The University of Nottingham Ningbo China

SCHOOL OF COMPUTER SCIENCE

A LEVEL 1 MODULE, SPRING SEMESTER 2019-2020

FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE

Time allowed: Ninety (90) Minutes (1.5 Hours)

Candidates may complete the front cover of their answer book and sign their desk card but must NOT write anything else until the start of the examination period is announced

Answer All THREE questions

Total Marks:75. Each of the three questions contributes to 25 marks

Only silent, self-contained calculators with a Single-Line Display or Dual-Line Display are permitted in this examination.

Dictionaries are not allowed with one exception. Those whose first language is not English may use a standard translation dictionary to translate between that language and English provided that neither language is the subject of this examination. Subject specific translation dictionaries are not permitted.

No electronic devices capable of storing and retrieving text, including electronic dictionaries, may be used.

DO NOT turn examination paper over until instructed to do so

INFORMATION FOR INVIGILATORS:
Collect both the exam papers and the answer booklets at the end of the exam.

Question 1: Search and AI basics

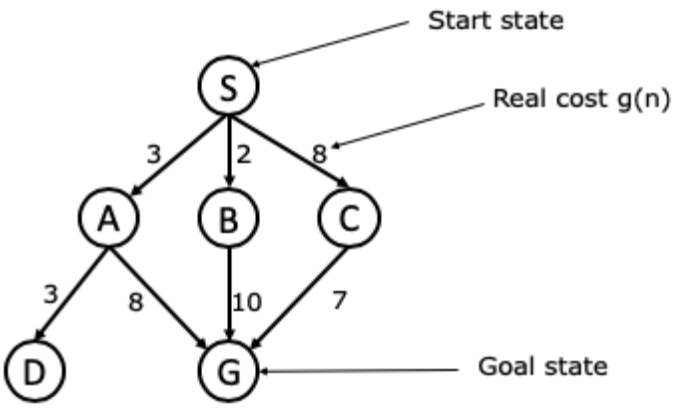
a. Describe the Chinese Room experiment. What view is the Chinese Room argument attempting to rebut?

[4 Marks]

b. Look at the graph shown below, with given real cost (g) in the graph and the heuristic value (h) given in the table.

i) Work out the solution with Greedy search and A* search. [6 Marks]

ii) In this problem, do you think the A* search algorithm will find the optimal solution? If yes, illustrate your answer with explanation. If no, why? Provide your explanation. [3 Marks]



Current Node N	h(n) to Node G
S	10
A	10
B	9
C	6
D	∞
G	0

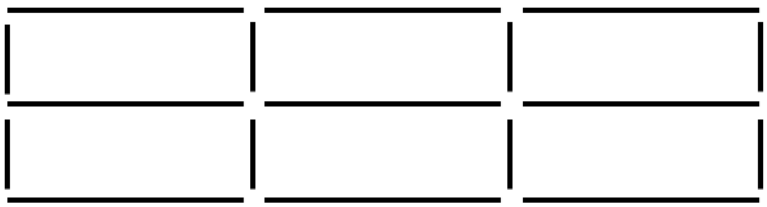
c. Assuming h1(n) and h2(n) are heuristic functions of A*algorithm, and they are both admissible, why is it important that the heuristic used be admissible? Which of the following would be better for A*? Are they admissible? h3(n) = **min**(h1(n), h2(n)) or h4(n) = **max**(h1(n), h2(n)). Briefly explain your answer.

[6 Marks]

d. Given the layout of 17 sticks (forming 6 squares) shown in the figure, you are required to remove exactly 5 sticks in such a way that the remaining configuration forms exactly 3 squares. How many states exist if we form the problem with the following two operators respectively?

i) Operator A: remove five sticks at a time.

ii) Operator B: remove three squares at a time.



[6 Marks]

End of Question 1: Total 25 marks

Question 2: Game Theory, Reasoning and Bayes Theorem

a. Pig is a dice a game that is played as follows (from Wikipedia). Each turn, a player repeatedly rolls a die until either a 1 is rolled or the player decides to "hold":
   - If the player rolls a 1, they score nothing and it becomes the next player's turn.
   - If the player rolls any other number, it is added to their turn total and the player's turn continues.
   - If a player chooses to "hold", their turn total is added to their score, and it becomes the next player's turn.

   The first player to score 100 or more points wins.
   For example, the first player, Donald, begins a turn with a roll of 5. Donald could hold and score 5 points, but chooses to roll again. Donald rolls a 2, and could hold with a turn total of 7 points, but chooses to roll again. Donald rolls a 1, and must end his turn without scoring. The next player, Alexis, rolls the sequence 4-5-3-5-5, after which she chooses to hold, and adds her turn total of 22 points to her score.

   i) Is it a zero-sum game? You may assume that there are only two players.
   [1 Mark]

   ii) Is it a fully observable or partially observable?
   [1 Mark]

   iii) Is it a deterministic or stochastic game?
   [1 Mark]

b. Wythoff's game is a two-player game, played with two piles of counters. Players take turns removing counters from one or both piles; when removing counters from both piles, the numbers of counters removed from each pile must be equal. The game ends when one person removes the last counter or counters, thus winning.
   A state of this game can be represented by a pair (n, m) where n represents the number of counters in the first pile and m corresponds to the number of counters in the second pile.

   i) Draw the complete search tree for this game if the initial state is (3, 1). For a more compact representation, you can merge nodes of the search tree if they represent the same state in the same turn of a player.
   [6 Marks]

   ii) Assume two players, min and max, play this game. Max plays first. With a utility function specified as:
   = 0 if min wins the game
   = 1 if max wins the game
   Apply the minimax algorithm to the search tree to assign utility functions to all nodes in the search tree.
   [4 Marks]

c. Assume we have run the minimax algorithm on some game. A null utility is computed for the initial node where it is the MAX player's turn.

   i) Is the MIN player guaranteed to win? Explain.

   [2 Marks]

   ii) Provide two conditions that would allow the max player to win. **Hint**: one condition on how the MIN player plays and one condition on the utilities on some nodes.

   [3 Marks]

d. A patient is tested positive for a disease. The test is 99% reliable, that is 99% of people who have this disease test positive and 99% of people who do not have this disease test negative. We know that 1% of the people have this disease. What is the probability of this patient having this disease? For partial credit, provide the random variables, their (possibly conditional) probabilities, and the Bayes' rule.

   [7 Marks]

End of Question 2: Total 25 marks

Question 3: Machine Learning

a. A bookshop would like to optimize their sales using machine learning techniques. As the owner knows that predicting how many copies a new book will sale is a hard task, she wants instead to know if a new book will be popular or not using the past sales information she has in her record. Whether a book is popular or not could be defined in various ways (e.g., sales > threshold). This is not important to answer the questions.

i) Which machine learning task is the most suitable for this problem? Explain.
[2 Marks]

ii) List **two** attributes or features that could be included in the dataset and explain why you expect them to be useful.
[4 Marks]

iii) List **two** machine learning models that could be used to solve this task.
[2 Marks]

iv) In order to know better its customers, the bookshop owner decides to use some descriptive data mining techniques. List two methods and how they could be used to increase sales.
[4 Marks]

b. You have recorded various daily meteorological measures (temperatures, atmospheric pressure, humidity…). You would like to predict the next-day temperature based on past information.

i) Which machine learning task is the most suitable for this problem? Explain.
[2 Marks]

ii) List **two** machine learning models that could be used for this task.
[2 Marks]

c. Consider a binary classification problem with the following training dataset:

x_1	x_2	y
0	1	1
1	3	0
2	2	0
2	4	1

i) Represent graphically the training points in the feature space. A point in class 0 should be represented as a circle and a point in class 1 should be represented as a triangle.
[2 Marks]

ii) Can this classification problem be solved with a single-layer perceptron? Explain.

[2 Marks]

iii) Draw the smallest neural network architecture that can learn this function. You can ignore the constant or bias term.

[2 Marks]

d. Consider the logic function described in the following table:

x_1	x_2	x_3	y
0	0	1	0
0	1	1	1
1	0	1	1
1	1	1	1

Run the perceptron algorithm with initial weights $w_1 = 0, w_2 = 1, w_3 = -1$, threshold value of zero, and learning rate $\alpha = 0.2$. You will provide the weighted sum, the output, the error, and the correction computed by the algorithm for each instance and for the first iteration. The training instances will be processed in the order given in the previous table.

[3 Marks]

End of Question 3: Total 25 marks