ELEC-E8107 - Stochastic models, estimation and control

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October 27, 2022

Exercises Session 4

Exercise 1

A nonlinear system dynamic model of a robot moving on the plane is given by the following equation.

$$\begin{bmatrix} x_{k+1} \\ y_{k+1} \\ \theta_{k+1} \\ v_{k+1} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & \Delta t cos(\theta_k) \\ 0 & 1 & 0 & \Delta t sin(\theta_k) \\ 0 & 0 & 1 & \frac{\Delta t}{L} tan(\phi) \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_k \\ y_k \\ \theta_k \\ v_k \end{bmatrix} + q_k \tag{1}$$

Where v is the speed of the vehicle, θ is the heading and q_k is the process noise vector with covariance matrix Q_k. This covariance matrix can be assumed to be a diagonal matrix. The parameter ϕ is the steering angle and is considered a known input to the system. The constant parameter L is the distance between the front and back wheel of the robot. Here we assume $L = 15cm$.

Only the positions x and y of the robot are measured. The measurement noise is assumed Gaussian with zero mean and has 0.5 meters standard deviation. The measurement noise of x-axis and y-axis are assumed independent.

1. Write the measurement equation for the system.
2. Compute the Jacobian matrix for the state transition model.
3. Implement a first order EKF using the measurement and input data provided in the files *measurement_data.mat* and *input_data.mat*.

4. A true data for the state is given in the file *True_trajectory.mat*. Plot the true trajectory (coordinate x versus coordinate y plot) and your estimated trajectory on the same figure to appreciate the accuracy of your estimation. Adjust the values of the covariance matrix Q to have a good estimation.

5. plot the true and estimated speed, and the true and estimated heading angle.

Exercise 2

Implement the bootstrap particle filter to estimate the state of the system given in the exercise 1 above.