

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
CS440/ECE448 Artificial Intelligence
Practice Exam 3
Spring 2023

Exam 3 will be May 9, 2023

Your Name: _____

Your NetID: _____

Instructions

- Please write your name and NetID on the top of every page.
- This will be a **CLOSED BOOK** exam. You will be permitted to bring three 8.5x11 page of handwritten notes (front & back).
- Calculators are not permitted. You need not simplify explicit numerical expressions.

1. (10 points) Captain Marble is flying over a thick cloud bank. Her estimated velocity is v m/s northward, with a standard deviation of p m/s. Once per second, she uses her x-ray vision to scan the ground below, and recognizes landmarks that specify her latitude, x , with a standard deviation of e meters. Based on all observations up through time t , her estimated latitude at time t is y meters north of the equator, with a standard deviation of s meters. At time $t + 1$ she is about to make another observation, but just then she wonders: what are the expected value and standard deviation of her position at time $t + 1$, on the basis of only the measurements up through and including time t ?

Solution: The expected value is $y + v$, with a standard deviation of $\sqrt{s^2 + p^2}$.

2. (10 points) Leira the merman is swimming eastward from Honolulu at a somewhat variable velocity: his velocity averages a m/s, but with a standard deviation of b m/s. Once every second, he checks his location using sonar. Based on all of his observations up through time $t - 1$, he believes that his longitude at time t is c meters east of Honolulu, with an uncertainty (standard deviation) of d meters. Since he's not sure, he takes another sonar measurement at time t ; his sonar reading says that he is e meters east of Honolulu, but he knows that his measurements sometimes have errors. The measurement errors are unbiased, but have a measurement uncertainty (standard deviation) of f meters. Based on all of his observations up through and including the observation at time t , what are the expected value and standard deviation of his longitude relative to Honolulu?

Solution: The Kalman gain is $k = d^2 / (d^2 + f^2)$. The expected value of his position at time t , given all observations up through and including time t , is $(1 - k)c + ke$, with a standard deviation of $d\sqrt{1 - k}$.