UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2005/2006

April/May 2006

EEE 551 – INTELLIGENT SYSTEMS

Time: 3 Hours

INSTRUCTION TO CANDIDATE:

Please check that this examination paper contains **ELEVEN** pages of printed material before you begin the examination.

Answer **FIVE** questions.

All questions must be answered in English.

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1. (a) What are the characteristics of a knowledge based engineering system? List in point form.

(10%)

(b) List and explain three situations where the use of an expert system may be desirable.

(15%)

(c) Describe, with reference to a certain problem, the differences between backward and forward chaining.

(15%)

(e) The following knowledge may be used for recommending garden trees:

"You should get a tree of suitable size for your garden, and one that is suitable for your family. If your garden is small then small trees are of suitable size. If you have children then non-poisonous trees are appropriate. Laburnum, Yew and Japanese Maple are all small, while Spruce and Sycamore are large. Laburnum and Yew are poisonous".

(i) Represent the above knowledge as a set of production rules (and possible initial facts).

(30%)

(ii) Briefly describe how the rules might be used to check on the suitability of a proposed garden tree (say, Japanese Maple) using backward chaining.

(30%)

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2. (a) What are searching strategies and write short notes on the searching strategies that are available.

(20%)

(b) Outline the search algorithms for the two search strategies:

(i) Depth first
(ii) Breadth first

(20%)

(c) Explain how heuristic search differs from the search strategies in (b) above.

(20%)

(d) For the tree displayed in Figure 1 list the order in which the nodes would appear after undergoing the following searches, namely the:

(i) Breadth first search
(ii) Depth first search
(iii) Hill climbing
(iv) Best first search

(40%)

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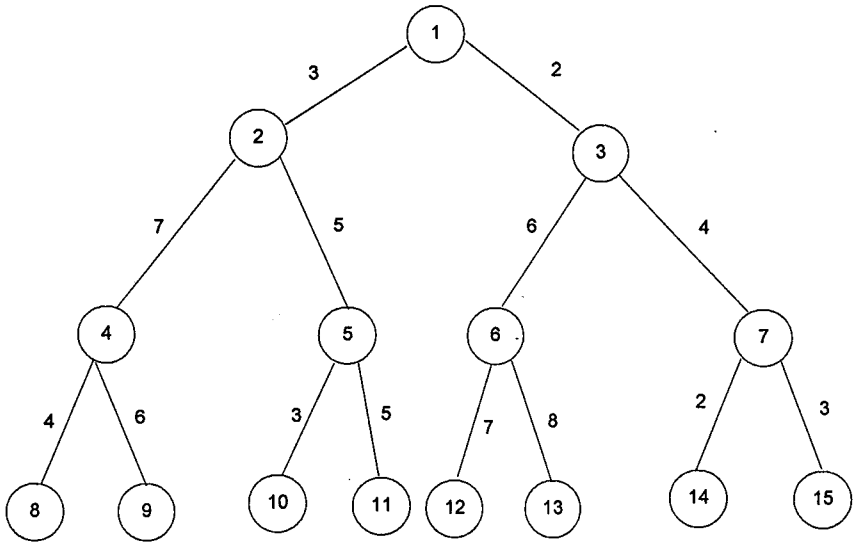

Figure 1

3. (a) How are fuzzy sets and crisp sets related to and distinguished from each other?

(15%)

(b) Describe the principle difference between the so-called Mamdani inference method and the Sugeno inference method.

(15%)

(c) Sony is contemplating a new DVD product – and has created the following FAM Table to relate Demand and Manufactured Cost to Price:

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Price

	Manufactured Cost	
Demand	Cheap	Expensive
Small	Low	Medium
Large	Medium	High

The product manager has estimated the following triangular normalized membership functions:

Demand (in millions of units annually)

Small $\{100,1 \quad 300,0\}$ Large $\{150,0 \quad 350,1\}$

Manufactured Cost (in yen per unit)

Cheap $\{10,1 \quad 20,0\}$ Expensive $\{12,0 \quad 24,1\}$

Price (in cost in yen per unit)

Low $\{20,1 \quad 35,0\}$ Medium $\{25,0 \quad 35,1 \quad 45,0\}$ High $\{35,0 \quad 50,1\}$

(i) Create the rule base for this situation. (20%)

(ii) Graph the membership functions for Demand, Manufactured Cost and Price. (20%)

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(iii) If the Demand Forecast = 250 and the Manufactured Cost Forecast = 15, decide upon Price using the max min technique and centroid defuzzification (you can estimate the centroid location).

(15%)

(iv) If the Demand Forecast = 300 and the Manufactured Cost Forecast = 18, decide upon Price using the max min technique and centroid defuzzification (you can estimate the centroid).

(15%)

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

(10%)

(ii) By using suitable diagrams, explain the similarities and differences between Perceptron and Adaline in their respective structures

(10%)

(b) Table 1(a) shows four patterns that belong to two classes. Illustrate how the Perceptron can be used to categorize the four patterns into two separate classes.

Table 1(a)

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

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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 detailed calculations for each parameter and tabulate the results in Table 1(b).

Table 1(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						

(40%)

(c) Repeat problem (b) using the ADALINE model. (40%)

5. (a) (i) What is Hebbian learning? Discuss a biological basis for Hebbian learning.

(10%)

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

(15%)

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(b) (i) Discuss the *three* main cortical maps or topological maps in brain cortex.

(10%)

(ii) A Self-Organising Map (SOM) network with 9 nodes is shown in Figure 2(a). The initial random weights are given in Table 2(a).

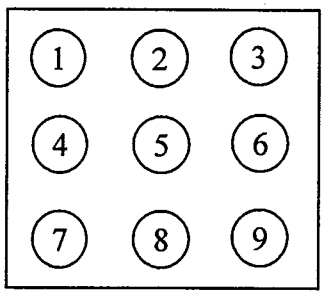

Figure 2(a)

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 2(a)

Assume that the learning rate is set to 0.1, and the neighbourhood "radius" is set to 1. Given an input pattern $\boldsymbol{x} = (0.91, 0.19)$

1. calculate the Euclidean distance between the all weight vectors and input $\boldsymbol{x}$;

2. determine the winning node;

3. update the weight vectors and tabulate the *new* weight values in Table 5

(25%)

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(c) (i) Given the following pattern pairs

$$\mathbf{x}_1 = \begin{bmatrix} 1 \\ 3 \\ 4 \end{bmatrix}, \quad \mathbf{y}_1 = \begin{bmatrix} 2 \\ 3 \\ 6 \end{bmatrix} \qquad \mathbf{x}_2 = \begin{bmatrix} 3 \\ 5 \\ 8 \end{bmatrix}, \quad \mathbf{y}_2 = \begin{bmatrix} 4 \\ 5 \\ 9 \end{bmatrix} \qquad \mathbf{x}_3 = \begin{bmatrix} 5 \\ 6 \\ 9 \end{bmatrix}, \quad \mathbf{y}_3 = \begin{bmatrix} 6 \\ 7 \\ 8 \end{bmatrix}$$

where ***x***'s are the input vectors, and ***y***'s are the desired output vector, find the final weight matrix using the Correlation Matrix Memory (CMM) model.

(40%)

6. (a) (i) Draw a diagram to illustrate the structure of an idealized *biological* neuron. List and describe *four* main structural and functional components of an idealized biological neuron.

(15%)

(ii) Draw a diagram to illustrate the structure of a simple *artificial* neuron. List and name the components of a simple artificial neuron corresponding to their biological components.

Given an input signal, describe the operations involved in processing the signal in a simple artificial neuron.

(15%)

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(b) There are two types of Content Addressable Memory (CAM). What are they?
Give an example for each type of CAM and explain how does it function.
(25%)

(c) (i) 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.

What is the main function of the orienting sub-system in an ART network?

(10%)

(ii) Discuss the similarities and differences between ART1 and Fuzzy ART in terms of their algorithms.

(10%)

(iii) A trained Fuzzy ART network has one committed node with complement-coded weight vector $\boldsymbol{w}_1 = [0.1,\ 0.2,\ 0.9,\ 0.8]$. Given an input pattern $\boldsymbol{a} = [0.2,\ 0.2]$

1. Calculate the complement-coded input vector, $\boldsymbol{A}$;

2. Assume the choice parameter $\alpha = 0.001$, determine the choice function, T, for input vector $\boldsymbol{A}$ and weight vector $\boldsymbol{w}_1$;

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