

COL864: Homework I

1 Description

- This problem concerns tracking an agent (an underwater vehicle) exploring a lake. The robot is submerged at a particular depth and not visible on the surface. Our goal is to estimate the agent's movement via an immersed acoustic receiver in the lake.
- We assume a discrete world and discretize the lake as a 2D grid of 5×5 grid. The robot can take 4 discrete actions of moving forward, backwards, left or right to an adjacent grid locations and these movements are equally likely within the grid.
- As the agent moves around in the lake it may encounter rocks emitting a bump sound. Further, the agent emits sound from its rotors that is heard by the receiver.
- The receiver can distinguish the two types of sounds (bump or rotor) and records the presence or absence of these sounds at each time instant. The likelihood of measuring the presence or absence of the rotor or bump sounds at each time step is stochastic and depends on local conditions in the lake.
- The spatial likelihood of hearing (observing) a bump sound or a rotor sound at each time step is represented as Figure 1. The likelihood of hearing the two types of sounds can be considered independent.

2 Questions

1. Write down the probabilistic graphical model for the problem identifying the state space, the observation space, the transition model and

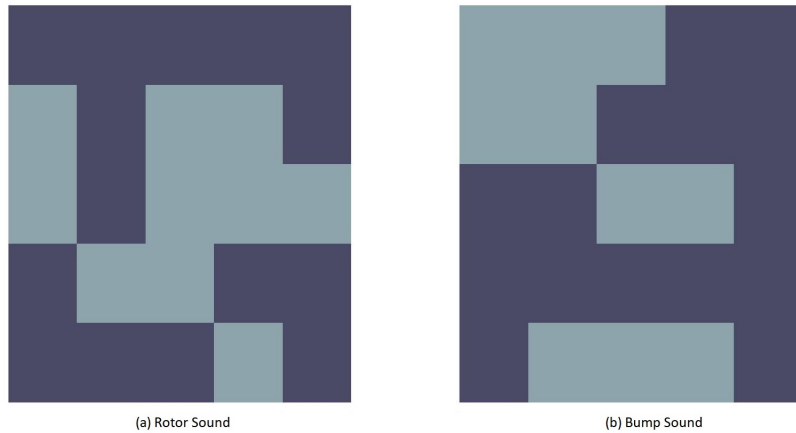


Figure 1: The spatial likelihood of hearing the presence or absence of a rotor sound (left) or a bump sound (right) over the 5×5 grid. The light squares represent probability 0.9 and dark square represents 0.1.

the observation model. Draw the graphical model for the problem and list the conditional independence assumptions implied in the model. Write down the joint distribution of the model and the specific inference tasks addressed in this problem. Simulate the agent moving in the 5×5 grid and generating the “*bump*”, “*no bump*” and “*rotor*” or “*no rotor*” sound observations at each time step. Record the simulated observations (the presence or absence of rotor and bump sounds) over 10 time steps.

2. Implement the filtering task of estimating the current position given the sequence of observations generated by the simulation above. Visualize and plot the estimated log-likelihood over the grid locations at each time step. Plot the most likely location against the ground truth.
3. Plot the above with only a single modality (say bump observations). Compute the predictive distribution over the agent’s future location given all the evidence till now. Plot the likelihood over the next 5 time steps.
4. Implement the smoothing task of estimating the agent’s past locations given the evidence up to the present time step. Plot the estimated location and the ground truth locations at each time step. This part

extends class discussion. Determine the agent's most likely path given the observation sequence. Please refer to Chapter 15 in the textbook *Artificial Intelligence: A Modern Approach*.

5. Increase the lake size to 25×25 and show the result for part 2. You can pick a random spatial distribution for the observation likelihood. Estimate the error between actual path and most likely path using a Manhattan distance metric. How does the computation scale with the size of the state space?

3 Submission Guidelines

- Please implement the solution in Python. Please submit the implementation alongside in a .zip file in the format {EntryNumber}.zip. Please ensure the reproduction (modulo probabilistic execution) of graphs while running your code. Submission will be setup on Moodle.
- Please submit a single report containing responses to the questions and the desired plots/graphs. For a graph/result please write a few lines describing the result.
- Please do not use an existing model implementations. The assignment is to be done individually and the code implementation must come from individual efforts.