Autonomous Mobile Robots
Homework 3

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Task Description

The robot needs to navigate from point A (0,0) to point B (D,S) using extended kalman filter ekf as state estimation. The control strategy and motion model have to be determined.

Problem solution

Motion Model

The model used in this solution is **bicycle model** on a circular path. The motion model is defined as follows:

$$\begin{bmatrix} x_{t+1} \\ y_{t+1} \\ \theta_{t+1} \end{bmatrix} = \begin{bmatrix} x_t + \frac{v}{\omega}\sin(\theta_t + \omega\delta t) \\ y_t - \frac{v}{\omega}\cos(\theta_t + \omega\delta t) \\ \theta_t + \omega\delta t \end{bmatrix} \tag{1}$$

The right hand side of the above equation is used as $f(x,t)$ in the code implementation.

Measurement Model

There are three landmarks in the environment: L1 (5,30), L2 (5,-30), L3 (-5,0). The sensor readings are defined as follows:

$$\begin{bmatrix} x_t^i \\ \theta_t^i \end{bmatrix} = \begin{bmatrix} \sqrt{(m_{i,x} - x)^2 + (m_{i,y} - y)^2} \\ 2(m_{i,y} - y, m_{i,x} - x) - \theta \end{bmatrix} + \mathcal{N}(0, R) \tag{2}$$

The right hand side of the above equation is used as $h(x,t)$ in the code implementation.

Control Strategy

The point A is at (D,S) which are assumed to be at 20 and 0 respectively. The planned path is computed analytically to be two half circles as shown in the figure below:

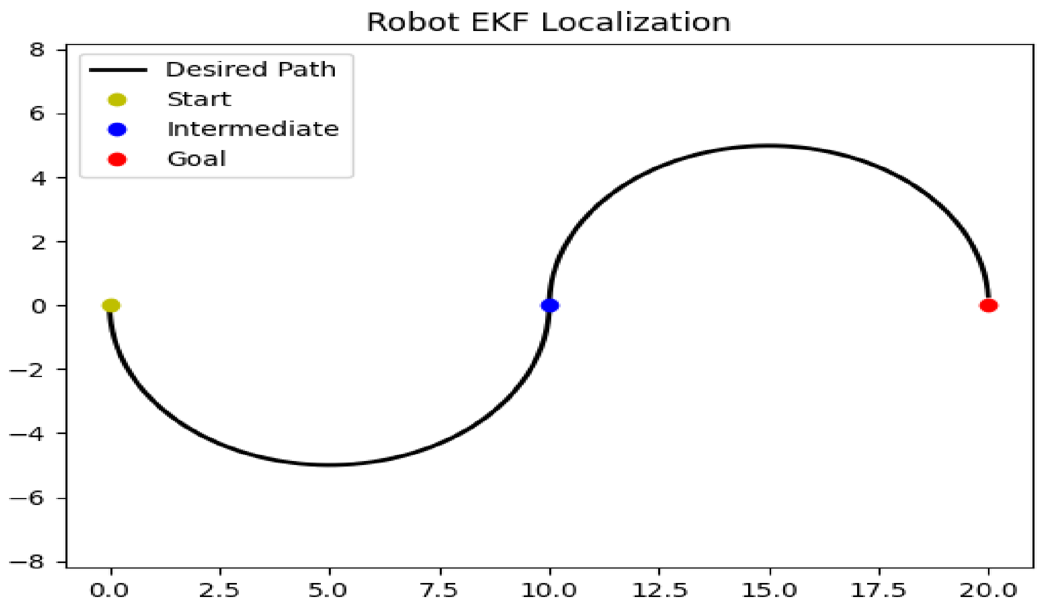


Figure 1: Desired path

Each circle has a radius of 5 and the intermediate point is located at (10,0). Thus, the control strategy will be:

Before intermediate point:

$$v = 1$$
$$w = 1/5$$

After intermediate point:

$$v = 1$$
$$w = -1/5$$

Also, there is a tolerance of 0.2 meters to determine whether the robot reaches either the intermediate point or the final goal.

Results and Discussion

The following graph shows the robot trajectory with ekf localization. The Desired data are obtained analytically while Estimated data are generated from ekf:

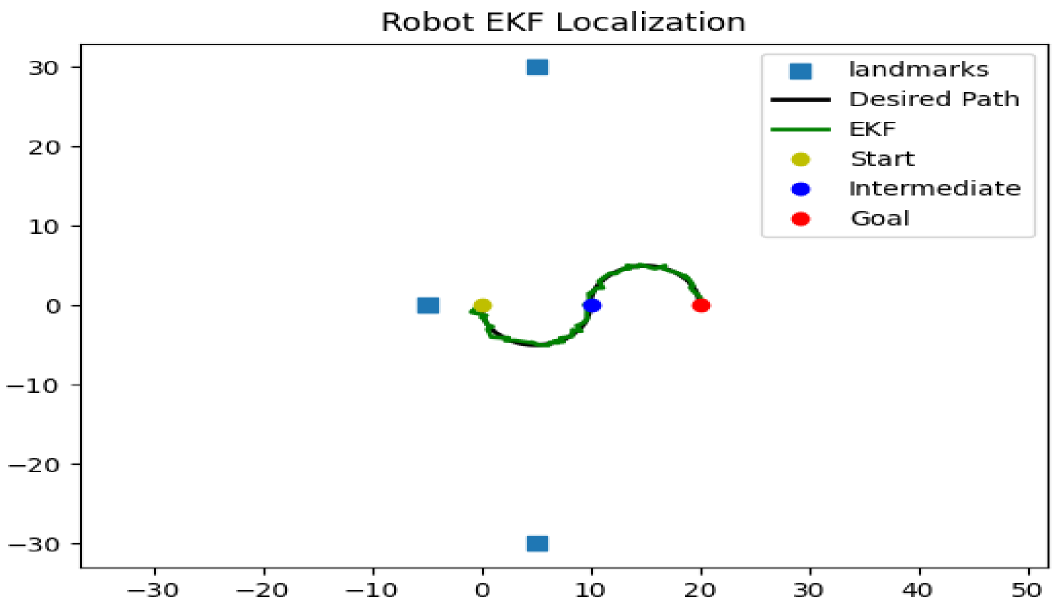
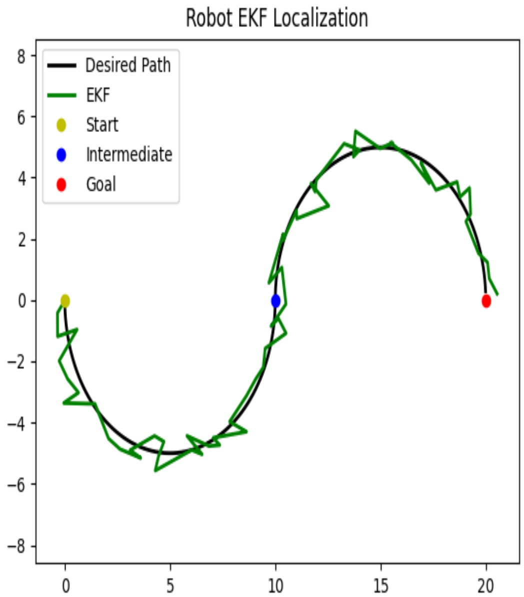
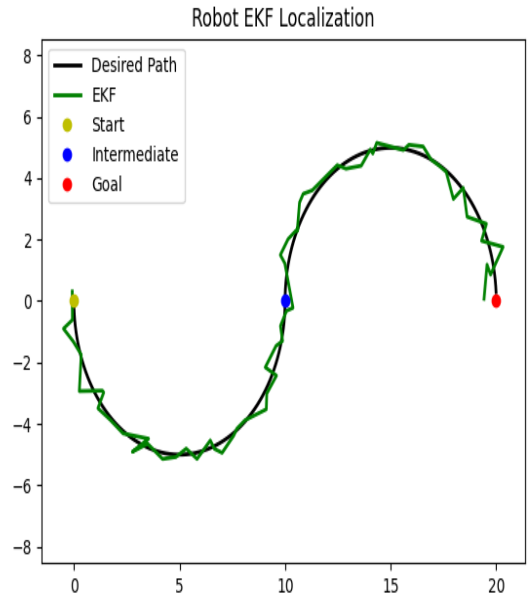


Figure 2: Robot EKF Localization

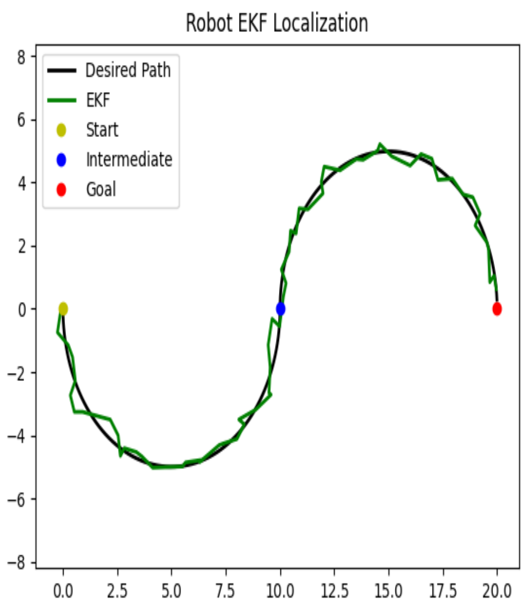
It is clear that both desired and estimated trajectories are similar even though estimates are little noisy. This noise comes from the uncertainty in the motion model, sensors measurement, and control signals. Also, the following figures show the performance of ekf localization with different variances values.



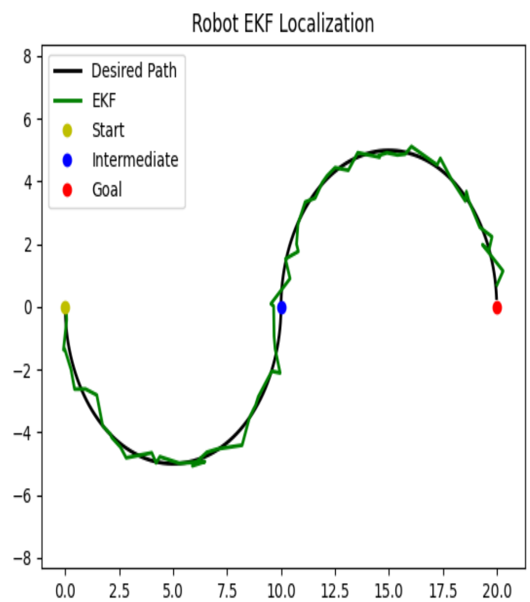
(a) Robot trajectory with increased range variance: $std\_range = 0.6$



(b) Robot trajectory with increased Q matrix: $Q = np.diag(3) * 10$



(c) Robot trajectory with increased steering variance: $std\_steer = 30$



(d) Robot trajectory with increased velocity $std\_vel = 0.8$

Figure 3: Trajectory data for different variances