# 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.

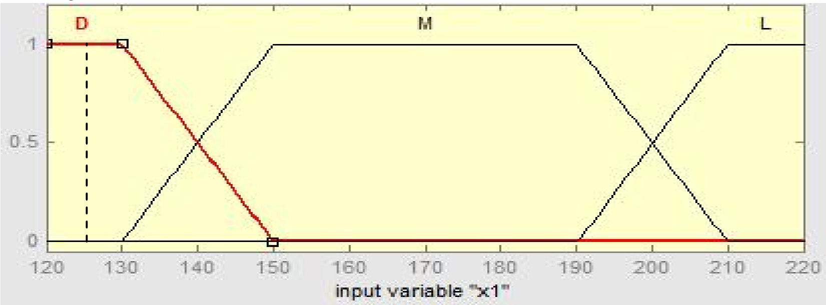
The output *DM* ranges between 0 and 10 and is divided into *Very-small (VS)*, *Small (S)*, *Big(B)*, and *Very-big (VB)*, with four membership functions: L(2,4), Λ(2,4,6), Λ(4,6,8), and Γ(6,8) for *VS*, *S*, *B*, and *VB* respectively.

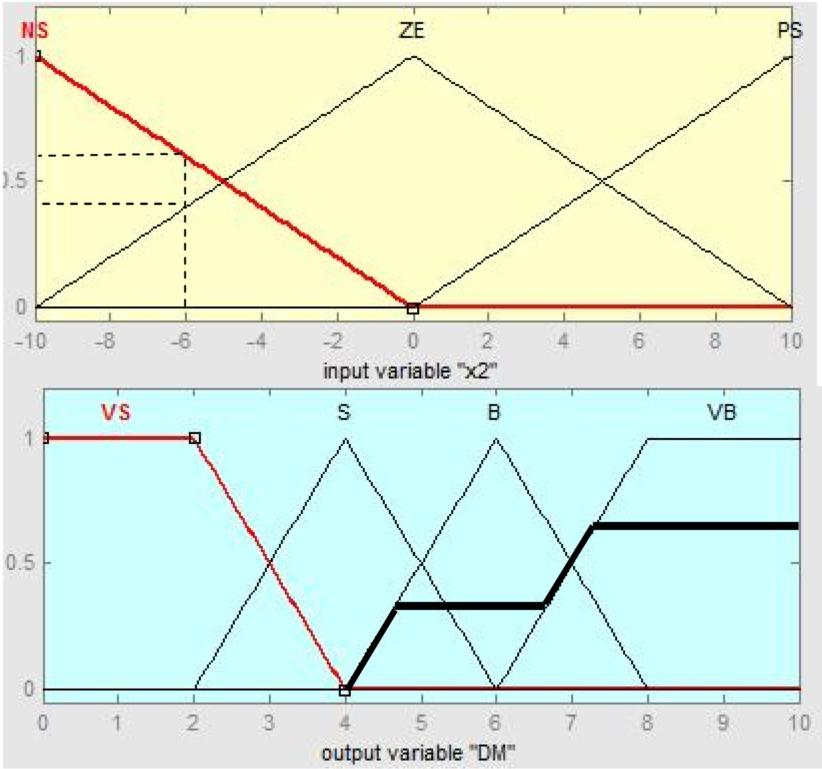
Evaluate the output for *x*1 = 125 and *x*2 = -6, having the following fuzzy rule base:

| x1 / x2 | 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:

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

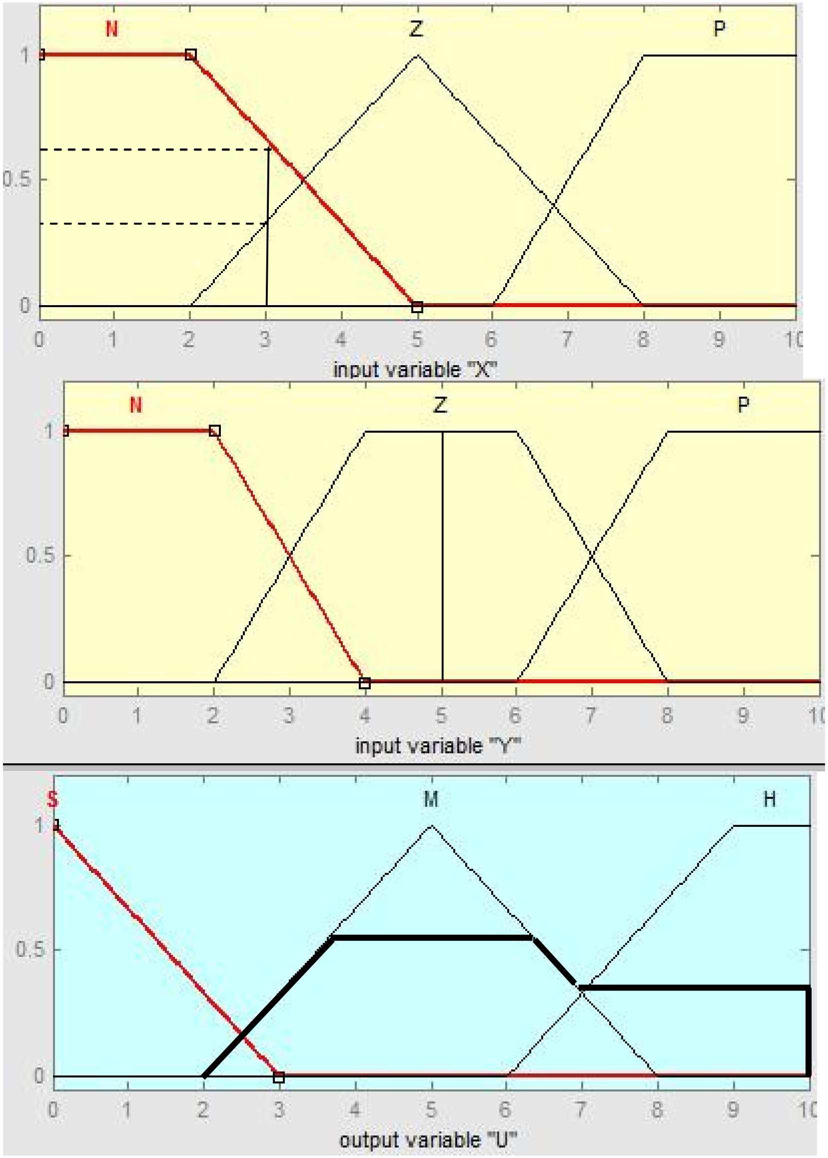
**Ex2:** Consider a fuzzy logic controller with two inputs x, y and a single output u, in which each of the inputs/output variables is quantified into three fuzzy sets with membership functions as illustrated in the table bellow. Suppose that the range of each variable is [0, 10] with number of intervals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

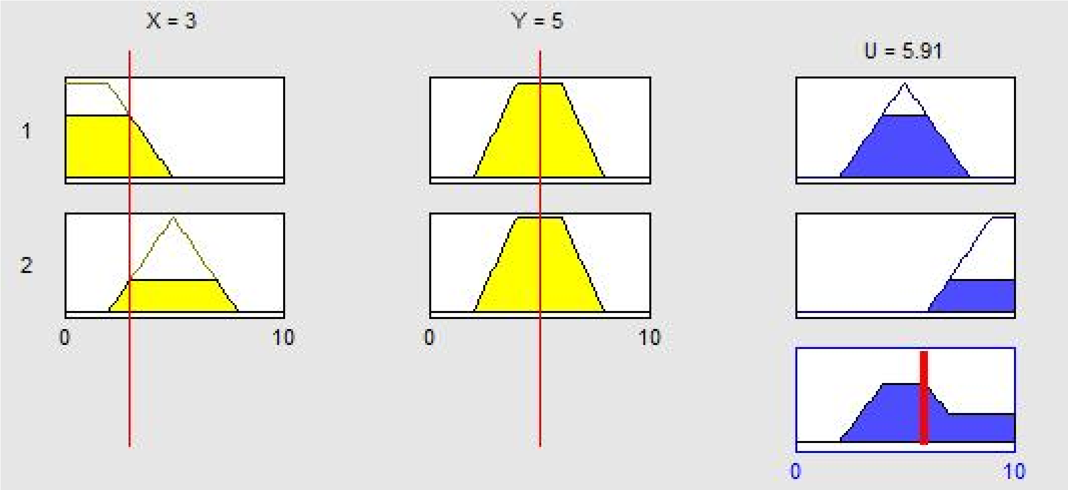
| ^ | N | Z | P |
|---|---|---|---|
| N | S | M | M |
| Z | M | H | H |
| P | M | H | H |

**Solution:**




1. If (X is N) and (Y is Z) then (U is M) → **«$_{N}$(*x*) = *.66*; «$_{Z}$(*y*)=1 →; «$_{M}$(*u*)=0.66**

2. If (X is Z) and (Y is Z) then (U is H) → **$«_Z(x) = .33$; $«_Z(y)=1$→; $«_M(u)=0.66$**




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

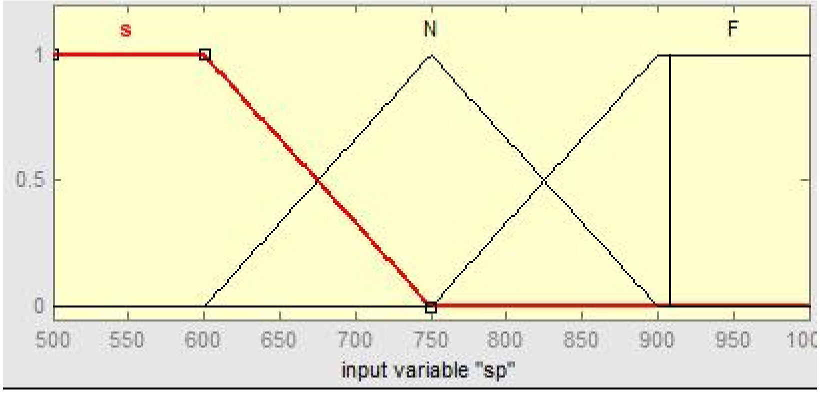
u=(0+0+0.333*3+0.666*(4+5+6)+0.333*(7+8+9+10))/(0.333*5+0.666*3)≈6

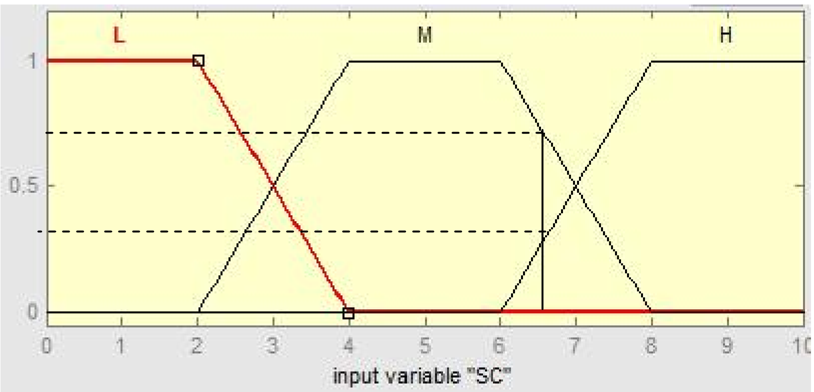
**Ex3:** Consider a fuzzy logic controller is used to control the speed of a motor by changing its input voltage (V) according to two input variables; speed (SP), and speed change rate SC. Let the fuzzy set of SP be {*Slow (S), Normal (N), Fast (F)*}, and the fuzzy set for SC be {*Low (L), Medium (M), 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:**



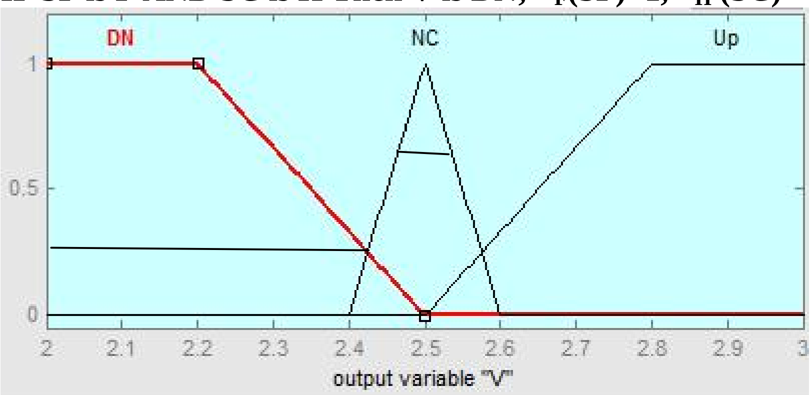




**«$_{M}$(SC)= (8-6.5)/(8-6) = 0.75**

**«$_{H}$(SC)= (6.5-6)/(8-6) = 0.25**

**If SP is F AND SC is M Then V is NC; «$_{F}$(SP)=1, «$_{M}$(SC)= 0.75, «$_{NC}$(V)=0.75**

**IF SP is F AND SC is H Then V is DN; «$_{F}$(SP)=1, «$_{H}$ (SC)= 0.25, «$_{DN}$(V)=0.25**




$$u = \frac{\sum_{n=1}^{N} I_n \text{«}_n}{\sum_{n=1}^{N} \text{«}_n}$$

**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**