FINAL EXAMINATION SOLUTION (BATCH 1)

Course: Introduction to Artificial Intelligent	
Time: 100 minutes	Term: 3 – Academic year: 2020-2021
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Class: 19CLC2	
Student name:	Student ID:

(Notes: Students must turn on the webcam when taking the online test)

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Question 1: (1.5pt)

Given a pair of **8-puzzle problem** as follow. Find the ***sequence of legal moves*** from the Initial state to the Goal state with the lowest cost, using **Hill Climbing algorithm** with heuristic function is the ***total number of misplaced tiles***. You can stop after **5** moves if you cannot find the Goal.

1	2	3
5		6
4	7	8

Initial State

1	2	3
4	5	6
7	8	

Goal State

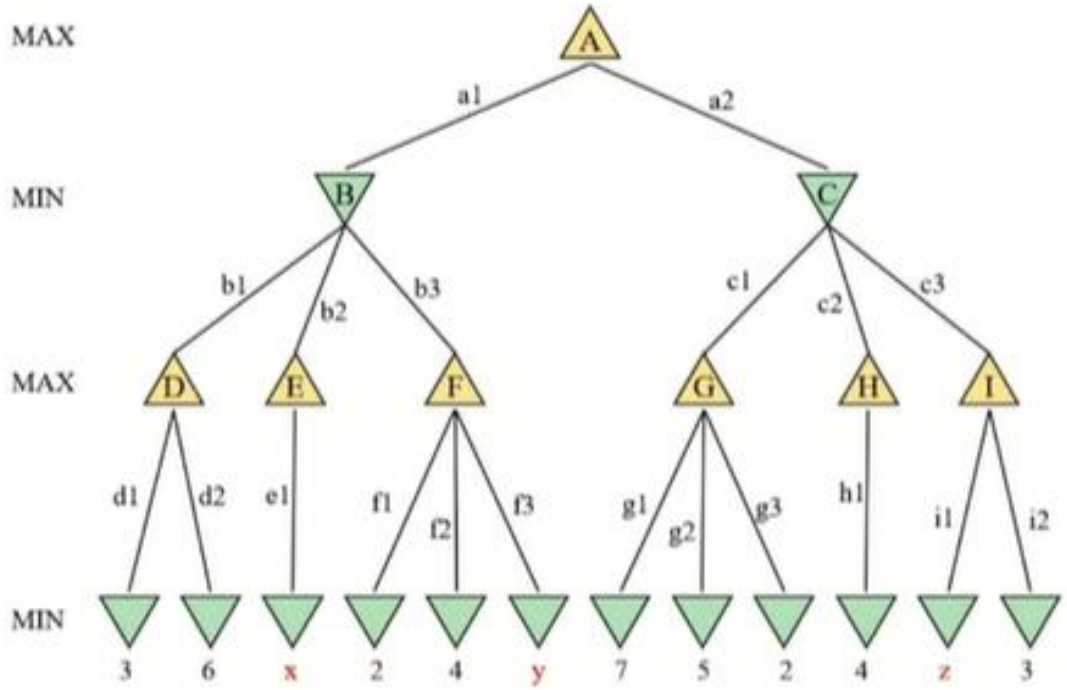
A state is denoted by a **9-digit** string from left to right, up to down; blank space is denoted by 0. For example: the initial state is **023164875**, the goal state is **123804765**.

1. Heuristic value of the Initial State is: h(Initial State) = 4
2. Fill the state in each move. Type xxxxxxxxx to the move and x to the heuristic value if you have found the goal state in previous move.
   1st move: 123064875, heuristic value = 3
   2nd move: 123864075, heuristic value = 2
   3rd move: 123864705, heuristic value = 1
   4th move: 123804765, heuristic value = 0
   5th move: xxxxxxxxx, heuristic value = x

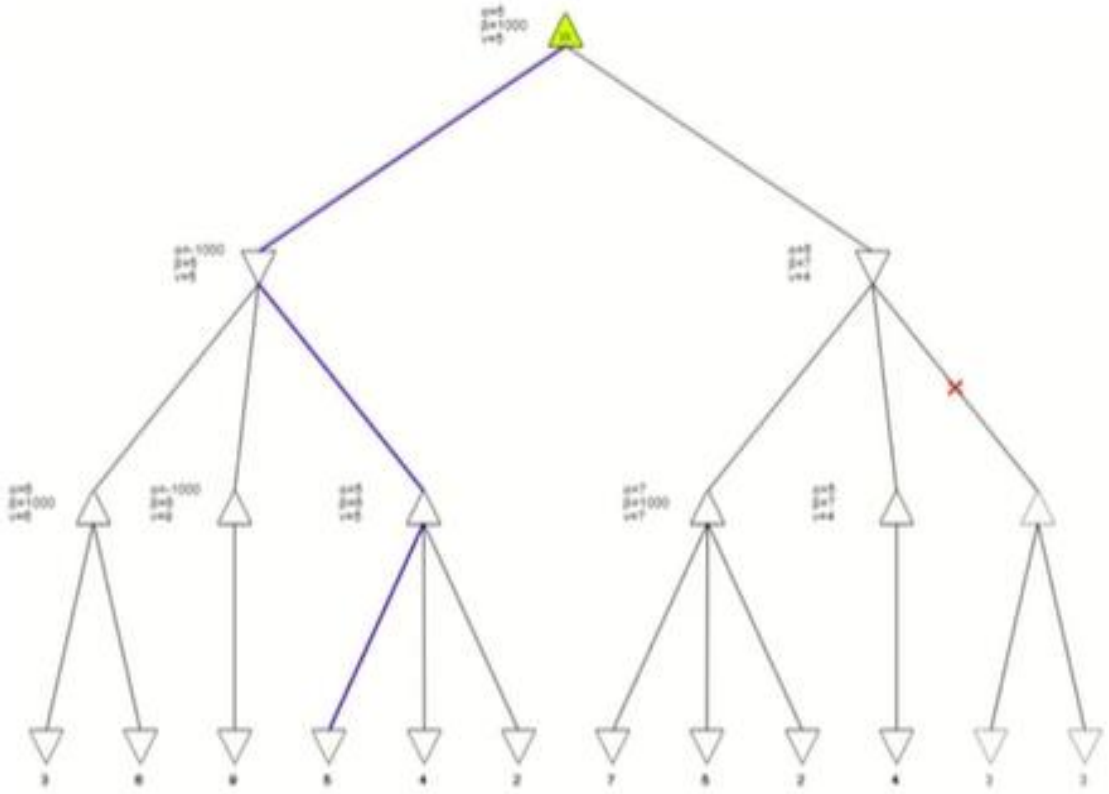
Note: if there are more than one states that have the same heuristic value, the best move is the state with smallest representation string (for example: 123506478 is better than 123576408)

Question 2: (1.5pt)

1. Run minimax algorithm for the following game tree where x = 9, y = 5, z = 3. What is the value of the root A?
   Answer: A = 5



2. Apply alpha-beta pruning for the tree in a). Which branch(es) of the tree should be pruned? If more than one branch are pruned, each branches should be separated by a comma without blank spaces (for example: a1,c3,i2) and be written in the order from left to right. If no branch is pruned, write 0
   Answer: c3
3. The game path returned by the algorithm is:
   Answer: a1,b3,f1



Question 3: (1pt)

Given a knowledge base KB as follows

- ¬A → B
- B → D
- A → C
- C → K
- D → K

a. Use resolution to prove that the above KB entails K. Your answer should be clearly, step by step to get full score.

Step 1: Convert KB to CNF

1. A ∨ B
2. ¬B ∨ D
3. ¬A ∨ C
4. ¬C ∨ K
5. ¬D ∨ K

Step 2: Negate conclusion and add to KB

6. ¬K

Step 3: Resolve each pairs of sentences

7. ¬C (resolve 4, 6)
8: ¬A (resolve 3, 7)
9: B (resolve 1, 8)

10: D (resolve 2, 9)
11: ¬D (resolve 5, 10)
12: empty (resolve 10, 11)
Therefore, KB entails K (since KB ∧ ¬K gives a contradiction)

b. Can the above problem be solved by using Forward chaining? Give your reason. (If no reason is given, you will be scored 0)
Answer: No
Reason: Not all clauses in KB are definite clauses which is a disjunction of literals of which exactly one is positive.
The first clause: A ∨ B, has 2 positive literals.
Furthermore, Forward chaining algorithm begins from known facts (positive literals) in the knowledge base. We don't have a known fact in our KB.

**However, if we consider two cases of A (A is true, ~A is true), then this KB -> K can be solved by Forward chaining algorithm.*

Question 4: (0.5pt)

Consider a knowledge base containing just two sentences S(a) and S(b).

1) Does this KB entail the sentence ∀x S(x)?
Answer: NO
2) Explain your answer using a specific example. You will be scored 0 if no explanation is given or the explanation is wrong.
Answer: For example, S is a predicate which means male. S(a) means a is a male, S(b) means b is a male but not everyone is male.
Therefore, KB cannot entail ∀x S(x)

Question 5: (1.5pt)

Given the following predicates:

a. CHILD(x): x is a child
b. FAIRY(x): x is a fairy
c. WITCH(x): x is a witch
d. LOVE(x,y): x loves y
e. PURPLEHAIR(x): x has purple hair
f. WEIRD(x): x is weird

a) Translate the following axioms into First-order logic sentences

1. Every child loves Pinocchio.
∀x (CHILD(x) → LOVE(x, Pinocchio))
2. Everyone who loves Pinocchio loves any fairy.
∀x (LOVE(x, Pinocchio) → ∀y (FAIRY(y) → LOVE(x,y)))

3. Ensley is a fairy, and Ensley has purple hair.
   FAIRY(Ensley) ∧ PURPLEHAIR(Ensley)
4. Anything who has a purple hair is weird or is a witch.
   ∀x (PURPLEHAIR(x) → WEIRD(x) ∨ WITCH(x))
5. No fairy is a witch.
   ¬∃x (FAIRY(x) ∧ WITCH(x))
6. Peter does not love anything which is weird.
   ∀x (WEIRD(x) → ¬LOVE(Peter, x))

b) Given the KB that includes 6 sentences in question a). What can be inferred from the above KB?

Answer: Peter is not a child.

Question 6: (2pt)

Followings are the observation of Corona virus effect on 12 patients. The data take into effect, whether the patient get severe or light covid symptoms.

Case	Background Disease	Age	Vaccinated	Effect
1	Yes	Young	Yes	*Light*
2	Yes	Young	No	*Light*
3	Yes	Middle	No	*Severe*
4	No	Young	Yes	*Light*
5	No	Old	No	*Severe*
6	Yes	Middle	Yes	*Light*
7	No	Middle	No	*Light*
8	No	Old	Yes	*Light*
9	Yes	Old	No	*Severe*
10	No	Middle	Yes	*Light*
11	Yes	Old	Yes	*Light*
12	No	Young	No	*Light*

Apply ID3 algorithm to decide the root node of the decision tree.
Note that

- Ties (i.e., attributes having the same best metric values) are broken in alphabetical order.
- Numbers are rounded to three decimal places (for example: 0.918 is correct, 0.92 or 0.9182 is incorrect)

Entropy of the whole dataset: H(S) = 0.811

The attribute Background_Disease?

H(Background_Disease = Yes) = 0.918
H(Background_Disease = No) = 0.650
AE(Background_Disease) = 0.784
IG(Background_Disease) = 0.027

The attribute Age?
H(Age = Young) = 0
H(Age = Middle) = 0.811
H(Age = Old) = 1
AE(Age) = 0.604
IG(Age) = 0.207

The attribute Vaccinated?
H(Vaccinated = Yes) = 0
H(Vaccinated = No) = 1
AE(Vaccinated) = 0.5
IG(Vaccinated) = 0.311

Thus, the root node is: Vaccinated

Question 7: (0.5pt)

Draw the result decision tree of the Corona Virus Effect database by text.

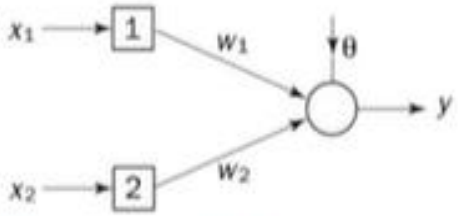
```
vaccinated = yes: light
vaccinated = no
|   age = young: light
|   age = middle
|   |   bd = yes: severe
|   |   bd = no: light
|   age = old: severe
```

Question 8: (1.5pt)

The table below shows the input and output of a Boolean function $y=f(x_1, x_2)$.

x_1	x_2	$y=f(x_1,x_2)$
1	1	0
0	0	0
1	0	1
0	1	0

Let us represent the function with a perceptron.



Assume that learning rate is α=0.1, threshold θ=0.5 and initial weights are w_1=-1 and w_2=1.

a) Show how the weights change in the first epoch. (Fill in all the blanks)

	Input		Init weight		Desired output	Actual output	Error	Final weights	
Iteration	x1	x2	w1	w2	y_d	y	e	w1	w2
1	1	1	-1	1	0	0	0	-1	1
2	0	0	-1	1	0	0	0	-1	1
3	1	0	-1	1	1	0	1	-0.9	1
4	0	1	-0.9	1	0	1	-1	-0.9	0.9

* Note: Actual output is calculated by the step function of sum weights of input.

$$y = step[x_1 w_1 + x_2 w_2 - \theta]$$

$$e = y_d - y$$

$$w_{i(p+1)} = w_{i(p)} + \alpha \times x_{i(p)} \times e_{(p)}$$

* *Iteration p refers to the p^{th} training example presented to the perceptron. (In this question, we have 4 training examples)*

b) Could the function be completely represented with a perceptron? Explain your answer. If there is no explanation, you will be scored 0.

The function can be completely represented with a perceptron since we can draw a linear function to separate 2 classes 0, 1 easily. (for example, with w1=1, w2=-1, θ=0.5)

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