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#105 

Q1 6

## 1. [10%] General AI Knowledge

For each of the statements below, fill in the bubble **T** if the statement is **always and unconditionally true**, or fill in the bubble **F** if it is **always false, sometimes false, or just does not make sense**. Each answer is worth 1%.

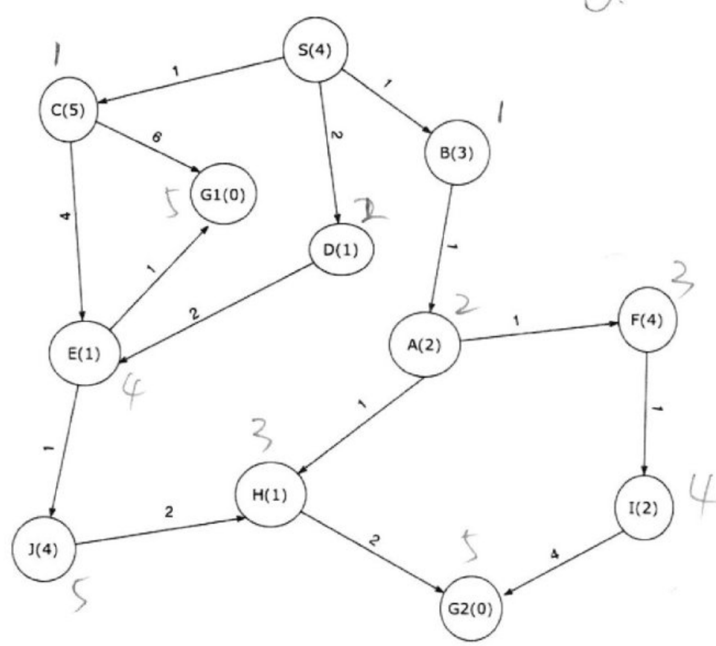
| | | |
|---|---|---|
| 1 | T | F |
| 2 | T | F |
| 3 | T | F |
| 4 | T | F |
| 5 | T | F |
| 6 | T | F |
| 7 | T | F |
| 8 | T | F |
| 9 | T | F |
| 10 | T | F |

1. A rational agent is always intelligent.
2. In an accessible environment, an agent can see everything at once.
3. A* is optimal when the heuristic function h(n) is admissible.
4. Learning agents use a critic to evaluate performance and adapt.
5. For complexity analysis, $o(f(n))$ is a tighter boundary than $O(f(n))$.
6. To solve a problem, an AI agent does not need to define the state space of the problem.
7. Genetic algorithms use a cross-over operator to create children from parents.
8. In deterministic MinMax search, the relative ordering of the evaluation function values determines the outcome.
9. Min-conflicts is a local search algorithm for CSPs.
10. Simulated annealing guarantees optimal solutions only if the temperature is lowered infinitely slowly.

## 2. [30%] Search

Consider the following graph. The start node is S, and the goal nodes are G1 and G2. The cost of each transition is shown on the corresponding edge and the heuristic value of each node is shown within parentheses on that node.

B:




***When nodes are of equal depth and/or equal value, pop the nodes off the front of the open queue in alphabetical and numerical order. Each answer below should be a sequence of states, e.g., "S-A-B-C-D-E-G1". Note how the arcs are directed. Terminate a search only when a goal state is popped off the open queue, even for BFS and DFS. Loop detection: apply the "clean and robust algorithm" studied in class.***

2A 3

### 2A. [4%] BFS

| [2%] The order of Nodes Expanded | [2%] Solution Path |
|---|---|
| S-B-C-D-A-E-G1 | A-C-G1 |

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2B 4

## 2B. [4%] DFS

| [2%] The order of Nodes Expanded | [2%] Solution Path |
|---|---|
| S-B-A-F-I-$G_2$ | S-B-A-F-I-$G_2$ |

2C 8

## 2C. [8%] UCS

| [6%] The order of Nodes Expanded | [2%] Solution Path |
|---|---|
| S-B-C-A-D-F-H-E-I-$G_1$ | S-D-E-$G_1$ |

2D 6

## 2D. [6%] Greedy Best-first Search

| [4%] The order of Nodes Expanded | [2%] Solution Path |
|---|---|
| S-D-E-$G_1$ | S-D-E-$G_1$ |

2E 8

## 2E. [8%] A* Search

| [6%] The order of Nodes Expanded | [2%] Solution Path |
|---|---|
| S-D-B-A-H-E-$G_1$ | S-D-E-$G_1$ |

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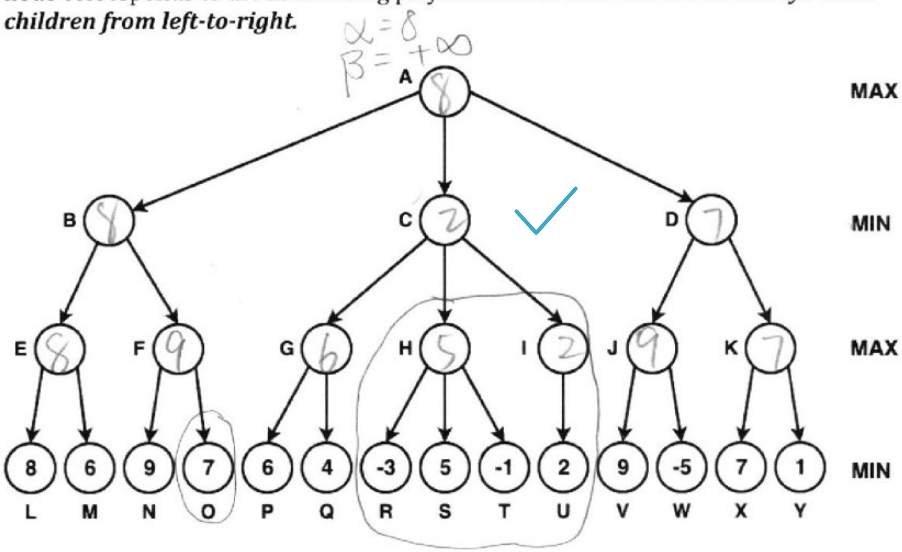
3A 4

3C 8

## 3. [16%] Game Playing

Consider the following game tree in which the evaluation function values are shown inside each leaf node. Each node is assigned a label ranging from A to Y. The root node corresponds to the maximizing player. ***Assume that the search always visits children from left-to-right.***




**3A. [4%]** Compute the backed-up values using the minimax algorithm. **Fill in the corresponding values for the nodes in the tree above.**

3B 4

**3B [4%]** In the search tree above, let us now treat node B as a chance node with an equal probability of selecting either children (only for this subproblem, use the original search tree for 3C and 3D). How does the utility of the root node change? Does the best choice at the root node change given this modification?

The utility will increase to 8.5. The choice of root node still will choose node B

**3C. [8%]** Which nodes will not be examined by the alpha-beta pruning algorithm? **Show your answer by circling in the given tree all the nodes that will be pruned.**

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## 4. [20%] CSP

Andrew Viterbi is looking for a group of friends for his start-up, which develops and provides some web-based p2p downloading solutions to college students (this is before the lawsuits). Andrew has determined that he needs 2 C# Programmers, 2 Flash Designers, 1 Photoshop Guru, 1 Database Admin, and 1 Systems Engineer. Andrew is skilled with C#.

Assume that if a person knows two languages or software, he or she can take on two roles in the company. Andrew has narrowed down his selections to the following people:

| Name | Abilities |
|---|---|
| Alan Turing | C# and Flash |
| Ada Lovelace | Photoshop and Flash |
| Grace Hopper | Flash and Systems |
| Nathaniel Rochester | C# and Database |
| Marvin Minsky | Photoshop and Flash |
| Claude Shannon | Systems and C# |
| John McCarthy | Photoshop and Flash |

4A 4

**4A) [4%]** Suppose Andrew only has funds to hire three people. Model this scenario as a CSP - (using variables, value domains, and constraints).

Domains: { Alan Turing, Ada Lovelace, Grace Hopper, Nathaniel Rochester, Marvin Minsky, claude shannon, John McCarthy } | Variables: { C#, photoshop, Flash, System, Database } | constrain: |photoshop| = 1, |C#| = 2, |Flash| = 2, |Database| = 1, |System| = 1, Besides Andrew, at most 3 domain can be chosen

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4B 4

**4B) [6%]** Suppose Andrew makes Grace a co-founder. Andrew and Grace discover that all the developers absolutely refuse to abandon their favorite platforms, and that they can only afford two single-booted workstations.

| Name | Abilities | OS |
|---|---|---|
| Andrew Viterbi | C# | Windows ✓ |
| Alan Turing | C# and Flash | Windows |
| Ada Lovelace | Photoshop and Flash | Windows |
| Grace Hopper | Flash and Systems | FreeBSD ✓ |
| Nathaniel Rochester | C# and Database | FreeBSD |
| Marvin Minsky | Photoshop and Flash | Linux |
| Claude Shannon | Systems and C# | Linux |
| John McCarthy | Photoshop and Flash | Windows |

What are the domains for the <u>two</u> remaining positions after constraint propagation?

Photoshop: {Ada Lovelace, John McCarthy}

Database: {Nathaniel Rochester}

-2 domain for first step of constraint prop. missing

**4C) [10%]** Assume Andrew and Grace hired Claude and Marvin and have a contract for a rush job due Friday at 5 PM. It's Monday at 9 AM and they must put in 50 total hours of work on it by the due date. There are constraints associated with their work schedules:

- These 4 employees only have access to two machines with the appropriate platform, and only have access between 9 AM and 5 PM every day.
- Each person can work a maximum of 20 hours over the course of the week.
- A single work session by an employee should be no less than 2 hours.
- Andrew can't work Tu,Th 12PM - 4 PM.
- Grace can't work M,W,F 9 AM -12 PM.
- Claude can only work between 12 PM and 2 PM every day.
- Marvin can only work Th and F.

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4C 7

Model this scheduling problem as a CSP. Indicate how the indicated constraints impact the domains for all variables.
(Note: The individual skill and favorite OS constraints don't apply here.)
(Abbreviations: M: Monday, Tu: Tuesday, W: Wednesday, Th: Thursday, F: Friday. 12PM: Noon)

Variables : {Andrew, Grace, Claude, Marvin}
Domains : $\bigcup (a, b[9,17])$ $a \in \{1,2\}$ $b \in \{M, Tu, W, Th, F\}$ 17 => 5pm

$|\text{person}| \leq 20$, where person $\in$ Variables. For $p_1, p_2 \in$ Variable, $p_1 \cap p_2 = \emptyset$

Constrain : Andrew $\neq \bigcup (a, b[12,16])$ $a \in \{1,2\}, b \in \{Tu, Th\}$
Grace $\neq \bigcup (a, b[9,12])$ $a \in \{1,2\}, b \in \{M, W, F\}$
Claude $\neq \bigcup (a, b[12,14]$ $a \in \{1,2\}, b \in \{M, Tu, W, Th, F\}$
Marvin $\neq \bigcup (a, b[9,17])$ $a \in \{1,2\}, b \in \{M, Tu, W\}$

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## 5. [14%] Reinforcement Learning

5A 12

**5A)** [12%] Consider a system with two states and two actions. You perform actions and observe the rewards and transitions listed below. Each step lists the current state, reward, action, and resulting transition as $S_i$; $R = r$; $a_k : S_i \rightarrow S_j$. Perform Q-learning using a learning rate of $\alpha = 0.5$ and a discount factor of $\gamma = 0.5$ for each step. The Q-table entries are all initialized to zero.

$$Q(a,s) \leftarrow Q(a,s) \quad +\alpha(\underbrace{R(s)}_{10} \quad +\gamma \max_{a'}[Q(a',s')] \quad -Q(a,s))$$

i) $S_1$ $R = 10$ $a_1 : S_1 \rightarrow S_1$

| Q | $S_1$ | $S_2$ |
|---|---|---|
| $a_1$ | 5 | 0 |
| $a_2$ | 0 | 0 |

$Q(a_2, s) = 0 + 0.5(10 + \gamma 0 - 0)$

ii) $S_1$ $R = 10$ $a_2 : S_1 \rightarrow S_2$

| Q | $S_1$ | $S_2$ |
|---|---|---|
| $a_1$ | 5 | 0 |
| $a_2$ | 5 | 0 |

$0 + 0.5 \times (-20 + 0.5 \times (\underline{\quad 5 \quad}) - 0)$

$2.5/2 = 1.25$

$-8.75$

iii) $S_2$ $R = -20$ $a_2 : S_2 \rightarrow S_1$

| Q | $S_1$ | $S_2$ |
|---|---|---|
| $a_1$ | 5 | 0 |
| $a_2$ | 5 | -8.75 |

iv) $S_1$ $R = -10$ $a_2 : S_1 \rightarrow S_2$

| Q | $S_1$ | $S_2$ |
|---|---|---|
| $a_1$ | 5 | 0 |
| $a_2$ | -2.5 | -8.75 |

$5 + 0.5 \times (-10 + 0.5 \times 0 - 5)$

$= 5 - \frac{15}{2} = -2.5$

5B 0

**5B)** [2%] What is the optimal policy after these steps?

| | |
|---|---|
| | ← |
| ↑ | ↑ |

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## 6. [10%] Multiple Choice related to Discussions

**Each question has zero or more correct choices. Circle the letters (a., b., c., etc) of all correct choices. Partial credit: beware that you lose 1% for each wrong answer, up to losing 2% for each question (so: all correct = 2%; 1 mistake = 1%, 2+ mistakes = 0%).**

6.1 0

1. In the discussions, we showed several potential measurements for intelligence, please circle all that are true

   a. An intelligent behavior must be completely rational
   b. A rational agent is intelligent by definition
   c. Intelligent agents are those that pass the basic Turing Test or behave rationally
   d. Only human-like behaviors are intelligent
   e. None of the existing AI systems today have any intelligence

6.2 1

2. In the discussions, we showed DARPA grand challenges for AI and Robotics, please circle all those that were a part of the grand challenges:

   a. Self-driving vehicles from Los Angeles to Las Vegas
   b. Deep Blue system to play Chess with human grand master
   c. Robots that perform fire-fighting tasks, including drive-to-site, enter-building, turn-on-water, drill-holes, climb stairs, etc.
   d. Play Go games against human masters
   e. Pass a full Turing Test

6.3 1

3. In the discussions, we discussed the characteristic of A*'s heuristic function h(n), please circle all that are true

   a. The function h(n) represents the estimated future cost
   b. If h(n)=0 for all n, it is still very useful for estimating the future costs
   c. The A* algorithm guarantees to find an optimal solution regardless of what h(n) is
   d. If h(n) is admissible, then A* can find the optimal solution without the g(n) function
   e. A* is a variation of the best-first search algorithm

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6.4 2

4. In the discussions, we discussed the characteristics of alpha and beta values for min-max search, please circle all that are true

a. The alpha value will only be changed by the Max agent
b. The beta value will only be changed by the Min agent
c. The meaning of the alpha value is "the least value that Max can already get"
d. The meaning of the beta value is "the maximum value that Min would give so far"
e. Using the alpha and beta values will change the outcome of the basic min-max game playing

6.5 2

5. In the discussions, we showed a variety of function optimization techniques, please circle all that is true

a. Hill climbing is a complete deterministic algorithm
b. Simulated Annealing can guarantee finding the global extreme value in a finite time
c. There is a proof for why Genetic Algorithm can find the global extreme value in the evolution
d. The optimization problem is one of the most fundamental problems in AI
e. Constraint-Satisfaction problems can also be solved by some optimization techniques

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