Location-Awareness: Fall 2016, Exercise: 3

Due on 23rd of November 2016 by 4:15pm (16:15)

Abstract

Instructions: All course participants are requested to submit their exercise solutions electronically to course instructors Farbod Faghihi (faghihib at cs.helsinki.fi) and Ella Peltonen (ella.peltonen at cs.helsinki.fi), and to the course lecturer (petteri.nurmi at cs.helsinki) by the due date (latest before the exercise session). In all the exercises, do not just give the answer, but also the derivation how you obtained it. Participants are encouraged to write computer programs to derive solutions to some of the given problems.

1 Location-Systems

a) What is beacon scan request and how it can be used for positioning?

b) What is the difference between a pseudorange and a range?

c) & d) Consider the errors of two location systems given in the file `https://www.cs.helsinki.fi/u/ptnurmi/teaching/LA16/positioningErrors.csv`. Create a CDF plot of the errors of both systems. Which system is more accurate on average? Which is more consistent?

2 GPS

Receiver	2884008	1341225	5509960
Satellite 1	160452	751500	7825491
Satellite 2	1874068	605150	6925491
Satellite 3	1822872	1385835	6811632
Satellite 4	3564658	1023739	6111277
Satellite 5	2298939	2257674	6224440

Table 1: ECEF coordinates for Exercise 2.

Index	**Weight**	**Distance**
1	0.05	3
2	0.17	3
3	0.03	2
4	0.16	2
5	0.1	2
6	0.19	3
7	0.01	2
8	0.08	1
9	0.02	3
10	0.19	2

Table 2: Particles for Exercise 3.

a) Given the position of five satellites and your current position ('Satellite' 1 through 5 and 'Receiver', respectively, in Table 3), derive the DOP matrix (i.e., 'A' in the lecture slides).

b) Using the above matrix, calculate the HDOP, VDOP, and PDOP values. Assume atmospheric errors have no influence on the estimates.

c) Which GPS component is least reliable? Are the location coordinates of GPS useful? Please justify your answer.

3 Particle Filter

Consider the particles given in Table 2. The weights correspond to the current likelihood of the particles. The distance column contains the movement in meters between the previous and new location of each particle.

a) Assume movement model is given by a Gaussian distribution $d \sim \mathcal{N}(0.5, 1.5)$. Derive new weights for the particles given the movement model.

b) Calculate the number of effective particles after the weights have been updated. Should we resample the particle distribution? Assume the threshold for resampling is $N_{eff} = 2$.

c) & d) Same as above, but use $d \sim \mathcal{N}(0.5, 0.5)$ as movement model. What are the new weights? What is the number of effective particles? Should we resample the particles given the threshold $N_{eff} = 2$?

4 Kalman Filter (2pts)

Consider the file given in `https://www.cs.helsinki.fi/u/ptnurmi/teaching/LA16/noisyCompass.csv`. The file contains compass (3D magnetometer) measurements collected over time by having the measurement device in a consistent orientation.

Implement a Kalman filter for tracking the heading (i.e., compass value) of the user using these measurements.

Either derive suitable noise parameters on your own, or use the default values given below.

$$\sigma = 1.25 * 10^{-4} \tag{1}$$

$$Q = \sigma \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{2}$$

$$A = H = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{3}$$

$$R = 0.15 \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{4}$$