Entry number: 2017CS10340 *Name:* POORVA GARG

COL 333/671 Autumn 2019 Minor 1

Welcome to Minor 1. The exam is for 1 hour 5 minutes. Questions numbered 1-20 are two points each. Note that if there are multiple correct choices for a question, write all of them.

Please use only pens while answering questions. Do not use a pencil.

Before starting the exam, close your eyes and take three deep breaths. Your performance in the exam is not an accurate reflection of your understanding of the material. Nevertheless, if you are relaxed, you will likely perform better.

Question Number	Maximum Marks	Marks Obtained
1-20	40	28
21	12	9
22	30	30
23	18	13
		80

Recall that:

b: the branching factor of the search tree
d: the least depth at which a goal is found in the tree
m: the maximum depth of the search tree

1. The worst case time complexity of Tree Search A* is

(A) $O(b^d)$
(B) $O(b^m)$
(C) $O(bm)$
(D) None of these

D

2. Which of these is not a search strategy

(A) IDA*
(B) Bidirectional search
(C) Domain relaxation
(D) None of these

C

3. If h_1 and h_2 are admissible heuristics (non-negative), which of the following are guaranteed to be admissible

(A) $0.25\times(h_1 + h_2)$
(B) $\sqrt{h_1 h_2}$
(C) $1+ max(h_1, h_2)$
(D) $max(0, h_1 - h_2)$

A B D.

4. Minimax algorithm outputs the best play even if the opponent is known to be suboptimal.

(A) True
(B) False

B

5. The term "artificial intelligence" was coined by

(A) Marvin Minsky
(B) Herbert Simon
(C) Alan Turing
(D) John McCarthy

D.

6. A* search will never expand more search nodes than

(A) Breadth First Search
(B) Depth First Search
(C) IDA* (with f-value increments = smallest edge cost)
(D) None of these

A C

7. Killer moves

(A) are saved early on and played when player position is weak
(B) are used to kill opponent's pieces in a game
(C) are used to achieve best pruning in adversarial search

C

8. Which of these are true about additive pattern databases for 24 puzzle?

(A) They yield inadmissible heuristic values due to double-counting
(B) Additive pattern databases will always compute a higher or equal heuristic value for a state compared to an equivalent (same patterns) non-additive pattern database
(C) None of the above

B.

9. The non-local jumps in genetic algorithms arise due to

(A) Fitness function
(B) Crossing over
(C) Mutation
(D) Natural selection

B

10. If the set of successors are ordered randomly then the complexity of minimax with alpha beta pruning (for moderate b) is closest to

(A) $O(b^{m/2})$
(B) $O(b^{3m/4})$
(C) $O(b^{3m/5})$
(D) $O(b^{2m/3})$

B

11. Consider a state space where the states are all positive integers. State i has two neighbors i − 1 and i + 1 (except for i = 1 which only has one neighbor i = 2). State i has score $\frac{1}{i}$. If one runs the greedy hill climbing algorithm, how many initial states can reach the global maximum?

(A) 0
(B) 1
(C) 2
(D) 3
(E) more than 3

E

12. Turing test as a demonstration for AI is closest to which definition of AI?

(A) acting like humans
(B) thinking like humans
(C) thinking rationally
(D) acting rationally

A

13. Which of these algorithms can escape local optima, if one is reached?

(A) Random restarts
(B) Simulated annealing with T>0
(C) Local beam search with beam size 1
(D) Enforced hill climbing

ABD

14. If h is an admissible heuristic (non-negative), which of following can *never* be admissible.

(A) $0.5h + 1$
(B) $2\sqrt{h}$
(C) $1.5h$
(D) they can all be admissible under some situations.

~~A~~ C

X

15. There exists a perfect evaluation function at each board state, such that no search is needed in the minimax algorithm for deciding the best move.

(A) True
(B) False

A

✓

16. Which of the following games are not zero-sum

(A) Nuclear world war
(B) AI course's assignment with relative grading
(C) U.S. presidential elections between two candidates
(D) India's general elections with many political parties
(E) None of the above

A D.

X

17. In a given amount of time, DFS could find goal in a tree of depth m. Given the same time, doubling computer's speed will guarantee that DFS can find goal in a search tree of size

(A) $m+1$
(B) $2m$
(C) m

A C

X

18. Which of the following will generally not be considered AI

(A) studying animals for their behavioral patterns
(B) finding a new approximation bound for a given algorithm
(C) finding an algorithm for an NP-hard problem that often has good empirical performance
(D) solving a task at which today humans are much better than machines

A B

✓ *

19. Weighted A* implementation does not need a priority queue.

(A) True
(B) False

B

✓

20. The unprecedented success of deep learning in the last five years is due to

(A) powerful compute hardware
(B) a combination of neural networks with logic
(C) large annotated datasets
(D) None of these

A B C

X

21. [12 pts] Answer in 1-2 sentences each. Assume no duplicate detection (except in part e).

(a) Give one benefit of iterative deepening A* over depth first search branch and bound.

For infinite state space with goal at finite depth, IDA* is complete but DFS B&B is not.

2

(b) Give one benefit of breadth first search over bidirectional search.

BFS finds the optimal path to the goal whereas bidirectional search is prone to find suboptimal path.

0

(c) Give one benefit of tabu search over hill climbing with sideways moves without tabu list.

Without tabu list, hill climbing with sideways moves can get infinitely stuck on a ~~local optimum~~ plateau or shoulder repeating its states. Tabu list helps in avoiding repetition and realizing that algo. is stuck.

2

(d) Give one benefit of beam search over uniform cost search.

The space complexity of beam search is constant whereas that of UCS is exponential.

2

(e) Give one benefit of graph search A* over tree search A*.

Graph search A* is complete over finite state space, tree search A* is not.

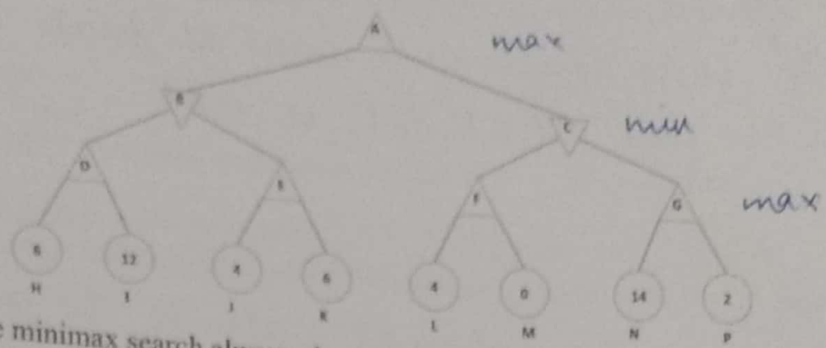
1

(f) Give one benefit of genetic algorithms over greedy hill climbing with random restarts.

Genetic algorithms, while going to non local state can retain some good characteristics of previous optimum. Greedy hill climbing, when restarted has a complete novel state.

2

22. [30 pts] The following figure shows an adversarial search tree.



15

(a) [15 pts] If the minimax search always chooses the children from left to right, find the value for each node in the tree. Assume that the search procedure is using alpha-beta pruning. If a subtree is pruned then label all nodes (including the leaves) of the subtree as X.

A= 6	B= 6	C= 4	D= 12	E= 6	F= 4	G= X	H= 6
I= 12	J= 4	K= 6	L= 4	M= 0	N= X	P= X	

Imagine now that the computer (maximizer) has mastered some black magic. With its magic, it can take control of the opponent's brain, and in doing so be fully in charge of the opponent's move. But the use of this black magic comes at a price – a price of c, which is measured in the same units as the values at the bottom of the tree. Note that for each of opponent's actions, the computer can choose to let opponent act (optimally according to minimax) or use black magic.

5

(b) [5 pts] Find the output of the tree (without any alpha-beta pruning) in this new game with black magic, if the cost c is 4.

A= 10	B= 8	C= 10.

(c) [10 pts] Let the game with black magic be a complete information game, i.e., both the computer and opponent are well-informed about computer's magical powers, and use this information to arrive at the best strategy for the game. Modify minimax procedure so that it returns the optimal value for each node. As a starting point, here is the pseudo code of minimax.

```
function MAX-VALUE(state)
    if state is leaf then
        return UTILITY(state)
    end if
    v ← −∞
    for successor in SUCCESSORS(state) do
        v ← max(v, MIN-VALUE(successor))
    end for
    return v
end function
```

```
function MIN-VALUE(state)
    if state is leaf then
        return UTILITY(state)
    end if
    v ← ∞
    for successor in SUCCESSORS(state) do
        v ← min(v, MAX-VALUE(successor))
    end for
    return v
end function
```

~~• MAX-VALUE function will remain~~

~~• MIN-VALUE function will remain same~~

~~function MAX-VALUE (state)~~

~~if state is leaf then~~

~~return UTILITY (state)~~

~~end if~~

~~$w \leftarrow \infty$~~

~~$v \leftarrow -\infty$~~

~~for successor in SUCCESSORS (state) do~~

~~$v \leftarrow$ max(v, MIN-VALUE(successor))~~

~~$w \leftarrow$~~

~~end for~~

~~return max(v, (MAX-VALUE(sa~~

~~$w \leftarrow \infty$~~

3 • MAX-VALUE function will remain same ✓

function MIN-VALUE (state)

if state is leaf then

return UTILITY (state)

end if

7 $v \leftarrow \infty$ $w \leftarrow -\infty$

for successor in Successors (state) do

$v \leftarrow$ min(v, MAX-VALUE(successor)) ✓

$w \leftarrow$ max(w, MAX-VALUE(successor)) ✓

end for

return max(v, w−c) ✓

end function

23. [18 pts] Suppose our search space is a tree but has negative costs.

4

(a) [4 pts] Explain why any optimal uninformed algorithm will have to explore the whole of search space.

An uninformed algorithm will be exploring whole of search space because, if it leaves any of the edges from exploring, it takes the risk of that edge having a high negative cost and path through that edge becomes the optimal path.

(b) [5 pts] Will A* search with admissible heuristic return an optimal solution? Why/why not?

0 Yes because tree search returns optim

(c) [9 pts] Let the max depth of the tree be finite (m) and each edge cost > $-s$ and < t. Suppose we ran a search algorithm and found the first goal G at depth d, with path cost c. Give an optimality bound for $(c-c^*)$ in terms of d, s, t and m, where c^* is the optimal cost, if the search algorithm is:

(i) depth first search

$c \leq dt$

$c^* \geq -sm$.

3 $(c-c^*) \leq dt + sm$

(ii) breadth first search

3 $(c-c^*) \leq dt + sm$.

(iii) uniform cost search

3 $(c-c^*) \leq s(m-1)$.