CSCE 580: Artificial Intelligence
Written Homework 1: Agents and Pathfinding
Due: 1/24/2024 at 11:58pm

You may either type your homework or upload a scanned copy of your written homework. However, your answers must be legible. **Answers that are not legible will be marked as incorrect.** Turn in **PDF** (not Word or any other format) of your answers to Blackboard.

1 Agents (10 pts)

List and **describe** the four components necessary to define a task environment? Remember the PEAS acronym.

Performance Measure – What is being measured in the task environment?
Environment – What do we already know about the task environment? What could happen in the task environment?
Actuators – What actions can be performed?
Sensors – How does the agent see the environment?

2 Environments (20 pts)

Imagine there is an artificially intelligent soccer playing robot playing the game of soccer in the real world. Choose the following characteristics for the environment and justify your answers.

2.1 (5 pts)

Discrete or continuous?

It is continuous because there can be an infinite number of actions based on the state of the soccer field (where the ball & players are located).

2.2 (5 pts)

Sequential or episodic?

It is sequential because each action taken has an effect on what the next action to take should be.

2.3 (5 pts)

Static or dynamic?

It is dynamic because if the agent isn't moving, the other players can still move around.

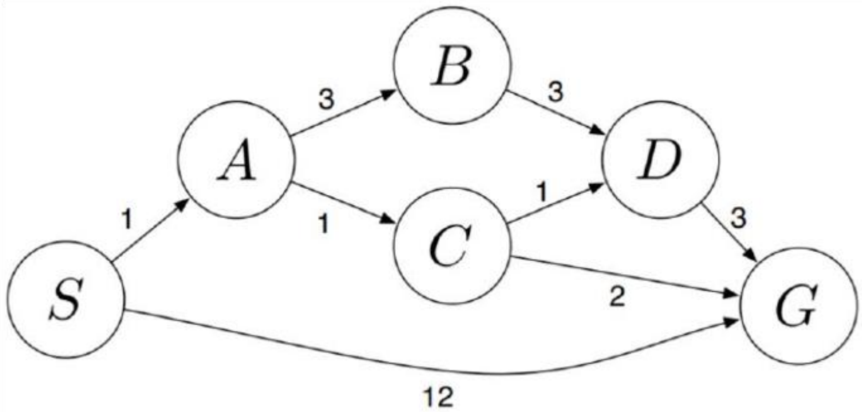
2.4 (5 pts)

Single agent or multi-agent?

It is multi-agent since there are multiple players on the board all taking their own actions.

3 A* Search (40 pts)

S is the start state and G is the goal state.



State n	S	A	B	C	D	G
h1(n)	4	3	6	2	3	0
h2(n)	4	2	5	2	2	0

3.1 (4 pts)

Does h1 dominate h2? Justify your answer.

H1 dominates h2 since all of its n values are greater than or equal to h2's.

3.2 (4 pts)

Is h1 admissible? Justify your answer.

H1 is admissible because it is able to find the shortest path in A*.

3.3 (4 pts)

Is h1 consistent? Justify your answer.

H1 is consistent. The heuristic values all don't overestimate.

3.4 (4 pts)

Is h2 admissible? Justify your answer.

H2 is admissible because it is able to find the shortest path in A*.

3.5 (4 pts)

Is h2 consistent? Justify your answer.

H2 is consistent. The heuristic values all don't overestimate.

3.6 (10 pts)

Give the order of node expansions when doing A* search (with reached/CLOSED) when using h1.

CLOSED	OPEN	Expanded
S:0	S:4	S
S:0, A:1, G:12	A:4, G:12	A
S:0, A:1, B:4, C:2, G:12	B:10, C:4, G:12	C
S:0, A:1, B:4, C:2, D:3, G:4	B:10, D:6, G:4	(G)

3.7 (10 pts)

Give the order of node expansions when doing A* search (with reached/CLOSED) when using h2.

CLOSED	OPEN	Expanded
S:0	S:4	S
S:0, A:1, G:12	A:3, G:12	A
S:0, A:1, B:4, C:2, G:12	G:12, B:9, C:4	C
S:0, A:1, B:4, C:2, G:4, D:3	G:12, B:9, D:5, G:4	(G)

4 Uninformed and Informed Search Concepts (30 pts)

4.1 Breadth-First Search (6 pts)

Suppose you are trying to solve the 8-puzzle and the transition cost of every action is 1. Will breadth-first search be guaranteed to find a shortest path? Justify your answer.

Yes. BFS will look at all options level by level until it finds the shortest path.

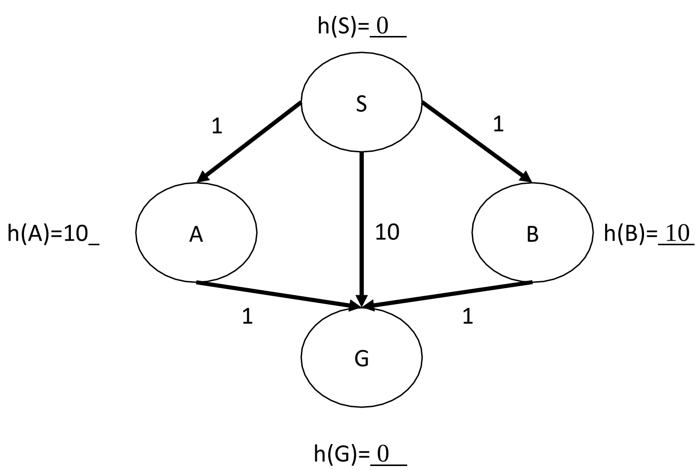
4.2 Iterative Deepening Search (9 pts)

For the same 8-puzzle task, will iterative deepening search be guaranteed to find a shortest path? How will breadth-first search and iterative deepening search differ in terms of time and memory usage? Justify your answers.

IDS will also find the shortest path in this 8-puzzle task. IDS has better memory usage, therefore more memory efficient. They both have the same time complexity.

4.3 A* Search (12 pts)

Consider the following state-space graph with starting state S and goal state G. Write an assignment to the heuristic values of each state so that A* search will **NOT** find a shortest path from S to G.



4.4 Priorities of Search Methods (3 pts)

In terms of the path cost of a node *n*, *g*(*n*), and the heuristic value of a node *n*, *h*(*n*), describe how the following search methods prioritize nodes:

Uniform cost search: Only considers g(n). Chooses the lowest g(n).

Greedy best-first search: Only considers h(n). Uses heuristic.

A* search: Combines g(n) and h(n). f(n) = g(n) + h(n)

5 Extra Credit: Admissibility Proof (10 pts)

If the heuristic function is admissible and if A* search has not terminated, then, for any shortest path P, from the start node, s, to the closest goal node, there exists a node n^j on path P in OPEN with a cost $f(n^j) \leq h_*(s)$. Given this information, prove that an admissible heuristic function guarantees that A* search will find a shortest path. Remember, an admissible heuristic function h satisfies $h(n) \leq h_*(n)$ for all nodes n, where $h_*(n)$ is the cost of a shortest path from node n.

Hint: This can be done using proof by contradiction.
All of your work must be your own.

Proof by condradiction:

Assume false (meaning there exists a shortest path P from the start node s to the closest goal node and for every node n^j on path P in OPEN the cost is greater than h*(s)).

Consider the node n* on path P in OPEN with the minimum f(n*) among all nodes on path P in OPEN.

Let g*(n) be the true cost of the shortest path from s to n. h is admissible, so h(n) <= h*(n) for all nodes n.

F(n*) = g(n*) + h(n*)
G(n*) + h(n*)
G*(n*) + h(n*) <= g*(n*) + h*(n*)
F(n*) <= h*(n*)

This contradicts that f(n*) is greater than h*(s).

Therefore, an admissible heuristic function guarantees that A* search will find the shortest path.