Examples on Mamdani FIS system

Ex1: Design a fuzzy lighting controller system, in which the control system dim the bulb light automatically according to the environmental Light. Assume that the inputs to the system are the environmental light ***x1*** and the changing rate of the environmental light ***x2***. While the output variable which represents the control value to the dimmer is ***DM***. Consider the following assumption:

Assume that *x1* can be *Dark (D), Medium (M),* and *Light (L)* and its range between 120 and 220, with three membership functions: L(130,150), Π(130, 150 190,210), and Γ(190, 210) for *D, M*, and *L* respectively.

x2 ranges between -10 and +10 and is divided into *Negative-Small (NS)*, *Zero (ZE)*, and *Positive-Small (PS)*, with three membership functions: Λ (-20, -10, 0), Λ (-10, 0, 10), and Λ (0,10,20) for *NS, ZE*, and *PS* respectively.

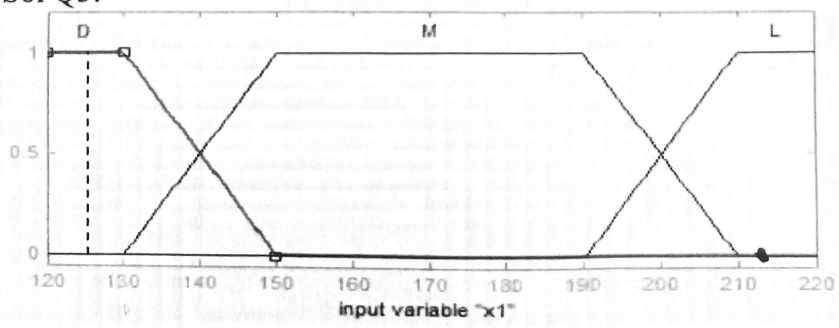
The output *DM* ranges between 0 and 10 and is divided into *Very-small (VS), Small (S), Big(B),* and *Very-big (VB)*, with four membership functions: L(2,4), Λ(2,4,6), Λ(4,6,8), and Γ(6,8) for *VS, S, B,* and *VB* respectively.

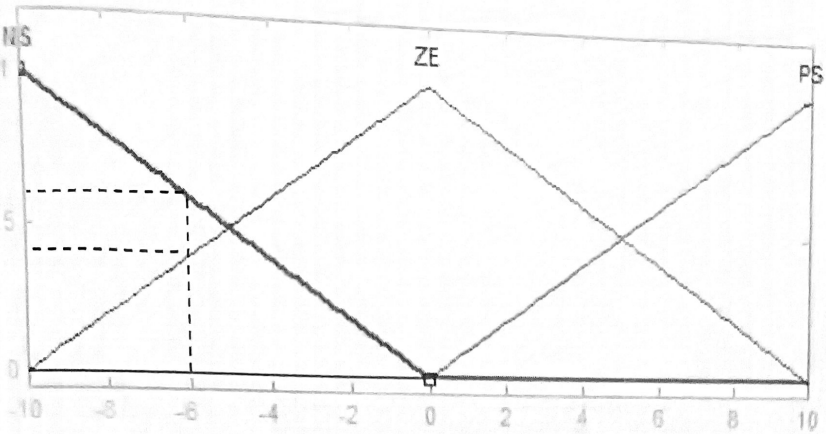
Evaluate the output for $x1 = 125$ and $x2 = -6$, having the following fuzzy rule base:

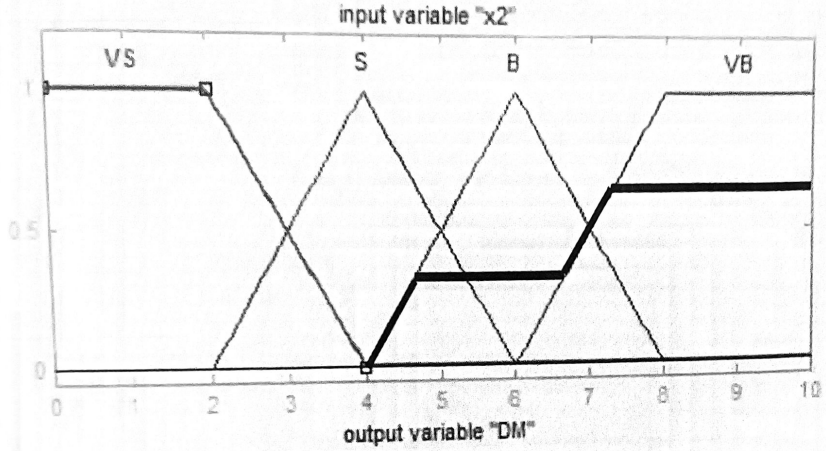
x2 \ x1	D	M	L
PS	B	S	VS
ZE	B	B	S
NS	VB	B	B

Solution:

Sol Q3:







X1=125 then it is D
X2= -6 then it is ZE and NS
Therefore two rules will be fired:
IF X1 IS D AND X2 IS ZE THEN DM IS B
IF X1 IS D AND X2 IS PS THEN DM IS VB

For the first rule $\mu_{X1} = 1$ and $\mu_{X2} = 0.4$ thus, $\mu_{DM} = 0.4$

For the second rule $\mu_{X1} = 1$ and $\mu_{X2} = 0.6$ thus, $\mu_{DM} = 0.6$

Now, the control action will be:

dm = {0, 0, 0, 0, .4, .4, .5, .6, .6, .6}

Finally, we apply center of gravity (CoG) defuzzification in order to obtain final crisp output:

$$DM = \frac{(0*0)+(0*1)+...+(0*4)+(.4*5)+(.4*6)+(.5*7)+(.6*8)+...+(.6*10)}{0+0+...+.4+.4+.5+.6+.6+.6} = \frac{24.1}{3.1} = 7.77$$

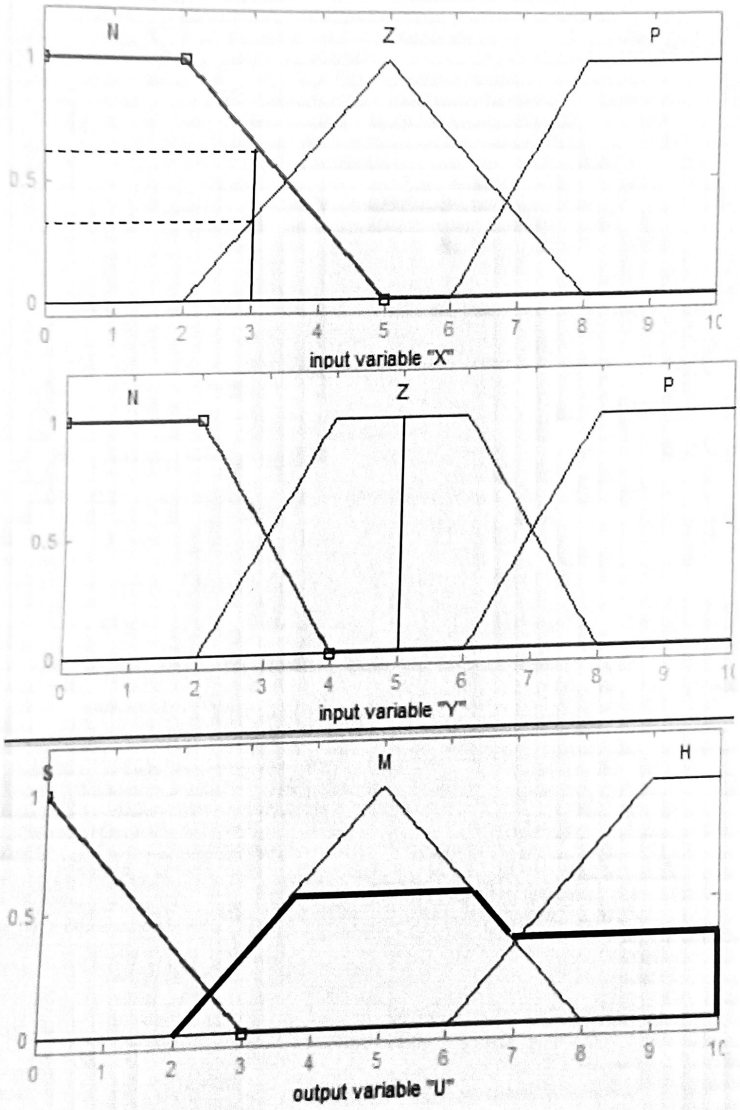
Ex2: Consider a fuzzy logic controller with two inputs x, y and a single output u, in which each of the inputs/output variables is quantified into three fuzzy sets with membership functions as illustrated in the table bellow. Suppose that the range of each variable is [0, 10] with number of intervals = 10.

X		Y		U	
Fuzzy terms	Membership function	Fuzzy terms	Membership function	Fuzzy terms	Membership function
N	L(x; 2,5)	N	L(y;2 ,4)	S	L(u;0 ,3)
Z	ʌ(x;2,5,8)	Z	Π(y;2,4 ,6, 8)	M	ʌ(u;2,5,8)
P	Γ(x;6,8)	P	Γ(y;6 ,8)	H	Γ(u;6,8)

Find the control action if x=3 and y=5, knowing that the fuzzy rules are

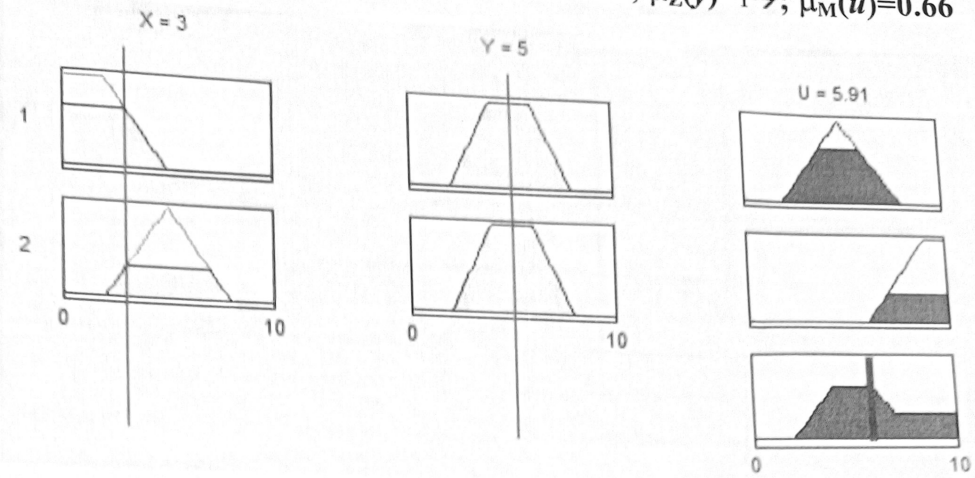
^	N	Z	P
N	S	M	M
Z	M	H	H
P	M	H	H

Solution:



1. If (X is N) and (Y is Z) then (U is M) → $\mu_N(x) = .66$; $\mu_Z(y)=1$ →; $\mu_M(u)=0.66$

2. If (X is Z) and (Y is Z) then (U is H) → $\mu_Z(x) = .33$; $\mu_Z(y)=1$→; $\mu_M(u)=0.66$



$$u = \frac{\sum_{n=1}^{N} I_n \mu_n}{\sum_{n=1}^{N} \mu_n}$$

u=(0+0+0.333*3+0.666*(4+5+6)+0.333*(7+8+9+10))/(0.333*5+0.666*3)≈6

Ex3: Consider a fuzzy logic controller is used to control the speed of a motor by changing its input voltage (V) according to two input variables; speed (SP), and speed change rate SC. Let the fuzzy set of SP be *{Slow (S), Normal (N), Fast (F)}*, and the fuzzy set for SC be *{Low (L), Medium (M), High (H)}*, and for the control action be *{Slow Down (DN), No Change (NC), Speed Up (Up)}*, where, (SP∈ [500, 1000]), (SC ∈ [0, 10]), and (V ∈ [2, 3]) with step = 0.1. The membership functions for the input/output variables are described in table 1. Find the control action if SP=910 And SC= 6.5 based on the fuzzy rules shown in table 2.

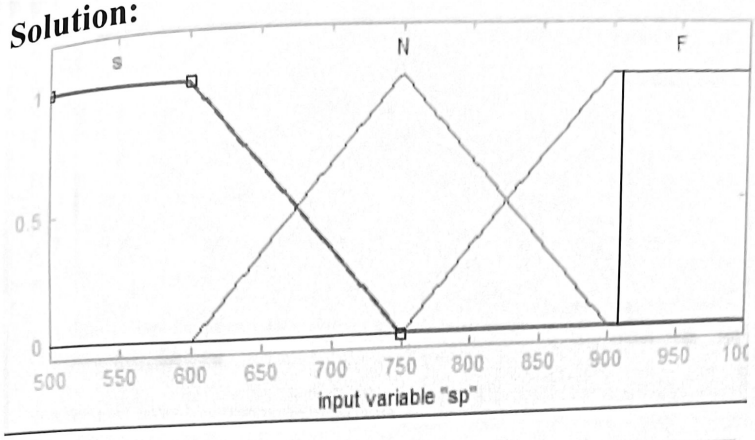
Table 1

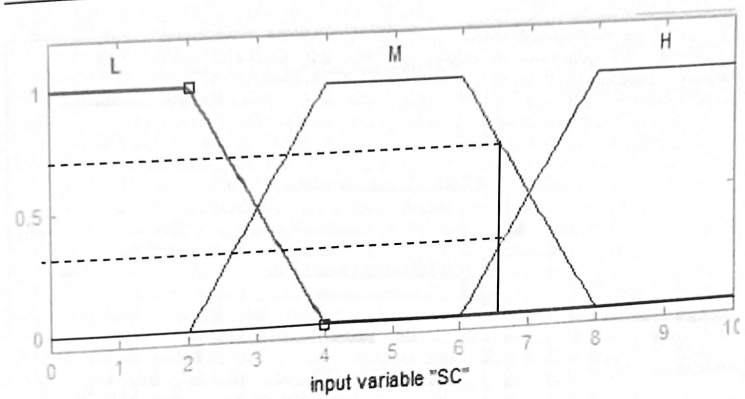
SP		SC		V	
Term	MF	Term	MF	Term	MF
S	L(600,750)	L	L(2 ,4)	DN	L(2.2 ,2.5)
N	Λ(600,750,900)	M	Π(2,4 ,6, 8)	NC	Λ(2.4, 2.5,2.6)
F	Γ(750,900)	H	Γ(6 ,8)	Up	Γ(2.5, 2.8)

Table 2

^	S	N	F
L	Up	NC	NC
M	Up	NC	NC
H	NC	DN	DN

Solution:



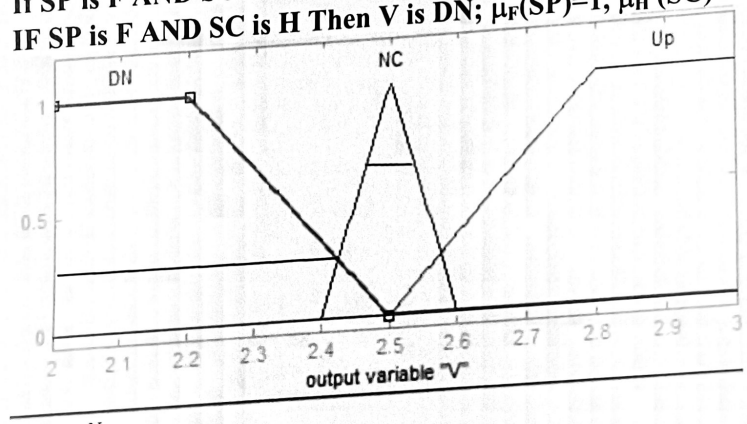


$\mu_M(SC)$= (8-6.5)/(8-6) = 0.75

$\mu_H(SC)$= (6.5-6)/(8-6) = 0.25

If SP is F AND SC is M Then V is NC; $\mu_F(SP)=1$, $\mu_M(SC)= 0.75$, $\mu_{NC}(V)=0.75$

IF SP is F AND SC is H Then V is DN; $\mu_F(SP)=1$, $\mu_H(SC)= 0.25$, $\mu_{DN}(V)=0.25$



$$u = \frac{\sum_{n=1}^{N} I_n \mu_n}{\sum_{n=1}^{N} \mu_n}$$

V= [0.25 * (2.1 +2.2+2.3+2.4)+ 0.75*2.5] / [0.25*4 + 0.75] = 4.125/1.75 = 2.357