Principles of Robot Autonomy I
Homework 5 SOLUTIONS

Problem 1

(i) 8×8 Identity

(ii) 8×8 Identity

(iii) Plots in solution code.

(iv)

(a) 0. Landmarks are stationary so no process noise.

(b) LTI system. Gaussian Noise.

Problem 2

(i)

$$G = \begin{bmatrix} 1 & 0 & -V_t \sin(\theta_t^r)\Delta t \\ 0 & 1 & V_t \cos(\theta_r^t)\Delta t \\ 0 & 0 & 1 \end{bmatrix} \tag{1}$$

(ii)

$$H = \begin{bmatrix} -\cos(\theta_r^t) & -\sin(\theta_t^r) & -(x_t^{m_1} - x_t^r)\sin(\theta_t^r) + (y_t^{m_1} - y_t^r)\cos(\theta_r^t) \\ \sin(\theta_t^r) & -\cos(\theta_r^t) & -(x_t^{m_1} - x_t^r)\cos(\theta_t^r) - (y_t^{m_1} - y_t^r)\sin(\theta_r^t) \\ -\cos(\theta_r^t) & -\sin(\theta_t^r) & -(x_t^{m_2} - x_t^r)\sin(\theta_t^r) + (y_t^{m_2} - y_t^r)\cos(\theta_r^t) \\ \sin(\theta_t^r) & -\cos(\theta_r^t) & -(x_t^{m_2} - x_t^r)\cos(\theta_t^r) - (y_t^{m_2} - y_t^r)\sin(\theta_r^t) \\ -\cos(\theta_r^t) & -\sin(\theta_t^r) & -(x_t^{m_3} - x_t^r)\sin(\theta_t^r) + (y_t^{m_3} - y_t^r)\cos(\theta_r^t) \\ \sin(\theta_t^r) & -\cos(\theta_r^t) & -(x_t^{m_3} - x_t^r)\cos(\theta_t^r) - (y_t^{m_3} - y_t^r)\sin(\theta_r^t) \\ -\cos(\theta_r^t) & -\sin(\theta_t^r) & -(x_t^{m_4} - x_t^r)\sin(\theta_t^r) + (y_t^{m_4} - y_t^r)\cos(\theta_r^t) \\ \sin(\theta_t^r) & -\cos(\theta_r^t) & -(x_t^{m_4} - x_t^r)\cos(\theta_t^r) - (y_t^{m_4} - y_t^r)\sin(\theta_r^t) \end{bmatrix} \tag{2}$$

(iii) Plots in solution code

(iv) Will fail if the Turtlebot has to make any sharp turns, the linear approximation won't be enough to account for this. Many appropriate strategies are possible here. The method from the hint is to use an Unscented Kalman Filter. Another option is Particle Filter.

Problem 3

(i) Solution in code.

(ii) Effectively the same due to the use of a Gaussian distribution in sampling the weights of the particle filter

(iii)

(a) F. They are independent of the dynamics and measurement model

(b) F. PFs are non-deterministic

(c) T. PFs are more useful for highly non-linear/ multi-modal distributions.

1 Problem 4

(iv) The first problem has certainty in its pose and only has to estimate landmarks, the second problem is reversed: pose is unknown, landmarks are known. The final problem has uncertainty in both the robot pose and landmarks.