UNIVERSITI SAINS MALAYSIA

Semester II Examination
Academic Session 2007/2008

April 2008

EEE 551 – INTELLIGENT SYSTEMS

Time : 3 hours

INSTRUCTION TO CANDIDATE:

Please ensure that this examination paper contains **SEVEN (7)** printed pages and **SIX (6)** questions before answering.

Answer **FIVE (5)** questions.

Distribution of marks for each question is given accordingly.

All questions must be answered in English.

1. (a) Explain what is meant by fuzzy logic. (2 marks)

(b) Explain the differences between crisp set theory and fuzzy set theory. (2 marks)

(c) Define fuzzification and defuzzification. Explain why each of the concepts are useful. (6 marks)

(d) State and explain TWO defuzzification methods. Write their equations and illustrate the use of the equations using an example. (10 marks)

2. (a) State and explain FOUR main sources of uncertain knowledge in a rule-based expert system. (10 marks)

(b) Sketch a diagram to illustrate the basic structure of a rule-based expert system and briefly explain the main function of each component. (10 marks)

3. (a) Define the term *likelihood of necessity*, write its probability equation and explain about the strength of its values in relation to the rule and hypothesis. (4 marks)

(b) Define the term *likelihood of sufficiency* and write its probability equation. (2 marks)

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(c) Consider the rules below:

Rule 1 : IF A = X
AND B = Y
THEN D = V

Rule 2 : IF F = W
THEN *goal* = no

Rule 3 : IF D = V
THEN B = Z

Suppose a user prompts for attribute A only and that variable goalis the database, explain (using ordering of fired rules) how an expert system inference engine fires the set of rules above:

(i) using forward chaining (7 marks)
(ii) using backward chaining (7 marks)

4. (a) Explain the Perceptron Convergence Theorem. (4 marks)

(b) By using suitable diagrams, explain the similarities and differences with respect to the decision boundary formed by the Perceptron and the Adaline.

(4 marks)

(c) Table Q4(a) shows four patterns that belong to two classes. Explain how the Perceptron can be used to categorize the four patterns into two separate classes.

Table Q4(a)

Input Pattern	Class
(0.9, 0.2)	A
(0.8, 0.3)	A
(0.2, 0.7)	B
(0.1, 0.9)	B

The initial weights are $w_0(t=0) = -0.4$, $w_1(t=0) = 0.3$, $w_2(t=0) = 0.1$.

Assume that the learning rate is 1.0. Calculate the net inputs, error signals, and weight vectors of the four patterns for the first cycle.

Show the detail calculations for each parameter and tabulate the results in Table Q4(b).

(12 marks)

Table Q4(b)

Pattern	Time, t	Net Input	Error Signal	Classification	Weight, w_0	Weight, w_1	Weight, w_2
-	T=0	-	-	-	-0.4	0.3	0.1
1	T=1						
2	T=2						
3	T=3						
4	T=4						

5. (a) By using a suitable example, explain the limitations of the Perceptron/Adaline, which subsequently leads to development of the Multi-layer Perceptron. Discuss how the Multi-layer Perceptron overcomes the limitation of the Perceptron/Adalinein

(4 marks)

(b) Explain *two* different learning methods of artificial neural networks. For each learning method, discuss an application example that is suitable for the corresponding method.

(4 marks)

(c) A Self-Organizing Map (SOM) network with 9 nodes is shown in Figure Q5. The initial random weights are given in Table Q5.

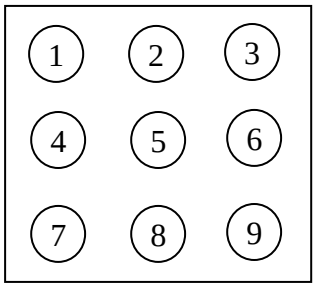

Figure Q5

Node	Weight 1	Weight 2
1	-0.3	0.4
2	0.9	0.2
3	-0.5	-0.9
4	0.6	0.1
5	0.1	-0.5
6	-0.2	0.6
7	-0.7	0.1
8	0.6	0.9
9	-0.3	0.5

Table Q5

Assume that the learning rate is set to 0.1, and the neighbourhood size is 2. Given an input pattern $\boldsymbol{x} = (0.91, 0.19)$

(i) calculate the Euclidean distance between the all weight vectors and input $\boldsymbol{x}$;

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(ii) determine the winning node;

(iii) update the weight vectors and tabulate the *new* weight values in Table Q5 when

(1) neighbourhood "radius" is set to 1

(2) neighbourhood "radius" is set to 2

(12 marks)

6. (a) Discuss four main properties of a genetic algorithm with that have made the method popular for solving optimization problems.

(4 marks)

(b) By using a suitable diagram, list and label the main components of the attentional sub-system and orienting sub-system in a generic architecture of an unsupervised Adaptive Resonance Theory (ART) network.

(6 marks)

(c) Consider the problem of maximizing the function $f(x) = x^2 - x$ using a genetic algorithm, where *x* is between 0 and 15 and is coded as a 4-bit binary string.

(i) Suggest a fitness function for the genetic algorithm.

(2 marks)

(ii) An initial population of 4 chromosomes is randomly generated. Referring to Table Q6(a), compute the fitness value for each chromosome, and the probability of selecting each chromosome (for use by the roulette-wheel parent selection).

Table Q6(a)

No.	Initial Population	Fitness (*i*)	Probability of Selection (*i*)
1	0111		
2	1110		
3	1001		
4	0011		

(4 marks)

(iii) After reproduction, the mating pool, the mating partner, and the crossover site for each chromosome are as shown in Table Q6(b). Determine the new population, as in Table Q6(b).

Table Q6(b)

No.	Mating Pool	Mate	Crossover Site	New Population
1	0111	2	1	
2	1110	1	2	
3	1110	4	2	
4	1001	2	3	

(4 marks)

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