King Saud University	College of Computer and Information Sciences Department of Computer Science
CSC 361: Artificial intelligence	**Final exam - Spring 2020**
Date: 05/05/2020	Duration: 180 minutes

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Question 1: Local Search .... 10 points

Circle the correct answer:

1. Simulated annealing guaranties to find the optimal solution. (A) True (B) False
2. In simulated annealing, as the temperature decreases the probability of accepting a bad move decreases. (A) True (B) False
3. Simulated annealing can be used to solve the TSP (traveling salesman problem). (A) True (B) False
4. Local beam search can be used to search for the local or global minimum but not the local or global maximum. (A) True (B) False
5. Local beam search selects the best successor among k neighbors. (A) True (B) False
6. Local beam search returns the k best states in the state space. (A) True (B) False
7. Genetic algorithms guaranty to find the best solution in any state space. (A) True (B) False
8. Mutation is always performed in Genetic algorithms. (A) True (B) False
9. Consider the search space in Figure 1. The numbers inside the nodes represent the value of the objective function. Simulated annealing is used to search for the state with the maximum value. The initial temperature is set to $T = 3$ and the initial state is A. If $current = A$ and B is randomly selected as a successor of A, then simulated annealing will:

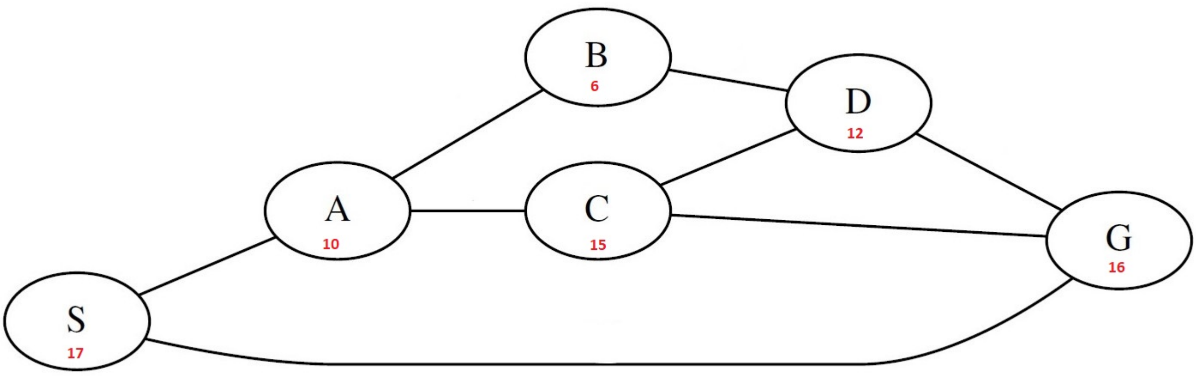

Figure 1: Search space

(A) Assign $current = B$.

(B) Generate a random number between 0 and 1. If this number is greater than $exp^{(\Delta e/T)}$, then *current* $= B$.

Ⓒ Reject B because it is worse than A.

Ⓓ None of the above

10. Consider the search space in Figure 1. Simulated annealing (SA) is used to search for the state with the maximum value. The initial temperature is set to $T = 3$, $T = T - 1$ at each iteration of SA and the initial state is A. If $current = D$ and G is randomly selected as a successor of D and simulated annealing has already visited B, C, D starting from A, then in the next iteration of simulated annealing:

    Ⓐ Simulated annealing selects S as a successor of G and since S is the global maximum, Simulated annealing will return S.

    Ⓑ Simulated annealing returns G.

    Ⓒ Simulated annealing selects S as a successor of G.

    Ⓓ None of the above

Question 2: CSP . . . . **8 points**

Answer the following questions:

1. When using the incremental state formulation and assigning a value to a single variable at each node, the size of the state space is:

    Ⓐ d^n, where d is the maximum size of the domain and n is the number of variables.

    Ⓑ $n!d^n$, where d is the maximum size of the domain and n is the number of variables.

    Ⓒ n^d, where d is the maximum size of the domain and n is the number of variables.

    Ⓓ None of the above.

2. Problem formulation in CSP consists in:

    Ⓐ Generating the constraint graph.

    Ⓑ Defining only the constraints.

    Ⓒ Defining the variables, their domains and the constraints.

    Ⓓ None of the above.

3. Which problem **cannot be solved** using CSP:

    Ⓐ Sudoku.

    Ⓑ N-queens.

    Ⓒ Finding the shortest path from one city to another.

    Ⓓ None of the above choices.

4. The MRV heuristic is used to:

    Ⓐ Select the variable with the smallest domain.

    Ⓑ Select the value that satisfies the fewest constraints.

    Ⓒ Select the variable with the maximum values.

    Ⓓ None of the above choices.

5. Given a set of n suitcases in an airport $s = \{s_1, s_2, ..., s_n\}$, you want to put them into two trucks t_1 and t_2 such as the sum of the weight of the suitcases in t_1 is equal to the sum of the weight of the suitcases in t_2. Which suggestion shows the correct set of variables and domains needed to solve the problem using CSP.

   (A) t_1 and t_2 are the variables. The domains are $D_{t_1} = \{s_1, s_2, ..., s_n\}$ and $D_{t_2} = \{s_1, s_2, ..., s_n\}$.

   (B) $\{s_1, s_2, ..., s_n\}$ is the set of variables. The domains are $D_{s_i} = \{t_1, t_2\}$, where $i = \{1..n\}$.

   (C) All above are correct.

   (D) None of the above are correct.

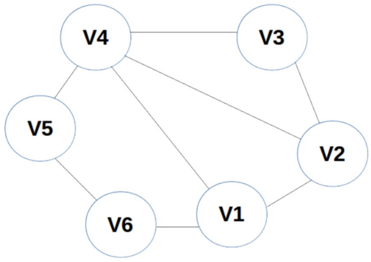

Figure 2: Graph coloring

6. Color the graph in Figure 2 so that no adjacent nodes have the same color, using backtracking with forward checking and **MRV** heuristics, assume you can use 3 colors:**{R, G, Y}**. Start with the variable with the highest degree. Ties are broken in the following order {V1,V2,V3,V4,V5,V6} and values in the following order {R, G, Y}. Which one is the obtained assignment:

   (A) $\{V1 = G, V2 = Y, V3 = G, V4 = R, V5 = G, V6 = R\}$

   (B) $\{V1 = R, V2 = G, V3 = R, V4 = Y, V5 = R, V6 = G\}$

   (C) $\{V1 = Y, V2 = G, V3 = Y, V4 = R, V5 = Y, V6 = R\}$

   (D) $\{V1 = G, V2 = R, V3 = G, V4 = Y, V5 = G, V6 = Y\}$

7. Apply AC3 algorithm to the graph in Figure 3.

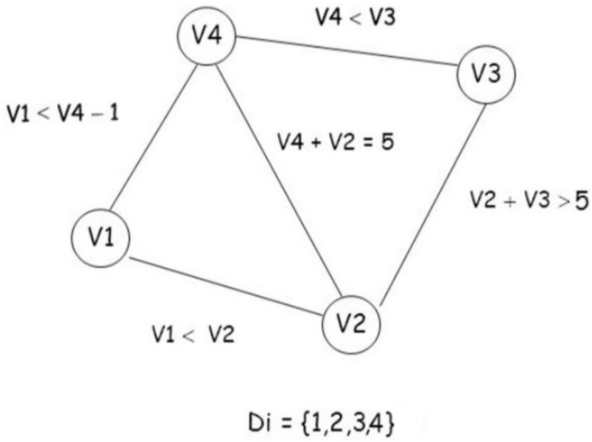

Figure 3: Graph

Table 1: AC3

Queue	V1 $\{1,2,3,4\}$	V2 $\{1,2,3,4\}$	V3 $\{1,2,3,4\}$	V4 $\{1,2,3,4\}$	added arcs
V_1V_2					
V_2V_1		**Y**			
V_1V_4	**X**		**W**		
V_4V_1				**Z**	
V_4V_2					
V_2V_4					
V_3V_4					
V_4V_3					
V_3V_2					
V_2V_3					

What are the values of **X, Y, W, Z** shown in Table 1:

(A) $X = \{1,2\}$, $Y = \{2,3,4\}$, $W = \{1,2,3,4\}$ and $Z = \{3,4\}$

(B) $X = \{1,2,3\}$, $Y = \{1,2,3,4\}$, $W = \{4\}$ and $Z = \{3\}$

(C) $X = \{1,2\}$, $Y = \{2,3,4\}$, $W = \{4\}$ and $Z = \{3\}$

(D) None of the above

8. What is the final domain of the variables **V1,V2,V3,V4** after applying AC3 algorithm:

(A) $V1 = \{1\}$, $V2 = \{2,3\}$, $V3 = \{4\}$, $V4 = \{3\}$

(B) $V1 = \{1\}$, $V2 = \{2\}$, $V3 = \{4\}$, $V4 = \{3,4\}$

(C) $V1 = \{1,2\}$, $V2 = \{2\}$, $V3 = \{4\}$, $V4 = \{3\}$

(D) None of the above

Question 3: Adversarial Search . . . . 8 points

Answer the following questions:

1. A utility function applies:

(A) Only to non-terminal states.

(B) Only to terminal states.

(C) Both to terminal and non-terminal states.

(D) None of the above.

2. Minimax algorithm:

(A) Can always reach the terminal states of the tree of any adversarial search problem.

(B) Cannot reach the terminal states in most adversarial search problems since it has a limited time to reach these states.

(C) Can return a solution even if it did not reach the terminal states.

(D) None of the above.

3. A good order of the terminal states when applying $\alpha - \beta$ pruning :

(A) Can result in a solution with a higher utility value.

(B) Can increase the depth of search.

(C) Can in some cases give a bad solution.

(D) None of the above.

4. Two evaluation functions are equivalent when applying MinimaxCutoff:

(A) Only if they give the same utility value for the solution.

(B) Only if they give the same value to the states that are at the cut-off level.

(C) Only if they give the same order to the states that are at the cut-off level.

(D) None of the above.

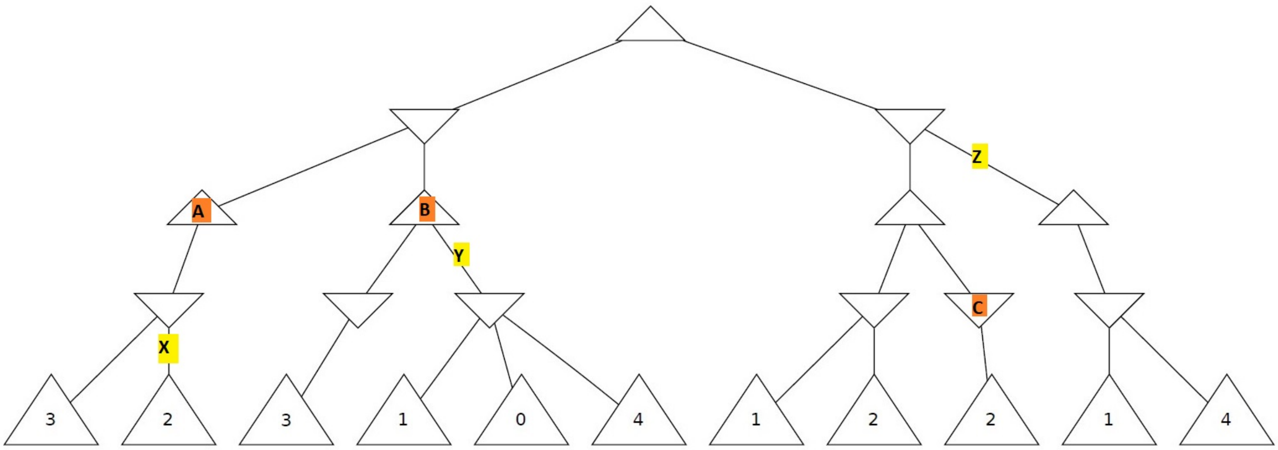

Figure 4: Game tree

5. After applying $\alpha - \beta$ to the game tree in Figure 4:

(A) For node A, the value of $\alpha = 2$ and $\beta = +\infty$.

(B) For node A, the value of $\alpha = -\infty$ and $\beta = +\infty$.

(C) For node A, the value of $\alpha = 3$ and $\beta = -\infty$.

(D) None of the above.

6. After applying $\alpha - \beta$ to the game tree in Figure 4:

(A) For node B, the value of $\alpha = 3$ and $\beta = 2$.

Ⓑ For node B, the value of $\alpha = 3$ and $\beta = +\infty$.

Ⓒ For node B, the value of $\alpha = -\infty$ and $\beta = 2$.

Ⓓ None of the above.

7. After applying $\alpha - \beta$ to the game tree in Figure 4:

Ⓐ For node C, the value of $\alpha = 2$ and $\beta = +\infty$.

Ⓑ For node C, the value of $\alpha = 1$ and $\beta = 2$.

Ⓒ For node C, the value of $\alpha = 2$ and $\beta = 2$.

Ⓓ None of the above.

8. After applying $\alpha - \beta$ to the game tree in Figure 4:

Ⓐ the edges X, Y, Z are pruned.

Ⓑ the edge Z only is pruned.

Ⓒ the edges Y and Z are pruned.

Ⓓ No edge is pruned.

Question 4: Decision trees .... 10 points

Answer the following questions:

1. ID3 algorithm is a supervised learning approach. Ⓐ True Ⓑ False
2. Unsupervised learning approaches need a training and a test set. Ⓐ True Ⓑ False
3. Always choose a hypothesis that is consistent with the data even if it does not generalize well. Ⓐ True Ⓑ False
4. A decision tree can be used to predict prices of houses based on their surfaces and the number of their rooms. Ⓐ True Ⓑ False

Example	P	Q	R	Output
1	1	0	0	1
2	0	0	1	1
3	1	0	1	1
4	0	1	0	0
5	1	1	0	0
6	0	1	1	0
7	0	1	1	0
8	0	1	1	1

Figure 5: Learning examples

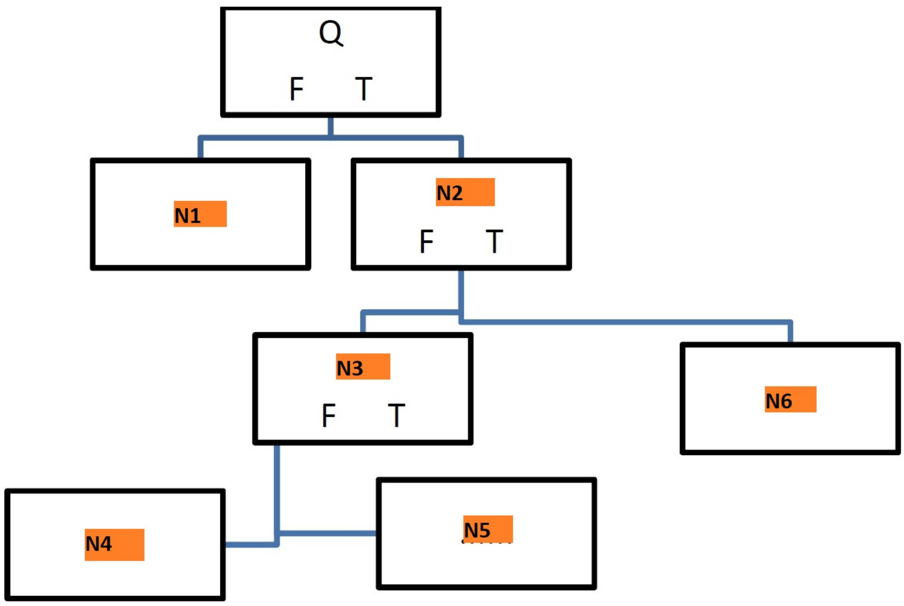

Figure 6: Learning tree

5. Consider the examples shown in Figure 5. Complete the decision tree in Figure 6. In the test node at the second level, the remainders are: $Remainder\,(R) = 0.95$, $Remainder\,(P) = 0.8$.

   What is the value of $N1$ in the decision tree shown in Figure 6:

   (A) False. (B) True. (C) P. (D) None of the previous

6. What is the value of $N2$ in the decision tree shown in Figure 6:

   (A) False. (B) True. (C) P. (D) None of the previous

7. What is the value of $N3$ in the decision tree shown in Figure 6:

   (A) False. (B) True. (C) P. (D) None of the previous

8. What is the value of $N4$ in the decision tree shown in Figure 6:

   (A) False. (B) True. (C) P. (D) None of the previous

9. What is the value of $N5$ in the decision tree shown in Figure 6:

   (A) False. (B) True. (C) P. (D) None of the previous

10. What is the value of $N6$ in the decision tree shown in Figure 6:

    (A) False. (B) True. (C) P. (D) None of the previous

Question 5: PL .... **11 points**

Given the following propositional KB:

- A1: $(U \wedge \neg Q) \leftrightarrow S$
- A2: $\neg P \vee T \vee R$
- A3: $S \implies P \vee R$
- A4: $U \wedge \neg Q$

- A5: $\neg T$

To prove R, a sequence of rules have been applied (as shown in Table 2).

Table 2: Proof

Premises	Conclusion	Rule name
A1	A6: $(U \wedge \neg Q) \rightarrow S \wedge S \rightarrow (U \wedge \neg Q)$	**X1**
A6	A7: $(U \wedge \neg Q) \rightarrow S$	**X2**
A4,A7	A8: **X3**	**X4**
A3, A8	A9: **X5**	**X6**
A2, A5	A10: **X7**	**X8**
X9, A10	A11: R	**X10**

Complete the table by assigning the correct value to each variable $X1, X2, X3, X4, X5, X6, X7, X9, X10$:

1. $X1$ is:

   (A) Implication elimination.

   (B) Biconditional elimination.

   (C) And elimination.

   (D) None of the above

2. $X2$ is:

   (A) Implication elimination.

   (B) Biconditional elimination

   (C) And elimination.

   (D) None of the above

3. $X3$ is:

   (A) $(U \wedge \neg Q) \wedge S$. (B) $(U \wedge \neg Q)$ (C) S (D) None of the above

4. $X4$ is:

   (A) Resolution rule.

   (B) And elimination.

   (C) Modus Ponens.

   (D) None of the above

5. $X5$ is:

   (A) $P \vee R$ (B) $\neg S \vee P \vee R$. (C) $\neg S \wedge P \vee R$. (D) None of the above

6. $X6$ is:

   (A) Resolution rule.

   (B) Implication elimination.

(C) Modus Ponens.

(D) None of the above

7. $X7$ is:

(A) $\neg P \lor R$ (B) $\neg P \lor T \lor R \land \neg T$. (C) $\neg P \lor T \lor R \lor \neg T$. (D) None of the above

8. $X8$ is:

(A) Resolution rule.

(B) Implication elimination.

(C) Modus Ponens.

(D) None of the above

9. $X9$ is:

(A) $P \lor R$ (B) $\neg P \lor R$. (C) $\neg P \lor T \lor R \lor \neg T$. (D) None of the above

10. $X10$ is:

(A) And elimination.

(B) Resolution rule.

(C) Modus Ponens.

(D) None of the above

11. Consider the following propositional logic KB in Horn form:

- A1: $A \land B \implies D$
- A2: $A \land F \implies G$
- A3: $B \land C \implies F$
- A4: $D \land C \implies H$
- A5: $A \land C \implies E$
- A6: $G \land E \land H \implies I$
- A7: A
- A8: B
- A9: C

Use **forward** chaining to prove I (when more than one rule is applicable, follow the order specified above). The 4^{th} rule to be fired is:

(A) A5. (B) A2. (C) A6. (D) None of the above