

# COMS 4701 - Homework 1 - Written

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## Question 1

1.

Performance: Response time, correctness

Environment: Bedroom, kitchen, office, lounge, noise, shelf, table

Actuators: Speakers, activation lights

Sensors: Microphones

2.

<b>Environment</b>	<b>Observable</b>	<b>Agents</b>	<b>Deterministic</b>	<b>Static</b>	<b>Discrete</b>
Alexa	Partially	Single	Stochastic	Dynamic	Continuous

## Question 2

Initial State: Mars

Possible states: All possible paths of visiting (and collecting soil from) 0 to 5 continents

Possible actions: Visit and collect soil from a continent that has not been yet collected from

Transition model: updated list of collected soils

Goal test: Soil samples from Asia, North America, Africa, Europe, and Australia

### Question 3

Note: The front of the queue is the left most letter.

Note: The top of the stack is the right most letter.

<b>1 – BFS — Queue</b>	<b>2 – DFS — Stack</b>
S	S
A, B, C	C, B, A
B, C, D	C, B, D
C, D, E	C, B
D, E, H	C, E
E, H	C
H	H
F, G	G, F
G	G
Path: S-C-H-G	Path: S-C-H-G
Visit Order: S, A, B, C, D, E, H, F, G	Visit Order: S, A, D, B, E, C, H, F, G

<b>3 – UCS — Priority Queue</b>	<b>4 – A* — Priority Queue</b>
S	S
B <sub>2</sub> , C <sub>5</sub> , A <sub>6</sub>	B <sub>3</sub> , C <sub>8</sub> , A <sub>11</sub>
C <sub>5</sub> , E <sub>5</sub> , A <sub>6</sub>	C <sub>8</sub> , E <sub>9</sub> , A <sub>11</sub>
E <sub>5</sub> , A <sub>6</sub> , H <sub>7</sub>	E <sub>9</sub> , A <sub>11</sub> , H <sub>14</sub>
A <sub>6</sub> , H <sub>7</sub>	A <sub>11</sub> , H <sub>14</sub>
H <sub>7</sub> , D <sub>15</sub> ,	H <sub>14</sub> , D <sub>24</sub>
F <sub>9</sub> , G <sub>14</sub> , D <sub>15</sub> ,	F <sub>9</sub> , G <sub>14</sub> , D <sub>24</sub>
D <sub>13</sub> , G <sub>14</sub>	G <sub>14</sub> , D <sub>18</sub>
G <sub>14</sub>	D <sub>18</sub>
Path: S-C-H-G	Path: S-C-H-G
Visit Order: S, B, C, E, A, H, F, D, G	Visit Order: S, B, C, E, A, H, F, G

## Question 4

1. The heuristic that takes the min of two admissible heuristics,  $h_1$  and  $h_2$ , is admissible.

Direct proof for  $\mathbf{h(n) \leq h^*(n)}$  where  $h(n) = \min(h_1(n), h_2(n))$ :

Let  $h^*(n)$  be the true values for the cost from  $n$  to the goal.

By definition of admissibility,  $h_1(n) \leq h^*(n)$  for all  $n$ . And  $h_2(n) \leq h^*(n)$  for all  $n$ .

Then, the  $\min(h_1(n), h_2(n)) \leq \min(h^*(n), h^*(n)) = \min(h^*(n)) = h^*(n)$

Therefore,  $\mathbf{h(n) \leq h^*(n)}$ .

2. The heuristic that takes the max of two admissible heuristics,  $h_1$  and  $h_2$ , is admissible.

Direct proof for  $\mathbf{h(n) \leq h^*(n)}$  where  $h(n) = \max(h_1(n), h_2(n))$ :

Let  $h^*(n)$  be the true values for the cost from  $n$  to the goal.

By definition of admissibility,  $h_1(n) \leq h^*(n)$  for all  $n$ . And  $h_2(n) \leq h^*(n)$  for all  $n$ .

Then, the  $\max(h_1(n), h_2(n)) \leq \max(h^*(n), h^*(n)) = \max(h^*(n)) = h^*(n)$

Therefore,  $\mathbf{h(n) \leq h^*(n)}$ .

3.  $h(n) = w \cdot h_1(n) + (1-w) \cdot h_2(n)$  with  $0 \leq w \leq 1$  is admissible.

Direct proof:

Let  $h^*(n)$  be the true values for the cost from  $n$  to the goal.

Consider an arbitrary node  $no$  with a true cost of  $c$  where  $\{no \in n\}$ .

Then, by definition of admissibility,  $h_1(no) \leq h^*(no) = c$  and  $h_2(no) \leq h^*(no) = c$ .

Notice that the maximum cost for both  $h_1(no)$  and  $h_2(no)$  is  $c$ .

Then,  $w \cdot h_1(no) + (1-w) \cdot h_2(no)$  with  $0 \leq w \leq 1$

is less than or equal to  $w \cdot c + (1-w) \cdot c = c(w + 1 - w) = c = h^*(no)$

Since,  $h(no) = w \cdot h_1(no) + (1-w) \cdot h_2(no)$  with  $0 \leq w \leq 1$

Then, it follows that  $h(no) \leq h^*(no)$ .

Since,  $no$  is an arbitrary node, we can then extend this to all nodes and

$h(n) = w \cdot h_1(n) + (1-w) \cdot h_2(n) \leq h^*(n)$ .

## Question 5

The order of the board can be written uniquely for each board position from left to right starting from the top row and moving downwards. Allow the blank spot to be notated as a zero. The solved state can then be written as:

1, 2, 3, 4, 5, 6, 7, 8, 0

There are  $9!$  permutations of these numbers, meaning that if you were to set up the board by putting the numbers into the 9 different slots on the board, there would be a total of 362,880 unique states. Now, not all these states are achievable. From Johnson and Story's "Notes on the '15' Puzzle", the number of interchanges necessary to convert the natural arrangement into the standard arrangement for 3 rows and 3 columns is  $\frac{1}{4}(3-1)(3-1) = 1$ . This means that the natural arrangement can be obtained from any arrangement whose order is odd, but not even. Now, this means that only half the states are achievable because we need an odd order. Half the states are of even order and half are of odd order. Therefore, the number of possible states are  $9!/2 = 181,440$ .