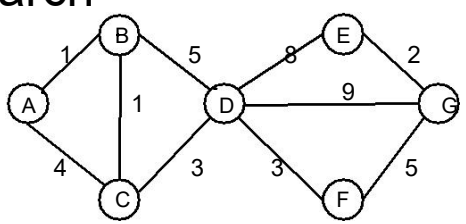


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Q1. Search



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.

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

(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?

$$h^*(B) = B - C - D - F - G = 12 \Rightarrow 0 \leq h_3(B) \leq 12$$

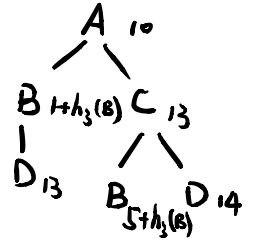
Therefore,  $[0, 12]$

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

$$\begin{cases} h_3(B) \leq \text{cost}(B \text{ to } C) + h_3(C) \\ h_3(B) \leq \text{cost}(B \text{ to } D) + h_3(D) \\ h_3(B) \leq \text{cost}(B \text{ to } A) + h_3(A) \end{cases} \quad \begin{cases} h_3(A) \leq \text{cost}(A \text{ to } B) + h_3(B) \\ h_3(C) \leq \text{cost}(C \text{ to } B) + h_3(B) \\ h_3(D) \leq \text{cost}(D \text{ to } B) + h_3(B) \end{cases} \Rightarrow 9 \leq h_3(B) \leq 10$$

Therefore  $[9, 10]$

(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?



$$\begin{cases} 13 < 1 + h_3(B) \\ 1 + h_3(B) < 14 \end{cases} \Rightarrow 12 < h_3(B) < 13$$

Therefore,  $(12, 13)$