CSCE 420: Artificial Intelligence

Homework 1

Due date: 17 September 2023 *Name: Huy Lai*

Problem 1. Consider depth first search. When the goal is 18 and the node is visited (taken out of node list):

Subproblem 1. What are the nodes that remain in the node list? (list them in the correct order).

Solution:
$[19, 5, 3]$

Subproblem 2. Which nodes have been visited until then, in what order?

Solution:
$[1, 2, 4, 8, 16, 9]$

Problem 2. Consider breadth first search. When the goal is 6 and the node is visited (taken out of node list):

Subproblem 1. What are the nodes that remain in the node list? (list them in the correct order).

Solution:
$[7]$

Subproblem 2. Which nodes have been visited until then, in what order?

Solution:
$[1, 2, 3, 4, 5]$

Problem 3. Why is the space complexity of BFS $O\left(b^{d+1}\right)$, not $O\left(b^{d}\right)$, where b is the branching factor and d is the goal depth?

Solution:
Since the BFS algorithm expands each node to get its children before visiting the node, the algorithm will expand the nodes at the d depth before finishing thus adding one more layer in the total space that to be considered by the algorithm.

Problem 4. Can depth limited search become incomplete in the case of the finite search tree above? If so, give an example (use Figure 1). If not, explain why not (use Figure 1).

Solution:
If the depth limit is 3 and the node to find is 11, depth limited search will never find the node.

Problem 5. Consider iterative deepening search. When the goal is 12, how many nodes are visited before reaching that node? Hint: Include repeated visits in the count. Include the visit to the goal 12 in the count.

Solution:
There are 30 nodes before the goal 12.

Problem 6. Show that the heuristic is admissible.

Solution:
$h^*(H) = 0, h^*(G) = 20, h^*(F) = 9 + 20 = 29, h^*(E) = 20$
$h^*(B) = 29 + 12 = 41, h^*(C) = 29 + 18 = 47, h^*(D) = 20 + 25 = 54, h^*(A) = 41 + 10 = 51$

Node	$h^*(n)$	$h(n)$	$h^*(n) \geq h(n)$
A	51	41	Yes
B	41	40	Yes
C	47	37	Yes
D	54	38	Yes
E	20	17	Yes
F	29	24	Yes
G	20	19	Yes
H	0	0	Yes

Table 1: Comparison of $h^*(n)$ and $h(n)$

Since $h^*(n) \geq h(n) \forall n \in \mathcal{G}$, The heuristic is admissible.

Problem 7. Manually conduct greedy best-first search on the graph below with initial node (A) and goal node (H).

NODE LIST:
(A): $h = 41$, path = (A)
→ VISIT: (A): $h = 41$, path = (A)

NODE LIST:
(B): $h = 40$, path = (A, B)
(C): $h = 37$, path = (A, C)
(D): $h = 38$, path = (A, D)
→ VISIT: (C): $h = 37$, path = (A, C)

NODE LIST:
(F): $h = 24$, path = (A, C, F)
(G): $h = 19$, path = (A, C, G)
(B): $h = 40$, path = (A, B)
(D): $h = 38$, path = (A, D)
→ VISIT: (G): $h = 19$, path = (A, C, G)

NODE LIST:
(H): $h = 0$, path = (A, C, G, H)
(F): $h = 24$, path = (A, C, F)
(B): $h = 40$, path = (A, B)
(D): $h = 38$, path = (A, D)
→ VISIT: (H): $h = 0$, path = (A, C, G, H)

Cost of final path: $41 + 37 + 19 + 0 = 97$
Final Path: (A, C, G, H)

Problem 8. Manually conduct greedy A* search on the graph below with initial node (A) and goal node (H)

NODE LIST:
(A): $f = 0 + 41$, path = (A)
→ VISIT: (A): f = 41,path = (A)

NODE LIST:
(B): $f = 10 + 40 = 50$, path = (A, B)
(C): $f = 12 + 37 = 49$, path = (A, C)
(D): $f = 9 + 38 = 47$, path = (A, D)
→ VISIT: (D): $f = 9 + 38 = 47$, path = (A, D)

NODE LIST:
(C_D): $f = 9 + 5 + 37 = 51$, path = (A, D, C)
(G): $f = 9 + 25 + 19 = 53$, path = (A, D, G)
(B): $f = 10 + 40 = 50$, path = (A, B)
(C_A): $f = 12 + 37 = 49$, path = (A, C)
→ VISIT: (C_A): $f = 12 + 37 = 49$, path = (A, C)

NODE LIST:
(F): $f = 12 + 18 + 24 = 54$, path = (A, C, F)
(G_C): $f = 12 + 29 + 19 = 60$, path = (A, C, G)
(C_D): $f = 9 + 5 + 37 = 51$, path = (A, D, C)
(G_D): $f = 9 + 25 + 19 = 53$, path = (A, D, G)
(B): $f = 10 + 40 = 50$, path = (A, B)
→ VISIT: (B): $f = 10 + 40 = 50$, path = (A, B)

NODE LIST:
(E): $f = 10 + 25 + 17 = 52$, path = (A, B, E)
(F_B): $f = 10 + 12 + 24 = 46$, path = (A, B, F)
(F_C): $f = 12 + 18 + 24 = 54$, path = (A, C, F)
(G_C): $f = 12 + 29 + 19 = 60$, path = (A, C, G)
(C_D): $f = 9 + 5 + 37 = 51$, path = (A, D, C)
(G_D): $f = 9 + 25 + 19 = 53$, path = (A, D, G)
→ VISIT: (F_B): $f = 10 + 12 + 24 = 46$, path = (A, B, F)

NODE LIST:
(G_F): $f = 9 + 12 + 10 + 19 = 50$, path = (A, B, F, G)
(H): $f = 36 + 12 + 10 + 0 = 58$, path = (A, B, F, H)
(E): $f = 10 + 25 + 17 = 52$, path = (A, B, E)
(F_C): $f = 12 + 18 + 24 = 54$, path = (A, C, F)
(G_C): $f = 12 + 29 + 19 = 60$, path = (A, C, G)
(C_D): $f = 9 + 5 + 37 = 51$, path = (A, D, C)
(G_D): $f = 9 + 25 + 19 = 53$, path = (A, D, G)
$\rightarrow$ VISIT: (G_F): $f = 9 + 12 + 10 + 19 = 50$, path = (A, B, F, G)

NODE LIST:
(H_G): $f = 20 + 9 + 12 + 10 + 0 = 51$, path = (A, B, F, G, H)
(H_F): $f = 36 + 12 + 10 + 0 = 58$, path = (A, B, F, H)
(E): $f = 10 + 25 + 17 = 52$, path = (A, B, E)
(F_C): $f = 12 + 18 + 24 = 54$, path = (A, C, F)
(G_C): $f = 12 + 29 + 19 = 60$, path = (A, C, G)
(C_D): $f = 9 + 5 + 37 = 51$, path = (A, D, C)
(G_D): $f = 9 + 25 + 19 = 53$, path = (A, D, G)
$\rightarrow$ VISIT: (C_D): $f = 9 + 5 + 37 = 51$, path = (A, D, C)

NODE LIST:
(F_C): $f = 9 + 5 + 18 + 24 = 56$, path = (A, D, C, F)
(G_C): $f = 9 + 5 + 29 + 19 = 62$, path = (A, D, C, G)
(H_G): $f = 20 + 9 + 12 + 10 + 0 = 51$, path = (A, B, F, G, H)
(H_F): $f = 36 + 12 + 10 + 0 = 58$, path = (A, B, F, H)
(E): $f = 10 + 25 + 17 = 52$, path = (A, B, E)
(F_C): $f = 12 + 18 + 24 = 54$, path = (A, C, F)
(G_C): $f = 12 + 29 + 19 = 60$, path = (A, C, G)
(G_D): $f = 9 + 25 + 19 = 53$, path = (A, D, G)
$\rightarrow$ VISIT: (H_G): $f = 20 + 9 + 12 + 10 + 0 = 51$, path = (A, B, F, G, H)

Cost of final path: $20 + 9 + 12 + 10 + 0 = 51$
Final Path: (A, B, F, G, H)