$w_{22}(new) = 0.7 + .3(1 - .7)$
$= .7 + .09$
$= .79$

$\therefore V = \begin{bmatrix} .2 & .51 \\ .4 & .65 \end{bmatrix}$

$w = \begin{bmatrix} .1 & .21 \\ .6 & .79 \end{bmatrix}$

Hamming NET

It is a classifier net that determines which of several exemplary vectors is most similiar to an i/p vector.

The parameters used are
$n \rightarrow$ no of i/p nodes (i/p vectors).
$m \rightarrow$ no of o/p nodes (exemplary vectors)
$e(j) =$ j^{th} exemplar vector

step-1
Weights are to be initialized for storing 'm' exemplar vectors

$w_{ij} = \frac{e_i(j)}{2}$ where $(i = 1, \ldots n, j = 1 \ldots m)$.

Initializing the bias
~~bj = n~~ $b_j = \frac{n}{2}$ $(j = 1, \ldots m)$.

step-2
For each vector x, perform steps 3 to 5

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step-3

Compute the net i/p to each unit Y_j

$Y_{inj} = b_j + \sum_i x_i w_{ij}$, where $j = 1, \ldots, m$

step-4.

Initialize activations for maxnet

$AF = f(x) = \begin{cases} x, & \text{if } x > 0 \\ 0, & \text{otherwise} \end{cases}$ $Y_j(0) = Y_{inj}$ where $j = (1, \ldots$

Given the exemplar vectors $e(1) = (-1\ 1\ -1\ 1)$

$e(2) = (1\ -1\ -1\ -1)$

Using hamming NET find which exemplar vector is close or similar to each of the i/p (bipolar) patterns

inputs $(1\ 1\ -1\ -1)$

$(-1\ 1\ 1\ -1)$

$(-1\ -1\ -1\ 1)$

$(-1\ -1\ 1\ 1)$

I/p pattern $x_1 = (1\ 1\ -1\ -1)$

$x_2 = (-1\ 1\ 1\ -1)$

$x_3 = (-1\ -1\ -1\ 1)$

$x_4 = (-1\ -1\ 1\ 1)$

step-1.

Initialize the weights to store the exemplar vector.

$e(1) = (-1\ 1\ -1\ 1)$

$= (-.5\ .5\ -.5\ .5)$

$e(2) = (1\ -1\ -1\ -1)$

$= (.5\ -.5\ -.5\ -.5)$

Scanned by CamScanner

$$W = \begin{array}{cc} e(1) & e(2) \\ \left[\begin{array}{cc} -.5 & .5 \\ .5 & -.5 \\ -.5 & -.5 \\ .5 & -.5 \end{array}\right] \end{array}$$

$b_1 = b_2 = \frac{n}{2} = \frac{4}{2} = 2.$

<u>step-2:</u>

For the vector $x_1 = (1\ 1\ -1\ -1)$ perform steps 3 to 5.

$Y_{in1} = 2 + (-.5 + .5 + .5 - -.5) = 2.$

$Y_{in2} = 2 + (.5 + .5 + .5 - .5) = 3.$

$AF = Y_1(0) = Y_{in1} = 2$

$Y_2(0) = Y_{in2} = 3$

$e_1 = (-1\ 1\ -1\ 1)$
$x_1 = (1\ 1\ -1\ -1)$ } 2 matches

$\Rightarrow$ close to 1^{st} e.

$e_2 = (1\ -1\ -1\ -1)$
$x_1 = (1\ 1\ -1\ -1)$ } 3 matches

For the vector $X_2 = (-1\ 1\ 1\ -1)$

$Y_{in1} = 2 + (.5 + .5 - -.5 - .5) = 2.$

$Y_{in2} = 2 + (-.5 - .5 - -.5 + .5) = 1$

$AF = Y_1(1) = Y_{in} = 2$

$Y_2(1) = Y_{in2} = 1$

e_1 & $x_2 \Rightarrow$ 2 matches

e_2 & $x_2 \Rightarrow$ 1 match. 2^{nd} close to 2^{nd} e

For The vector $x_3 = (-1\ -1\ -1\ 1)$
$y_{in1} = 2 + (.5 - -.5 + .5 + .5) = 3$.
$y_{in2} = 2 + (-.5 + -.5 + .5 + -.5) = 2$.

$Y_1(2) = y_{in1} = 3$
$Y_2(2) = y_{in2} = 2$
e_1 & $x_3 \rightarrow$ 3 matche
e_2 & $x_3 \rightarrow$ 2 matches

For the vecto $x_4 = (-1\ -1\ 1\ 1)$
$y_{in1} = 2 + (.5 - -.5 - -.5 + .5) = 2$
$y_{in2} = 2 + (-.5 + .5 - .5 - .5) = 1$

e_1 & $x_4 \rightarrow$ 2 matche } x_4 close to e_1
e_2 & $x_4 \rightarrow$ 1 match }

(2). o/p: $e_1 = (1\ 1\ 1\ 1\ 1)$
$e_2 = (-1\ -1\ 1\ 1\ 1)$

I/p: $x_1 = (1\ 1\ -1\ -1\ 1)$
$x_2 = (1\ -1\ 1\ 1\ 1)$

$$w = \begin{bmatrix} .5 & -.5 \\ .5 & -.5 \\ .5 & .5 \\ .5 & .5 \\ .5 & .5 \end{bmatrix}$$

$b_1 = b_2 = 5/2 = 2.5$

$y_{in1} = 2.5 + (.5 + .5 - .5 - .5 + .5)$
$= 2.5 + (.5) = 3$.
$y_{in2} = 2.5 + (-.5 + .5 + .5 + .5 + .5)$
$= \underline{4}$

Date
Page

Learning Vector Quantization

Construct and test LVQ with 4 vectors assigned to two classes assume learning rate $\alpha = .1$ & perform 2 iteration.

vector	class	
1 0 1 0	1	weights (training)
0 0 1 1	2	
1 1 0 0	1	Testing
1 0 0 1	2	

Solution

Iter - 1

step-1

Initialize the weights, $w_1 = (1\ 0\ 1\ 0)$

$w_2 = (0\ 0\ 1\ 1)$

$\alpha = 0.1$

step 2

Begening of training process.

I^{st} test vector $x = (1\ 1\ 0\ 0) \longrightarrow c = 1$

Distance (D)

$x \to D(1) \to w_1$

$x \to D(2) \to w_2$

step 3 :-

Calculating distance 'D'

$D(1) = \sum_i (w_{ij} - x_i)^2$

$D(1) = ((1-1)^2 + (0-1)^2 + (1-0)^2 + (0-0)^2)$

$= 2$

$D(2) = ((0-1)^2 + (0-1)^2 + (1-0)^2 + (1-0)^2)$ $w_2 = (0\ 0\ 1\ 1)$

$= 4$ $x = (1\ 1\ 0\ 0)$

c = 1. check for c = = 1

c = = 1 = = 1

Formula for updating w

$w_1(new) = w_1(old) + \alpha(x - w_1(old))$

$= (1\ 0\ 1\ 0) + .1((1\ 1\ 0\ 0) - (1\ 0\ 1\ 0))$

$= [1\ \ .1\ \ .9\ \ 0]$

$$\rightarrow c \rightarrow 2$$

I/P 2 $\rightarrow$ $x = [1\ 0\ 0\ 1]$

$D(1) = 0^2 + .9^2 + .9^2 + 1^2$
$= 1.82$

$D(2) = 1^2 + 0^2 + 1^2 + 0^2 = 2$

$x \xrightarrow{D_1} w_1$
$x \xrightarrow{D_2} w_2 (0\ 0\ 1\ 1)$

$J = 1$
$c = 2$
if $J \neq c$ $\quad w(new) = w(old) - \alpha(x - w_{old})$.

~~$w_1(new) =$~~
IInd test vector
$w_1(new) = w_1(old) - \alpha(x - w_{1old})$

$= (1\ .1\ 0.9\ 0) - .1(0\ -.1\ -.9\ 1)$

$= (1\ .11\ .99\ -.1)$

~~$w_2 = (0\ 0\ 1\ 1)$~~

~~X~~ as I/P - 2
$w_1 = [1\ .11\ .99\ -.1]$
$w_2 = (0\ 0\ 1\ 1)$.
$x_1 = (1\ 1\ 0\ 0)$
$x_2 = (1\ 0\ 0\ 1)$.

$D(1) = (1-1)^2 + (.11-1)^2 + (.99-0)^2 + (-.1-0)^2$
$= .89^2 + .99^2 + .01$
$= 1.7822$
$D(2) = (1^2 + 1^2 + 1 + 1) = 4$
$J = 1;\ c = 1$
$\therefore$
$w_1(new) = w_1(old) + \alpha(x - w_{1old})$

$(1 \quad .11 \quad .99 \quad -.1) + .1(0 \quad .89 \quad -.99 \quad +.1)$

$= (1 \quad .19 \quad .891 \quad -.1)$

X_2

$D(1) = 2.02$

$D(2) = 2$

$W_2 = W_{2old} + \alpha(X_2 - W_{2old})$

$= (0 \quad 0 \quad 1 \quad 1) + .1(.1 \quad 0 \quad -1 \quad 0)$

$= [.01 \quad 0 \quad .99 \quad 1]$

Q-2.

V	C	
1 1 0 0	1	w (training)
0 0 0 1	2	
0 0 1 1	2	testing
1 0 0 0	1	
0 1 1 0	2	

$D(1) = 4$

$D(2) = 1$

Fuzzy Logic

Crisp Set

ex

ON - 1 ; True

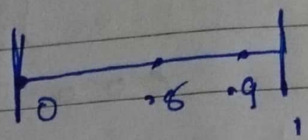
OFF - 0 False

Fuzzy set

Ex

Is RAM honest.

Fuzzy
- → Extremely honest (1)
- → Very honest (.9)
- → ocasionaly honest (.
- → Extremely dishonest



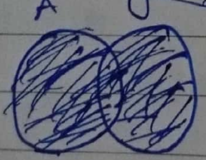
Union (∪) :

$A = \{a, b, c, 1, 2\}$

$B = \{1, 2, 3, a, c\}$

$A \cup B = \{a, b, c, 1, 2, 3\}$.

Venn diagram -



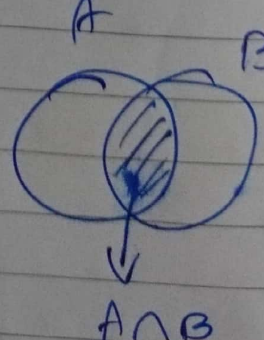
→ $A \cup B$

Intersection (∩).

$A = \{a, b, c, 1, 2\}$

$B = \{1, 2, 3, a, c\}$.

$A \cap B = \{a, c, 1, 2\}$

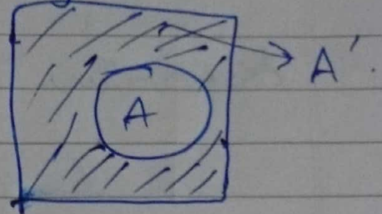


Complement of A ($\bar{A}$).

Universal set $X = \{1, 2, 3, 4, 5, 6, 7\}$.

$A = \{5, 4, 3\}$

$A' = \{1, 2, 6, 7\}$

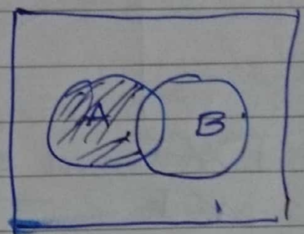


Difference

$A = \{a, b, c, d, e\}$

$B = \{b, d\}$

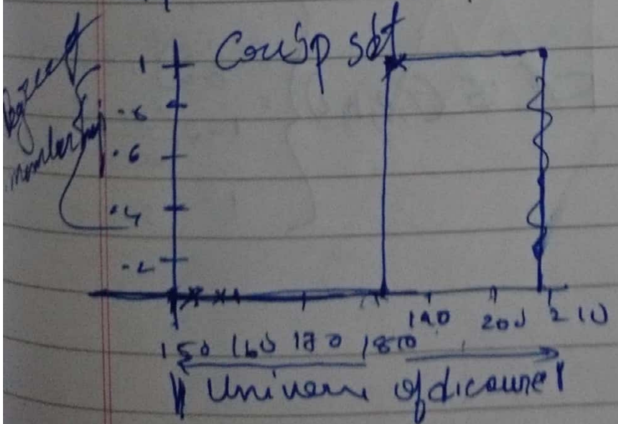
$A - B = \{a, c, e\}$.

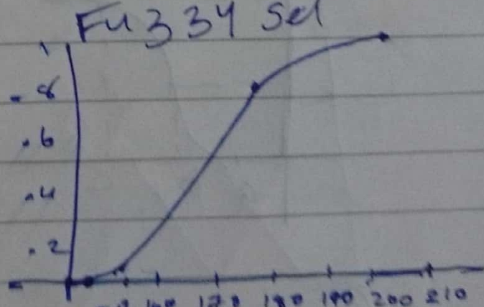


Plot membership function of Tall man.

Degree of membership of tallness.

Name	Height	Degree of membership Crisp	Fuzzy	
A_1	206	1	1	Very tall
A_2	181 nearest to ⇒	1	0.82.	Avg
A_3	155	0	0.01	Short
A_4	152	0	0	Very short





Fuzzy set $\left\{ \frac{1}{200}, \frac{.82}{181}, \frac{0.01}{155}, \frac{0}{152} \right\} \rightarrow A$

Short man $\bar{A} = \left\{ \frac{0}{208}, \frac{.18}{181}, \frac{.99}{155}, \frac{.1}{152} \right\}$.

$2 + (b+3)$
$6 + 5 + 3$

Properties of Crisp set

Commulative, $A \cup B = B \cup A$
$A \cap B = B \cap A$

Associative $(A \cup B) \cup C = A \cup (B \cup C)$

$(A \cap B) \cap C = A \cap (B \cap C)$.

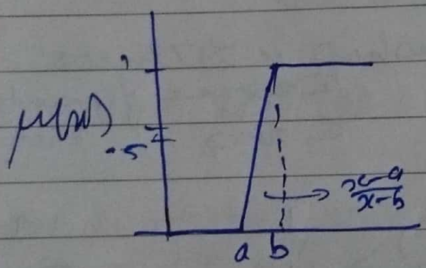
Dissociative $A \cup (B \cap C) = (A \cup B) \cap (B \cap C)$.

$A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$

Different shapes of M.F

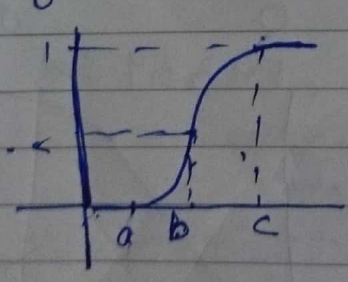
~~M.F~~

Linearly expressed gamma M.F



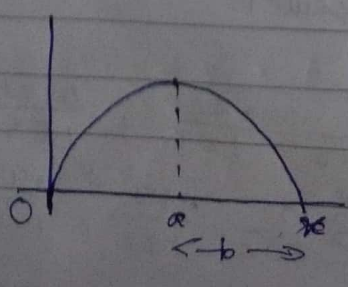
$$\Gamma(x,a,b) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & x \ge b \end{cases}$$

Sigmoidal M.F



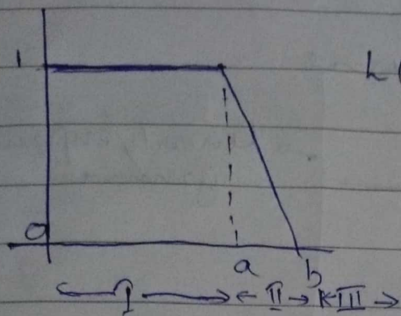
$$F\alpha \cdot S(x,a,b,c) = \begin{cases} 0, & x < a \\ 2\left(\frac{x-a}{c-a}\right)^2, & a \le x \le b \\ 1-2\left(\frac{x-c}{c-a}\right)^2, & b \le x \le c \\ 1 & x \ge c \end{cases}$$

Gaussian MSF.



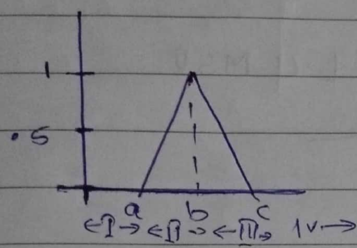
$$G(x,a,b) = e^{-b(a-x)^2}.$$

L-L MSF



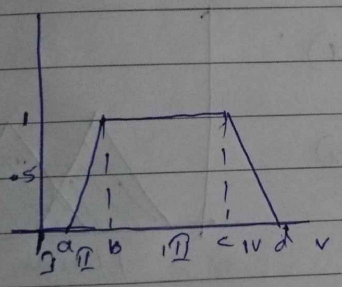
$$L(x,a,b) = \begin{cases} 1, & x < a \\ \frac{b-x}{b-a}, & a \le x \le b \\ 0, & x \ge b \end{cases}$$

Triangle MSF (λ-MSF)



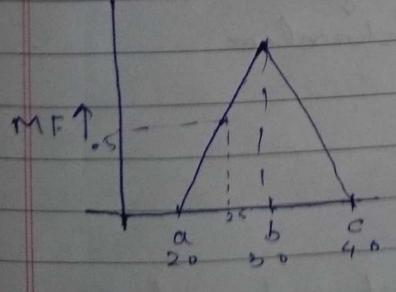
$$\lambda(x,a,b,c) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \le x \le b \\ \frac{c-x}{c-b}, & b \le x \le c \\ 0, & x \ge c \end{cases}$$

Trapezoidal MSF / Π-MSF



$$\Pi(x,a,b,c,d) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b < x < c \\ \frac{d-x}{d-c}, & c \le x < d \\ 0, & x \ge d \end{cases}$$

Plot triangular MSF; $a=20$, $b=30$, $c=40$



Consider $x=20$:

$\frac{x-a}{b-a} = \frac{20-20}{10} = 0$

$x = 21$

$\frac{21-20}{10} = 0.1$

$x = 25$

$\frac{25-20}{10} = .5$

$x=30$

$\frac{30-20}{10} = 1$

$x=35$

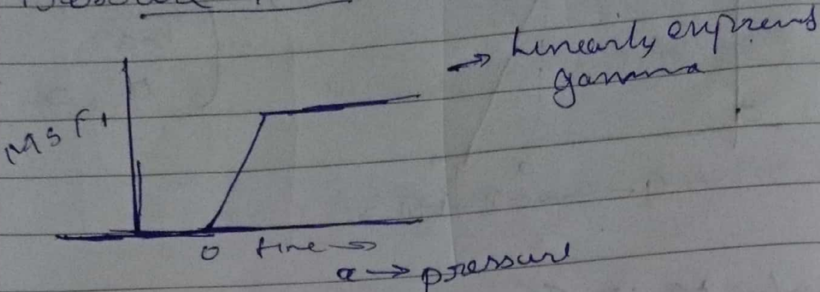
$\frac{c-x}{c-b} = \frac{40-35}{10} = .5$

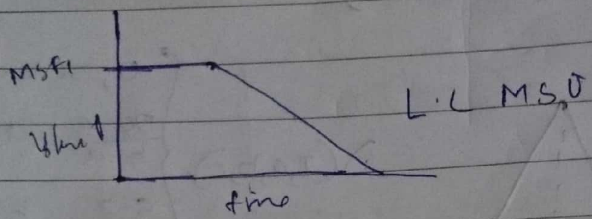
$x=39$ $\frac{40-39}{10} = .1$

$x=40$; $\frac{40-40}{10} = 0$

Fuzzy Implications

Pressure & Volume



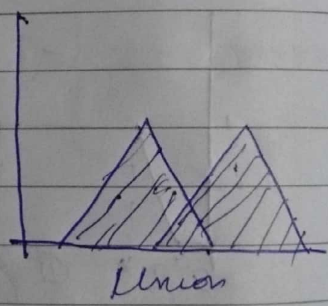


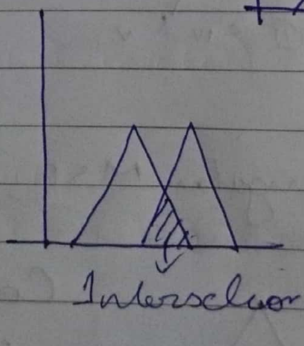
Operation of Fuzzy logic sets

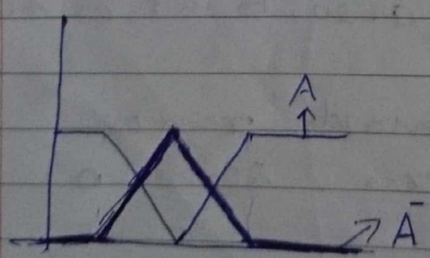
$\mu(A \cup B)(x) = \mu_A(x) \cup \mu_B(x)$

$\mu(A \cap B)(x) = \mu_A(x) \cap \mu_B(x)$

$\mu_{\bar{A}}(x) = 1 - \mu_A(x)$







Consider 2 Fuzzy sets A and B
Find complement, Union, Intersection
Difference, Verification of DeMorgan's Law

$$A = \left\{ \frac{1}{2} + \frac{0.5}{3} + \frac{0.6}{4}, \frac{0.2}{5} + \frac{0.6}{6} \right\}$$

$$B = \left\{ \frac{0.5}{2} + \frac{0.8}{3} + \frac{0.4}{4} + \frac{0.7}{5} + \frac{0.3}{6} \right\}$$

$$\bar{A} = \left\{ \frac{0}{2} + \frac{.5}{3} + \frac{.4}{4} + \frac{.8}{5} + \frac{.4}{6} \right\}$$

$$\bar{B} = \left\{ \frac{.5}{2} + \frac{.2}{3} + \frac{.6}{4} + \frac{.3}{5} + \frac{.7}{6} \right\}$$

$$A \cup B = \left\{ \frac{1}{2} + \frac{.8}{3} + \frac{.6}{4} + \frac{.7}{5} + \frac{.6}{6} \right\}$$

AUB is maximum value of corresponding elements

$$A \cap B = \left\{ .1/2 + .5/3 + .4/4 + .2/5 + .3/6 \right\}$$

$$A/B = A \cap \bar{B}$$
$$= \left\{ .5/2 + .2/3 + .6/4 + .2/5 + .6/6 \right\}$$

$$B/A = B \cap \bar{A}$$
$$= \left\{ .0/2 + .5/3 + .4/4 + .7/5 + .3/6 \right\}$$

De Morgans Law

$$\overline{A \cup B} = \bar{A} \cap \bar{B} = \left\{ .0/2 + .2/3 + .4/4 + .3/5 + .4/6 \right\}$$

$$\overline{A \cap B} = \bar{A} \cup \bar{B} \quad \left\{ .5/2 + .5/3 + .6/4 + .8/5 + .7/6 \right.$$

Fuzzification

It is the conversion of crisp quantity into Fuzzy quantity. Defuzzification is the process of converting Fuzzy quantity into crisp quantity

Fuzzification

Height	Crisp quantity
A_1	50
A_2	100
A_3	25
A_4	10

↓

Lowest - 10 → 0

Highest - 100 → 1

Fuzzy quantity Crisp

Normalized data

$$\boxed{Z_i = \frac{x_i - \min(x)}{\max(x) - \min(x)}}$$

$$A_1 = \frac{50-10}{100-10} = .44$$

$$A_2 = \frac{100-10}{100-10} = 1$$

$$A_3 = \frac{25-10}{90} = \frac{15}{90} = .17$$

$$A_4 = \frac{10-10}{90} = 0$$

Defuzzification:

$$= x(\max(x) - \min(x)) + \min(x)$$

$$A_1 = .44(100-10)+10$$

$$= .44(90)+10 = 50 \rightarrow \text{Real}$$

$$A_2 = 1(100-10)+10 = 100$$

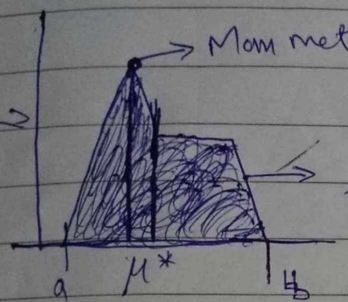
$$A_3 = .17(90)+10 \approx 25$$

$$A_4 = 0(100-10)+10 = 10$$

Scanned by CamScanner

Types of defuzzification

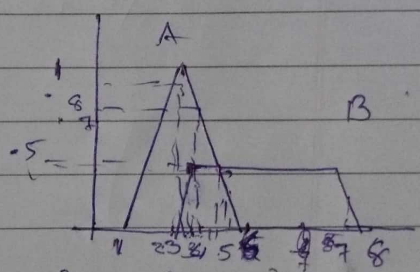
1. Max-membership method
2. Centroid method
3. Weighted average
4. Mean-Max membership method
5. Center of sums
6. Center of largest area.
7. ~~Fast~~ Curve or loss of Maxima



finding fuzzy value btw a and b.

3)

$$\mu^* = \frac{\sum_{i=1}^{N} u_i \mu_{out}(u_i)}{\sum_{i=1}^{N} \mu_{out}(u_i)}$$



1.2 2.4 2.8 2 3 2.7

$$u^* = \frac{(2\times0.6 + 3\times.8 + 4\times.7 + 5\times.4 + 6\times.5 + 7\times.3 + 8\times0}{.6 + .8 + .7 + .4 + .5 + .3}$$

$=$ 13.3 4.09