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MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

SIXTH SEMESTER B.TECH (INFORMATION TECHNOLOGY / COMPUTER AND COMMUNICATION ENGINEERING) DEGREE END SEMESTER EXAMINATION-APRIL/MAY 2019
SUBJECT:PROGRAM ELECTIVE-III NEURAL NETWORKS AND FUZZY LOGIC (ICT 4012)
(REVISED CREDIT SYSTEM)

TIME: 3 HOURS — **03/05/2019** — **MAX. MARKS: 50**

Instructions to candidates

- Answer **ALL FIVE** full questions. All questions carry equal marks.
- Missing data if any, may be suitably assumed.

1A. Consider the situation depicted in Figure Q.1A. The environment is probed by applying a set of inputs constituting the regressor $X = [x_1, x_2, \ldots, x_m]^T$. The resulting output of the environment denoted by d constitutes the corresponding response. The linear regression model is parameterized by

$$d = \sum_{i=1}^{m} w_i x_i + \epsilon$$

where $w_1, w_2, \ldots, w_m$ denotes unknown parameters. Make the required assumption and derive the expression for *maximum a posteriori* (MAP) estimate of the parameter vector in a linear regression model. [5]

1B. Figure Q.1B shows the signal-flow graph of a 2-2-2-1 feedforward network. The function $\varphi(.)$ denotes a logistic function. The network shown in Fig.Q.1B has no biases. Suppose that biases equal to -1 and +1 are applied to the top and bottom neurons of the first hidden layer, and biases equal to +1 and -2 are applied to the top and bottom neurons of the second hidden layer. Write the input-output mapping defined by the network.

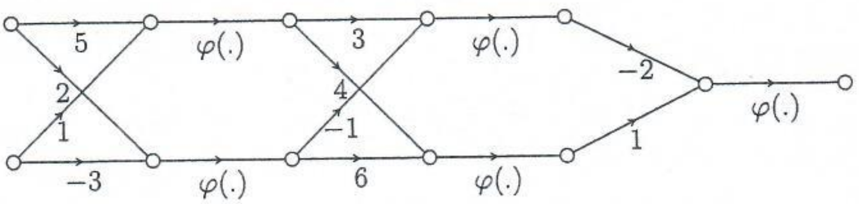

Figure: Q.1B

[3]

1C. Briefly describe methods to build invariances into neural network design. [2]

2A. Consider an exact solution of the XOR problem using an RBF network with four hidden units, with each radial-basis function center being determined by each piece of input data. The four possible input patterns are defined by (0,0), (0,1), (1,1) and (1,0), which represent the cyclically ordered corners of a square. Construct the interpolation matrix $\mathbf{\Phi}$ for the resulting RBF network. Hence, compute the inverse matrix $\mathbf{\Phi}^{-1}$. [5]

2B. For the Gaussian environment, Bayes classifier behaves like a perceptron. However, there are subtle difference between the two classifiers. Illustrate those differences. [3]

2C. Derive the expression for weight update as per the *least-mean-square* (LMS) algorithm. [2]

3A. Two companies bid for a contract. A committee has to review the estimates of those companies and give reports to its chairperson. The reviewed reports are evaluated on a non dimensional scale and assigned a weighted score that is represented by a fuzzy membership function, as illustrated by the two fuzzy sets B_1 and B_2, in Figure Q.3A. The chairperson is interested in the lowest bid, as well as a metric to measure the combined "best" score. For the logical union of the membership function shown we want to find the defuzzified quantity. Calculate the defuzzified value, z^* using centroid method, which is defined as

$$z* = \frac{\int \mu_C(z).zdz}{\int \mu_C(z)dz}$$

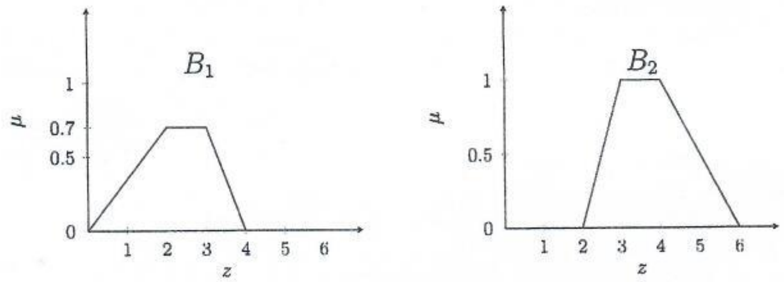

Figure: Q.3A

[5]

3B. In a ground transportation system, consider the relationship between number of people moved from point to point and the number of wheels used to accomplish this movement. For example, a bicycle uses two wheels to move one person. Let X be a universe of speeds (in mph) at which these systems move people, that is, $X = \{5, 30, 50, 100, 300+\}$. Let Y be the universe of the number of wheels that the system has, that is, $Y = \{2, 4, 8, 10, 16\}$. We define a "fast" system as fuzzy set on X as

$$\text{Fast} = \left\{ \frac{0}{5} + \frac{0.1}{30} + \frac{0.3}{50} + \frac{0.8}{100} + \frac{1.0}{300+} \right\}$$

and we define a "personally" owned system as a fuzzy set on Y as

$$\text{Personal} = \left\{ \frac{0.7}{2} + \frac{1.0}{4} + \frac{0.1}{8} + \frac{0}{10} + \frac{0}{16} \right\}$$

i) Find a fuzzy relation using the Cartesian product relating a "fast" system to a "personal" system.

ii) Now, consider a "slow" system defined on X, given by the fuzzy set

$$\text{Slow} = \left\{ \frac{1.0}{5} + \frac{0.8}{30} + \frac{0}{50} + \frac{0}{100} + \frac{0}{300} \right\}$$

Find a relation between "slow" system and the previously determined relation of part (i) using max-min composition.

[3]

3C. Consider a fuzzy set, $A = \{\frac{0.1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{0.4}{4} + \frac{03}{5}\}$. Find the following

i) Core element of the set

ii) Boundary elements of the set

iii) Support element of the set

iv) Whether the given fuzzy set a normal fuzzy set? [2]

4A. You are assigned the task of identifying images in an overhead reconnaissance photograph. You design computer software to do image processing to locate objects within a scene. Define two fuzzy sets representing a car and a truck image:

$$Car = \left\{\frac{0.5}{truck} + \frac{0.4}{motorcycle} + \frac{0.3}{boat} + \frac{0.9}{car} + \frac{0.1}{house}\right\}$$

$$Truck = \left\{\frac{1}{truck} + \frac{0.1}{motorcycle} + \frac{0.4}{boat} + \frac{0.4}{car} + \frac{0.2}{house}\right\}$$

Find the following set combination for these two sets:

(i) $Car \cup Truck$

(ii) $Car \cap Truck$

(iii) $\overline{Car}$

(iv) $\overline{Truck}$

(v) $Car|Truck$

(vi) $\overline{Car \cap Truck}$ [5]

4B. Two fuzzy sets A and B both defined on X, are as follows: Express the following λ-cut

$\mu(x_i)$	x_1	x_2	x_3	x_4	x_5	x_6
A	0.1	0.6	0.8	0.9	0.7	0.1
B	0.9	0.7	0.5	0.2	0.1	0

sets using Zadeh's notation:

(i) $(\overline{A})_{0.7}$

(ii) $(B)_{0.4}$

(iii) $(A \cup \overline{A})_{0.7}$

(iv) $(B \cap \overline{B})_{0.5}$

(v) $(\overline{A \cap B})_{0.7}$

(vi) $(\overline{A} \cup \overline{B})_{0.7}$ [3]

4C. Using the inference approach, find the membership values for each of the triangular shapes (I,R,IR,E,T) for the triangle, $80^0, 75^0, 25^0$. [2]

5A. For the data shown in Table Q.5A, show the first iteration of back propagation algorithm in trying to compute the membership values for the input variables x_1, x_2, and x_3 in the output regions R_1 and R_2. Use a $3 \times 3 \times 2$ neural network. Assume a random set of weights for your neural network. [5]

5B. Consider the two discrete fuzzy sets A and B, which are defined on universe $X = \{-5, 5\}$:

$$A = \text{"zero"} = \left\{\frac{0}{-2} + \frac{0.5}{-1} + \frac{1.0}{0} + \frac{0.5}{1} + \frac{0}{2}\right\}$$

$$B = \text{"positive medium"} = \left\{\frac{0}{0} + \frac{0.5}{1} + \frac{1.0}{2} + \frac{0.5}{3} + \frac{0}{4}\right\}$$

Table: Q.5A

x_1	x_2	x_3	R_1	R_2
1.0	0.5	2.5	1.0	0.0

i) Construct the relation for the rule IF A, THEN B (that is, IF x is "zero" THEN y is "positive medium") using Mamdani implication.

ii) If we introduce a new antecedent,

$$A' = \textbf{"positive small"} = \left\{ \frac{0}{-1} + \frac{0.5}{0} + \frac{1.0}{1} + \frac{0.5}{2} + \frac{0}{3} \right\}$$

Find the new consequent B', using max-min composition for the relation obtained in (i).

[3]

5C. In a problem related to the computer tracking of soil particles as they move under stress, the program displays desired particles on the screen. Particles can be small and large. Because of segmentation problems in computer imaging, the particles can become too large and obscure particles of interest or become too small and be obscured. To solve this problem linguistically, suppose we define the following atomic terms on a scale of sizes [0, 50] in units of mm^2:

$$"Large" = \left\{ \frac{0}{0} + \frac{0.1}{10} + \frac{0.3}{20} + \frac{0.5}{30} + \frac{0.6}{40} + \frac{0.7}{50} \right\}$$
$$"Small" = \left\{ \frac{1}{0} + \frac{0.8}{10} + \frac{0.5}{20} + \frac{0.3}{30} + \frac{0.1}{40} + \frac{0}{50} \right\}$$

For these atomic terms find membership functions for the phrase, *Not very small but large.*

[2]

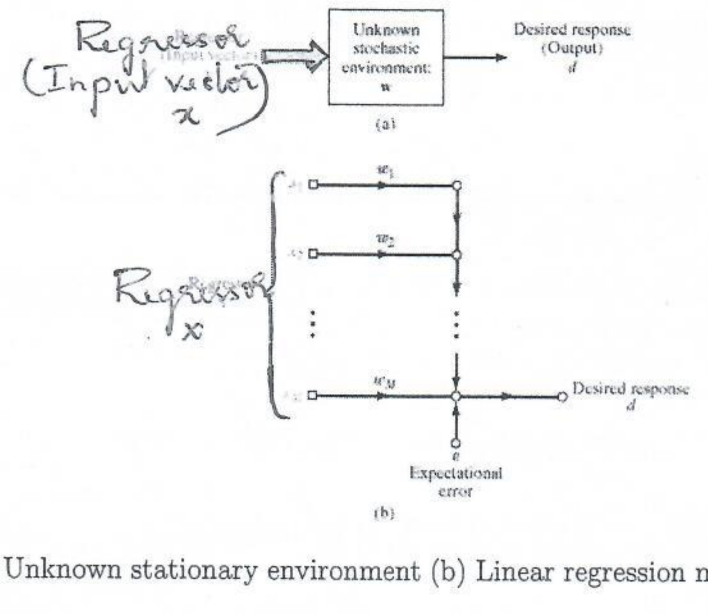

Fig.Q1A: (a) Unknown stationary environment (b) Linear regression model of the environment