Cairo University
Faculty of science
Mathematics Department
120 minutes

Final Exam (Spring 2015)
Artificial Intelligence
MSc. 691-b

Answer the following questions. The total credit is 100.

Question (1) (20 points)

A. **(6 points)** Provide brief and precise definition of the following

1. Perceptron
2. Supervised and unsupervised learning (give an example of each)

B. **(6 points)** Consider these two fuzzy sets and *min* and *max* fuzzy set operations

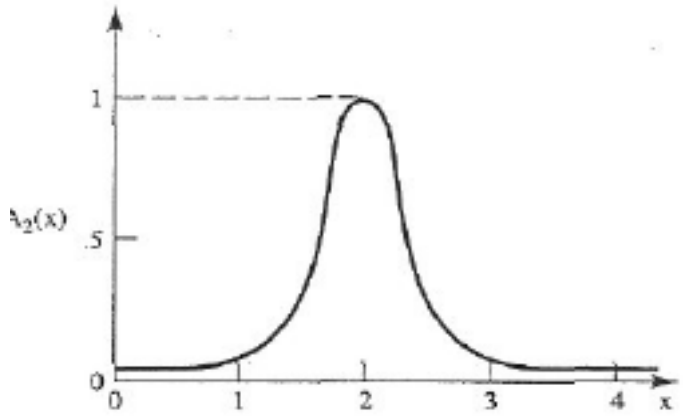
$A = \frac{0.4}{1} + \frac{0.6}{2} + \frac{0.7}{3} + \frac{0.8}{4} + \frac{1.0}{5}$ and $B = \frac{0.3}{1} + \frac{0.65}{2} + \frac{0.4}{3} + \frac{0.1}{4}$

a. Find the union of the two *A, B*.

b. Find the intersection of *A* and its complement. Comment on the result with respect to the difference between crisp and fuzzy sets

C. **(8 points) Multiple choice:**

1. The ID3 algorithm builds:
   - **a.** the simplest tree
   - **b.** the optimal tree
   - **c.** the shortest tree
   - **d.** the most efficient
2. Decision tree learning is:
   - **a.** supervised
   - **b.** unsupervised
   - **c.** reinforcement
   - **d.** active
3. Which of the following is a fuzzy set
   - **a.** $A = \frac{0.7}{1} + \frac{1.0}{2} + \frac{0.8}{3} + \frac{0.4}{4}$
   - **b.** $A = \frac{0.4}{1} + \frac{0.4}{2} + \frac{0.4}{3} + \frac{0.4}{4}$
   - **c.** $A = \frac{0}{1} + \frac{0}{2} + \frac{0}{3} + \frac{0}{4}$
   - **d.** All of the above



4. For the above fuzzy set, which of the following is true
   - **a.** Its support is bounded
   - **b.** The zero-cut (i.e. α=0) is not a closed set
   - **c.** The zero-cut (i.e. α=0) is a closed set
   - **d.** The core is empty.

Question (2) (20 points)

A. (6 points) Discuss three practical concerns while building a decision tree.

B. (14 points) Use the table of examples below:

Exam	Use Calculator	Duration (hrs) of lecture	Lecturer	Term	Difficulty
1	Yes	3	Jones	Fall	easy
2	Yes	3	Jones	Spring	difficult
3	No	3	Smith	Spring	difficult
4	No	2	Sam	Fall	easy
5	Yes	2	Jones	Fall	easy

i. Calculate the Entropy of the set of five examples with respect to the binary categorization into difficult and easy problems.

ii. What is the information gain from selecting the attribute "Duration of lecture" for tree-building.

iii. (True / False) The data in the table can be represented by a Two-layer neural network using sufficient hidden units. Explain why

Question (3) (20 points)

The nodes in a multi-layer neural network often contain sigmoid units, which perform the following calculation for a given weighted sum S:

$$\sigma = \frac{1}{1 + e^{-S}}$$

a. Calculate the output from a sigmoid unit which takes the set {0.1, 0.8, 0.8, 0.3} as input.
b. Is this unit "firing"? why?
c. Suppose we have a multi-layer network with two output nodes, and the target output for example E from output unit 1 is 1 and for output unit 2 is 0, yet the observed value produced for E was 0.3 for output unit 1 and 0.7 for output unit 2. What is the error term for O_1 and O_2?
d. Suppose, in the ANN discussed in (b), the weight from hidden node H_1 to O_1 was 0.25 and from H_1 to O_2 it was 0.4. Suppose further that the output from H_1 for example E was 0.9.

Use the following formula to calculate the error term of H_1 with respect to E:

$$\delta_{H_k} = h_k(E)(1 - h_k(E)) \sum_{i \in outputs} w_{ki} \delta_{O_i}$$

Question (4) (22 points)

A. (6 points) Show that the algebraic product *i(a,b)=ab* satisfies the four t-norm axioms.

B. **(16 points)** Consider two triangular fuzzy numbers *A=(-3,2,4), B=(-1,0,6)* , And consider the *standard t-norm* and *t-conorm* (i.e. min and max). Find each of the following:

a. (4pts) The membership function of *A* and *B*.
b. (2pts) The membership function of the *t-norm* of *A* and *B*
c. (2pts) The membership function of the *t-conorm* of *A* and *B*
d. (1pt) The support of *B*
e. (1pt) The core of the *t-conorm* of *A* and *B*
f. (4pts) The α-cuts of the *t-conorm* of *A* and *B*
g. (2 pt)Their difference *A-B*.

Question (5) (20 points)

A. **(10 points)** Choose one of the following questions to answer:

a. Solutions to crisp inequalities may be expressed as intervals ($-4 < 2x-6 \leq 10$ has (1,8] as its solution.) ; Define a similar notation for continuous fuzzy numbers. Then, For three triangles fuzzy numbers

A=(2,4,5), B=(-6,-3,-1), C=(10,14,15)

Solve $AX + B \leq C$

b. State and explain briefly the steps of developing a fuzzy expert system.
c. Give an example of a Fuzzy Logic Controller, and explain each step in its architecture.

B. **(10 points)** Choose one of the following questions to answer:

a. In competitive learning; Briefly, explain how does the Winner-Take-All algorithm work. What happens if we replaced the Euclidean distance by just $X - W$; Where X is the input pattern and W is the weight vector.
b. Briefly explain how does Kohonen algorithm work. Do you think the algorithm will perform better for supervised learning? Explain why?

c. In Support Vector Machine (SVM): Explain briefly how does the SVM algorithm work? Does the learning in SVM supervised or unsupervised

d. In Hopfield network: Explain briefly an algorithm for the Hopfield network. How may the architecture differ in the asynchronous and synchronous?

Best Wishes
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