National University of Singapore
School of Computing

Semester 2, AY2023-24

CS4246/CS5446 AI Planning and Decision Making

Due: 1 April 2024 @ 11:59 pm

Assignment 2

Instructions

- This assignment requires multiple submissions.
  - Submit the PDF file containing your solutions to this assignment on Canvas.
  - You can use this Overleaf project to write your solutions.
  - Submit the zip containing your code on AiRENA portal for grading.
  - Submit the zip file containing your code to this assignment on Canvas.
- You have only one attempt on Canvas.
- You are required to specify your group details in your attempt (group number can be found on Canvas) by updating the `team.tex` file with the relevant details.
- **Total marks: 20; Weightage 10% of final marks**
- On collaboration:
  - The goal of the assignment is to understand and apply the concepts in the class.
  - You may discuss the assignment with other groups via the discussion forum.
  - It is OK for the solution ideas to arise out of such discussions. However, it is considered plagiarism if the solution submitted is highly similar to other submissions or to other sources.
- Citing help and reference
  - At the end of the assignment, clearly cite the sources you referred to when arriving at the answer (Books, External notes, Generative AI tools, etc.,).

Team members

Group number:
Member 1 details:
- Name:
- NUSNet id:
- Student number:

Member 2 details:
- Name:
- NUSNet id:
- Student number:

1 Decision Analysis

[8 marks]

Curious, a little girl, has just found a delicious-looking cake in the fridge. She is concerned that the cake contains Durian, which she really dislikes but she still wants to eat the cake.

If she eats the cake and it contains Durian, she will receive a utility of -100 and if the cake doesn't contain Durian she will receive a utility of 10. If she doesn't eat the cake she will get 0 utility. Being orange in color, there is a probability of 0.1 that the cake contains Durian.

1. (2 marks) Should Curious eat the cake? Why or why not?

Curious can now smell the cake to judge whether it contains Durian before she eats it. However, since she has a stuffy nose and cannot smell well, she will incorrectly identify Durian when there is No Durian with probability 0.2 and will incorrectly identify No Durian when there is Durian with probability 0.3.

2. Represent Curious' decision problem by

   (a) (3 marks) drawing a decision network and

   (b) (3 marks) drawing a decision tree,

   using the following variables: E is her choice to eat, U is her utility earned, D is whether the cake contains Durian, and S is her attempt at smelling. Show all the known details. You can use lower-case letters to represent probabilities that are unknown.

2 MDP

[6 marks]

Jarvis Rover powered by AI planning and decision making deployed on Mars. There are three buttons: $1, 2, 3$ on Jarvis that can be activated, one at a time, to automatically send Jarvis to each of the three bases on Mars: A, B, C to gather rock samples. Jarvis receives 1 unit of power from base C, and none from any other bases. As the technology is new, the effects of activating the buttons can sometimes be uncertain. In particular, the following patterns are observed:

- At Base A:
  - Button 1: 0.2 probability of no-effect, and 0.8 probability of getting to base B
  - Button 2: 0.2 probability of no-effect, and 0.8 probability of getting to base C
- At base B
  - Button 2: 0.2 probability of no-effect, and 0.8 probability of getting to base C
  - Button 3: 0.2 probability of no-effect, and 0.8 probability of getting to base A
- At base C
  - Button 1: 0.5 probability of getting back to base C, and 0.5 probability of getting to base A
  - Button 3: Always getting to base B

Jarvis needs to decide on the right button to activate at each base, so that it can maximize the power units it receives to work as long as possible on Mars. Assume that it will always get the power unit as long as it gets to base C, regardless of its previous base.

Note: In questions 1) and 2) below, use only the information given in the description. Do not assume or add any new information.

1. (2 marks) Write the state space, action space and the reward function to model Jarvis' decision problem as a Markov Decision Process(MDP)

2. (2 marks) Write the transition function for Jarvis using $T(s, a, s')$ to represent the transition probability of going to state s' when action a is taken in state s.

3. (2 marks) Consider the case when a new rover, Friday, is deployed to join Jarvis on the same mission. Assume that both Jarvis and Friday are made in exactly the same way, with the same button effects. They operate independently (i.e., do not interfere with each other). Can the MDP as defined above, be modified or adjusted to accommodate the new decision problem with two agents? If so, explain how you would do it. If not, explain why not.

3 Programming component

[6 marks]

In this programming assignment, we will use a modified form of the elevator domain from the International Planning Competition, 2023.

The Elevator domain models evening rush hours when people from different floors in a building want to go down to the ground floor using elevators. Potential passengers arrive at a floor according to the Poisson process, with specific rates that can be different across different floors. An elevator can move upwards to pick up passengers; once it opens its door to let people in, it can only move down towards the ground floor, though the elevator can stop at intermediate floors to pick up more passengers.

Per each person in an elevator, there is a small penalty in rewards. Additionally, there is a penalty for each person waiting for an elevator. When an elevator delivers a passenger to their destination, a large positive reward is given per person. So, a good policy should be able to minimize the penalties while maximizing the positive rewards by delivering many people so that they can go back home!

Handout and task

- Use the `assignment2_handout.zip` file on Canvas to attempt the programming assignment.
- The `README.md` file has additional details about the environment.
- Your task is to complete the `solve_value_iteration` function that implements the Value Iteration algorithm in the `agent/agent.py` file. (It is marked with `FILL_ME`)

Submission

- Please write both the team member names and student numbers (Axxxxxxx) at the top of the agent file (as comments) to help us identify your submissions.
- **Zip the `agent.py` file alone and submit this zip file.**
- Submissions for the programming part will happen on the AiRENA portal for grading.
- You are **also required** to submit the zip file on Canvas for record-keeping/backup purposes.
- Please refer to the user guide (`AiRENA Guide for CSxx46.pdf` file on Canvas) for submission instructions.
  - **Please ensure you follow the instructions provided to create your account.**
  - **If the account details don't match your information on Canvas, such submissions will not be graded.**
- You need to use the following token to join the course:
  59d74e53-9b5e-4643-ab75-404b2c7d4bdb

Grading

- We will evaluate your implementation using three private test cases, and take the average of the score obtained.
- To obtain full 6 marks for this part, you need to attain an average score of -300 and above.

Support

- We have prepared a Google collab file for you to play around and understand the elevator domain.
- If you have questions about the assignment, please ask on the discussion forums.

References

Use this file to declare your reference sources.