CS 188 Spring 2019 | Introduction to Artificial Intelligence | Written HW 1

Due: Monday 2/4/2019 at 11:59pm (submit via Gradescope).

Leave self assessment boxes blank for this due date.

Self assessment due: Monday 2/11/2018 at 11:59pm (submit via Gradescope)

For the self assessment, **fill in the self assessment boxes in your original submission** (you can download a PDF copy of your submission from Gradescope). For each subpart where your original answer was correct, write "correct." Otherwise, write and explain the correct answer.

Policy: Can be solved in groups (acknowledge collaborators) but must be written up individually

Submission: Your submission should be a PDF that matches this template. Each page of the PDF should align with the corresponding page of the template (page 1 has name/collaborators, question 1 begins on page 2, etc.). **Do not reorder, split, combine, or add extra pages.** The intention is that you print out the template, write on the page in pen/pencil, and then scan or take pictures of the pages to make your submission. You may also fill out this template digitally (e.g. using a tablet.)

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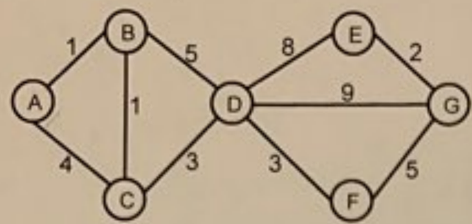
Collaborators	

Q1. Search



Node	h_1	h_2
A	9.5	10
B	9	12
C	8	10
D	7	8
E	1.5	1
F	4	4.5
G	0	0

Consider the state space graph shown above. A is the start state and G is the goal state. The costs for each edge are shown on the graph. Each edge can be traversed in both directions. Note that the heuristic h_1 is consistent but the heuristic h_2 is not consistent.

(a) Possible paths returned

For each of the following graph search strategies (*do not answer for tree search*), mark which, if any, of the listed paths it could return. Note that for some search strategies the specific path returned might depend on tie-breaking behavior. In any such cases, make sure to mark *all* paths that could be returned under some tie-breaking scheme.

Correct

Search Algorithm	A-B-D-G	A-C-D-G	A-B-C-D-F-G
Depth first search	O	O	O
Breadth first search	O	O	
Uniform cost search			O
A* search with heuristic h_1			O
A* search with heuristic h_2			O

(b) Heuristic function properties

Suppose you are completing the new heuristic function h_3 shown below. All the values are fixed except $h_3(B)$.

Node	A	B	C	D	E	F	G
h_3	10	?	9	7	1.5	4.5	0

For each of the following conditions, write the set of values that are possible for $h_3(B)$. For example, to denote all non-negative numbers, write $[0, \infty]$, to denote the empty set, write $\emptyset$, and so on.

(i) What values of $h_3(B)$ make h_3 admissible? Correct

For h3(B) to be admissible, $h3(B) \le$ optimal cost from B to G.

Optimal cost from B to G is 12, B-C-D-F-G.

So $h3(B) \le 12$. (0 <= h(b) <= 12)

(ii) What values of $h_3(B)$ make h_3 consistent? Correct

h3(B) is consistent if :

$c(A,B) + h3(B) \le h3(A)$. $\quad c(B,A) + h3(B) \le h3(A)$

$c(C,B) + h3(B) \le h3(B)$ $\quad c(B,C) + h3(B) \le h3(C)$

$c(C,D) + h3(B) \le h3(D)$ $\quad c(B,D) + h3(B) \le h3(D)$

(iii) What values of $h_3(B)$ will cause A* graph search to expand node A, then node C, then node B, then node D in order? A - C - B - D

Wrong.
For A* to expand the node in the order A-C-B:
1 + h(B) > 13,
5+h(b)<14[B`] or 1+h(b)<14.
So 12 < h(b) < 13.

$9 \le h3(B) \le 10$ <-- this solution was for the problem above.

↑ h3(C) ↑ h3(A)

Q2. n-pacmen search

Consider the problem of controlling n pacmen simultaneously. Several pacmen can be in the same square at the same time, and at each time step, each pacman moves by at most one unit vertically or horizontally (in other words, a pacman can stop, and also several pacmen can move simultaneously). The goal of the game is to have all the pacmen be at the same square in the minimum number of time steps. In this question, use the following notation: let M denote the number of squares in the maze that are not walls (i.e. the number of squares where pacmen can go); n the number of pacmen; and $p_i = (x_i, y_i) : i = 1 \dots n$, the position of pacman i. Assume that the maze is connected.

(a) What is the state space of this problem? Wrong

State space representation for n pacmans.

n lists with $\{1, \dots, m\}$ <-- Should be n-tuples instead of lists.

↑ board representation.

(b) What is the size of the state space (not a bound, the exact size)? Correct

m^n.

(c) Give the tightest upper bound on the branching factor of this problem.

5 movements available (stop, N, S, E, W) Correct

5^n

(d) Bound the number of nodes expanded by uniform cost *tree* search on this problem, as a function of n and M. Justify your answer. Correct

On worst case when pacmans are furthest away from each other, depth of the search tree is $\frac{m}{2}$.

$5^{n \cdot \frac{m}{2}} = 5^{\frac{nm}{2}}$

Max depth: m/2
Branching factor: 5^n

(e) Which of the following heuristics are admissible? Which one(s), if any, are consistent? Circle the corresponding Roman numerals and briefly justify all your answers.

1. The number of (ordered) pairs (i, j) of pacmen with different coordinates:

$$h_1(p_1, \dots, p_n) = \sum_{i=1}^{n} \sum_{j=i+1}^{n} 1[p_i \neq p_j] \quad \text{where} \quad 1[p_i \neq p_j] = \begin{cases} 1 & \text{if } p_i \neq p_j \\ 0 & \text{otherwise} \end{cases}$$

(i) Consistent? (ii) Admissible? Correct

neither.

If all pacman are in the same coordinate, h=0

but if clustered in different cells, h = num of pacman / 2.

2. $h_2((x_1, y_1), \dots, (x_n, y_n)) = \frac{1}{2} \max\{\max_{i,j} |x_i - x_j|, \max_{i,j} |y_i - y_j|\}$

(i) Consistent? (ii) Admissible? Wrong (not justified)

heuristic assumes max distance between 2 pacmans

Admissible: The heuristic here is the number of steps needed solve the problem if pacman could move diagonally disregarding the walls.

Consistent: Because each absolute value will change at most per 2 steps, meaning that h2 will decrease by at most 1 for each action. (each action costs 1)