ELEC-E8107 - Stochastic models, estimation and control

Arto VISALA, and Tabish BADAR

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Exercises Session 5

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 wheels 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 the x-axis and y-axis are assumed independent.

1. Write the measurement equation for the system.

2. Implement the bootstrap particle filter to estimate the state of the system.

Exercise 2

The objective is to estimate the pose and movement of a ship moving in the inland waterways. The GPS position and the National Marine Electronics Association (NMEA) standard velocity, true speed, and ground heading (VTG) measurements are available.

The task is to set up an Extended Kalman Filter (EKF) to estimate the instantaneous position of the ship.