Fuzzy

Defⁿ: A fuzzy set is a set which allow partial belonging to a set, that is defined by a degree of membership denoted by 'μ', that can take any value from 0 to 1.

Crisp set: If we remove all the values of belonging except 0 & 1 the set will collapses into a crisp set.

Membership function: The membership function of the set is the relationship between the elements of the set & their degree of belonging.

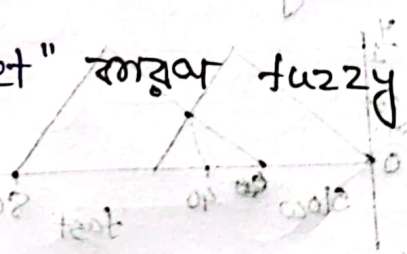
(2,0) . (2,0.1)

Example of Crisp set:

$F = \{i | i$ is an integer and $4 \leq i \leq 12\}$

If $i = 4$ to 12 then it will be 1 otherwise 0

"Fuzzy is one kind of crisp set" মানে fuzzy set-এ 0, 1 র combination ও থাকে তাই।



Ques: Fuzzy Vs Crisp

Defination:

Crisp set: A crisp set is a collection of discrete value.

Fuzzy set: 'Already given'

Membership:

Crisp set: Elements either belong to the set (membership value 1) or do not belong check m. value is 0.

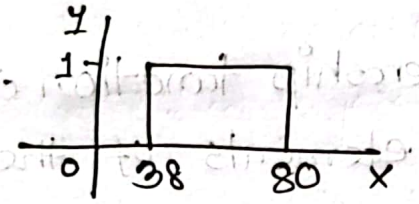


Fig: Crisp set

So if x is less than 38 or $80 < x$ then it will be zero.
x will be 1 if it remains between 38 & 80.

More precisely, A set of red apples {apples, not apples}

Fuzzy: Elements have degree of membership between 0 and 1, indicating the extent to which they belong to the set.

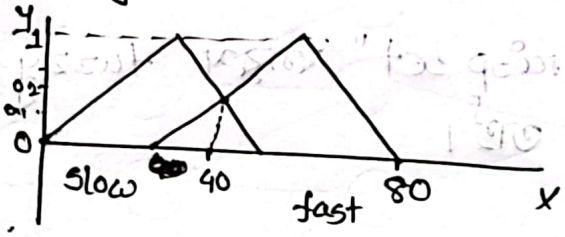


Fig: fuzzy set

So, here starting from zero it gradually speed up not directly goes to 1. For 40, there is an equal possibility of being slow or fast. It's a continuos value.

Example: The set of ripe apple, where the degree of membership varies for each apple based on its ripeness.

Boundary:

Crisp set has a clear, well defined boundary but fuzzy set lacks a precise boundary and elements can have partial membership.

8: Advantages & Disadvantages of Fuzzy logic system.

Advantages:

1. Handling Uncertainty: Excel at managing imprecise information, uncertainty making them ideal for real-world scenarios.

2. Flexibility: Can adapt to different situations and understand various input.

3. Interpretability: Produce easily understandable results using natural language terms, enhancing accessibility for non experts.

4. Fault Tolerance: Handle imperfect or incomplete data without a problem.

Disadvantages:

1. Complexity: Can get complicated with lots of rules, making them harder to understand.

2. Subjectivity: Rely on personal interpretation, which leads to different opinion.

3. Performance: In tasks needing exact results, fuzzy systems may not be as good as other system.

4. Training & Tuning: Making fuzzy system work well takes skill and effort in adjusting different settings.

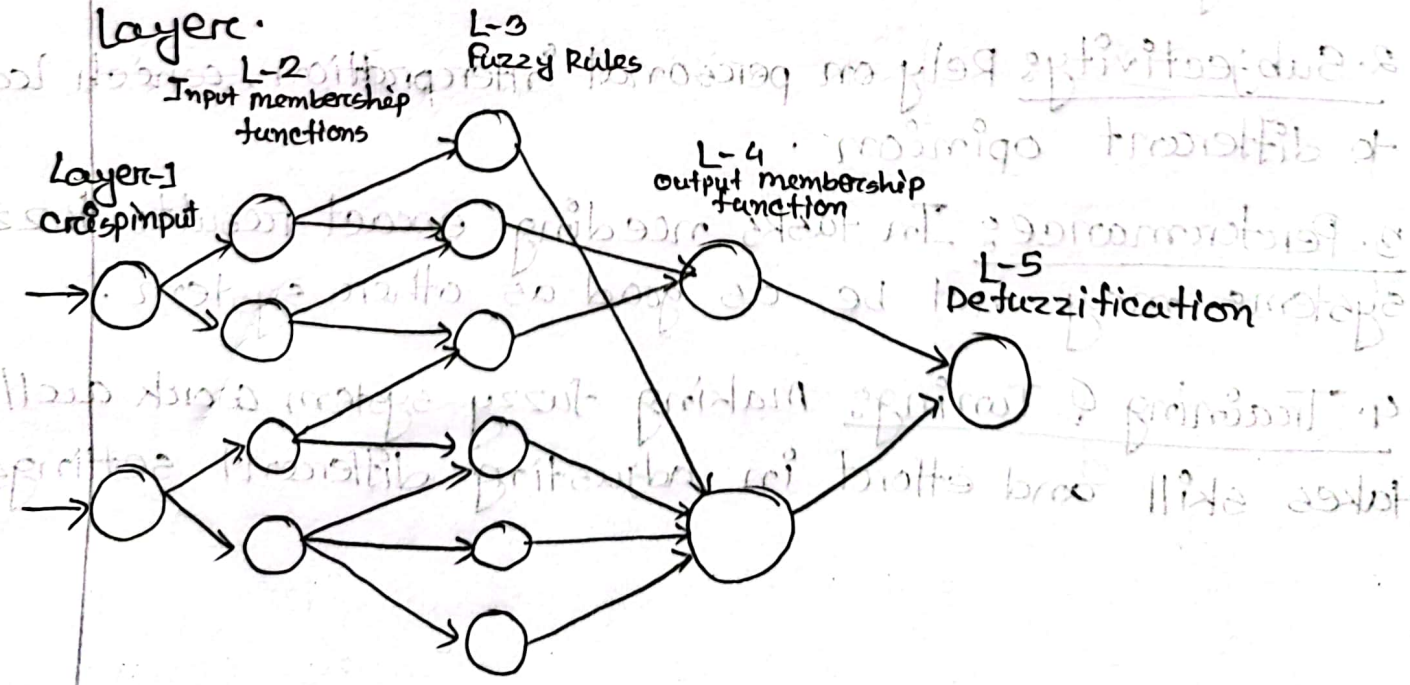
Q: How a Neuro-fuzzy system can be built?

→ A neuro fuzzy system is based on a fuzzy system which is trained by a learning algorithm derived from neural network theory.

→ A neuro fuzzy system can be built as a 3-layer feed forward neural network

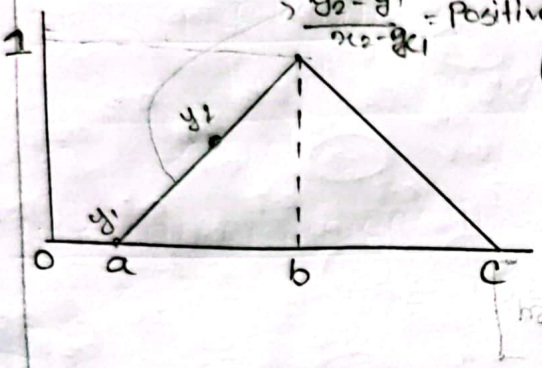
* First layer represents input variables
* Middle layer (hidden) represents fuzzy rules.
* Third layer represents output variables.

Fuzzy sets are encoded as (fuzzy) connection weights. It represents the data flow of input processing and learning with the model. Sometimes 5-layer architecture is used, where fuzzy sets are represented in the units of the second and forth layers.



→ A neuro-fuzzy system can be always interpreted as a system of fuzzy rules. It is also possible to create the system out of training data from scratch, as it is possible to initialize it by prior knowledge in the form of fuzzy rules.

Triangular MF: (Membership function)



$\mu_A(x) = (x, a, b, c)$

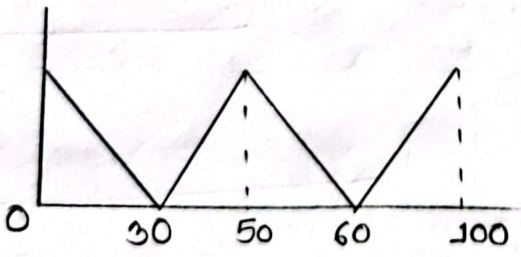
$$\begin{cases} 0 & \text{if } x \le 0 \\ \frac{x-a}{b-a} & \text{if } a \le x < b \\ \frac{c-x}{c-b} & \text{if } b \le x < c \\ 0 & \text{if } x \ge c \end{cases}$$

→ Positive ঢাল তখন equation $\frac{x-a}{b-a}$. Positive ঢাল = $\frac{y_2-y_1}{x_2-x_1}$

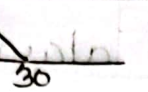
→ Positive ঢাল-এ x-র sign (+)

→ Negative ঢাল-এ x-র sign (-)

Now suppose there is given,



Ans: তখন আমরা যেকোন equation-কে $\mu_A(x)$ format-এ নেয়ার try করব যদি given figure triangular হয়।

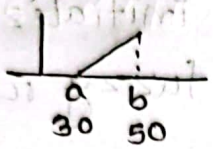
Step 1: 

উত্তর negative তাল তাই $(-x)$ হবে।

$\frac{30-x}{30-0}$ [নিচে always (high range - loco range)]

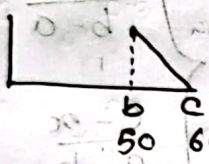
$\left(\frac{c-x}{c-b}\right)$ → neg তাল

Step 2:



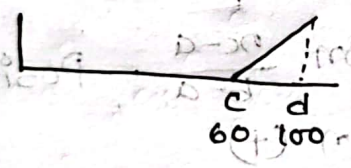
$\frac{x-30}{50-30}$ $\left[\frac{x-a}{b-a}\right.$ positive তাল$\left.\right]$

Step 3:



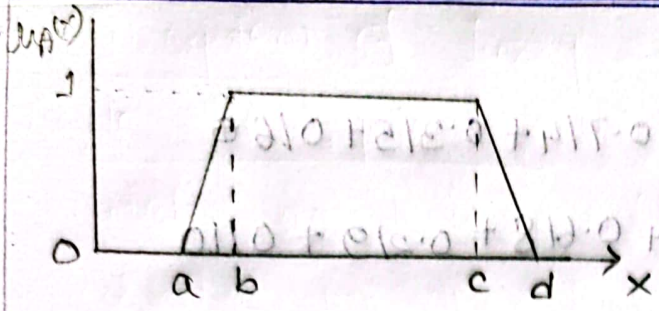
$\frac{60-x}{60-50}$ $\left[\frac{c-x}{c-b}\right.$ negative তাল$\left.\right]$

Step 4:

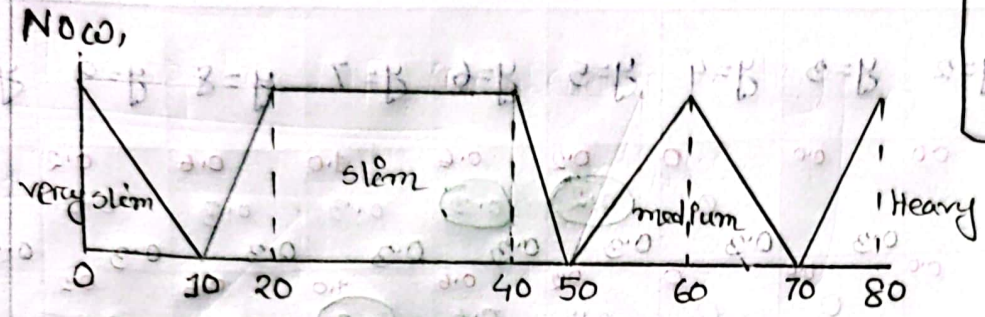


$\frac{x-60}{100-60}$ $\left[\frac{x-a}{bd-c}\right.$ positive তাল$\left.\right]$ like $\frac{x-a}{b-a}$

Trapezoidal Membership Function:



$$\mu_A(x) = (x, a, b, c, d) = \begin{cases} 0 & \text{if } x < a \\ \frac{x-a}{b-a} & \text{if } a \le x < b \\ 1 & \text{if } b \le x < c \\ \frac{d-x}{d-c} & \text{if } c \le x < d \\ 0 & \text{if } x > d \end{cases}$$



For very slim,

$\mu = \frac{10-x}{10-0}$ [it's a negative slope] Range → $x < 10$

For slim,

$\mu = \frac{x-10}{20-10}$ Range → $10 \le x < 20$ [Positive slope]

$\mu = \frac{1}{\text{~~~~}}$ Range → $20 \le x \le 40$ [Slope zero]

$\mu = \frac{50-x}{50-40}$ Range → $40 \le x < 50$ [negative slope]

to remove (-) we use negative slop formula by negating x]

For medium,

$\mu = \frac{x-50}{60-50}$ Range → $50 \le x < 60$ [Positive slope]

$\mu = \frac{70-x}{70-60}$ Range → $60 \le x < 70$. [negative slope]

For Heavy:

$\mu = \frac{x-70}{80-70}$

Fuzzy Addition using Extension Principle

From slide:

$A = 3 = 0.3/1 + 0.7/2 + 1.0/3 + 0.7/4 + 0.3/5 + 0/6$ ⊛

$B = 7 = 0.2/5 + 0.6/6 + 1.0/7 + 0.6/8 + 0.2/9 + 0/10$

A \ B	y=1	y=2	y=3	y=4	y=5	y=6	y=7	y=8	y=9	y=10
x=1	0.0 / 0.3	0.0 / 0.3	0.0 / 0.3	0 / 0.3	0.2 / 0.3	0.6 / 0.3	1.0 / 0.3	0.6 / 0.3	0.2 / 0.2	0.0 / 0
x=2	0.0 / 0.7	0.0 / 0.7	0.0 / 0.7	0 / 0.7	0.2 / 0.7	0.6 / 0.7	1.0 / 0.7	0.6 / 0.7	0.2 / 0.7	0.0 / 0.7
x=3	0.0 / 1.0	0.0 / 1.0	0 / 1.0	0 / 1.0	0.2 / 1.0	0.6 / 1.0	1.0 / 1.0	0.6 / 1.0	0.2 / 1.0	0.0 / 1.0
x=4	0.0 / 0.7	0.0 / 0.7	0 / 0.7	0 / 0.7	0.2 / 0.7	0.6 / 0.7	1.0 / 0.7	0.6 / 0.7	0.2 / 0.7	0.0 / 0.7
x=5	0.0 / 0.3	0.0 / 0.3	0 / 0.3	0 / 0.3	0.2 / 0.3	0.6 / 0.3	1.0 / 0.3	0.6 / 0.3	0.2 / 0.3	0.0 / 0.3
x=6	0.0 / 0	0.0 / 0	0 / 0	0 / 0	0.2 / 0	0.6 / 0	1.0 / 0	0.6 / 0	0.2 / 0	0.0 / 0
x=7	0.0 / 0	0.0 / 0	0 / 0	0 / 0	0.2 / 0	0.6 / 0	1.0 / 0	0.6 / 0	0.2 / 0	0.0 / 0
x=8	0.0 / 0	0.0 / 0	0 / 0	0 / 0	0.2 / 0	0.6 / 0	1.0 / 0	0.6 / 0	0.2 / 0	0.0 / 0
x=9	0.0 / 0	0.0 / 0	0 / 0	0 / 0	0.2 / 0	0.6 / 0	1.0 / 0	0.6 / 0	0.2 / 0	0.0 / 0
x=10	0.0 / 0	0.0 / 0	0 / 0	0 / 0	0.2 / 0	0.6 / 0	1.0 / 0	0.6 / 0	0.2 / 0	0.0 / 0

max 0 মান অগ্রাহ্য করা

12 (10+2) 13 (10+3) 14 (10+4) 15

↳ এখানে যাবে co2 max'd অর্জেছে

diagonally check করব(x,y) র value বস আজো।

Suppose for addition of 5

(x=4, + y=1), (x=3 + y=2) (x=2 + y=3) (x=1 + y=4)

it creates a diagonal from (x=4 to y=4)

** similarly for 6 → (x=5 to y=5) ; 7 → (x=6 to y=6)

Output of C

= 0/5 + 0.2/6 + 0.3/7 + 0.6/8 + 0.7/9 + 1.0/10 + 0.7/11

+ 0.6/12 + 0.3/13 + 0.2/14 + 0/15

For addition of 12 → (x=10, y=2) - এই box থেকে diagonally আগাবো। same for 13 → (x=10 + y=3) ....

& rest of all.