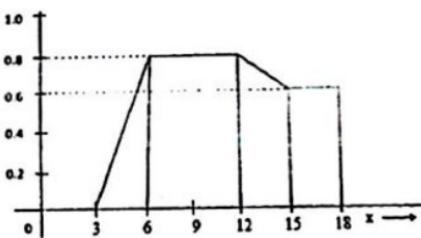


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الفصل: السطح
رمز المادة: CT411
التاريخ: 14/03/2022
الزمن: ساعتان و نصف
رقم القيد:

Answer the following questions:

Q1: For the following fuzzy set, find The crisp value which is obtained by CoG, MoM, SoM and LoM. {8 marks}



Q2: Let $X = \{1, 2, 3, 4, 5\}$ and $Y = \{1, 2, 3, 4, 5\}$. The membership functions

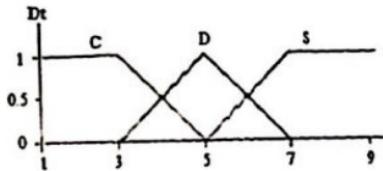
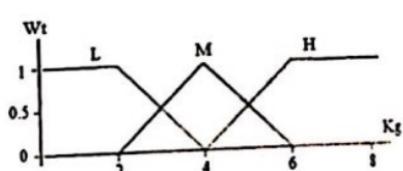
Q2: Let $X = \{1, 2, 3, 4, 5\}$ and $T = \{1, 2, 3, 4, 5\}$. Small = $\{1/1+0.5/2+0/3+0.5/4+1/5\}$, Medium = $\{0/1+0.5/2+1/3+0.5/4+0/5\}$, and

Large = {0/1+0.2/2+0.5/3+0.8/4+1/5}. The rule-base of the fuzzy logic controller is:

- 1- If x is small Then y is medium
 - 2- If x is medium Then y is large
 - 3- If x is large Then y is small

Using the fuzzy graph model and max-min method; find the output y if the input:
 $x^* = \{0/1+0.5/2+1/3+0.7/4+0.3/5\}$ {10 marks}

Q3: A controller in washing machine has two inputs; W_t is the weight of clothes (0-8 Kg) with linguistic variables {Light, Medium, Heavy}, and D_t is the amount of dirt {1-9} with linguistic variables {Clean, Dirty, Soiled}, the output Liq is the amount of cleaning liquid in mL {10-200}. The membership function distributions of the controller inputs are shown in the figure below.

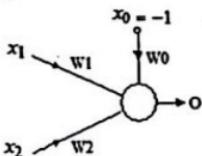


Based on Sugeno approach, the rule-base of the fuzzy logic controller is:

- 1- IF W_t is L AND D_t is C THEN $L_{iq} = 2 W_t + D_t$.
- 2- IF W_t is M OR D_t is D THEN $L_{iq} = 6 W_t + 7 D_t + 10$.
- 3- IF W_t is M AND D_t is S THEN $L_{iq} = 8 W_t + 10 D_t - 6$.
- 4- IF W_t is H OR D_t is C THEN $L_{iq} = 14 W_t + 16 D_t + 3$.
- 5- IF W_t is H AND D_t is D THEN $L_{iq} = 18 W_t + 16 D_t + 15$.

Find the Output \emptyset at $W_t = 4.5 \text{ Kg}$ and $D_t = 4$. {10 marks}

Q4: The shown Neural Network has $\alpha=0.2$ and threshold value $\theta = 0$.



This network will be trained to perform AND gate. Find the required weights W_0 , W_1 , and W_2 .

Write the results in the following table: {12 marks}

Epoch	Input			Desired output t	Initial weights			Actual output O	Error e	Final weights		
	x0	x1	x2		W0	W1	W2			W0	W1	W2
1	-1	0	0	0	0.5	1	1					
	-1	0	1	0								
	-1	1	0	0								
	-1	1	1	1								
...	-1	0	0	0								
	-1	0	1	0								
	-1	1	0	0								
	-1	1	1	1								

Q₁:

$$A_1 = 3 \times 0.8 \times 0.5 = 1.2$$

$$A_2 = 6 \times 0.8 = 4.8$$

$$A_3 = 3 \times 0.6 = 1.8$$

$$A_4 = 3 \times 0.2 \times 0.5 = 0.3$$

$$A_5 = 3 \times 0.6 = 1.8$$

$$\bar{x}_1 = (3+6+6)/3 = 5$$

$$\bar{x}_2 = (6+12)/2 = 9$$

$$\bar{x}_3 = (12+15)/2 = 13.5$$

$$\bar{x}_4 = (12+12+15)/3 = 13$$

$$\bar{x}_5 = (15+18)/2 = 16.5$$

(0.5)

(0.5)

(0.5)

(0.5)

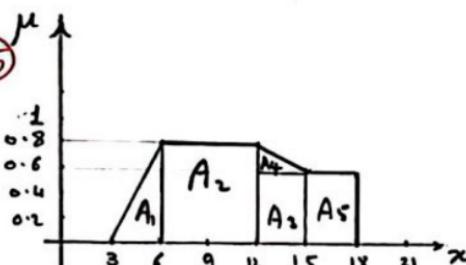
(0.5)

$$(COG) x^* = \frac{1.2 \times 5 + 4.8 \times 9 + 1.8 \times 13.5 + 0.3 \times 13 + 1.8 \times 16.5}{1.2 + 4.8 + 1.8 + 0.3 + 1.8} = \frac{107.1}{9.9} = 10.82 \quad (2)$$

$$MOM (x^* = \frac{12+6}{2} = 9) \quad (1,5)$$

$$SOM (x^* = 6) \quad (1)$$

$$LDM (x^* = 12) \quad (1)$$



Q₂: $R_1 = \begin{bmatrix} 1 \\ 0.5 \\ 0 \\ 0.5 \\ 1 \end{bmatrix} \circ \begin{bmatrix} 0 & 0.5 & 1 & 0.5 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0.5 & 1 & 0.5 & 0 \\ 0 & 0.5 & 0.5 & 0.5 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0.5 & 0.5 & 0.5 & 0 \\ 0 & 0.5 & 1 & 0.5 & 0 \end{bmatrix} \quad (1)$

$$R_2 = \begin{bmatrix} 0 \\ 0.5 \\ 1 \\ 0.5 \\ 0 \end{bmatrix} \circ \begin{bmatrix} 0 & 0.2 & 0.5 & 0.8 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0.2 & 0.5 & 0.5 & 0.5 \\ 0 & 0.2 & 0.5 & 0.8 & 1 \\ 0 & 0.2 & 0.5 & 0.5 & 0.5 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (1)$$

$$R_3 = \begin{bmatrix} 0 \\ 0.2 \\ 0.5 \\ 0.8 \\ 1 \end{bmatrix} \circ \begin{bmatrix} 1 & 0.5 & 0 & 0.5 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0.2 & 0.2 & 0 & 0.2 & 0.2 \\ 0.5 & 0.5 & 0 & 0.5 & 0.5 \\ 0.8 & 0.5 & 0 & 0.5 & 0.8 \\ 1 & 0.5 & 0 & 0.5 & 1 \end{bmatrix} \quad (1)$$

$$R = R_1 U R_2 U R_3 = \begin{bmatrix} 0 & 0.5 & 1 & 0.5 & 0 \\ 0.2 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0.5 & 0.5 & 0.5 & 0.8 & 1 \\ 0.8 & 0.5 & 0.5 & 0.5 & 0.8 \\ 1 & 0.5 & 1 & 0.5 & 1 \end{bmatrix} \quad (1)$$

max-min

$$y^* = \left([0 \ 0.5 \ 1 \ 0.7 \ 0.3] \circ \begin{bmatrix} 0 & 0.5 & 1 & 0.5 & 0 \\ 0.2 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0.5 & 0.5 & 0.5 & 0.8 & 1 \\ 0.8 & 0.5 & 0.5 & 0.5 & 0.8 \\ 1 & 0.5 & 1 & 0.5 & 1 \end{bmatrix} \right)$$

$$y^*(1,1) = \max(0, 0.2, 0.5, 0.7, 0.3) = 0.7 \quad (1)$$

$$y^*(1,2) = \max(0, 0.5, 0.5, 0.5, 0.3) = 0.5 \quad (1)$$

$$y^*(1,3) = \max(0, 0.5, 0.5, 0.5, 0.3) = 0.5 \quad (1)$$

$$y^*(1,4) = \max(0, 0.5, 0.8, 0.5, 0.3) = 0.8 \quad (1)$$

$$y^*(1,5) = \max(0, 0.5, 1, 0.7, 0.3) = 1 \quad (1)$$

$$y^* = \left\{ \frac{0.7}{1} + \frac{0.5}{2} + \frac{0.5}{3} + \frac{0.8}{4} + \frac{1}{5} \right\}$$

$$CoA(y) = \frac{0.7 \times 1 + 0.5 \times 2 + 0.5 \times 3 + 0.8 \times 4 + 1 \times 5}{0.7 + 0.5 + 0.5 + 0.8 + 1} = \frac{11.4}{3.5} = 3.26 \quad (1)$$

(Q3:

$$F_1 = 2 \times 4.5 + 4 = 13$$

$\underbrace{0.5}_{0.5}$

$$F_2 = 6 \times 4.5 + 7 \times 4 + 10 = 65$$

$\underbrace{0.5}_{0.5}$

$$F_3 = 8 \times 4.5 + 10 \times 4 - 6 = 70$$

$\underbrace{0.5}_{0.5}$

$$F_4 = 14 \times 4.5 + 16 \times 4 + 3 = 130$$

$\underbrace{0.5}_{0.5}$

$$F_5 = 18 \times 4.5 + 16 \times 4 + 15 = 160$$

$\underbrace{0.5}_{0.5}$

-

Q4:

$$\begin{aligned} O' &= \omega_0 x_0 + \\ \Delta w &= \alpha (O - O') x_i + \\ &= \alpha (\omega_0 x_0 + \omega_1 x_1 + \omega_2 x_2) - \end{aligned}$$

$w_0 = 0.8$
$w_1 = 0.8$
$w_2 = 0.8$

Epoch	Inputs	Desired output	Error	Δw	Final weight
1	x ₀	1	1	-0.5	0.3
2	x ₀ , x ₁	1	1	-0.5	0.3
3	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
4	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
5	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
6	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
7	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
8	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
9	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
10	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
11	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
12	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
13	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
14	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
15	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
16	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
17	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
18	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
19	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
20	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
21	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
22	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
23	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
24	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
25	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
26	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
27	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
28	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
29	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
30	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
31	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
32	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
33	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
34	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
35	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
36	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
37	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
38	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
39	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
40	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
41	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
42	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
43	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
44	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
45	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
46	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
47	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
48	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
49	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
50	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
51	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
52	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
53	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
54	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
55	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
56	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
57	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
58	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
59	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
60	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
61	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
62	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
63	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
64	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
65	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
66	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
67	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
68	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
69	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
70	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
71	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
72	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
73	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
74	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
75	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
76	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
77	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
78	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
79	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
80	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
81	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
82	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
83	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
84	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
85	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
86	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
87	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
88	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
89	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
90	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
91	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
92	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
93	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
94	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
95	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
96	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
97	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
98	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
99	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3
100	x ₀ , x ₁ , x ₂	1	1	-0.5	0.3