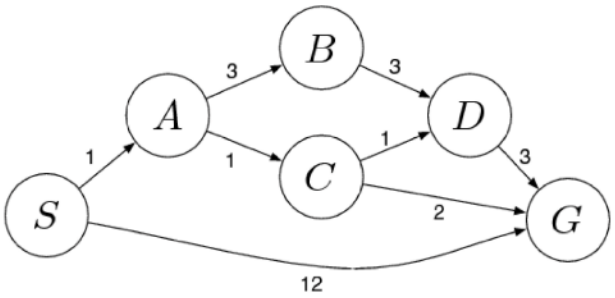
Midterm 1 - Fall 2023

Q1 (10*1%, no partial) (#1~#10)

T/F	Reference	Description
F	1-35	In the basic Turing test, a computer needs natural language processing techniques to communicate with testers and graphic processing techniques to see the actions of the tester.
T	1-68	For an (intelligent) agent, it percepts information from the environment and takes actions to achieve the goals.
T	2-37	To define a general search problem, you will need to define the initial state, operators for actions you can take, a goal test to check whether you have achieved the goal, and, if necessary, a cost evaluation method for the path.
T	2-77	The existing algorithms to solve a Traveling Salesman Problem (TSP) have an exponential complexity.
F	3	Depth limited search will always get to the same, optimal goal state as BFS.
T	3-26	BFS is a special case of Uniform-cost search where the path cost equals the node depth.
F	4-5	Greedy search always expands the node that is the closest to the starting point.
F	5-16	Backtracking search is a basic **informed** algorithm for CSPs
F	6-6	Solving a Game problem is like solving a search problem since everything is predictable.
T	7-40	The difference between a standard MDP and POMDP is that a POMDP has a sensor model P(e|s) and a belief of what the current state is b(s).

Q2. Search（20%）



State	h_1	h_2
S	5	4
A	3	2
B	6	6
C	2	1
D	3	3
G	0	0

Answer the following questions about the search problem shown above. Break any ties alphabetically.

(#11) Q1: What path would breadth-first graph search return for this search problem?(3%)

A. $S \rightarrow G$
B. $S \rightarrow A \rightarrow C \rightarrow G$
C. $S \rightarrow A \rightarrow C \rightarrow D \rightarrow G$
D. $S \rightarrow A \rightarrow B \rightarrow D \rightarrow G$

Answer: A

(#12) Q2: what path would uniform cost graph search return for this search problem? (3%)

A. $S \rightarrow G$
B. $S \rightarrow A \rightarrow C \rightarrow G$
C. $S \rightarrow A \rightarrow C \rightarrow D \rightarrow G$
D. $S \rightarrow A \rightarrow B \rightarrow D \rightarrow G$

Answer: B

(#13) Q3: what path would depth-first graph search return for this search problem? (3%)

A. $S \rightarrow G$
B. $S \rightarrow A \rightarrow C \rightarrow G$
C. $S \rightarrow A \rightarrow C \rightarrow D \rightarrow G$
D. $S \rightarrow A \rightarrow B \rightarrow D \rightarrow G$

Answer: D

(#14) Q4: what path would A* graph search using h_1 heuristic return for this search problem? (3%)

A. $S \rightarrow G$
B. $S \rightarrow A \rightarrow C \rightarrow G$

C. $S \rightarrow A \rightarrow C \rightarrow D \rightarrow G$
D. $S \rightarrow A \rightarrow B \rightarrow D \rightarrow G$

Answer: B

Consider the h_1 and h_2 heuristics for this problem, shown in the table above. Comment.

(#15) Q5: Is h_1 admissible? (2%)
Yes
NO

Answer: NO

(#16) Q6: Is h_1 consistent? (2%)
Yes
NO

Answer: NO

(#17) Q7: Is h_2 admissible? (2%)
Yes
NO

Answer: Yes

(#18) Q8: Is h_2 consistent? (2%)
Yes
NO

Answer: NO

3. [20%] Constraint Satisfaction

Given the cryptarithmetic problem below:

```
   R A I N
+
   R A I N
+
   R A I N
_____________
 S N O W
```

This is formulated as a CSP model as follows:

- Variables: the letters: R, A, I, N, S, O, and W
- Possible values: {0,1,..,9}
- Constraints: all letters (carry variables excluded) have different values, addition works as intended, leading digits aren't zero.
- Consider X1, X2, X3 as corresponding carry forward variables.

[2%] Select all that are considered as "variables" from following options:

(#19) **A, I, N, O, R, S, W, *X1, X2, X3,*** Right Minus Wrong Selections (±0.1 pts per answer)

[1%] What are the domain values for A? Select all that applies:

(#20) **A: {0,1,2,3,4,5,6,7,8,9}** (no partial)

[1%] What are the domain values for N? Select all that applies:

(#21) **N: {0,1,2,3,4,5,6,7,8,9}** (no partial)

[1%] What are the domain values for R? Select all that applies:

(#22) **R: {1,2,3}** (no partial)

[1%] What are the domain values for S? Select all that applies:

(#23) **S: {1,2,3,4,5,6,7,8,9}** (no partial)

[1%] What are the domain values for X2? Select all that applies:

(#24) **X2: {0,1,2}** (no partial)

[5%] From the following options, select all correct constraints that applies to this question:
Right Minus Wrong Selections (±0.5 pts per answer)
(#25)
ALLDIFF(A, I, N, O, R, S, W)
W = 3*N -10*X1
O = 3*I + X1 - 10*X2
N = 3*A + X2 - 10*X3
S = 3*R + X3

[4%] Considering MRV [Minimum Remaining Values] as a heuristic, which of the variables will be chosen for assignment first? In case of a tie, list all such variables.

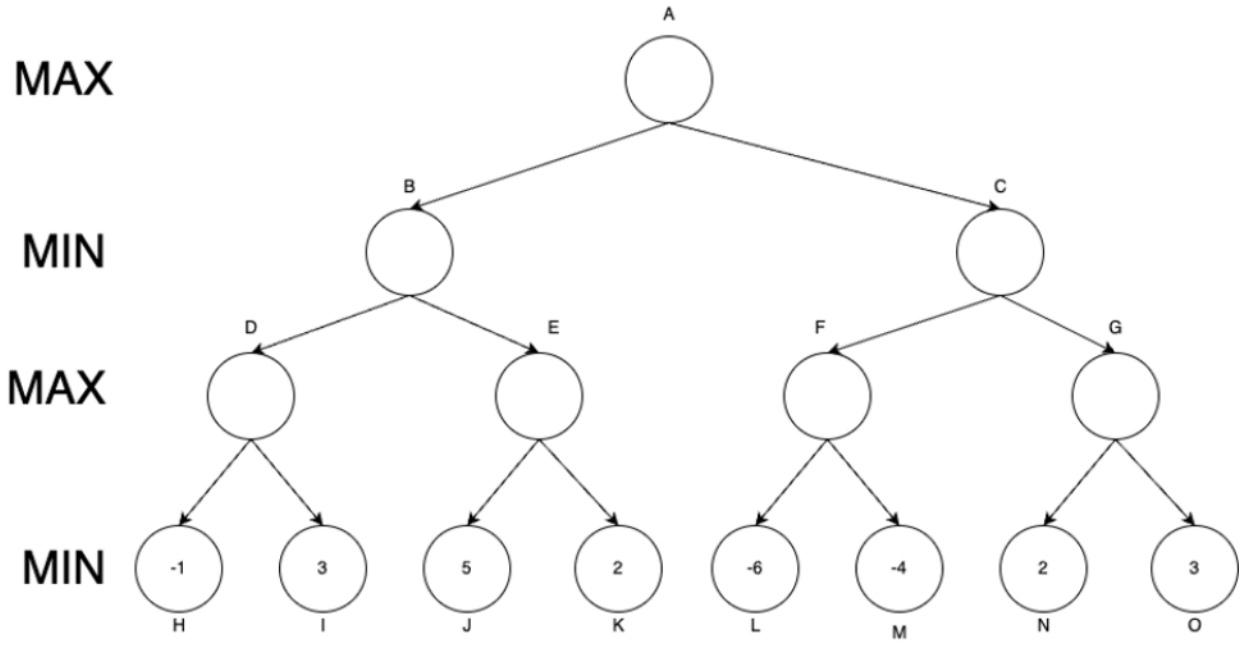
Right Minus Wrong Selections (±0.4 pts per answer)
(#26)
R, X1, X2, X3

[2%] Let's say X1 is set to 1. What are the domains of A after arc-consistency is enforced?
Right Minus Wrong Selections (±0.2 pts per answer)
(#27) **A: {1,2,4,5,8}**

[2%] Let's say X1 is set to 1. What are the domains of **N** after arc-consistency is enforced?
Right Minus Wrong Selections (±0.2 pts per answer)
(#28) **N: {4,5,6}**

Q4. [20%] Game Playing

Consider the following game tree in which the evaluation function values are shown inside each leaf node.
Assume that the root node corresponds to the maximizing player. ***Assume that the search always visits children left-to-right.***



3.A [6%] What are the expected values of the following nodes after applying the minimax algorithm?

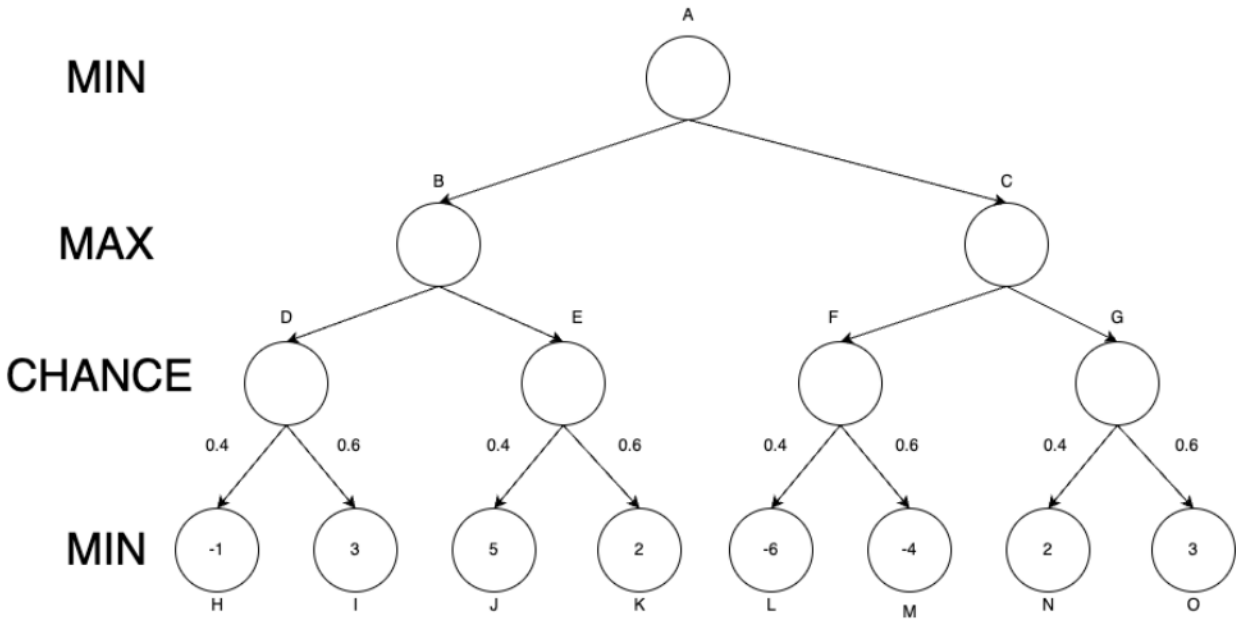
i. (#29)[2%] A - 3
ii. (#30)[2%] C - -4
iii. (#31)[2%] G - 3

3.B (#32) [8%] Will the mini max algorithm examine the following nodes with Alpha Beta pruning? Enter "Y" for yes and "N" for no.

i. [2%] H - Y
ii. [2%] K - N
iii. [2%] G - N
iv. [2%] N - N

3.C [6%] Consider the following changes to the tree –
Level 0 – A – MIN

Level 1 – B,C – MAX
Level2 – D, E, F, G – CHANCE
Level3 – H, I, J, K, L, M, N, O – MIN
Suppose the chance nodes always pick the left branch with a probability of 0.4 and the right branch with a probability of 0.6



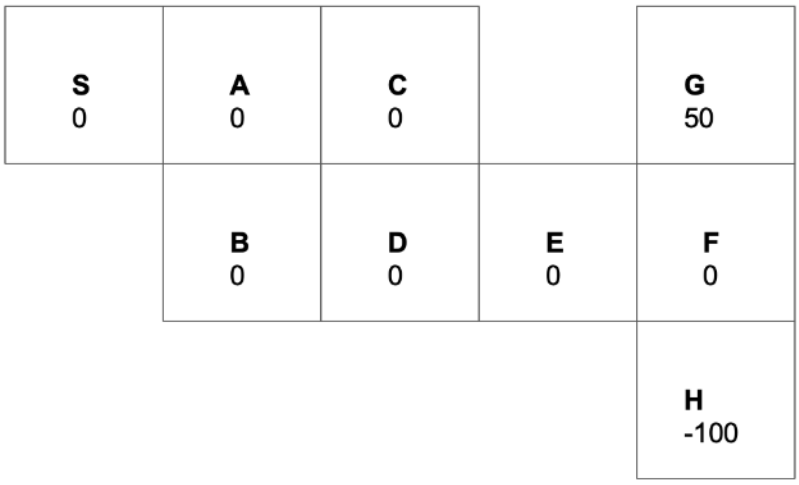
What are the values of the following nodes after applying the minimax algorithm to the modified tree?

i. (#33)[2%] A – 2.6
ii. (#34)[2%] B – 3.2
iii. (#35)[2%] F – -4.8

Q5 - Reinforcement Learning (20%)

Reinforcement Learning [20%]

Consider a square grid world as shown below. This world operates like the square grid world MDP which we saw in the class.



Each grid square is a state, identified by its labels $[S, A, B, C, D, E, F, H]$.

The player always starts at state **S**, and **G** is the goal state. The agent is allowed to move in any of the 4 directions(up, down, left, right) on the square grid, given that there is an adjacent square in that direction. If there is no adjacent grid in a direction, then that action will result in no state change (i.e. remaining in the same grid square). There are **no actions available** from the goal state (G). The actions are labeled UP, DOWN, LEFT, and RIGHT.

The rewards $R(s, a, s')$ for reaching a particular state s' from s using an action a is mentioned at the center of each state in the grid. (The reward for a state is received as the agent moves into the state)

The transition probability for any given action resulting in the intended movement is 0.8, and the transition probability for that action resulting in moving in the opposite direction is 0.2. So for example:

$P(A, DOWN, B') = 0.8$
$P(A, DOWN, A') = 0.2$

$P(A, RIGHT, C') = 0.8$
$P(A, RIGHT, S') = 0.2$

The utility formula is given below:

$$U_{t+1}(s) \leftarrow max_a \sum_{s'} P(s, a, s')[R(s, a, s') + \gamma U_t(s')]$$

Given the future discount factor $\gamma = 0.9$, perform the Utility Value Iteration using the above-given formula (also given in lecture slides) for this grid to answer the following questions. For each Utility value, round your answer to the tenths decimal place (i.e. 30.05 would become 30.1, and 30.04 would become 30.0) **[NOTE: During the exam we announced that answers should be ROUNDED to THREE(3) decimal places, and this is the standard that was used to grade this question]**

You can assume the initial Utility value for all states as 0 i.e., $U_0(s) = 0,\ \forall s \in \{S,\ A,\ B,\ C,\ D,\ E,\ F,\ H\}$. Use the policy $\pi_t(s) = UP$ if no best policy is available.

A. **[6%]** Calculate the Utility value and the best policy (i.e., action) of all the states $[S,\ A,\ B,\ C,\ D,\ E,\ F,\ G,\ H]$ at time 1, i.e., $U_1(s)\ and\ \pi_1(s),\ \forall s \in \{S,\ A,\ B,\ C,\ D,\ E,\ F,\ G,\ H\}$

[Rubric: deduct 0.33 point for each wrong answer]

Answer:

(#36~#53)

s	$U_1(s)$	$\pi_1(s)$
S	0.000	UP
A	0.000	UP
B	0.000	UP
C	0.000	UP
D	0.000	UP
E	0.000	UP
F	+20.000	UP
G	+50.000	N/A
H	-20.000	UP

B. **[6%]** Calculate the Utility value and the best policy (i.e., action) of all the states $[S, A,\ B,\ C,\ D,\ E,\ F,\ G,\ H]$ at time 2, i.e., $U_2(s)\ and\ \pi_2(s),\ \forall s \in \{S, A,\ B,\ C,\ D,\ E,\ F,\ G,\ H\}$

[Rubric: deduct 0.33 point for each wrong answer]

Answer:

(#54~#71)

s	$U_1(s)$	$\pi_1(s)$
S	0.000	UP
A	0.000	UP
B	0.000	UP
C	0.000	UP
D	0.000	UP
E	+14.400	RIGHT
F	+52.400	UP
G	+50.000	N/A
H	-9.200	UP

C. **[6%]** Calculate the Utility value and the best policy (i.e., action) of all the states $[S, A,\ B,\ C,\ D,\ E,\ F,\ G,\ H]$ at time 3, i.e., $U_3(s)\ and\ \pi_3(s),\ \forall s \in \{S, A,\ B,\ C,\ D,\ E,\ F,\ G,\ H\}$

[Rubric: deduct 0.33% for each wrong answer]

Answer:
(#72~#89)

s	$U_1(s)$	$\pi_1(s)$
S	0.000	UP
A	0.000	UP
B	0.000	UP
C	0.000	UP
D	+10.368	RIGHT
E	+37.728	RIGHT
F	+54.344	UP
G	+50.000	N/A
H	16.072	UP

D. **[2%]** What should be the best agent policy path after convergence of the Utility Value Iteration algorithm i.e., the path with the highest rewards? (Do not solve for more iterations, give the answer based on intuition.Your path must be comma-separated without spaces and lexicographically smallest)
[Rubric: no partial marking]
(#90) Answer: S,A,B,D,E,F,G

Q6 - Multiple Choice for Discussion Sessions

Right Minus Wrong Selections (±0.4 pts per answer)

Answer	Description	A	B	C	D	E
A,C,E	(#91) An intelligent agent uses the PAGE framework to operate and achieve its goals. Select the statements that are true:	The "P" in PAGE stands for Percepts, representing the information the agent gathers from its environment.	Intelligent agents need to be coded in a new programming language.	The "G" in PAGE refers to Goals, the objectives the agent aims to achieve.	The environment of an intelligent agent is always well-defined and static.	The "A" in PAGE signifies the Actions an agent can perform to interact with its environment.
A,C,D	(#92) Select the correct statements that are commonly utilized criteria for evaluating the effectiveness of search algorithms in artificial intelligence:	Completeness	Responsiveness	Optimality	Time complexity	Structural Complexity
C	(#93) In the context of iterative improvement algorithms, which of the following statements is true?	The pathway in the state space is the main focus of the solution.	The state space consists of incomplete configurations that are refined over time.	The algorithms aim to find either an optimal configuration (e.g., TSP) or a configuration satisfying certain constraints (e.g., n-queens).	The algorithms work on several "current" states at a time, aiming to improve them concurrently.	The main goal is to trace the path from the start state to the goal state, regardless of the goal state's configuration.
B	(#94) In the context of constraint propagation, when determining which variable should be	Choosing the variable that is least constrained.	Choosing the variable with the minimum	Selecting the variable that has been	Assigning a value to the variable with the most	Choosing a variable randomly without considering

	assigned a value next, which strategy might be used for variable selection?		remaining values or the most constraints on others.	involved in the fewest constraints on others.	constraining value first.	any constraints or values.
A,B	(#95) Which of the following are steps of Genetic Algorithm cycle?	Mutation	Selection	Feedback	Documentation	Analysis