The discrete-time extended Kalman filter

1. The system and measurement equations are given as follows:

$$\begin{aligned} x_k &= f_{k-1}(x_{k-1}, u_{k-1}, w_{k-1}) \\ y_k &= h_k(x_k, v_k) \\ w_k &\sim (0, Q_k) \\ v_k &\sim (0, R_k) \end{aligned} \tag{13.44}$$

2. Initialize the filter as follows:

$$\begin{aligned} \hat{x}_0^+ &= E(x_0) \\ P_0^+ &= E[(x_0 - \hat{x}_0^+)(x_0 - \hat{x}_0^+)^T] \end{aligned} \tag{13.45}$$

3. For $k = 1, 2, \cdots$, perform the following.

   (a) Compute the following partial derivative matrices:

$$\begin{aligned} F_{k-1} &= \left.\frac{\partial f_{k-1}}{\partial x}\right|_{\hat{x}_{k-1}^+} \\ L_{k-1} &= \left.\frac{\partial f_{k-1}}{\partial w}\right|_{\hat{x}_{k-1}^+} \end{aligned} \tag{13.46}$$

   (b) Perform the time update of the state estimate and estimation-error covariance as follows:

$$\begin{aligned} P_k^- &= F_{k-1}P_{k-1}^+F_{k-1}^T + L_{k-1}Q_{k-1}L_{k-1}^T \\ \hat{x}_k^- &= f_{k-1}(\hat{x}_{k-1}^+, u_{k-1}, 0) \end{aligned} \tag{13.47}$$

   (c) Compute the following partial derivative matrices:

$$\begin{aligned} H_k &= \left.\frac{\partial h_k}{\partial x}\right|_{\hat{x}_k^-} \\ M_k &= \left.\frac{\partial h_k}{\partial v}\right|_{\hat{x}_k^-} \end{aligned} \tag{13.48}$$

   (d) Perform the measurement update of the state estimate and estimation-error covariance as follows:

$$\begin{aligned} K_k &= P_k^- H_k^T (H_k P_k^- H_k^T + M_k R_k M_k^T)^{-1} \\ \hat{x}_k^+ &= \hat{x}_k^- + K_k[y_k - h_k(\hat{x}_k^-, 0)] \\ P_k^+ &= (I - K_k H_k) P_k^- \end{aligned} \tag{13.49}$$

   Note that other equivalent expressions can be used for K_k and P_k^+, as is apparent from Equation (5.19).