CS 4710 - Artificial Intelligence
Homework 2: Search, Knowledge-based Agent

Due: **2/28/2024** 23:59PM

Instructions
1. Please choose your favorite way to finish the homework. If you decide to use handwriting, make sure it is clear enough for reading and grading. For the coding part, you can use Google Colab or your own Jupyter Notebook instance, make sure your submissions have all the required code filled in.
2. Please make sure your submission is in PDF and .ipynb format.
3. A penalty will be applied for late submissions. Please refer to the first lecture for more information.

Questions
1. [60%] Implement the search algorithms: *breath-first search*, *depth-first search*, and *A* search*. You can find the details in this notebook (also in the attached .ipynb file): https://colab.research.google.com/drive/1oSxODEGJhFefrsde5AwBQf_4CAayhqKS Before you start implementing your functions, please make a copy of this notebook so you can edit it. There are two ways to do it:
   a. In Colab, select "File > Save a copy in Drive" – this will save a copy of the notebook to your Google Drive where you have the edit permission.
   b. Upload the attached .ipynb file to any Jupyter notebook you like.
   Once you finish it, please download the .ipynb file and submit it along with your PDF (for the next two questions) to Canvas.

   Here are the cells/functions you need to write. We will grade them using new test cases.
   - [1%] Your compute ID & name (the first cell)
   - [10%] breadth_first_search(start_state, goal_state, successors_f)
   - [10%] depth_first_search(start_state, goal_state, successors_f)
   - [15%] Astar_search(start_state, actions_f, take_action_f, goal_test_f, h_f)
   - [4%] actions_8p(state)
   - [4%] take_action_8p(state, action)
   - [6%] h_8p(state, goal)

2. [15%] Suppose an agent is in a modified wumpus world where there are several pits, one gold brick, and one wumpus. An example of such world is like the one shown here:
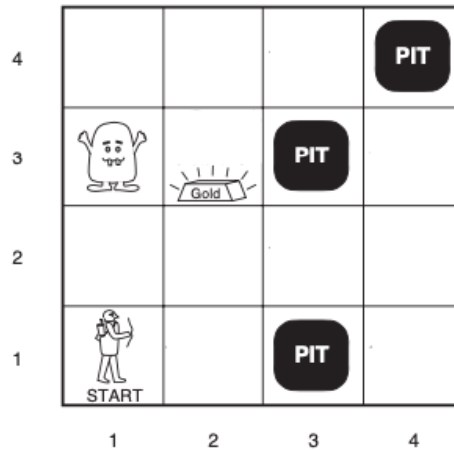
The agent can face one of the four directions: North (N), South (S), East (E), and West (W). The agent cannot go to the square that has a pit. The agent is walking at an adjustable velocity v. At each time step, the agent chooses one of the following actions to take: *move faster, move slower, turn left, turn right*.

- *Move faster*: This increases the agent's velocity by 1 and then moves the number of squares equal to this new adjusted velocity.
- *Move slower*: This decreases the agent's velocity by 1 and then moves the number of squares equal to this new adjusted velocity.
- *Turn left*: This changes the agent's direction by 90 degrees left. The agent can only turn at $v = 0$.
- *Turn right*: This changes the agent's direction by 90 degrees right. The agent can only turn at $v = 0$.

The agent will keep velocity v between 0 and V_{max}. The agent's goal is to find a plan that leads to the gold brick so the agent can use the gold brick to kill the wumpus later. We want to use as few actions, i.e., time steps, as possible. A $t=0$, the agent is at position (1, 1) facing east with velocity $v=0$.

(1) [4%] If the grid size is M x N, what is the size of the state space? Justify your answer. You can assume that the agent can reach any square that doesn't have a pit.
(2) [5%] Is the Manhattan distance from the position of the agent position to the position of the gold brick admissible? Explain why or why not.
(3) [6%] Design an admissible heuristic for this modified wumpus world that is not the Manhattan distance to the gold brick. Justify your design, if you design it based on a relaxation, please describe the relaxation of the problem.

3. [25%] Suppose an agent has progressed to the point shown in Figure 7.4(b), page 239, having perceived nothing in [1,1], a breeze in [2,1], a stench in [1,2], nothing in [2,2], and a breeze & stench in [2,3] (ignore the glitter percept). In this game, there is only one wumpus. The agent is now concerned with the contents of [1,3], [3,3], and [2,4].

(1) [16%] Construct a knowledge base (in truth-table format) showing the set of possible worlds (there should be 32 truth tables).

(2) [9%] For each of the following, mark the worlds in which the sentence is true:
   (a) There is a wumpus in [1,3].
   (b) There are no locations with both a pit and a wumpus.
   (c) (a) and (b) are true.

1,4	2,4	3,4	4,4
1,3 W!	2,3	3,3	4,3
1,2 A S OK	2,2 OK	3,2	4,2
1,1 V OK	2,1 B V OK	3,1 P!	4,1

A = Agent
B = Breeze
G = Glitter, Gold
OK = Safe square
P = Pit
S = Stench
V = Visited
W = Wumpus

1,4	2,4 P?	3,4	4,4
1,3 W!	2,3 A S G B	3,3 P?	4,3
1,2 S V OK	2,2 V OK	3,2	4,2
1,1 V OK	2,1 B V OK	3,1 P!	4,1

(a)   (b)

Figure 7.4   Two later stages in the progress of the agent.   (a) After the third move, with percept [*Stench, None, None, None, None*].   (b) After the fifth move, with percept [*Stench, Breeze, Glitter, None, None*].