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प्रज्ञानं ब्रह्म

Manipal INSPIRED BY LIFE

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

KNOWLEDGE IS POWER — MANIPAL INSTITUTE OF TECHNOLOGY

VII SEMESTER B.TECH (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, DEC 2015/JAN 2016

SUBJECT: INTELLIGENT CONTROLLERS [ELE 461]

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** the questions.
- Missing data may be suitably assumed.
- Use the table of fuzzy operations given at the end of the paper wherever required.

1A. Consider a 2- input 1- output fuzzy system that is constructed from the following two rules:
Rule 1: If X1 is A1 or X2 is A2, then Y is A2.
Rule 2: If X1 is A2 and X2 is A1, then Y is A1.
Where A1 and A2 are fuzzy sets with membership functions:

$$\mu_{A_1}(u) = \begin{cases} 1-|u| & \text{if} -1 \le u \le 1 \\ 0 & \text{otherwise} \end{cases}$$

$$\mu_{A_2}(u) = \begin{cases} 1-|u-1| & \text{if} \quad 0 \le u \le 2 \\ 0 & \text{otherwise} \end{cases}$$

If the input to the fuzzy system is $[X_1^*, X_2^*] = [0.5, 0.9]$ determine the output of the fuzzy system using Minimum inference engine and Center average defuzzifier. **(4)**

1B. Train a single –Layered network using the perceptron learning rule. The set of input and desired output training vectors are

$\{X_1 = [0.5, -1]^T,\ d1 = 1\}$, $\{X_2 = [-1, -1]^T,\ d2 = -1\}$
$\{X_3 = [2, -1]^T,\ d3 = 1\}$ $\{X_4 = [0.5, -1]^T,\ d4 = -1\}$
And the initial weight vector is $W^1 = [-2\ \ 1.5]^T$. The learning constant is set as 0.5 **(4)**

1C. Differentiate classical and fuzzy set **(2)**

2A. A BAM net is used to associate letters T and O (given by 4*3 patterns) with simple bipolar code shown in **Fig.2A**, to following bipolar target code (1, -1) and (1, 1) respectively. **(4)**

```
*  *  *        *  *  *
•  *  •        *  •  *
•  *  •        *  •  *
•  *  •        *  *  *
   T              O
```

Fig.2A

i) Find weight matrix with input pattern T and O.
ii) Test the BAM net with input pattern and target.

2B. Consider the following fuzzy relation defined on U1 x U2 x U3 where $U1 = \{a, \quad b, \quad c\}$ $U2 = \{s, \quad t,\}$ $U3 = \{x, \quad y,\}$:

$$Q = \frac{0.3}{b,t,x} + \frac{0.01}{a,s,x} + \frac{1}{b,s,y} + \frac{0.9}{b,t,y} + \frac{0.4}{a,t,y} + \frac{0.6}{c,s,y}$$ **(3)**

i) Compute the projection of Q on U1 x U2, U1 x U3.
ii) Compute the cylindrical extensions of the projections in i) to U1 x U2 x U3.

2C. Write a note on winner take all learning algorithm with network architecture and suitable expressions **(3)**

3A. Consider the problem of controlling the speed of a motor. Two variables related to this problem are speed S (in rpm) and load L (torque), having following membership functions:

$$S = \frac{0.2}{x_1} + \frac{0.6}{x_2} + \frac{1}{x_3} + \frac{0.7}{x_4} + \frac{0.5}{x_5}$$ where S is on universe X

$$L = \frac{0.3}{y_1} + \frac{0.4}{y_2} + \frac{0.7}{y_3} + \frac{1}{y_4} + \frac{0.7}{y_5} + \frac{0.4}{y_6} + \frac{0.1}{y_7}$$ where L is on universe Y

a) Find a fuzzy relation that relates these two variables as $R = S \times L$ **(5)**

b) Current I that relates elements in the universe Y to elements in Z as

$$I = \begin{array}{c} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \\ y_7 \end{array} \begin{bmatrix} 0.2 \\ 0.4 \\ 0.7 \\ 0.2 \\ 0.5 \\ 0.8 \\ 1.0 \end{bmatrix}$$

Find $Q = IoR$ using max –product composition.

3B. Classify two dimensional input patterns, given in **Fig.3B** (representing letters) using Hebb rule. Assume bipolar input and output data. (Where + indicates 1 and open square -1). **(3)**

+	+	+
	+	
+	+	+

+	+	+
	+	
+	+	

Fig.3B

3C. Realize XOR gate using McCulloch Pitts Model of the neuron **(2)**

4A. Find the relation for "If temperature is hot then fan speed is high" using Zadeh Implication. Given

$$Hot = \left[\frac{0}{60} + \frac{0.1}{70} + \frac{0.7}{80} + \frac{0.9}{90} + \frac{1}{100}\right]$$ **(3)**

$$High = \left[\frac{0}{0} + \frac{0.2}{1} + \frac{0.5}{2} + \frac{0.9}{3} + \frac{1}{4}\right]$$

4B. Determine s –norm $s_x(a,b)$ such that $s_x(a,b)$, the minimum t – norm and the Yager Complement with w = 2 form an associated class. **(2)**

4C. For the network shown in **Fig.4C** perform single step error back propagation for a target output of 0.5. Assume the neurons are unipolar sigmoidal and η = λ = 1. Assume bias input to be '0'. **(5)**

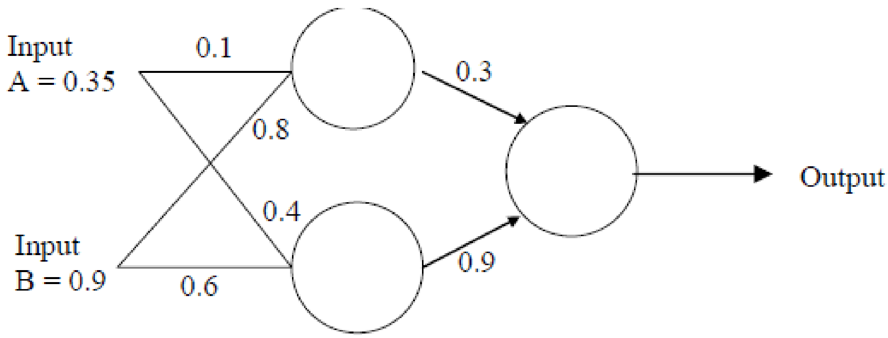

Fig. 4C

5A. A 3 class classifier using 3 discrete bipolar perceptron network has been trained in 3 steps with the augmented pattern component of -1 and C = 1. Initial weights are $w_1^1 = w_2^1 = w_3^1 = 0$.
Step 1: Presentation of input Y1 resulted in adjustment of all weights
Step 2: Presentation of input Y2 resulted in adjustment of weight w_3^2 only.
Step 3: Presentation of input Y3 resulted in adjustment of weight w_2^3 only.
.
The final weights are $w_1^4 = \begin{bmatrix} 1 \\ 3 \\ -1 \end{bmatrix}, w_2^4 = \begin{bmatrix} 5 \\ -1 \\ 2 \end{bmatrix}, w_3^4 = \begin{bmatrix} 1 \\ -1 \\ 2 \end{bmatrix}$. Find the input patterns X1, X2 and X3 used for training. The desired outputs are $d_1 = \begin{bmatrix} 1 \\ -1 \\ -1 \end{bmatrix}$, $d_2 = \begin{bmatrix} -1 \\ 1 \\ -1 \end{bmatrix}$ and $d_3 = \begin{bmatrix} -1 \\ -1 \\ 1 \end{bmatrix}$. **(4)**

5B. Given "Thick" = $\left[\frac{0}{1} + \frac{0.2}{2} + \frac{0.5}{3} + \frac{0.8}{4} + \frac{1}{5}\right]$, "Thin" = $\left[\frac{1}{1} + \frac{0.9}{2} + \frac{0.5}{3} + \frac{0.3}{4} + \frac{0}{5}\right]$ Find the membership function for the following phrases: **(3)**
a)Thick and Thin
b) Thick or very Thin where $\mu_{very}(x) = [\mu(x)]^2$.

5C. Design a multilayer perceptron network to realize an odd parity generator for a 2 – bit input data. **(3)**

6A. In a recurrent network, the neurons are connected to each other with the exception that no neuron has any connection to itself. Identify the recurrent network and explain the recurrent network with network architecture and suitable expressions **(3)**

6B. Design a fuzzy rule based system to simulate the aircraft landing control system shown in **Fig.6B**. At higher altitudes, a large downward velocity is desired. As the height (altitude) diminishes, the desired downward velocity gets smaller and smaller. In the limit, as the height becomes vanishingly small, the downward velocity also goes to zero. In this way, the aircraft will descend from altitude promptly but will touch down very gently to avoid damage. The two state variables for this simulation will be the height above ground, h, and the vertical velocity of the aircraft, v. The control output will be **(7)**

a force that, when applied to the aircraft, will alter its height, h, and velocity, v. Assume force in the range [-30 30] lbs, velocity in the range [-30 30] ft/s and height in range [0 1000] ft in the design. Use mamadani min implication for rule interpretation, min for intersection operation and max for union operation. Also test the system for height = 1000 ft and vertical velocity= -20ft/sec using center average defuzzification.

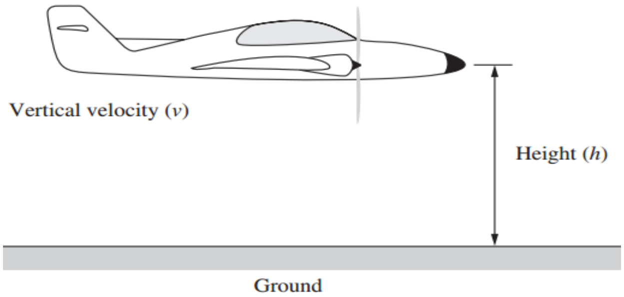

Fig. 6B

Table of S-norm, T-norm & Fuzzy complement

S - norm	T -norm	Fuzzy Complement
$s_{ds}(a,b) = \begin{cases} a & if\ b=0 \\ b & if\ a=0 \\ 1 & otherwise \end{cases}$	$t_{dp}(a,b) = \begin{cases} a & if\ b=1 \\ b & if\ a=1 \\ 0 & otherwise \end{cases}$	$c_\lambda(a) = \dfrac{1-a}{1+\lambda a}$
$s_w(a,b) = min\left[1, (a^w + b^w)^{\frac{1}{w}}\right]$	$t_w(a,b) = 1 - min\left[1, ((1-a)^w + (1-b)^w)^{\frac{1}{w}}\right]$	$c_w(a) = (1 - a^w)^{\frac{1}{w}}$
$s_{as}(a,b) = a + b - ab$	$t_{ap}(a,b) = ab$	
$s_{es}(a,b) = \dfrac{a+b}{1+ab}$	$t_{ep}(a,b) = \dfrac{ab}{2-(a+b-ab)}$	

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