UNIVERSITI SAINS MALAYSIA

Semester II Examination
Academic Session 2011/2012

Jun 2012

EEE 551 – INTELLIGENT SYSTEMS

Time: 3 Hours

INSTRUCTION TO CANDIDATE:

Please ensure that this examination paper contains **ELEVEN** printed pages and **SIX** questions before answering.

Answer **FIVE** questions.

Answer to any question must start on a new page.

Distribution of marks for each question is stated accordingly.

All questions must be answered in English.

1. (a) List the major players in the expert system development team. Then, explain the role of each player.

(20 marks)

(b) Describe the fundamental characteristics of an expert system. Then, compare the differences between expert systems and conventional programs.

(20 marks)

(c) (i) Describe the forward and backward chaining inference process.

(ii) Design a rule-based expert system for **Pesticide Control**. Your design must incorporate knowledge base (number of rules at least 6), linguistic objects (at least 2), linguistic values (at least 6), options / final goal of your rule-based expert system (at least 1) and dialogue between expert system interface and user (at least 3). Please state the inference techniques of your expert system.

(iii) Summarize your developed pesticide control expert system in (c) (ii) using tree diagram.

(50 marks)

(d) Describe mathematically the conditional probability of event A occurring given that the event B has occurred.

(10 marks)

2. (a) Give the definition of probability and prior probability mathematically. Give example.

(10 marks)

(b) What is fuzzy rule? What are the differences between classical and fuzzy rules? Provide some examples.

(20 marks)

(c) What are the differences between Mamdani and Sugeno fuzzy inferences?

(20 marks)

(d) An article in Solid State Technology describes an experiment in photolithography for manufacturing integrated circuit. The variables in this experiment are prebake temperature and exposure energy. The response variable is delta line width, the difference between the line on the mask and the printed line on the devise. Consider the following rules and membership functions below:

Rule 1: **IF** prebake temperature is high
OR exposure energy is inadequate
THEN delta line width is short

Rule 2: **IF** prebake temperature is medium
OR exposure energy is adequate
THEN delta line width is Normal

Rule 3: **IF** prebake temperature is low
THEN delta line width is long

The membership functions for the linguistic variables prebake temperature, exposure energy and delta line width are given as:

$\forall$ means for all

$\mu^{\text{High}}_{\text{Prebake Temperatue}}(x) = 0, \forall x \le 45;$	$\mu^{\text{High}}_{\text{Prebake Temperatue}}(x) = 1, x \ge 65;$
$\mu^{\text{Medium}}_{\text{Prebake Temperatue}}(x) = 0, \forall x \le 30 \,\&\, \forall x \ge 50;$	$\mu^{\text{Medium}}_{\text{Prebake Temperatue}}(x) = 1, x = 40;$
$\mu^{\text{Low}}_{\text{Prebake Temperatue}}(x) = 0, \forall x \ge 35;$	$\mu^{\text{Low}}_{\text{Prebake Temperatue}}(x) = 1, x \le 10;$
$\mu^{\text{Inadequate}}_{\text{Exposure Energy}}(x) = 0, \forall x \ge 25;$	$\mu^{\text{Inadequate}}_{\text{Exposure Energy}}(x) = 1, x \le 10;$
$\mu^{\text{Adequate}}_{\text{Exposure Energy}}(x) = 0, \forall x \le 10;$	$\mu^{\text{Adequate}}_{\text{Exposure Energy}}(x) = 1, x \ge 35;$
$\mu^{\text{Short}}_{\text{Delta Line}}(x) = 0, \forall x \ge 40\%;$	$\mu^{\text{Short}}_{\text{Delta Line}}(x) = 1, x \le 20\%;$
$\mu^{\text{Normal}}_{\text{Delta Line}}(x) = 0, \forall x \le 20\% \,\&\, \forall x \ge 80\%$	$\mu^{\text{Normal}}_{\text{Delta Line}}(x) = 1, 40\% \le x \le 60\%$
$\mu^{\text{Long}}_{\text{Delta Line}}(x) = 0, \forall x \le 60\%$	$\mu^{\text{Long}}_{\text{Delta Line}}(x) = 1, x \ge 80\%$

Let say, the prebake temperature is 70 (normalised) and exposure energy is 35 (normalised). Then, use the graph paper to calculate the delta line width. Please use Mamdani method, min and max methods for AND and OR operations respectively, maximum method for aggregation and centroid for defuzzification.

(50 marks)

3. (a) Consider the facts and rules for the backward chaining process given in the Figure Q3. Explain comprehensively the process from pass 1 to pass 6. Please update the database for each cycle and use arrows to show the matching and firing process until the Goal z is proved.

(30 marks)

(b) In order to improve the performance of an expert system, we should supply the system with metaknowledge. What do you understand with metaknowledge process in expert system. Then, list 5 metarules that can be used for a diagnosis of infectious blood disease.

(20 marks)

(c) How do you define **hybrid intelligent systems**? Give 2 examples and describe them.

(15 marks)

(d) Analysis of SPECT images has been used to diagnose cardiac diseases. By injecting a patient with radioactive tracer, two sets of SPECT images are obtained: one is taken 10-15 minutes after the injection when the stress is greatest (stress image) and the other is taken 2-5 hours after the injection (rest image). The distribution of the radioactive trace in the cardiac muscle is proportional to the muscle's perfusion. Thus by comparing stress and rest images, a cardiologist can often detect abnormalities in the heart function. However, visual inspection of the SPECT images is highly subjective. Doctors often rely on experience in detecting abnormalities.

A system expert wants to develop an intelligent diagnosis system for cardiac diseases. The expert decides to employ a neuro-fuzzy system. Fuzzy logic may provide the means for modelling how the cardiologists assess the risk of a heart attack.

To develop the system, 267 cardiac diagnosis cases have been collected. Each case is accompanied by two SPECT images and each image is divided into 22 regions. Thus, each cardiac diagnostic case is represented by 44 continuous features and one binary feature that assign an overall diagnosis – normal or abnormal. The entire SPECT data set consists of 55 cases classified as normal and 212 cases classified as abnormal.

A back-propagation network has been suggested to act as the classifier. Can you give a reason for this choice?

(5 marks)

(i) What would be the suitable number of neurons in the input layer? Why?

(5 marks)

There are two neurons in the output. The first output corresponds to the SPECT image that belongs to the class normal and the second to the image that belongs to the class abnormal. The outputs of the neural network become inputs to the fuzzy system.

(ii) Can you suggest the suitable fuzzy sets for this fuzzy system? Explain by using suitable sketches. State assumptions made, if any.

(25 marks)

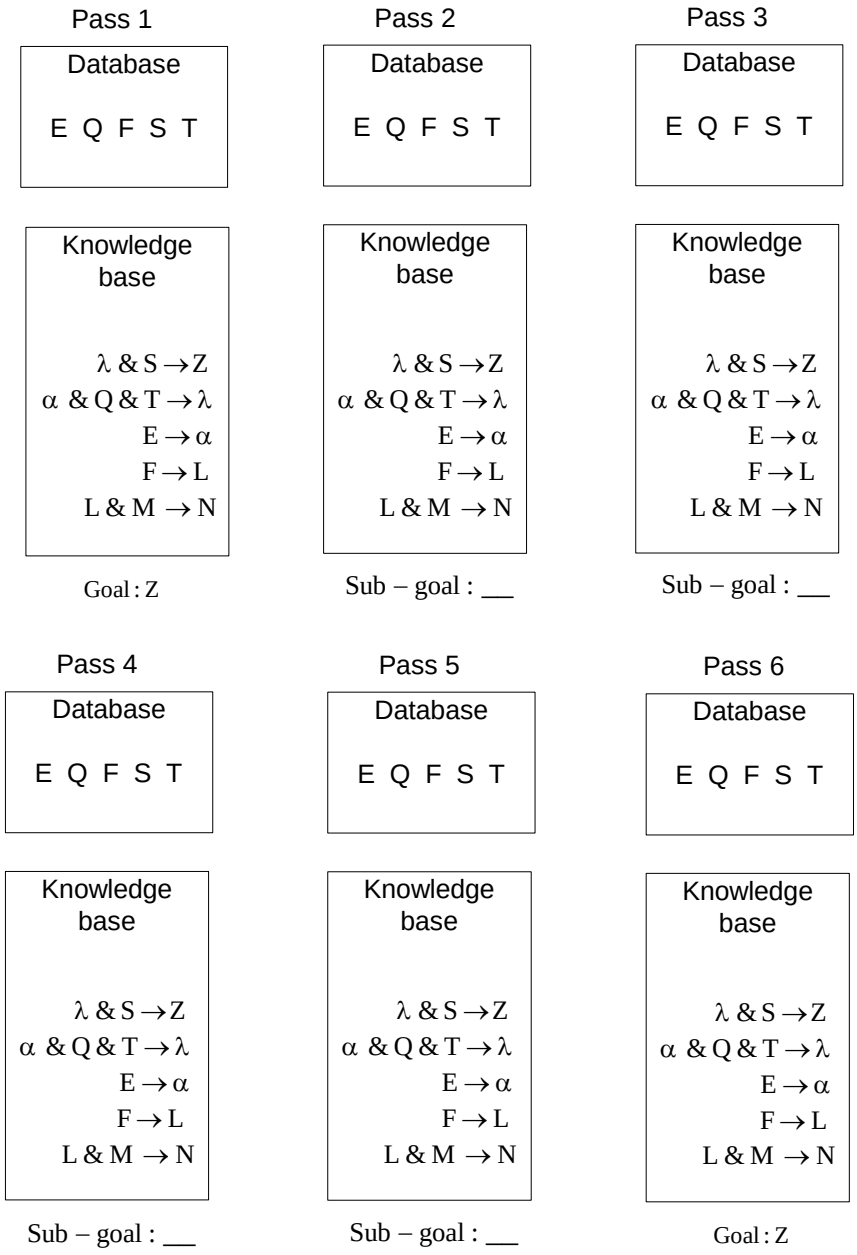

Figure Q3: Backward Chaining

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4. (a) What does ‘learning’ means in artificial neural network? Discuss the different types.

(25 marks)

(b) In your opinion, which method of learning is the most popular for multilayer neural network? Discuss the method.

(25 marks)

(c) Explain what is meant by artificial neural network **overfitting** and how to prevent it. Give an example.

(40 marks)

(d) How can learning be accelerated in multilayer neural networks?

(10 marks)

5. (a) Give three differences between genetic algorithms and evolution strategies.

(30 marks)

(b) Briefly describe the main processes involved in simulating evolution as often conducted in evolutionary computation.

(20 marks)

(c) Answer these questions in relation to Holland's simple genetic algorithm.

(i) How does a crossover operator work?

(10 marks)

(ii) How does the mutation operator work?

(10 marks)

(iii) What is the common termination criterion used in genetic algorithm? Please explain.

(15 marks)

(iv) What is roulette wheel selection technique? Please explain.

(15 marks)

6. We want to apply genetic algorithm for optimization of a simple function of one real variable. The function is defined as;

From the range [0, 1, 2, …., 31], we want to find which maximizes the function . We use a binary string as a chromosome to represent real values of the variable .

(a) How many bits are required as a chromosome? Give reasons for your answer.

(10 marks)

(b) What would be the fitness function?

(10 marks)

(c) Assume that the chromosome has five bits. The initial population consists of four chromosomes which have been randomly selected as shown in Table Q6 (a). Calculate the value of fitness for each initial population.

Table Q6 (a): Initial population

String number	Initial population	Fitness
1	01101	
2	11000	
3	01000	
4	10011	

(20 marks)

(d) Which string number will be chosen to mate and produce the next population? Give your answers by filling the entries in column 1 and 2 in Table Q6 (b).

(20 marks)

(e) By applying the crossover operator at points as given in column 3 in Table Q6 (b), give the offspring after each crossover and their value of fitness. Give your answers by filling the entries in column 4 and 5 in Table Q6 (b).

(40 marks)

Table Q6 (b): New population

String number	Mating pool	Crossover bit	Offspring after crossover	Fitness
		4		
		4		
		2		
		2		

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