

ECE183DA (Winter 2021)

Design of Robotic Systems I

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Problem set 6: Bayesian filtering and POMDPs Due 3pm PST Wednesday Feb. 24, 2021

Key takeaways

After this lecture, you should understand:

- The mathematical formulation of the state estimation problem as an input-output system;
- How to make use of principles of probability (i.e. Bayes theorem etc.) along with principles of systems (i.e. Markov property) to derive exact and approximate algorithmic implementations of a state estimator; and
- Several ways in which we can connect a state estimator to a planner to allow for planning under uncertainty.

Assignment

- 6(a). What is the mathematical input (action) space of the state estimator system?
- 6(b). Describe in two or three English sentences a comparison of the following two options, with respect to the computational cost needed for a single (one time-step) update of its belief state:
- Bayes Filter, vs.
 - particle filter starting with one particle per state.
- 6(c). Write out a defining (non-recursive) equation for the optimal value function V^* for a POMDP problem that uses the belief state to define the system. (You don't need to solve this equation.) What is the functional form of a stochastic policy π on that belief state POMDP?
- 6(d). *Optional.* Based on an optimal policy π^* for a fully observable MDP, write out a mathematical expression (not coded implementation) for the following two policies on a POMDP of the corresponding system (with noisy observations):
- A stochastic policy with a probability distribution over actions illustrated by the following pseudocode:
 - 1: Set the state of a hypothetical robot according to (drawn from) the belief state probability distribution,
 - 2: Have that robot execute the optimal policy π^* ,
 - 3: Collect all such robots and compute the overall probability distribution over actions.
 - A deterministic policy that chooses the most likely action from the above stochastic policy.
- 6(e). Would you be willing to let us use your correct responses as (anonymized) examples for the class?