# Exercise 5 – Extended Kalman Filter (Constraint the position of the robot)

Ola Bengtsson

School of Information Science, Computer and Electrical Engineering, Halmstad University, P O Box 823, Halmstad, Sweden



## 1 Introduction

This exercise deals with the so important Extended Kalman filter, in which you have non-linear measurement equations. These equations are first linearized (in the same way as the state equations are linearized when doing a error prediction) to keep the errors Gaussian. In this exercise you should use a simulator for a Khepera look-alike vehicle and use corners (in the environment) as landmarks, i.e. your map of the environment consists of the locations of corners. The vehicle is assumed to have a rotating range measuring device, which measures the distance to the landmarks, i.e. the distance from the robots position to the corners. (Hint: Follow the example given in Section 5 in the Crowley paper from 1995 'Mathematical Foundations of Navigation and Perception for an Autonomous Mobile Robot'.)

## 2 Run the simulator

Start with simple running the simulator (run the script 'khepera_simulator.m') and see if you can figure out what it does. The vehicle walks randomly and when it get close to a wall it simple rotates on the spot and then walks in then continues in the forward direction. The walk is done by setting the rotational velocities of the left and right wheel. During the simulation the correct path (black path - based on correct measurements of the wheel encoders) and the estimated path (blue path – based on erroneous encoder readings) are continuously updated and plotted in a graph (see Figure 1). Also seen is the observations (red lines – distances between the robots centre position and the landmarks) done by the rotating range measuring device. Once the simulation finish another graph shows the paths together with the estimated uncertainties (see Figure 2).

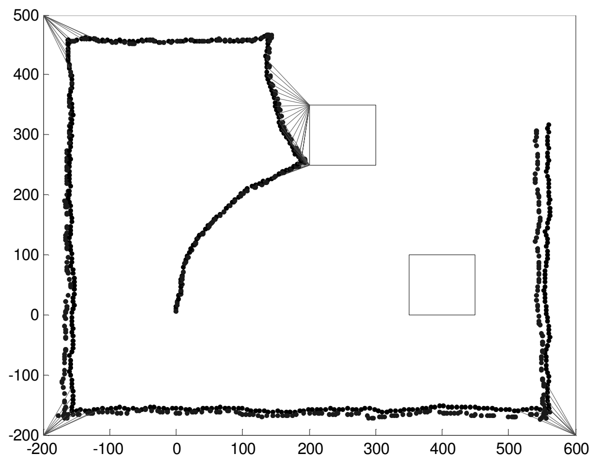


Figure 1: Simulation - Estimated path (blue dots), true path (black dots) and observations (red lines).

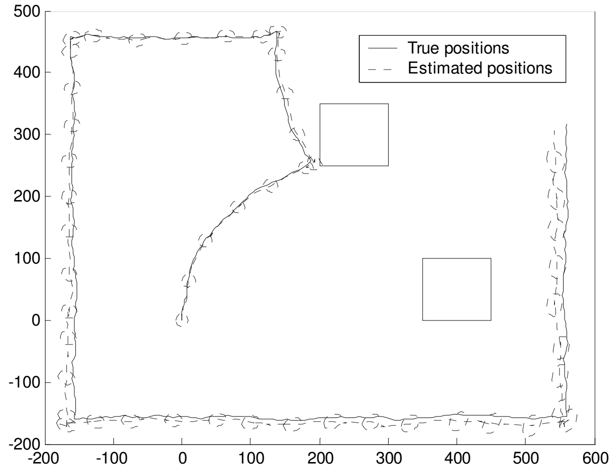


Figure 2: Estimated path, True path and estimated uncertainties.

## 3 Constrain the robots position (based on the observed landmarks (beacons))

Follow the example in Crowley paper and predict the beacon locations, calculate the innovations (difference between predicted beacon locations and observed one) and the Kalman Gains and update the vehicles estimate of its position. If you succeeded you should vary the information you get from the beacons, i.e. you could e.g. use the angle to the landmarks (i.e. instead of using the distance) or maybe both the angle and the distance to the landmark. You can also add noise to the sensor readings, i.e. add some noise to the length given by the measuring device.

## 4 Others

The reports (which are individual, although you are more than welcome to solve the exercises in smaller groups, e.g. by groups of two students) should contain all necessary equations with all assumptions motivated. You should also interpretive your results, i.e. handing in a plot without any explanations is not enough.