UNIVERSITY OF GHANA

BACHELOR OF SCIENCE IN ENGINEERING
FIRST SEMESTER 2018/2019 EXAMINATIONS
DEPARTMENT OF COMPUTER ENGINEERING
LEVEL 400: CPEN 405: ARTIFICIAL INTELLIGENCE
(3 CREDITS)

TIME ALLOWED: 3 Hours

INSTRUCTION: Attempt All Questions

Q1. (a) Explain the different approaches used in defining artificial intelligence? [4 marks]

(b) Describe briefly the Turing Test for artificial intelligence systems. [4 marks]

(c) If The Turing Test is passed does this show that computers exhibit intelligence? State your reasons. [4 marks]

(d) What advances do you think need to be made in order for The Turing Test to be passed? [4 marks]

(e) What is Machine Learning? Give five (5) application areas. [7 marks]

(f) What is difference between supervised and unsupervised learning algorithms ? Give an example each of both supervised and unsupervised learning algorithms. [6 marks]

Q2. (a) Consider the 8-puzzle problem described in the textbook and homework assignments. We would like to search for a solution using A^* - search. Describe the following aspects of the problem formulation: **a) states, b) successor function, c) goal test, d) step cost,** and **e) path cost.** [8 marks]

(b) For A^*-search the evaluation function, $f(n)$, consists of the path cost, $g(n)$, plus the heuristic function, $h(n)$. We will use the Manhattan distance between the current state and the goal state to be the heuristic function. Explain when a heuristic function is admissible and prove this fact for the Manhattan distance heuristic. [5 marks]

(c) Describe when a heuristic is consistent and proof this for the Manhattan distance heuristic. [6 marks]

(d) For each of the following activities, give a **PEAS** description of the task environment and characterize it in terms of **observability, number of agents, randomness, dynamism** and **continuity**.

i. Playing soccer. [5 marks]

ii. Taxi driving agent [5 marks]

Q3. Suppose you have the following search space:

State	Next	Cost
A	B	4
A	C	1
B	D	3
B	E	8
C	C	0
C	D	2
C	F	6
D	C	2
D	E	4
E	G	2
F	G	8

(a) Draw the state space of this problem. [2 marks]

(b) Assume that the initial state is **A** and the goal state is **G**. Show how each of the following search strategies would create a search tree to find a path from the initial state to the goal state:

i. Uniform cost search [4 marks]

ii. Iterative deepening search [4 marks]

At each step of the search algorithm, show which node is being expanded, and the content of fringe. Find the eventual solution found by each algorithm, and the solution cost.

(c) Sudoku is a logic-based number placement puzzle. The objective is to fill a 9x9 grid so that each column, each row, and each of the nine 3×3 boxes contains the digits from 1 to 9. Each digit can only appear once per column, row, and 3×3 box. A sample Sudoku puzzle to use for this question is given in the figure below. The squares are labelled $S_{1,1}$ (upper-left corner) to $S_{9,9}$ (lower-right corner). For example, the 5 in the upper-right side of the grid is $S_{3,9}$. Assume you have access to a function $Y = Box(X)$ which takes in a square X on the grid and returns Y, the list of eight squares that belong to the same 3×3 box.
For example, $Box(S_{2,2}) = (S_{1,1}, S_{1,2}, S_{1,3}, S_{2,1}, S_{2,3}, S_{3,1}, S_{3,2}, S_{3,3})$.

i. Define the properties of the environment for Sudoku. [2 marks]

ii. Write Sudoku as a well-defined problem. [5 marks]

iii. Write Sudoku as a constraint satisfaction problem (CSP). [5 marks]

iv. Propose a good heuristic to search the CSP tree. [3 marks]

	6							1
			7	9	3			
								5
		9			1	3	2	
		2				7		
	3	5	8			4		
4								
			5	2	6			
1							8	

Figure 1: Sudoku problem formulation

Q4. (a) Name three (3) strengths and three (3) weaknesses of fuzzy expert systems. [6 marks]

(b) Consider the following real variables from everyday life:

i. Income measured in GHC.

ii. Speed measured in meters per second.

iii. A TV show measured in how much you are interested in watching it.

iv. A meal measured in how much you like to eat it.

v. A traffic light measured in what colour is on.

In each case, suggest a fuzzy variable corresponding to these real variables. For which of these five (5) variables the use of a fuzzy variable is not really necessary and why?

[7 marks]

(c) Methane biofilters can be used to oxidize methane using biological activities. It has become necessary to compare performance of two test columns, A and B. The methane outflow level at the surface, in nondimensional units of $X = 50, 100, 150, 200$, was detected and is tabulated below against the respective methane inflow into each test column. The following fuzzy sets represent the test columns: $A = \left\{ \frac{0.15}{50}, \frac{0.25}{100}, \frac{0.5}{150}, \frac{0.7}{200} \right\}$ and $B = \left\{ \frac{0.2}{50}, \frac{0.3}{100}, \frac{0.6}{150}, \frac{0.65}{200} \right\}$

Calculate the following:

i. union ($A \cup B$) for the test columns,

ii. intersection ($A \cap B$) of the test columns, and the

iii. difference ($A \cap \neg B$) for the test columns. [6 marks]

(d) List the different parts of a fuzzy controller. Describe the roles and purposes of the different parts based on Mamdani and Sugeno Control theory. [10 marks]

(e) Assume that the control of the heating and cooling device takes a $12 - bit$ value where 0 represents the coolest setting and 4096 represents the warmest. The value is transmitted from the remote to the heating and cooling device using the infrared transmitter. Design a fuzzy logic controller that attempts to find the correct setting for the heating and cooling device which matches the desired temperature. Be creative in your controller design. Show your diagrams. [5 marks]

i. What are your control inputs and outputs? [2 marks]

ii. What crisp inputs will you use and why? [2 marks]

iii. What fuzzy membership sets will you use for the input ? [2 marks]

iv. What fuzzy membership sets will you use for the output ? [2 marks]

v. Give four(4) examples of the fuzzy rules. [2 marks]

Q5. (a) Design a two-input neural network with McCulloch-Pitts neurons to perform the logical operations (a) $A \wedge \neg B$, and (b) $A \oplus B$, where A and B are Boolean variables. Draw the network and show the weights. [8 marks]

A	B	$A \wedge \neg B$	$A \oplus B$
1	1	0	0
1	0	1	1
0	1	0	1
0	0	0	0

(b) By definition, a learning system (like a neural network) can learn and adapt to its environment. It is therefore essential that such systems have a feedback mechanism. Clearly and briefly explain this concept in the context of neural networks. [4 marks]

(c) State the requirements for a neural network for it to be a universal approximator. [3 marks]

(d) Consider a fully connected 3-layer feedforward network with 10 input nodes, 8 compute nodes each in the hidden layers, and 4 compute nodes in the output layer. Each compute node has a bias associated with it. [8 marks]

i. Draw and label the neural network architectural diagram for the above description.

ii. What is the number of free parameters in the network?

(e) What is a training set and how is it used to train neural networks? [2 marks]

(f) Suppose that a credit card company decided to deploy a new system for assessing the credit-worthiness of its customers. The new system is using a feed-forward neural network with a supervised learning algorithm. Write detailed explanatory notes of what the bank should have before the system can be developed and deployed for use? Discuss problems associated with this requirement. [8 marks]