ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institute for Dynamic Systems and Control
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Institut für Dynamische Systeme und Regelungstechnik

151-0566-00 **Introduction to Recursive Filtering and Estimation** (Spring 2010)

Programming Exercise #2 Topic: Particle Filter

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Particle Filter for Tracking an Object Moving on a Circle

A particle filter is to be designed for tracking the position of an object B that is randomly moving on a circle with radius 1. The distance to the object can be measured from a given observation point P at location $x = L$. A schematic drawing is shown in Fig. 1.

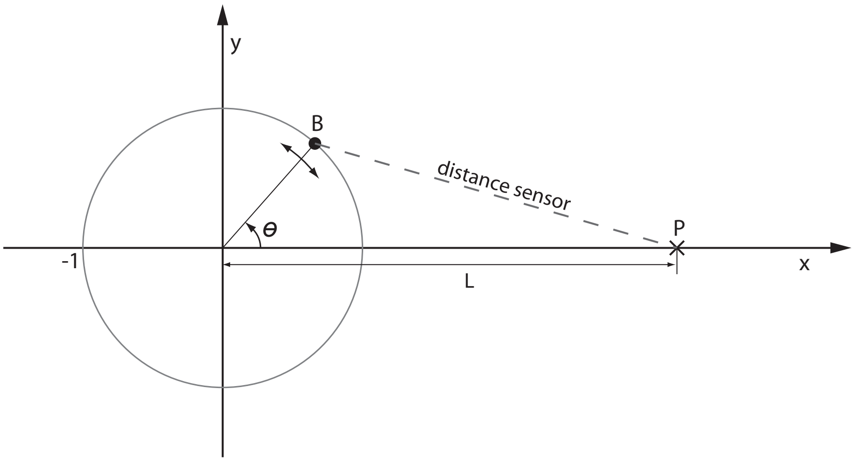

Figure 1: The moving object with relevant physical quantities.

At time k, the location of the object on the circle is given by $\theta(k) \in [0, 2\pi)$. The random motion of the object is described by

$$\theta(k) = \mod\left(\theta(k-1) + s(k-1) + p\,,\, 2\pi\right), \qquad k = 1, 2, \ldots,$$

where $s(k) \in [-\bar{s}, \bar{s}]$ is a uniformly distributed random variable, and the constant unknown bias p is uniformly distributed on the interval $[-\bar{s}, \bar{s}]$.
At varying instances of time, measurements of the distance sensor may be received that are corrupted by sensor noise, i.e.

$$z_1(k) = \left((L - \cos\theta(k))^2 + (\sin\theta(k))^2\right)^{\frac{1}{2}} + w(k)\,,$$

with $w(k) \in [-e, e]$ uniformly distributed. An additional half-plane sensor occasionally provides information about the vertical position of the object,

$$z_2(k) = \begin{cases} 1 & \text{if } \theta(k) \in [0, \pi) \\ -1 & \text{if } \theta(k) \in [\pi, 2\pi)\,. \end{cases}$$

At any instance of time k, measurements may be available from one, two, or none of the sensors. All random variables $s(k)$, p, and $w(k)$ are assumed to be mutually independent and independent over time.

Objective

The objective is to design a particle filter to estimate the object's location on the circle. The estimator has access to the time k, and possibly the measurements $z_1(k)$ and/or $z_2(k)$. Furthermore, the total number N of particles in the filter and the values of all physical constants L, $\overline{s}$, and e are known to the estimator. The angle $\theta(k)$ and the bias p are estimator states.

Provided Matlab Files

A set of Matlab files is provided on the class website. Please use them for solving the above problem.

`script.m`	Matlab script that is used to simulate the truth system, run the estimator, and display the results.
`Estimator.m`	Matlab function template to be used for your implementation of the particle filter.
`PhysicalConstants.m`	Physical constants, known to the estimator.
`SimulationConstants.m`	Sample problem data, **not** known to the estimator.
`Uniform.m`, `UniformMinMax.m`	Uniform random number generators.

Task

Implement your solution for the particle filter in the file `Estimator.m`. Your code has to run with the Matlab script `script.m` and problem data as for example given in `PhysicalConstants.m` and `SimulationConstants.m`. For your estimator, use the function definition as given in the template `Estimator.m`.
For evaluating your solution, we will test it on the given problem data. Moreover, we will do suitable modifications of the parameters in `PhysicalConstants.m` and `SimulationConstants.m` and also test your estimator on those.

Deliverables

Please hand in by e-mail your implementation of the particle filter in `Estimator.m`. Include the file into a `zip`-file, which you name `RFE10Ex2_Names.zip`, where *Names* is a list of the **pre- and surnames** of all students[1] who have worked on the solution (for example `RFE10Ex2_AngelaSchoellig_SebastianTrimpe.zip`).

Send your file to Angela (`aschoellig@ethz.ch`) until the due date indicated above. We will send a confirmation e-mail upon receiving your solution. You are ultimately responsible that we receive your solution in time.

[1] Up to three students are allowed to work together on the programming exercise. They will all receive the same grade.