ECE183DA (Winter 2022)

Design of Robotic Systems I

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Problem set 6 | Bayesian filtering and POMDPs

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?