Homework 3

Introduction to Robotics
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1. An ultrasound sensor measures distance $x = c\Delta t/2$. Here, c is the speed of sound and Δt is the difference in time between emitting and receiving a signal. Let the variance of your time measurement Δt be σ_t^2. What can you say about x, when c is assumed to be constant? Hint: how does a change in Δt affect x?

2. Consider a unicycle that turns with angular velocity $\dot{\phi}$ and has radius r. Its speed is thus a function of $\dot{\phi}$ and r and is given by

$$v = f(\dot{\phi}, r) = r\dot{\phi}$$

   Assume that your measurement of $\dot{\phi}$ is noisy and has a standard deviation σ_ϕ. Use the error propagation law to calculate the resulting variance of your speed estimate σ_v^2.

3. Assume that the ceiling is equipped with infra-red markers that the robot can identify with some certainty. Your task is to develop a probabilistic localization scheme, and you would like to calculate the probability $p(marker|reading)$ to be close to a certain marker given a certain sensing reading and information about how the robot has moved.

   (a) Derive an expression for $p(marker|reading)$ assuming that you have an estimate of the probability to correctly identify a marker $p(reading|marker)$ and the probability $p(marker)$ of being underneath a specific marker.

   (b) Now assume that the likelihood that you are reading a marker correctly is 90%, that you get a wrong reading is 10%, and that you do not see a marker when passing right underneath it is 20%. Consider a narrow corridor that is equipped with 4 markers. You know with certainty that you started from the entry closests to marker 1 and move right in a straight line. The first reading

you get is “ Marker 3”. Calculate the probability to be indeed underneath marker 3.

(c) Could the robot also possibly be underneath marker 4?