MeEn 595R – Autonomous Systems
Homework #2

You are to design an extended Kalman filter (EKF) to estimate the location of an autonomous two-wheeled robot operating on a 20 m by 20 m field. Located on this field are three landmarks that are continuously visible to the robot. The robot can measure the range and bearing to each of these landmarks as it moves about. The dynamics of the moving robot are described by a velocity motion model as discussed in Chapter 5.

The robot has initial conditions x_0 = -5 m, y_0 = -3 m, θ_0 = 90 deg. Its commanded velocities are given by

$$v^c = 1 + 0.5\cos(2\pi(0.2)t)$$
$$\omega^c = -0.2 + 2\cos(2\pi(0.6)t).$$

You should assume that the velocities experienced by the robot are noisy versions of the commanded velocities where the noise characteristics are modeled by $\alpha_1 = \alpha_4 = 0.1$ and $\alpha_2 = \alpha_3 = 0.01$.

The landmark locations are (6, 4), (-7, 8), and (6, -4). The standard deviation of the range and bearing sensor noise for each of the landmarks is given by $\sigma_r = 0.1$ m and $\sigma_\phi = 0.05$ rad respectively.

You are to implement your EKF with a sample period of 0.1 s for a duration of 20 s.

Tasks:

1. Implement the velocity motion model and simulate the motion of the robot. Does it make sense? I recommend that you create a simple animation of the robot moving in the horizontal plane (like you did in 431/483). This will help you visualize what is happening and confirm that your simulation is working properly. NOTE: the velocity motion model doesn't work for straight-line motion. Why not?
2. Simulate the range and bearing measurements produced by sensing the landmarks. Double check to be certain your measurements make sense.
3. Implement the full EKF algorithm found in Table 7.2. Create plots comparing your true states to the estimated states versus time. Plot estimation error and 95-percent uncertainty bounds (from your variances) versus time for each of your states. Plot your Kalman gains vesus time.
4. Exercise your EKF by changing the input velocities, landmark locations, sensor noise levels, and control noise levels. What happens to the quality of your estimates if you reduce the number of landmarks? Increase? Does your EKF behave as expected?
5. Extra mile: Modify your simulation and EKF to handle both curvy and straight-line motions.

Hints:

- Just one hint: Take it step by step and carefully check your code along the way. At each step, verify that your code is producing results that make sense.