UNIVERSITI TUNKU ABDUL RAHMAN

ACADEMIC YEAR 2018/2019

DECEMBER EXAMINATION

UEMH3163/ UECS2053/ UECS2153 ARTIFICIAL INTELLIGENCE

THURSDAY, 13 DECEMBER 2018 TIME : 2.00 PM – 4.00 PM (2 HOURS)

BACHELOR OF ENGINEERING (HONOURS) MECHATRONICS ENGINEERING
BACHELOR OF SCIENCE (HONOURS) SOFTWARE ENGINEERING
BACHELOR OF SCIENCE (HONOURS) APPLIED MATHEMATICS WITH COMPUTING

Instructions to Candidates :

This paper consists of **FIVE (5)** questions.

Answer **ALL THREE** questions in **Section-A** and Answer **ANY ONE** question in **Section-B**.

EACH question carries **25 MARKS**.

Answer questions only in the answer booklet provided.

Section-A (Answer **ALL THREE** questions.)

Q1. An M&E contractor is currently using a fuzzy inference system to automate the internal air conditioning for a shopping mall. The system is defined with the following input linguistic variables:-

Humidity as a percentage value from full saturation
Low – [0 0 60] (triangular membership function)
Moderate – [0 50 100] (triangular membership function)
High – [40 100 0] (triangular membership function)

Temperature in Celsius
Cool – [16 16 24] (triangular membership function)
Neutral – [16 22 27] (triangular membership function)
Warm – [20 28 30 30] (trapezoidal membership function)

and the following output linguistic variable:-

Power as a ratio from minimum to maximum capacity
Weak – [0 0 0.5] (triangular membership function)
Average – [0 0.5 1] (triangular membership function)
Strong – [0.5 1 1] (triangular membership function)

The fuzzy rules are as follows:-

1. If **Humidity** is *High* or **Temperature** is *Warm* then **Power** is *Strong*
2. If **Humidity** is *Moderate* then **Power** is *Average*
3. If **Temperature** is *Neutral* then **Power** is *Weak*
4. If **Humidity** is *Low* or **Temperature** is *Cool* then **Power** is *Weak*

(a) Illustrate the fuzzy sets for both input linguistic variables **Humidity** and **Temperature**, as well as the fuzzy sets for output linguistic variable **Power**. Use one graph per linguistic variable. (9 marks)

(b) Evaluate the degree of membership for each fuzzy set when humidity is 20% and the temperature is 26 degrees Celsius. (6 marks)

(c) Tenants in the shopping mall have reported that the air conditioning system is not producing a comfortable environment. On investigation, the majority of tenants believe that the environment is too cold on rainy days, but comfortable otherwise. Recommend modifications to this fuzzy inference system that will address the tenant's complaints. (5 marks)

Q1. (Continued)

(d) A consultancy firm has recommended that the fuzzy inference system be replaced by a Bayesian Reasoning-based expert system. Give your professional opinion on whether such an expert system is an improvement on the existing fuzzy inference system, and justify that opinion based on the fundamental principles involved. (5 marks)

[Total : 25 marks]

Q2. (a) (i) Explain the fundamental concept of genetic algorithms. (2 marks)

(ii) Describe the flow of a genetic algorithm. Specifically emphasize on the selection, crossover and mutation operators. (6 marks)

(iii) Describe TWO (2) applications of Genetic Algorithms. (2 marks)

(b) Suppose a genetic algorithm uses chromosomes with a fixed length of 8 genes to represent solutions to a problem. Each gene can take the value of 0 and 1. Let the fitness of individual x be calculated as:

$$F(x) = x^2 - 10x.$$

Let the initial population consist of four randomly generated individuals with the following chromosomes:

x_1	=	0	1	1	0	0	0	0	1
x_2	=	0	1	0	0	1	1	0	0
x_3	=	0	0	0	0	0	0	1	1
x_4	=	0	0	0	1	1	1	0	0

(i) Assuming the survivor rate of a string is consistent with the fitness scores to be calculated in column 4. Only the top two fittest chromosomes will survive and be selected for mating the next generation. The selected two chromosomes will each replace the other less fit chromosomes respectively to generate the next generation mating pool. Fill in the rest of the Table 2.1.

Q2(b)(i). (Continued)

Table 2.1

Chromosome No.	Chromosome	Decimal, x	F_i
1	01100001		
2	01001100		
3	00000011		
4	00011100		
		Average fitness	

(2 marks)

(ii) Perform the following crossover operations on the new mating pool. Fill in the rest of the Table 2.2, Table 2.3 and Table 2.4. Compute the fitness scores for the new population.

Table 2.2 Crossover the fittest two chromosomes using one–point crossover at the middle point

Chromosome No.	Mating Pool	Mate	Offspring of the new population	Decimal, x	F_i

(2 marks)

Table 2.3 Crossover the third and fourth fittest chromosomes using a two-point crossover (points after 3 and 7).

Chromosome No.	Mating Pool	Mate	Offspring of the new population	Decimal, x	F_i

(2 marks)

Table 2.4 Crossover the first and third fittest chromosomes (ranked first and third) using a uniform crossover (uniformly exchange of odd and even number genes of the chromosomes respectively).

Chromosome No.	Mating Pool	Mate	Offspring of the new population	Decimal, x	F_i

(2 marks)

Q2(b). (Continued)

(iii) Suppose the new population consists of the top four offspring chromosomes received by the crossover operations in the above question. Determine if the fitness improves over the two generations. Also, compare the best-performing chromosomes of the two generations. Show your workings. (3 marks)

(iv) By looking at the fitness function and considering that genes can only be digits of 0 or 1, find the chromosome representing the optimal solution (i.e. with the maximum fitness). Find the value of the maximum fitness. (2 marks)

(v) Predict if it is possible for the population to achieve the globally optimal solution in (v) without mutation. Explain. (2 marks)

[Total : 25 marks]

Q3. (a) Explain what is K-means clustering. (2 marks)

(b) K-means clustering can be applied to assist in making business assumptions about numbers and characteristics of groups and/or identifying unknown groups in complex data sets. Give five examples of such applied cases. (5 marks)

(c) Describe the main steps in executing K-mean clustering. (5 marks)

(d) States THREE (3) limitations of K-mean clustering. (3 marks)

(e) Requiring users to decide the number of clusters in a data set. Name and describe the procedures of any method that can be used to assist users in determining the number of clusters. You are expected to describe the main procedures of the method in details including its limitation and handling method when the method does not straightforwardly work. (10 marks)

[Total : 25 marks]

Section-B (Answer **ANY ONE** question.)

Q4. (a) Explain the components the acronym PEAS, and give an example of the PEAS for an Artificial Intelligence agent tasked with automatically generating English and Malay subtitles for Japanese animes. (8 marks)

(b) Describe (with examples) how rules can be used to represent FIVE (5) different types of knowledge. (10 marks)

(c) Give an example of a situation where conflict resolution needs to take place in expert systems, suggest some conflict resolution methods, and explain how metaknowledge can be used to guide the conflict resolution process. (7 marks)
[Total : 25 marks]

Q5. (a) Machine learning usually refers to learning a target function that maps input variables to output variables. One of the main concerns is to assess the generalization of the learned model on new data. Overfitting and underfitting are the two main causes for poor generalization in machine learning.

(i) Define the term "generalization" in the context of machine learning. (2 marks)

(ii) Explain the importance of a well generalized learning model. (2 marks)

(iii) Explain the difference between overfitting and underfitting. (2 marks)

(iv) Explain the reasons why overfitting occurs during machine learning. (3 marks)

(v) In your own words, explain why the problem of underfitting is seldom discussed in applied machine learning despite the fact that both overfitting and underfitting cause poor learning model performance. (2 marks)

(vi) Name and describe TWO (2) important techniques that you can use when evaluating machine learning algorithms to limit overfitting. (4 marks)

Q5. (Continued)

(b) Figure 5.1 shows an architecture of a feed-forward artificial neural network with two inputs, two hidden layer neurons, and one output neuron. The initial weights, biases, training inputs and output values are given to you as shown inside the figure.

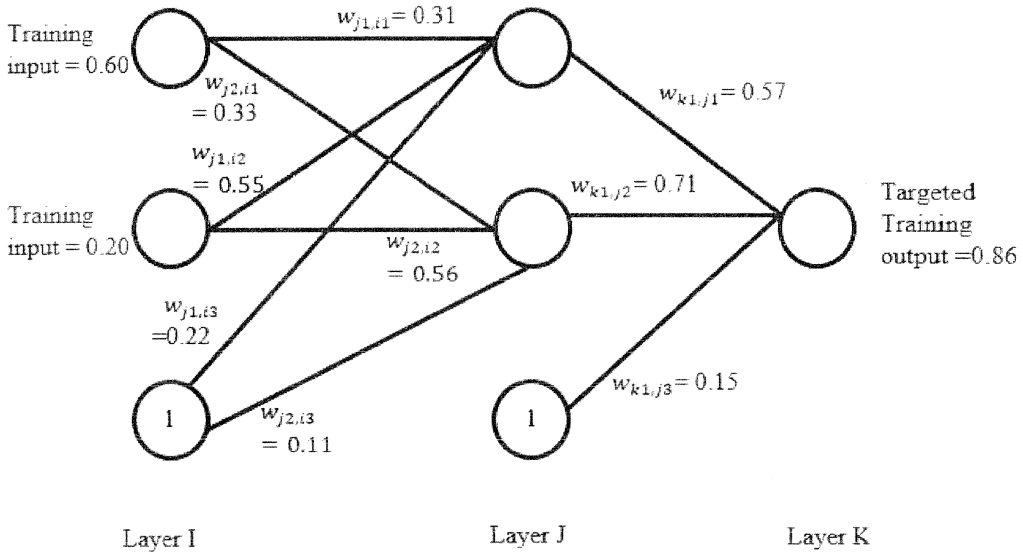

Figure 5.1

You are instructed to compute the new neuron weights for $w_{k1,j1}$ and $w_{j1,i1}$ after the first iteration of backpropagation for one training sample. You are expected to specify the learning rate as 0.5 and adopt a sigmoid function as the activation function. All results of calculations are required to be rounded to four decimal places. (10 marks)

[Total : 25 marks]