ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

QUIZ 1 **WINTER SEMESTER, 2020-2021**

DURATION: 30 Minutes **FULL MARKS: 30**

CSE 4711: Artificial Intelligence

There are **2 (two)** questions. Answer **both** of them.

Figures in the right margin indicate marks.

Consider the following state space graph and the table containing two heuristic functions:

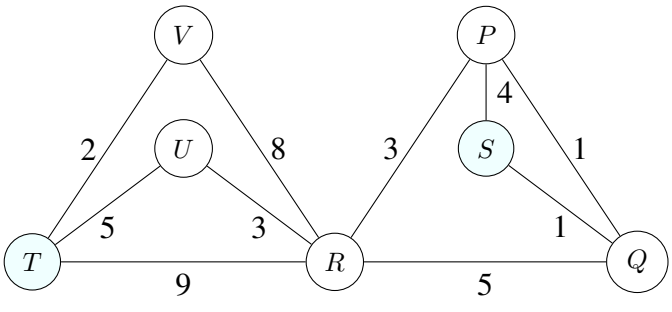


Figure 1: State Space Graph for Question 1

Node	h_0	h_1
P	8	10
Q	9	12
R	7	8
S	9.5	10
T	0	0
U	4	4.5
V	1.5	1

Table 1: Heuristic Functions for Question 1

In Figure 1, S is the start state and T is the goal state. The cost for taking each edge (in both directions) is shown on the graph. In Table 1, h_0 is consistent, but h_1 is not consistent.

1. We can apply *Graph Search Strategy* to find a path from start state to the goal state using: 5×3

   - Depth First Search
   - Breadth First Search
   - Uniform Cost Search
   - A* Search with Heuristic h_0
   - A* Search with Heuristic h_1

   Which of the following paths will be returned for each of the algorithms mentioned above?

   (i) $S \to P \to R \to T$
   (ii) $S \to Q \to R \to T$
   (iii) $S \to Q \to P \to R \to U \to T$

   Understand that for some of the algorithms mentioned above, the path from the start state to the goal state can vary based on how we break ties among multiple options. In such cases, mention *all* possible paths returned.

Solution:

- DFS: (i), (ii), (iii)
- BFS: (i), (ii)
- UCS: (iii)
- A* with h_0: (iii)
- A* with h_1: (iii)

Rubric:

- For each of the correctly identified paths: 1 point
- For each of the correctly omitted paths: 1 point

2. You are designing a new heuristic function h_2 for the given state space graph in Figure 1. You have come up with all the values except $h_2(Q)$.

Node	P	Q	R	S	T	U	V
h_2	9	?	7	10	0	4.5	1.5

For each of the following scenarios, write the possible range of values for $h_2(Q)$ with a brief explanation:

a) What values $h_2(Q)$ will make h_2 admissible? 4

Solution: To make h_2 admissible, $h_2(Q)$ has to be less than or equal to the actual optimal cost from Q to goal T, which is the cost of the path $Q \to P \to R \to U \to T$, i.e. 12. And the minimum possible value for heuristic is no heuristic, which makes all the values 0.
The answer is $0 \leq h_2(Q) \leq 12$.

Rubric:

- For the correct range: 2 points
- For a correct explanation of the lower bound: 1 point
- For a correct explanation of the upper bound: 1 point

b) What values of $h_2(Q)$ will make h_2 consistent? 5

Solution: All the other nodes except node Q satisfy the consistency conditions. The consistency conditions that involve the state Q are:

- $h(S) \leq c(S,Q) + h(Q)$
  $\to 10 \leq 1 + h(Q)$
  $\to 9 \leq h(Q)$
- $h(Q) \leq c(Q,S) + h(S)$
  $\to h(Q) \leq 1 + 10$
  $\to h(Q) \leq 11$
- $h(P) \leq c(P,Q) + h(Q)$
  $\to 9 \leq 1 + h(Q)$
  $\to 8 \leq h(Q)$
- $h(Q) \leq c(Q,P) + h(P)$
  $\to h(Q) \leq 1 + 9$
  $\to h(Q) \leq 10$
- $h(R) \leq c(R,Q) + h(Q)$
  $\to 7 \leq 5 + h(Q)$
  $\to 2 \leq h(Q)$
- $h(Q) \leq c(Q,R) + h(R)$
  $\to h(Q) \leq 5 + 7$
  $\to h(Q) \leq 12$

Using the tightest bounds from the equations above: $9 \leq h_2(Q) \leq 10$

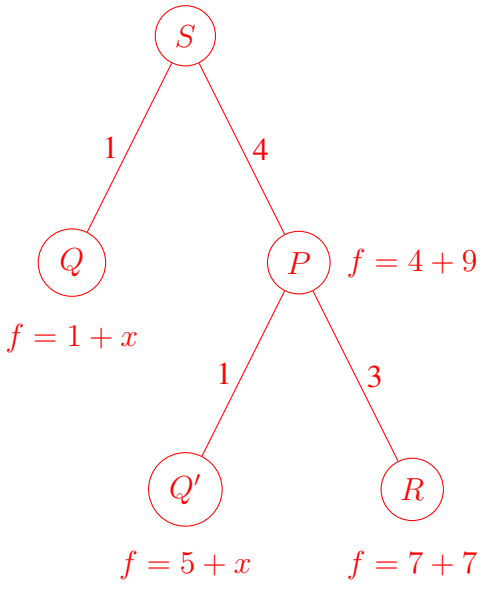
Rubric:

- For the correct range: 2 points

- For a correct explanation of the lower bound: 1.5 point
- For a correct explanation of the upper bound: 1.5 point

c) What values of $h_2(Q)$ will cause A* Graph Search to expand node S, then node P, then node Q, then node R in order? 6

Solution: Let, $h_2(Q) = x$.



The A* search tree using the heuristic h_2 is shown above. Node S is expanded first since it's the start state.

To make A* graph search expand node P before node Q, we need

$$1 + x > 13$$
$$x > 12$$

After expanding P, we need to either expand Q' or Q before R. To expand Q',

$$5 + x < 14$$
$$x < 9$$

which violates the earlier constraint. To expand Q,

$$1 + x < 14$$
$$x < 13$$

So we can get $12 < h_2(Q) < 13$

Rubric:

- For the correct range: 2 points
- For a correct explanation of the lower bound: 2 points
- For a correct explanation of the upper bound: 2 points