National University of Singapore
School of Computing

Semester 2, AY2023-24

CS4246/CS5446 AI Planning and Decision Making

Due: 23 Feb 2024 @ 11:59 pm

Assignment 1

Instructions

- Submission instructions:
  - Submit the PDF file containing your solutions to this assignment on Canvas.
  - You can use this Overleaf project to write your solutions.
- 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 Classical Planning

[10 marks] The original STRIPS planner was designed to control Shakey the robot. Figure 1 shows a version of Shakey's world consisting of four rooms lined up along a corridor, where each room has a door and a light switch. The actions in Shakey's world include moving from place to place, pushing movable objects (such as boxes), climbing onto and down from rigid objects (such as boxes), and turning light switches on and off. Shakey's six actions are the following:

- $Go(from, to, r)$, which requires that Shakey be At $from$ and that $from$ and to are locations in the same room r. By convention a door between two rooms is in both of them.
- Push a box b from location x to location y within the same room: $Push(b, x, y, r)$. You will need the predicate Box and constants for the boxes.
- Climb onto a box from position x: $ClimbUp(b, x)$; climb down from a box to position x: $ClimbDown(b, x)$. We will need the predicate On and the constant Floor.
- Turn a light switch on or off: $TurnOn(s, b)$; $TurnOff(s, b)$. To turn a light on or off, Shakey must be on top of a box at the light switch's location.

Shakey can only move within a room or push object to a location accurately when the light is on in that particular room. Initially, the only rooms that have the light on are room 1 and room 3 (ignore the position of the switch in the schematics). Corridor's light is always on. Assume the (horizontal) location of the switch in a room can be treated the same as the location of the door of the same room.

1. Define all the predicates you will use in your solution using functional form e.g., $Door(d)$ established d is door; $At(r, x) \wedge Robot(r) \wedge Location(x)$ establishes that robot r is at location x.
   Note:
   - This item is not directly marked; however, missing this will result in reducing the marks of the other questions due to undefined predicates.
   - After you have defined the predicates here, you don't need to specify the predicates in the action schema the way we did in the air-cargo problem.
2. (6 marks) Write PDDL sentences for Shakey's six actions.
3. (2 marks) Assume Figure 1 represents Shakey's initial state. Write the initial state in PDDL format.
4. (2 marks) Construct a plan for Shakey to get Box_2 to location P in $Room_2$.

   NOTE:
   1. You are required to write the PDDL statements as described in the lecture notes. Writing a PDDL program (or in program syntax) will not receive any marks.
   2. Negative preconditions and contitional effects are NOT allowed.

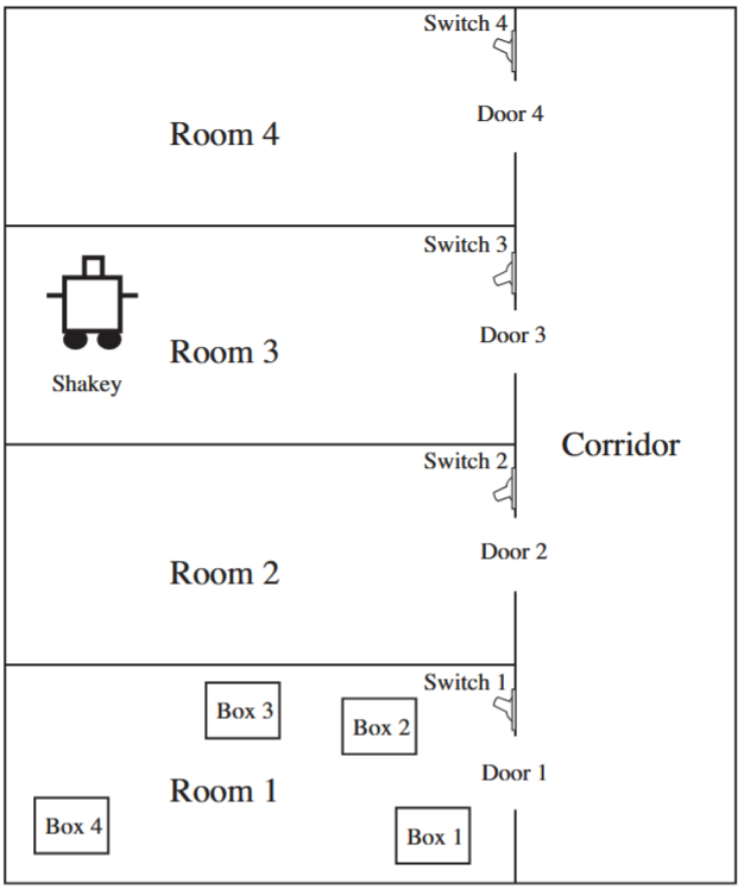

Figure 1: Shakey's world. Shakey can move between landmarks within a room, can pass through the door between rooms, can climb climbable objects and push pushable objects, and can flip light switches.

2 Hierarchical Planning

[6 marks] Consider modeling the Shakey's problem (from Question 1) using HTN. Assume the same primitive actions are available as in Question 1. Define high level actions for the following:

1. (2 marks) Moving the robot from one room to another.
2. (2 marks) Switching on/off the light.
3. (2 marks) Pushing an object from one room to another.

For each HLA, specify the refinement(s) and the execution order clearly using primitive actions from Question 1.
You are not required to write the precondition-effect schemas for the HLA.

3 Decision Theory

[4 marks] Tickets to a lottery cost \$1. There are two possible prizes: a \$12 payoff with probability $\frac{1}{25}$, and a \$1,200,000 payoff with probability $\frac{1}{3{,}000{,}000}$; you get zero payoff otherwise.

1. (1 mark) What is the expected monetary value of a lottery ticket?

2. (3 marks) When (if ever) is it rational to buy a ticket? Be precise; show an equation involving utilities. You may assume current wealth of $\$k$ and that $U(S_k) = 0$. You may also assume that $U(S_{k+12}) = 12 \times U(S_{k+1})$, but you may not make any assumptions about $U(S_{k+1{,}200{,}000})$.

References

[Optional] Use this file to declare your reference sources.