CAP 6635 Artificial Intelligence
Midterm Quiz | Matthew Acs

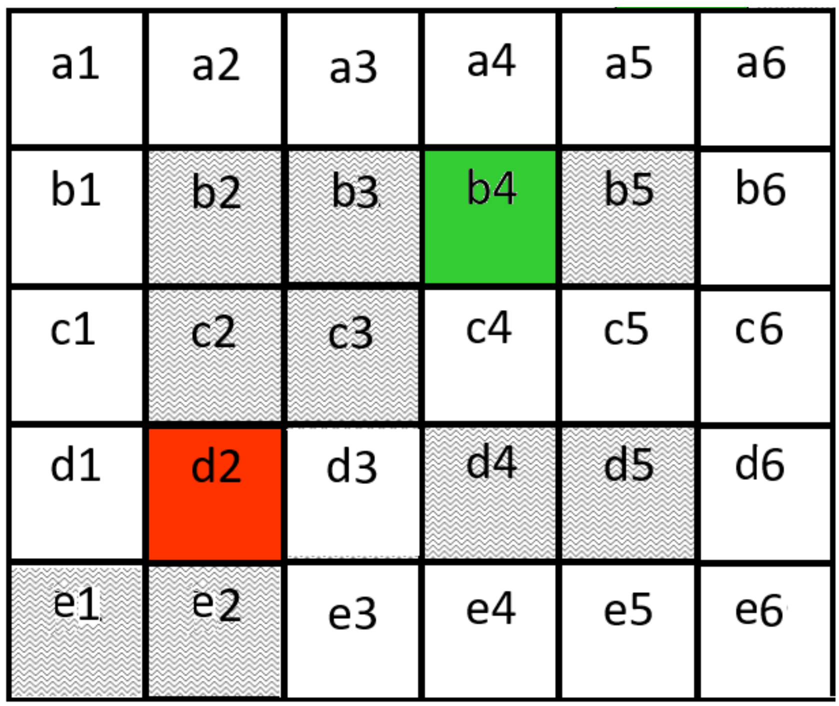


Figure 1

Question 1 [12 pts] Figure 1 shows a robot navigation field, where the red square (d2) is the robot, and green square (b4) is the goal. The shad squares (such as b2, c2, etc.) are obstacles. The robot is not allowed to move in diagonal line. Nodes are coded using an alphabet letter followed by a digit (such as a1, b1, b2 etc.).

- Use Depth First Search to find path from d2 to b4.
  - Report nodes in the fringe in the orders they are included in the fringe. [1 pt]
  - Report the order of the nodes being expanded. [1 pt]
  - Report the final path from d2 to b4. [1 pt]

Depth First Search

Fringe (Last → Next):	**Node visited/expanded**
d2	d2
d3, d1	d1
d3, c1	c1
d3, b1	b1
d3, a1	a1
d3, a2	a2
d3, a3	a3
d3, a4	a4
d3, b4’, a5	a5
d3, b4’, a6	a6
d3, b4’, b6	b6
d3, b4’, c6	c6
d3, b4’, d6, c5	c5
d3, b4’, d6, c4	c4
d3, b4’, d6, b4	**b4 FOUND**

Order of node expansion: d2, d1, c1, b1, a1, a2, a3, a4, a5, a6, b6, c6, c5, c4, b4
Final path: d2, d1, c1, b1, a1, a2, a3, a4, a5, a6, b6, c6, c5, c4, b4

- Use Breadth First Search to find path from d2 to b4.
    - Report nodes in the fringe in the orders they are included in the fringe. [1 pt]
    - Report the order of the nodes being expanded. [1 pt]
    - Report the final path from d2 to b4. [1 pt]

Breadth First Search

Fringe (Last → Next):	**Node visited/expanded**
d2	d2
d3, d1	d1
c1, d3	d3
e3, c1	c1
b1, e3	e3
e4, b1	b1
a1, e4	e4
e5, a1	a1
a2, e5	e5
e6, a2	a2
a3, e6	e6
d6, a3	a3
a4, d6	d6
c6, a4	a4
b4, a5, c6	c6
c5, b6, b4, a5	a5
a6, c5, b6, b4	**b4 FOUND**

Order of node expansion: d2, d1, d3, c1, e3, b1, e4, a1, e5, a2, e6, a3, d6, a4, c6, a5, b4
Final path: d2, d1, c1, b1, a1, a2, a3, a4, b4

- Use Best First Search to find path from d2 to b4. (Using Manhattan distance as the heuristic function)
    - Report nodes in the fringe (including their f(N) values) in the orders they are included in the fringe. [1 pt]
    - Report the order of the nodes being expanded. [1 pt]
    - Report the final path from d2 to b4. [1 pt]

Best First Search

Fringe (Last → Next): f(N)=h(N)	**Node visited/expanded**
d2 (4)	d2
d1 (5), d3 (3)	d3
d1 (5), e3 (4)	e3
d1 (5), e4 (3)	e4
d1 (5), e5 (4)	e5
e6 (5), d1 (5)	d1
e6 (5), c1 (4)	c1
e6 (5), b1 (3)	b1
e6 (5), a1 (4)	a1
e6 (5), a2 (3)	a2
e6 (5), a3 (2)	a3
e6 (5), a4 (1)	a4
e6 (5), a5 (2), b4 (0)	**b4 FOUND**

Order of nodes expanded: d2, d3, e3, e4, e5, d1, c1, b1, a1, a2, a3, a4, b4
Final path: d2, d1, c1, b1, a1, a2, a3, a4, b4

- Use A* to find path from d2 to b4. (Using Manhattan distance as the heuristic function).
  - Report nodes in the fringe (including their f(N) values) in the orders they are included in the fringe. [1 pt]
  - Report the order of the nodes being expanded. [1 pt]
  - Report the final path from d2 to b4. [1 pt]

A* Search

Fringe (Last → Next): f(N)=g(N)+h(N)	**Node visited/expanded**
d2 (4)	d2
d1 (6), d3 (4)	d3
e3 (6), d1 (6)	d1
e3 (6), c1 (6)	c1
e3 (6), b1 (6)	b1
a1 (8), e3 (6)	e3
a1 (8), e4 (6)	e4
e5 (8), a1 (8)	a1
e5 (8), a2 (8)	a2
e5 (8), a3 (8)	a3
e5 (8), a4 (8)	a4
a5 (10), e5 (8), b4 (8)	**b4 FOUND**

Order of node expansion: d2, d3, d1, c1, b1, e3, e4, a1, a2, a3, a4, b4
Final path: d2, d1, c1, b1, a1, a2, a3, a4, b4

Question 2 [4 pts]. In the game tree showing in Figure 2, the root node (node a) is a Min node, and its two children (nodes b and c) are Max nodes. Other layers are marked respectively using Max and Min notation to the right of the figure.

- Report utility values for each node (*i.e.*, nodes a, b, ..., o) (1 pt).
- Mark nodes (or branches) which are pruned by the α-β pruning method (2 pts)
- Report final path of node a's decision (1 pt)

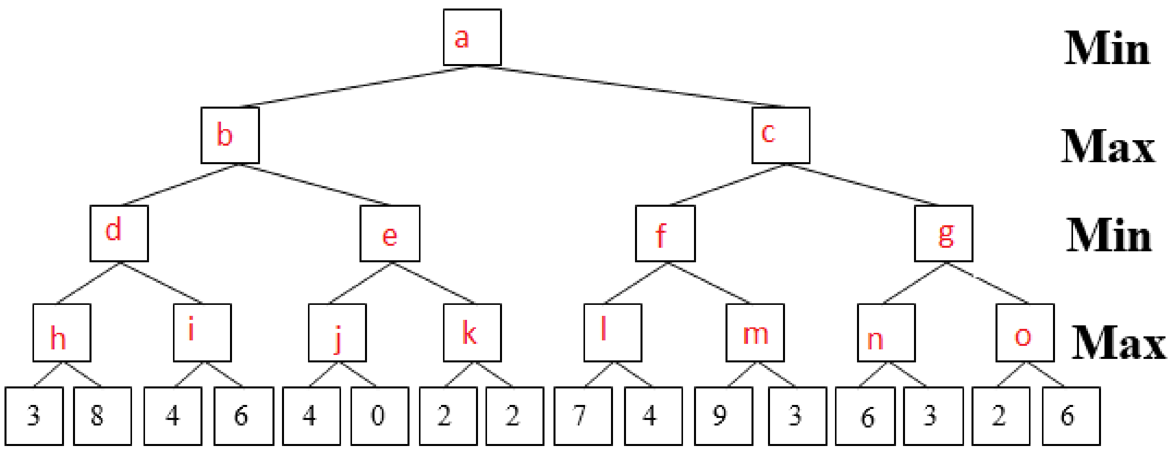
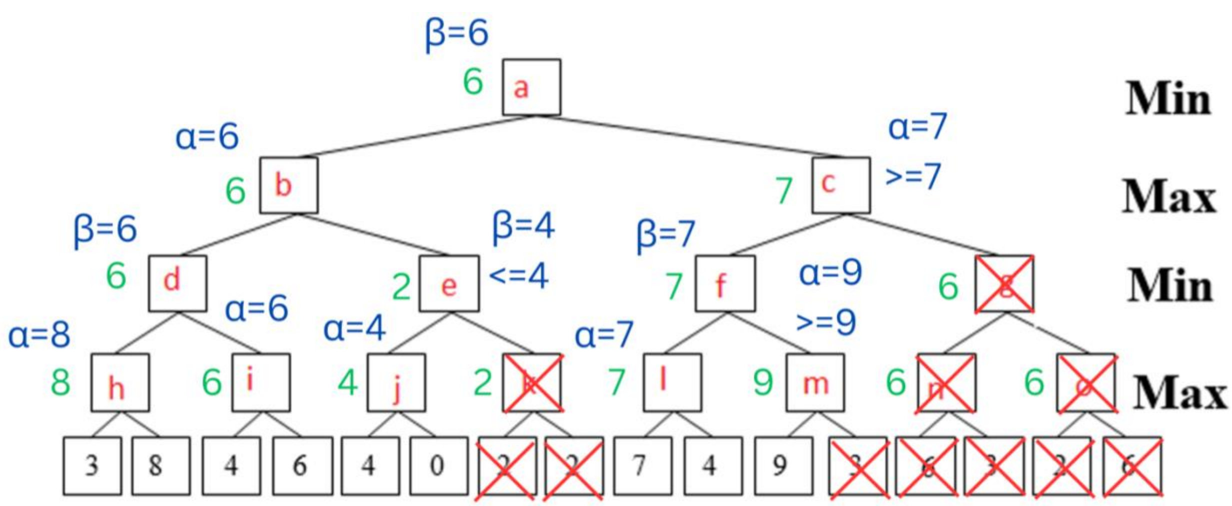


Figure 2



Green numbers are utility values and blue numbers are alpha/beta values used in pruning. The red Xs represent nodes that would be pruned by alpha-beta pruning.

<u>Utility values:</u> a = 6, b = 6, c = 7, d = 6, e = 2, f = 7, g = 6, h = 8, i = 6, j = 4, k = 2, l = 7, m = 9, n = 6, o = 6
<u>Pruned nodes:</u> Marked by Xs
<u>Final path:</u> a, b, d, i, 6

Question 3 [4 pts]: Figure 3 shows a search tree where A denotes the node corresponding to the initial state, and E is the goal node. In the figure, h=x denotes the heuristic function value and c=x denotes the actual cost between nodes (i.e., arch cost).

a. Please explain why (or why not) the heuristic function in Figure 3 is (or is not) an admissible heuristic (0.5 pt).
b. Please explain why (or why not) the heuristic function in Figure 3 is (or is not) a consistent heuristic (0.5 pt).
c. Correct heuristic values in Figure 3, such that A* search using corrected heuristics can find optimal path from A to E without revisiting nodes. Solutions must show corrected heuristic values for all nodes (1.5 pt)
d. Create a search tree using corrected heuristic values to carry out A* search from A to find goal node E (Node expanded/visited does not need to be revisited). Show the search tree (The tree must show the complete search process with each node's f(N), g(N), and h(N) values), and report the order of the nodes being expanded, and the final discovered path from A to E (1.5 pt)

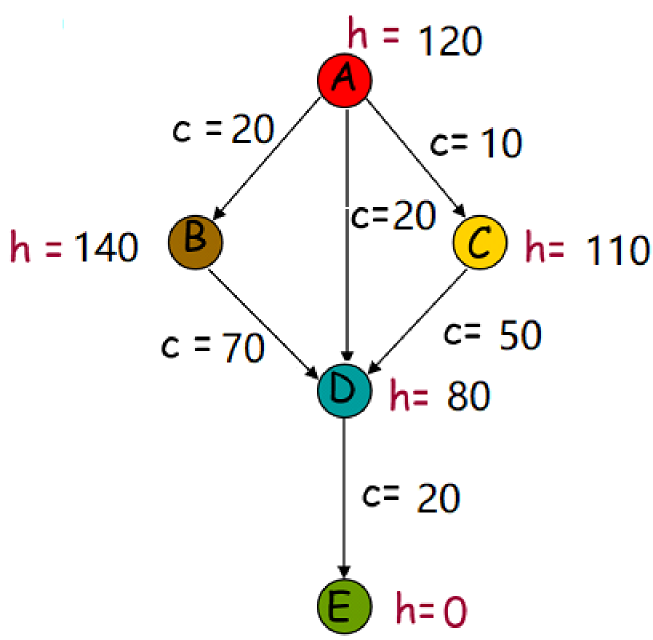
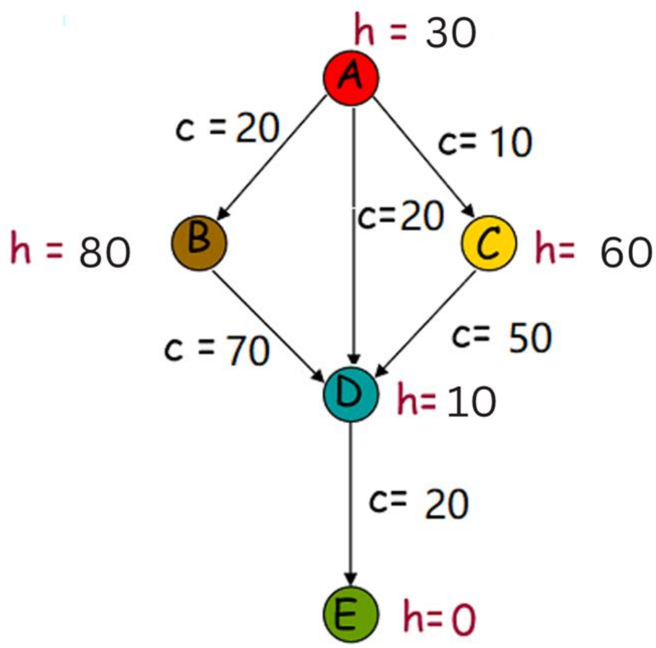


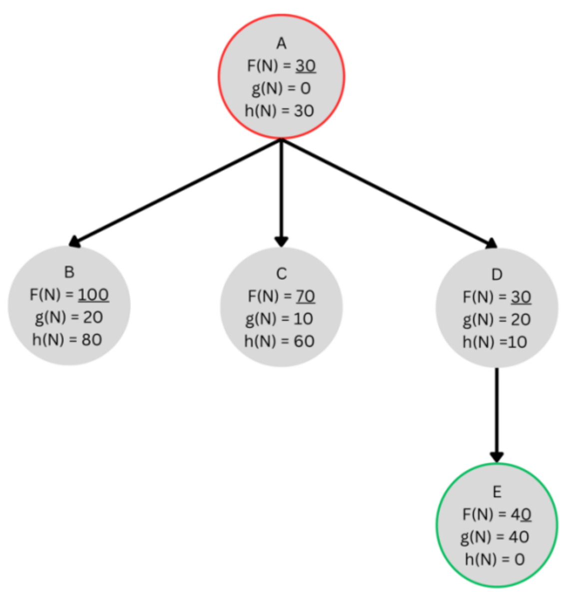
Figure 3

An admissible heuristic is one that is always optimistic. That is, 0 <= h(N) <= h*(N), where h*(N) is the cost of the optimal path from N to the goal node. In figure 3, the heuristic for node A is 120, however, the cost of the optimal path from A to E is 40. Thus, h(N) > h*(N), which violates the condition for an admissible heuristic. Therefore, the heuristic in figure 3 is not admissible.

A consistent heuristic is one in which the heuristic for a node is less than or equal to the cost to go from that node to any child node plus the heuristic of that child node, h(N) <= c(N,N') + h(N'). Furthermore, a consistent heuristic is one in which the goal node has a heuristic of 0. In figure 3, the heuristic for node D is 80, and the cost to go from D to the goal node is 20. In this case, the heuristic for node D is greater than the cost to go from D to E (20) plus the heuristic of E (0). Therefore, the heuristic in figure 3 is not consistent. Finally, a consistent heuristic is also admissible. The heuristic in figure 3 is not admissible, and therefore it cannot be consistent.



Corrected heuristic values for figure 3



A search tree for corrected heuristic values*

A* Search

Fringe (Last → Next): f(N)=g(N)+h(N)	**Node visited/expanded**
A (30 = 0 + 30)	A
B (100 = 20 + 80), C (70 = 10 + 60), D (30 = 20 + 10)	D
B (100 = 20 + 80), C (70 = 10 + 60), E (40 = 40 + 0)	**E FOUND**

Order of node expansion: A, D, E
Final path: A, D, E