t)^2} \\ \tan^{-1}\left(\dfrac{m_y^1 - y_t}{m_x^1 - X_t}\right) - \Psi_t \\ \vdots \\ \tan^{-1}\left(\dfrac{m_y^n - y_t}{m_x^n - X_t}\right) - \Psi_t \end{bmatrix} + \begin{bmatrix} V_{t,\,distance}^{1} \\ \vdots \\ V_{t,\,distance}^{n} \\ V_{t,\,bearing}^{1} \\ \vdots \\ V_{t,\,bearing}^{n} \end{bmatrix}$$

$$F_t = \left.\frac{\partial f}{\partial x}\right|_{\hat{X}_{t-1|t-1},\,u_t} \quad \text{and} \quad H_t = \left.\frac{\partial h}{\partial x}\right|_{\hat{X}_{t|t-1}}$$

$$F_t = \begin{bmatrix} 1 & 0 & \delta t(-\dot{X}_t \sin\hat{\Psi}_{t-1|t-1} - \dot{y}_t\cos\hat{\Psi}_{t-1|t-1}) & 0 & 0 & \cdots & 0 \\ 0 & 1 & \delta t(\dot{X}_t\cos\hat{\Psi}_{t-1|t-1} - \dot{y}_t\sin\hat{\Psi}_{t-1|t-1}) & 0 & 0 & \cdots & 0 \\ 0 & 0 & 1 & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & 0 & 1 & 0 & \cdots & 0 \\ \vdots & \vdots & 0 & 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & 0 & 0 & \cdots & 1 \end{bmatrix}$$

$$H_t = \left.\frac{\partial h}{\partial x}\right|_{\hat{x}_{t|t-1}}$$

$$H_t = \begin{array}{c} \\ n \text{ rows} \\ \\ \\ \\ n \text{ rows} \\ \\ \end{array}
\begin{bmatrix}
-\frac{(m_x^1-\hat{x}_{t|t-1})}{\|m^1-p_t\|} & -\frac{(m_y^1-\hat{y}_{t|t-1})}{\|m^1-p_t\|} & 0 & \frac{m_x^1-\hat{x}_{t|t-1}}{\|m^1-p_t\|} & \frac{m_y^1-\hat{y}_{t|t-1}}{\|m^1-p_t\|} & 0 & 0 & \cdots & \cdots & 0 \\
-\frac{(m_x^2-\hat{x}_{t|t-1})}{\|m^2-p_t\|} & -\frac{(m_y^2-\hat{y}_{t|t-1})}{\|m^2-p_t\|} & 0 & 0 & 0 & \frac{m_x^2-\hat{x}_{t|t-1}}{\|m^2-p_t\|} & \frac{m_y^2-\hat{y}_{t|t-1}}{\|m^2-p_t\|} & \cdots & \cdots & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & & & \vdots \\
-\frac{(m_x^n-\hat{x}_{t|t-1})}{\|m^n-p_t\|} & -\frac{(m_y^n-\hat{y}_{t|t-1})}{\|m^n-p_t\|} & 0 & 0 & 0 & 0 & 0 & \cdots & \frac{m_x^n-\hat{x}_{t|t-1}}{\|m^n-p_t\|} & \frac{m_y^n-\hat{y}_{t|t-1}}{\|m^n-p_t\|} \\
\frac{m_y^1-\hat{y}_{t|t-1}}{\|m^1-p_t\|^2} & -\frac{(m_x^1-\hat{x}_{t|t-1})}{\|m^1-p_t\|^2} & -1 & -\frac{(m_y^1-\hat{y}_{t|t-1})}{\|m^1-p_t\|^2} & \frac{m_x^1-\hat{x}_{t|t-1}}{\|m^1-p_t\|^2} & 0 & 0 & \cdots & \cdots & 0 \\
\frac{m_y^2-\hat{y}_{t|t-1}}{\|m^2-p_t\|^2} & -\frac{(m_x^2-\hat{x}_{t|t-1})}{\|m^2-p_t\|^2} & -1 & 0 & 0 & -\frac{(m_y^2-\hat{y}_{t|t-1})}{\|m^2-p_t\|^2} & \frac{m_x^2-\hat{x}_{t|t-1}}{\|m^2-p_t\|^2} & \cdots & \cdots & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & & & \vdots \\
\frac{m_y^n-\hat{y}_{t|t-1}}{\|m^n-p_t\|^2} & -\frac{(m_x^n-\hat{x}_{t|t-1})}{\|m^n-p_t\|^2} & -1 & 0 & 0 & 0 & 0 & \cdots & -\frac{(m_y^n-\hat{y}_{t|t-1})}{\|m^n-p_t\|^2} & \frac{m_x^n-\hat{x}_{t|t-1}}{\|m^n-p_t\|^2}
\end{bmatrix}$$

$\underbrace{\qquad\qquad\qquad}_{3 \text{ columns}} \quad \underbrace{\qquad\qquad\qquad\qquad\qquad}_{2n \text{ columns}}$

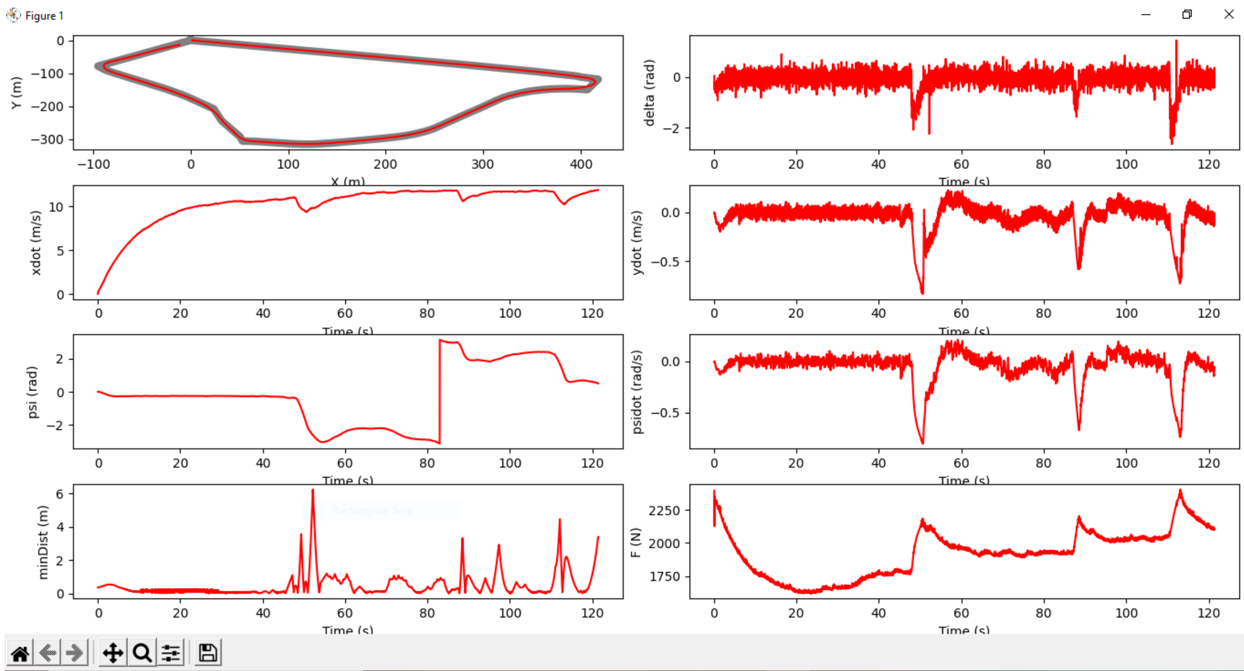
$\|\cdot\|$ denotes the Euclidean distance

For eg, $\|m^1-p_t\| = \sqrt{(m_x^1-\hat{x}_{t|t-1})^2+(m_y^1-\hat{y}_{t|t-1})^2}$

In the above expression for H_t, $m^1, m^2 \ldots m^n$ denote the x and y co-ordinates of the landmarks and p_t are the predicted x and y co-ordinates of the robot (in this case the vehicle).

PROJECT 4 - 24677

-Navodit Chandra



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 121.408
Your total score is : 100.0/100.0
total steps: 121408
maxMinDist: 6.228035767624085
avgMinDist: 0.4997701123410772

Time to complete the loop: 121.408s
Nickname - Majesty