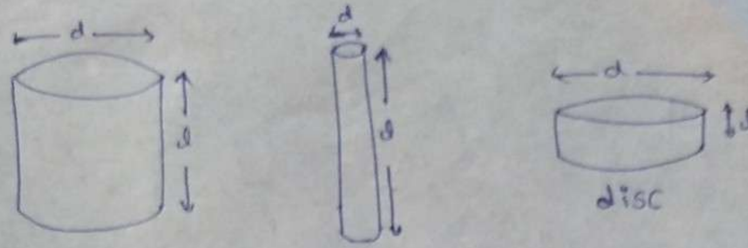
14/08/2019

UNIT- I

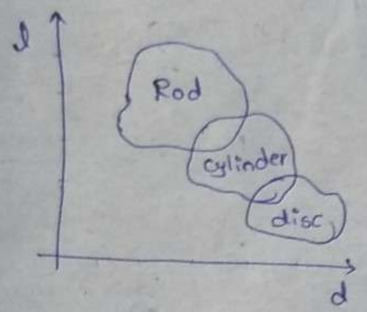
The mathematics of fuzzy control

* 

Cylinder — $d \approx l$

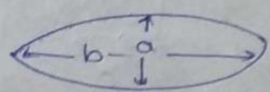
Rod — $d << l$

disc — $d >> l$



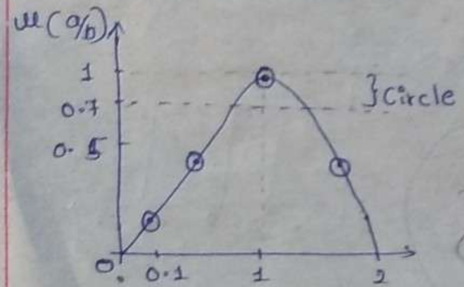
Nikita Kohamma
Sapna Holsamma

* Ellipse



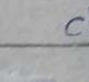
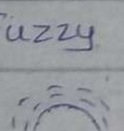
$\left.\begin{array}{l} a = b \\ \frac{a}{b} = 1 \end{array}\right\}$ Circle

$\left.\begin{array}{l} a >> b \\ a << b \end{array}\right\}$ ellipse



$\mu(a/b) = \exp\{-3\,(a/b - 1)^2\}$

• difference b/w classical & Fuzzy system

classical system	fuzzy system.
1)  fixed boundary	1)  Flexible boundary or Not having fixed boundary.
2) precission is more [Accuracy]	2) Comparatively less precission
3) Used for Non. Ambiqeous information	3) Used for Ambiqeous information.
4) It has values either 0 or 1	4] It has values in b/w 0 or 1.

classical system.

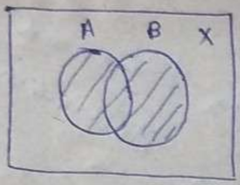
① Union ② Intersection ③ Compliment

- Fuzzy system

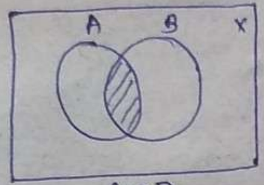
① Union ⇒ max [∪]

② Intersection ⇒ min [∩]

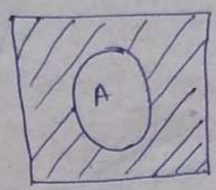
③ compliment ⇒ (1-A) [$\overline{A}$]



A∪B



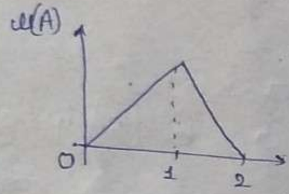
A∩B

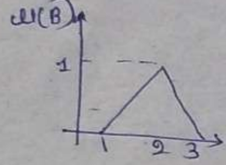


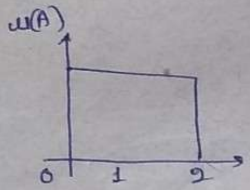
$\overline{A}$

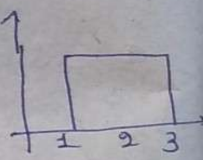
* classical.

* Fuzzy

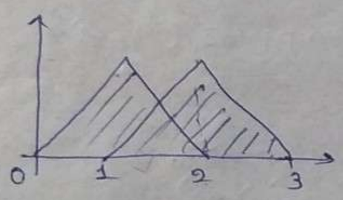


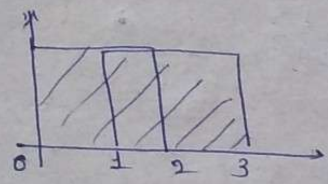




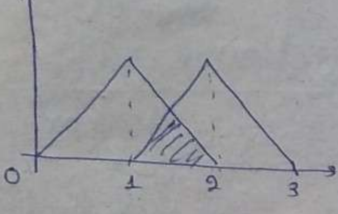


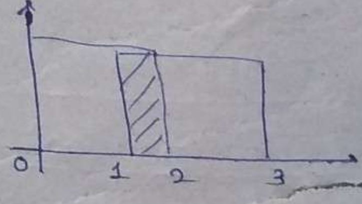
A∪B ⇒



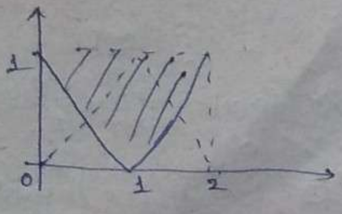


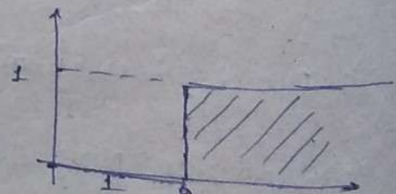
A∩B ⇒





$\overline{A}$





→ Demorgan's Law :-

① $\overline{A \cup B} = \overline{A} \cap \overline{B}$

② $\overline{A \cap B} = \overline{A} \cup \overline{B}$

→ Law of contradaction

$A \cap \overline{A} = \phi$ [Null set

→ law of excluded middle.

$A \cup \overline{A} = X$ [Universe].

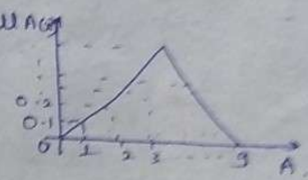
* Representation of fuzzy system /set :-

$$A = \left\{ \frac{\mu_A(x_1)}{x_1} + \frac{\mu_A(x_2)}{x_2} + \ldots \frac{\mu_A(x_9)}{x_9} \right\}.$$

x_1 = Universe of discourse.

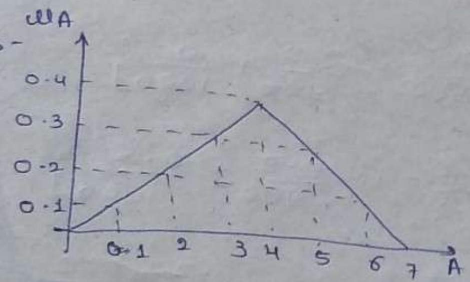
$\mu(x_1, x_2 \ldots x_9)$ are degree of membership fn.

$$A = \left\{ \frac{0.1}{1} + \frac{0.2}{2} + \ldots \frac{0.9}{9} \right\}$$



+ → sign indicates separation.

Ex :-



Fuzzy set :-

$$A = \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.3}{3} + \frac{0.4}{4} + \frac{0.3}{5} + \frac{0.2}{6} + \frac{0}{7}.$$

* Operation in fuzzy system

1) Union = max   2) Intersection = min   3) Compliment (1-A)

4) Difference => $\frac{A}{B} = A \cap \overline{B}$ $\frac{B}{A} = B \cap \overline{A}$

Ex1 :-

$$A = \left\{ \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.3}{3} \right\} \quad B = \left\{ \frac{0.5}{1} + \frac{0.3}{2} + \frac{0.1}{3} \right\}$$ Find

$A \cup B$, $A \cap B$, $\overline{A}$, $\overline{B}$

$$A \cup B_{(max)} = \left\{ \frac{0.5}{1} + \frac{0.3}{2} + \frac{0.3}{2} \right\}$$

$$A \cap B\,(min) = \left\{ \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.1}{3} \right\}$$

$\overline{A} = \{ \frac{0.9}{1} + \frac{0.8}{2} + \frac{0.7}{3} \}$

$\overline{B} = \{ \frac{0.5}{1} + \frac{0.7}{2} + \frac{0.9}{3} \}$

$\frac{A}{B} = A \cap \overline{B} = \{ \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.3}{3} \}$

$\frac{B}{A} = B \cap \overline{A} = \{ \frac{0.5}{1} + \frac{0.3}{2} + \frac{0.1}{3} \}$.

Ex 2) $A = \{ \frac{0.1}{100} + \frac{0.2}{200} + \frac{0.3}{500} + \frac{0.8}{900} + \frac{1}{1000} \}$

$B = \{ \frac{0}{100} + \frac{0.6}{200} + \frac{1}{500} + \frac{0.8}{900} + \frac{0.5}{1000} \}$

Find $\overline{A \cup B}$, $\overline{A}$, $\overline{B}$, $\overline{A} \cap \overline{B}$, $\frac{A}{B}$, $A \cap \overline{A}$, $A \cup \overline{A}$

$\longrightarrow$ $A \cup B_{(max)} = \{ \frac{0.1}{100} + \frac{0.6}{200} + \frac{1}{500} + \frac{0.8}{900} + \frac{1}{1000} \}$.

* $\overline{A \cup B} = \{ \frac{0.9}{100} + \frac{0.4}{200} + \frac{0}{500} + \frac{0.2}{900} + \frac{0}{1000} \} \longrightarrow ①$

* $\overline{A} = \{ \frac{0.9}{100} + \frac{0.8}{200} + \frac{0.7}{500} + \frac{0.2}{900} + \frac{0}{1000} \}$

* $\overline{B} = \{ \frac{1}{100} + \frac{0.4}{200} + \frac{0}{500} + \frac{0.2}{900} + \frac{0.5}{1000} \}$

* $\overline{A} \cap \overline{B}_{(min)} = \{ \frac{0.9}{100} + \frac{0.4}{200} + \frac{0}{500} + \frac{0.2}{900} + \frac{0}{1000} \} \longrightarrow ③$

* $\frac{A}{B} = A \cap \overline{B}_{(min)} = \{ \frac{0.1}{100} + \frac{0.2}{200} + \frac{0}{500} + \frac{0.2}{900} + \frac{0.5}{1000} \}$

* $A \cap \overline{A}_{(min)} = \{ \frac{0.1}{100} + \frac{0.2}{200} + \frac{0.3}{500} + \frac{0.2}{900} + \frac{0}{1000} \}$

* $A \cup \overline{A}_{(max)} = \{ \frac{0.9}{100} + \frac{0.8}{200} + \frac{0.7}{500} + \frac{0.8}{900} + \frac{1}{1000} \}$

fo eqn ① = ③ Hence demorgan's Law proved.

3> for the problem 2 prove that i> exclusive middle ii> Law of Contradaction.

i> $A \cap \overline{A} \neq \phi$ Hence not proved. ii> $A \cup \overline{A} \neq X$

Ex 3) $car = \left\{ \frac{0.5}{truck} + \frac{0.4}{motarcycle} + \frac{0.3}{boat} + \frac{0.9}{car} + \frac{0.1}{house} \right\}$

$Truck = \left\{ \frac{1}{truck} + \frac{0.1}{mo.cy} + \frac{0.4}{boat} + \frac{0.4}{car} + \frac{0.2}{house} \right\}$

Find $car \cup Truck$, $car \cap Truck$, $\overline{car \cup Truck}$,

$\overline{car} \cup Truck$, $\overline{car \cap Truck}$, $car/Truck$

→ $car \cup Truck_{(max)} = \left\{ \frac{1}{truck} + \frac{0.4}{M.C} + \frac{0.4}{boat} + \frac{0.9}{car} + \frac{0.2}{house} \right\}$

$car \cap Truck_{(min)} = \left\{ \frac{0.5}{Truck} + \frac{0.1}{M.C} + \frac{0.3}{boat} + \frac{0.4}{car} + \frac{0.1}{house} \right\}$.

$\overline{car \cup Trcuk}_{(1-A)} = \left\{ \frac{0}{truck} + \frac{0.6}{M.C} + \frac{0.6}{boat} + \frac{0.1}{car} + \frac{0.8}{house} \right\}$

$\overline{car} = \left\{ \frac{0.5}{truck} + \frac{0.6}{M.C} + \frac{0.7}{boat} + \frac{0.1}{car} + \frac{0.9}{house} \right\}$

$\overline{car} \cup Truck_{(max)} = \left\{ \frac{1}{truck} + \frac{0.6}{M.C} + \frac{0.7}{boat} + \frac{0.4}{car} + \frac{0.9}{house} \right\}$

$\overline{car \cap Truck} = \left\{ \frac{0.5}{Truck} + \frac{0.9}{M.C} + \frac{0.7}{boat} + \frac{0.6}{car} + \frac{0.9}{house} \right\}$

$car/Truck = car \cap \overline{Truck} = \left\{ \frac{0}{truck} + \frac{0.4}{cycle} + \frac{0.3}{boat} + \frac{0.6}{car} + \frac{0.1}{house} \right\}$

Ex 4)

clock freq (MHz)	MSI (M)	FPGA (F)	MCM (C)
1	1	0.3	0
10	0.7	1	0
20	0.4	1	0.5
40	0	0.5	0.7
80	0	0.2	1
100	0	0	1

Find $M \cup F$, $M \cap F$, $\overline{M \cap C}$, $C \cap \overline{F}$, $M \cap \overline{M}$

$M = \left\{ \frac{1}{1} + \frac{0.7}{10} + \frac{0.4}{20} + \frac{0}{40} + \frac{0}{80} + \frac{0}{100} \right\}$

$F = \left\{ \frac{0.3}{1} + \frac{1}{10} + \frac{1}{20} + \frac{0.5}{40} + \frac{0.2}{80} + \frac{0}{100} \right\}$

$$c = \left\{ \frac{0}{1} + \frac{0}{10} + \frac{0.5}{20} + \frac{0.7}{40} + \frac{1}{80} + \frac{1}{100} \right\}$$

$$\underset{(max)}{M \cup F} = \left\{ \frac{1}{1} + \frac{1}{10} + \frac{1}{20} + \frac{0.5}{40} + \frac{0.2}{80} + \frac{0}{100} \right\}$$

$$M \cap F = \left\{ \frac{0.3}{1} + \frac{0.7}{10} + \frac{0.4}{20} + \frac{0}{40} + \frac{0}{80} + \frac{100}{100} \right\}$$

$$\underset{(min)}{\overline{M \cap C}} = \left\{ \frac{1}{1} + \frac{1}{10} + \frac{0.6}{20} + \frac{1}{40} + \frac{1}{80} + \frac{1}{100} \right\}$$

$$C \cap \overline{F} = \left\{ \frac{0}{1} + \frac{0}{10} + \frac{0}{20} + \frac{0.5}{40} + \frac{0.8}{80} + \frac{1}{100} \right\}$$

$$M \cup \overline{M} = \left\{ \frac{1}{1} + \frac{0.7}{10} + \frac{0.6}{20} + \frac{1}{40} + \frac{1}{80} + \frac{1}{100} \right\}$$

Ex

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* **Properties of Fuzzy set :**

1) T- Narm => (min) [Triangular Norms]

2) S- Narm => (max). [Triangular Co-Narm].

3) C - Narm => $(1 - \mu(x))$ [Compliment Norms]

4) α - Cut ⟶ 29/08/2019.

1) T- Norm. ⟶

i) $a \wedge b = b \wedge a \rightarrow T_1$

ii) $(a \wedge b) \wedge c = a \wedge (b \wedge c) \rightarrow T_2$

iii) $a \wedge 1 = a \rightarrow T_3$

iv) $a \wedge 0 = 0 \rightarrow T_4$

v) if $a \leq c$ & $b \leq d$, $a \wedge b \leq c \wedge d$.

2) S- Norm ⟶

i) $a \cup b = b \cup a$

ii) $(a \cup b) \cup c = a \cup (b \cup c)$

iii) if $a \leq c$ & $b \leq d$, $a \cup b \leq c \cup d$

iv) $a \cup 1 = 1$

v) $a \cup 0 = a$

3) C - Norm ⟶

i) $c(0) = 1$

ii) $c(1) = 0$

iii) $a < b$, then $c(a) > c(b)$.

iv) $c(c(a)) = a$.

Ex 1) $a = \left\{\frac{0.1}{1}\right\}$, $b = \left\{\frac{0.4}{1}\right\}$, $c = \left[\frac{0.8}{1}\right\}$, $d = \left\{\frac{1}{1}\right]$

⟶ * T-Norms ⇒

i) $a \wedge b = \left\{\frac{0.1}{1}\right\}$ ii) $a \wedge 1 = \left\{\frac{0.1}{1}\right\}$

(iii) $(a \cap b) \cap c = a \cap (b \cap c)$ iv) $a \cap 0 = \left\{\frac{0}{1}\right\}$

$\left\{\frac{0.1}{1}\right\} = \left\{\frac{0.1}{1}\right\}$

(v) $a = \left\{\frac{0.1}{1}\right\} \leq c = \left\{\frac{0.8}{1}\right\}$, & $b = \left\{\frac{0.4}{1}\right\} \leq d = \left\{\frac{1}{1}\right\}$

$a \wedge b \leq d \wedge c$.

$\left\{\frac{0.1}{1}\right\} \leq \left\{\frac{0.8}{1}\right\}$

* S-Norms ⇒ i) $a \cup b = \left\{\frac{0.4}{1}\right\}$ ii) $a \cup 1 = \left\{\frac{1}{1}\right\}$ iii) $a \cup 0 = \left\{\frac{0.1}{1}\right\}$

iv) $(a \cup b) \cup c = a \cup (b \cup c)$

$\left\{\frac{0.8}{1}\right\} = \left\{\frac{0.8}{1}\right\}$

v) $a = \left\{\frac{0.1}{1}\right\} \leq c = \left\{\frac{0.8}{1}\right\}$ & $b = \left\{\frac{0.4}{1}\right\} \leq d = \left\{\frac{1}{1}\right\}$

$a \cup b \leq c \cup d$

$\left\{\frac{0.4}{1}\right\} \leq \left\{\frac{1}{1}\right\}$.

* C-Norms.

i) $C(0) = 1$ ii) $C(1) = 0$.   iii) $C(C(a))$.

$C(a) = \frac{0.9}{1}$

$C[C(a)] = \frac{0.1}{1}$

iv) $a < b$.

$C(a) > C(b)$

$\frac{0.9}{1} > \frac{0.6}{1}$

Zadeh Implication :-

S-Norms ⇒ (max)

T-Norms ⇒ min

C-Norms ⇒ $(1-a)$ or $(1-b)$

4) Yoger's family Implication (T- Norms)

If the value of q is not given then consider 1.

T- Norm

$$\boxed{y_q(a,b) = 1 - \min[1, (1-a)^q + (1-b)^q]}$$

$A = \left\{ \frac{0.2}{1} + \frac{0.3}{2} \right\}$ $B = \left\{ \frac{0.7}{1} + \frac{0.1}{2} \right\}$.

$$y_q(0.2, 0.7) = 1 - \min[1, (1-0.2)^1 + (1-0.7)^1]$$
$$= 1 - \min[1, 0.8 + 0.3]$$
$$= 1 - \min[1, 1.1]$$
$$= 1 - \min[1].$$
$$y_1(0.2, 0.7) = 0$$

$$y_1(0.3\ 0.1) = 1 - \min[1, (0.7 + 0.9)]$$
$$= 1 - \min[1, 1.6]$$
$$= 1 - 1$$
$$= 0$$

$\therefore A \cap B = \left\{ \frac{0}{1}, \frac{0}{1} \right\}$.

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3> Dubos & Prada (S- Norms)

$$S_\alpha(a,b) = \frac{a \times b}{\max(a, b, \alpha)}$$

> assume $\alpha = 1$.

a> $A = \left\{ \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.3}{3} \right\}$ $B = \left\{ \frac{0.2}{1} + \frac{0.1}{2} + \frac{0.6}{3} \right\}$

$S_\alpha(a.b)$

$$S_\alpha(0.1, 0.2) = \frac{0.1 \times 0.2}{ma(0.1, 0.2, 1)} = \frac{0.02}{1} = 0.02$$

$$S_\alpha(0.2, 0.1) = \frac{0.2 \times 0.1}{\max(0.2, 0.1, 1)} = \frac{0.02}{1} = 0.02.$$

$$S_\alpha(0.3, 0.6) = \frac{0.3 \times 0.6}{\max(0.3, 0.6, 1)} = 0.18$$

$A \cup B = \left\{ \frac{0.02}{1} + \frac{0.02}{2} + \frac{0.18}{3} \right\}$

4> **Franks family Implications:** (T-Norms)

$F_s(a,b) = \log\left(1 + \frac{(s^a - 1)(s^b - 1)}{s-1}\right) \qquad 0 < s < 1$

$a = \left\{ \frac{0.1}{1} + \frac{0.2}{2} \right\} \qquad b = \left\{ \frac{0.6}{1} + \frac{0.9}{2} \right\}$

$|a \cap b| = \log\left(1 + \frac{(0.5^{0.1} + 1)(0.5^{0.6} - 1)}{s-1}\right)$

$= 1 - 0.0201$

$= 0.020$

$|a \cap b| = \log\left(1 + \frac{(0.5^{0.2} + 1)(0.5^{0.9} - 1)}{0.5-1}\right)$

$= 1 - 0.0551$

$= 0.05$

$\therefore a \cap b = \left\{ \frac{0.02}{1} + \frac{0.055}{2} \right\}$

Ex: $A = \left\{ \frac{1}{2} + \frac{0.8}{3} + \frac{0.7}{4} + \frac{0.6}{5} \right\} \quad B = \left\{ \frac{0.6}{2} + \frac{0.9}{3} + \frac{0.1}{4} + \frac{0.2}{5} \right\}$.

Find $A \cup B$, $A \cap B$, $\overline{A}$

	$A \cup B$	$A \cap B$	$\overline{A}$
1. Zadeh	✓	✓	✓
2. yougers	×	✓	×
3. Franks	×	✓	×
4. Dubos	✓	×	×

$q = 1,\ s = 2,\ \alpha = 1$ assume

1> Zadeh :-

$A \cup B = \left\{ \frac{1}{2} + \frac{0.9}{3} + \frac{0.7}{4} + \frac{0.6}{5} \right\}$

$A \cap B = \left\{ \frac{0.6}{2} + \frac{0.8}{3} + \frac{0.1}{4} + \frac{0.2}{5} \right\}$

$\overline{A} = \left\{ \frac{0}{2} + \frac{0.2}{3} + \frac{0.3}{4} + \frac{0.4}{5} \right\}$

$\overline{B} = \left\{ \frac{0.4}{2} + \frac{0.1}{3} + \frac{0.9}{4} + \frac{0.8}{5} \right\}$

2> Yoger's :-

TNorms

$$y_q(a,b) = 1 - \min[1, (1-a)^q + (1-b)^q]$$

$$= 1 - \min[1, (1-1)^q + (1-0.6)^q]$$

$$= 1 - \min[1, 0.4]$$

$$= 0.6$$

$$y_q(a,b) = 1 - \min[1, (1-0.8)^1 + (1-0.9)]$$

$$= 1 - \min[1, 0.2 + 0.1]$$

$$= 1 - \min[1, 0.3]$$

$$= 0.7$$

$$y_q(a,b) = 1 - \min[1, (0.3) + (0.9)]$$

$$= 1 - \min[1, 1.2]$$

$$= 0$$

$$y_q(a,b) = 1 - \min[1, (0.4) + (0.8)]$$

$$= 1 - \min[1, 1.2]$$

$$= 0$$

$$\therefore a \cap b = \left\{ \frac{0.6}{2} + \frac{0.7}{3} + \frac{0}{4} + \frac{0}{5} \right\}$$

3> franks :-

TNorms

$$F_s(a,b) = \log\left(1 + \frac{(s^a + 1)(s^b - 1)}{s - 1}\right)$$

$$F_s(a,b) = \log\left(1 + \frac{(2+1)(2^{0.6} - 1)}{2-1}\right)$$

$$= 0.806$$

$$f(a,b) = \log\left(1 + \frac{(2^{0.8}+1)(2^{0.9}-1)}{2-1}\right) = 0.2153$$

$$= 0.528$$

$$f(a,b) = \log\left(1 + \frac{(2^{.7}+1)(2^{.1}-1)}{2-1}\right) = 0.019049$$

$$f(a,b) = \log\left(1 + \frac{(2^{0.6}+1)(2^{0.2}-1)}{2-1}\right) = 0.038$$

$$a \cap b = \left\{ \frac{0.1806}{2} + \frac{0.2158}{3} + \frac{0.0049}{4} + \frac{0.032}{5} \right\}$$ //

4> Dubos

S Norms.

$$\sigma_\alpha(a, b) = \frac{a \times b}{\max(a, b, \alpha)} = \frac{1 \times 0.6}{\max(0.6, 1, 1)}$$

$$= \frac{0.6}{1} = 0.6$$

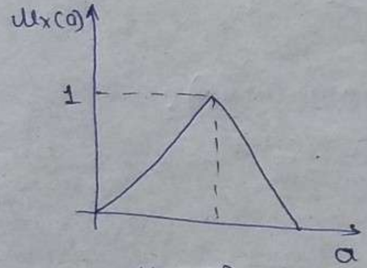
$$\sigma_\alpha(a, b) = \frac{0.72}{1} \qquad \sigma_\alpha(a, b) = 0.07$$

$$\sigma_\alpha(a, b) = 0.12$$

$$\therefore a \cup B = \left\{ \frac{0.6}{2} + \frac{0.72}{3} + \frac{0.07}{4} + \frac{0.12}{5} \right\}$$ //

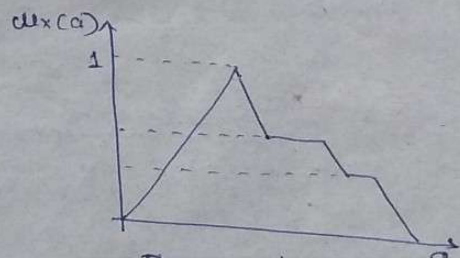
- **Types of Fuzzy set:**

1> Normal Fuzzy set.



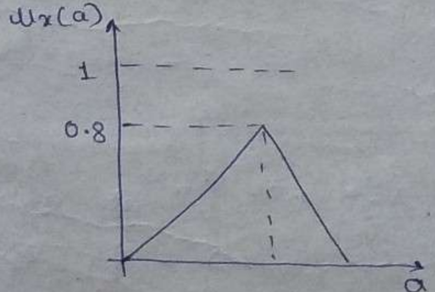
$\mu_x(a) = 1$

3> Convex Fuzzy set



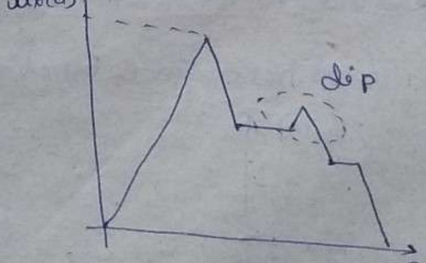
Do not have dips.

2> Sub Normal Fuzzy set



$\mu_x(a) \neq 1$.

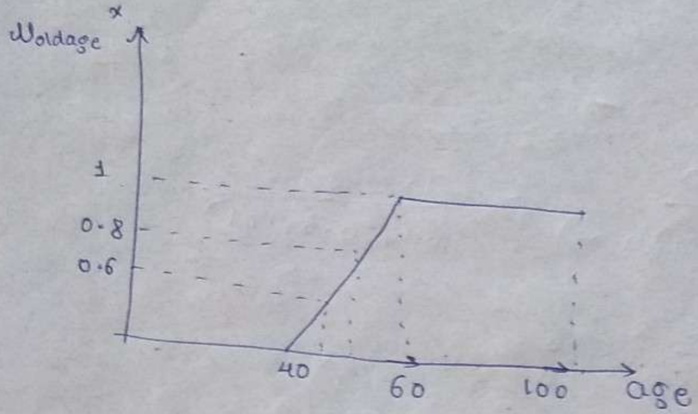
4> Non-convex fuzzy set



which has dip

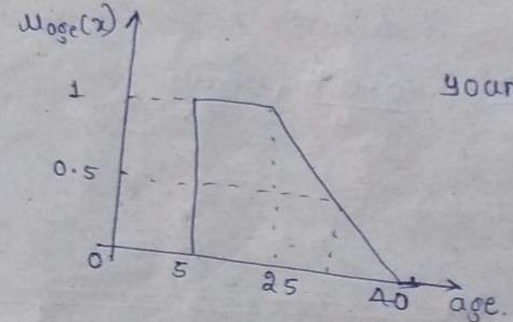
* Types of fuzzy function

1> Incremental function



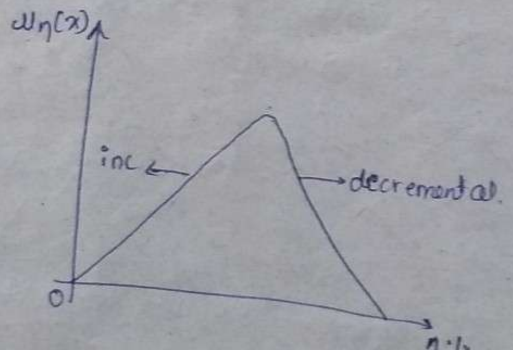
* Decremental function

Ex



young age

*. Mixed function.



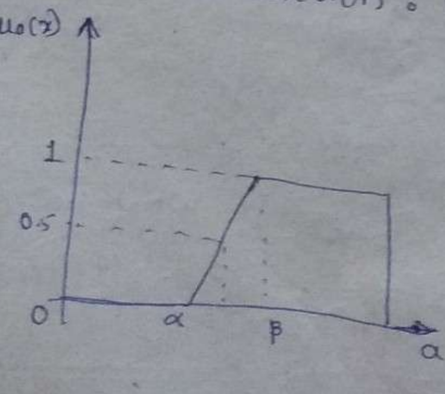
(efficiency curve).

(1, β)
(1, α)

$\frac{y_2-y_1}{x_2-x_1} = \frac{y_1-y}{x_1-x}$

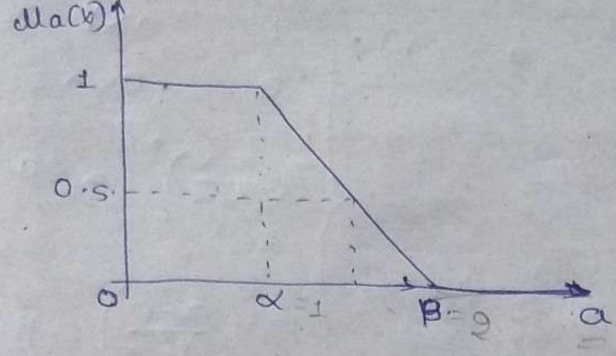
- Shaper of membership function.

1) Incremental function : Γf_D



$$\Gamma(a;\alpha,\beta) = \begin{cases} 0 & \text{for } a<\alpha \\ 1 & \text{for } a>\beta \\ \frac{a-\alpha}{\beta-\alpha} & \text{for } \alpha\le a\le\beta \end{cases}$$

2> Decremental function :- L function.

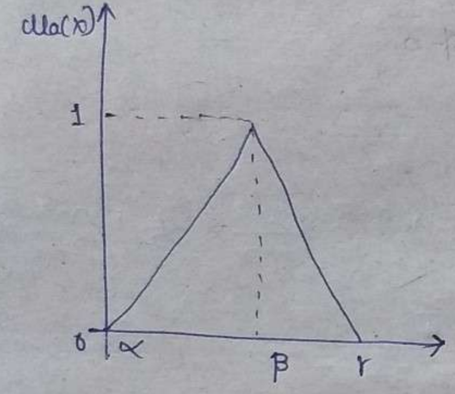


$$L(a;\alpha,\beta) = \begin{cases} 1 & \text{for } a<\alpha \\ 0 & \text{for } a>\beta \\ \dfrac{a-\beta}{\alpha-\beta} & \text{for } \alpha \le a \le \beta \end{cases}$$

or

$$\frac{\beta-a}{\beta-\alpha}$$

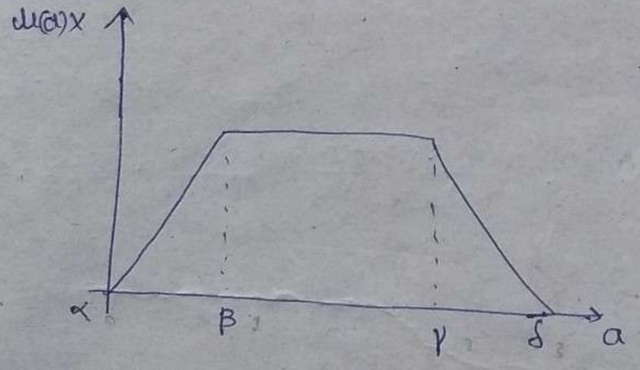
3> Mixed function :- (Triangular function)



$$\Lambda(a;\alpha,\beta,r) \begin{cases} 1 & \text{for } a=\beta \\ 0 & \text{for } \gamma<a<\alpha \\ \dfrac{a-\alpha}{\beta-\alpha} & \text{for } \alpha \le a \le \beta \\ \dfrac{\cancel{\beta}-a}{\cancel{\beta}-\cancel{\beta}} & \text{for } \cancel{\beta} \le a \le \cancel{\alpha} \end{cases}$$

$$\frac{a-\alpha}{\beta-\alpha} \qquad \frac{\beta-a}{\beta-\alpha}.$$

4> π - Function.



$$\pi(a;\alpha,\beta,\gamma,\delta) \begin{cases} 1 & \text{for } \beta \le a \le \gamma \\ 0 & \text{for } \delta \le a \le \alpha \\ \dfrac{\delta-a}{\delta-\gamma} & \gamma \le a \le \delta \\ \dfrac{a-\cancel{\beta}}{\beta-\alpha} & \alpha \le a \le \beta. \end{cases}$$

$$\frac{1-0}{1-0} = 1 = \beta.$$

$$\frac{x_2-x_1}{x-x_1} = a$$

$$\frac{y-y_1}{y_2-y_1} = \frac{a-x_1}{x_2-x_1}$$

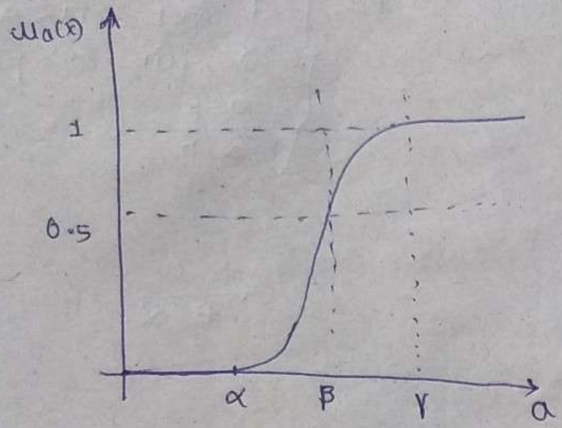
$$\frac{\beta-\alpha}{a-\alpha} = \frac{y_2-y_1}{y_1-y}$$

$$= \frac{1-0}{0-y}$$

$$= -\frac{1}{y}$$

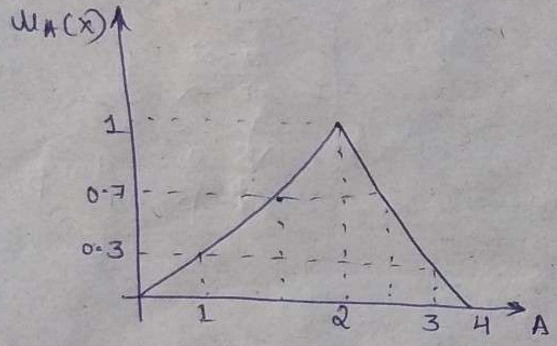
$$y = \frac{a-\alpha}{\beta-\alpha}$$

* S-function :-



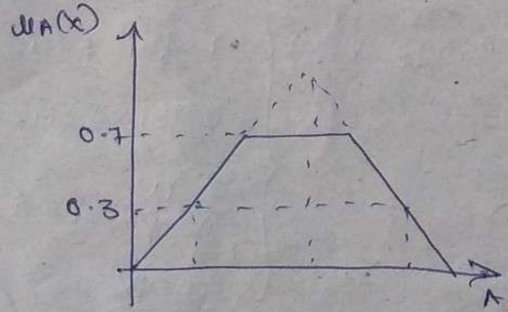
$$S(a;\alpha,\beta,\gamma)=\begin{cases}1 & a>\gamma\\ 0 & a<\alpha\\ 2\left(\frac{x-\alpha}{\gamma-\alpha}\right)^2 & \alpha\le a\le\beta\\ 1-2\left(\frac{x-\gamma}{\gamma-\alpha}\right)^2 & \beta\le a\le\gamma\end{cases}$$

- 4) α - cut



$$A=\frac{0}{0}+\frac{0.5}{1}+\frac{0.7}{1.5}+\frac{1}{2}+\frac{0.7}{2.5}+\frac{0.5}{3}+\frac{0}{4}$$

α - cut = 0.7



$$A=\frac{0}{0}+\frac{0.5}{1}+\frac{0.7}{1.5}+\frac{0.7}{2.5}+\frac{0.5}{3}+\frac{0}{4}$$

Fuzzy Relation :-

It gives explicitaly relation of two sets which are different domain

Let A be fuzzy set on universe x
" B " " " " y } Thus the Relation of A & B can be follow as below.

$$A = \left\{ \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.3}{3} \right\} = x$$

$$B = \left\{ \frac{0.1}{7} + \frac{0.8}{10} + \frac{0.9}{12} \right\} = y.$$

Find A∪B.

Relation :-

A∪B =

B \ A	1	2	3
7	0.1	0.2	0.3
10	0.8	0.8	0.8
12	0.9	0.9	0.9

* Cartation Product :-

Representation ⇒ x (min)

$A \times B = \min(\mu_A(x), \mu_A(y))$

1) Suppose we have two fuzzy sets, A defined on universe of temperature i.e $x = \{x_1; x_2, x_3\}$ & B defined on universe of pressure i.e $y = \{y_1, y_2\}$ we want to find the cartesian product b/w them. Fuzzy set A represent ambient temperature & fuzzy set B represents near optimum pressure, for a certain Heat exchanger & the cartation product represents the condition of exchanger that are associated with efficient operation.

$$A = \left\{ \frac{0.2}{x_1} + \frac{0.5}{x_2} + \frac{01}{x_3} \right\} \qquad B = \left\{ \frac{0.3}{y_1} + \frac{0.9}{y_2} \right\}$$

Fuzzy Relation $= (A \times B)$ min

B \ A	x_1	x_2	x_3
y_1	0.2	0.3	0.3
y_2	0.2	0.5	0.9

03/09/2019.

* Lingestic variable

> These are the values in terms of words or statment.

Ex:-

Size: S, M, L, XL

temperature: Hot, cold, medium,

hig, low, medium.

---

* **Lingistick head**:- These are the adjective associated with Lingstick variable.

Ex: Very, Very Very, slightly, Plus, minus.

$\therefore \underbrace{\text{Slightly}}_{\text{head}}$ Hot

$$\alpha = \int_0^n \frac{[\mu(y)]^2}{y}$$

$$\text{cold} = \left\{ \frac{0.1}{low} + \frac{0.2}{medium} + \frac{0.3}{high} \right\}$$

$$\text{Very cold} = \left\{ \frac{0.1^2}{low} + \frac{0.2^2}{medium} + \frac{0.3^2}{high} \right\}.$$

$\therefore$ ① Very $= \alpha = \int_0^n \frac{[\mu(y)]^2}{y}$

② Very very $= \alpha = \int_0^n \frac{[\mu(y)]^4}{y}.$

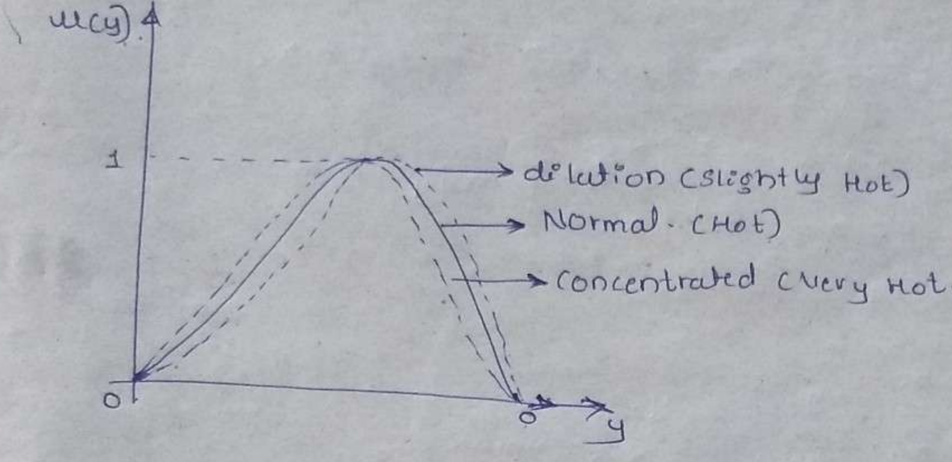
Plus $= \alpha = \int_0^n \frac{[\mu(y)]^{1.5}}{y}.$

* Slightly $= \alpha = \int_0^n \frac{[\mu(y)]^{0.75}}{y}$

* minus $= \alpha = \int_0^n \frac{[\mu(y)]^{0.75}}{y}.$

Here the lingstick heads, very, very very, plus, are used for concentrating system.

minus, slightly are used for diluting the system



Ex 1 :- Small $= \left\{ \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.6}{3} + \frac{0.8}{4} \right\}$

Large $= \left\{ \frac{0.5}{1} + \frac{0.6}{2} + \frac{0.8}{3} + \frac{0.2}{4} \right\}$

Find " Not very very large and slightly small ".

$\downarrow \cap$

$\longrightarrow$ A = Not very very larg $= \left\{ \frac{1-0.5^4}{1} + \frac{1-0.6^4}{2} + \frac{1-0.8^4}{3} + \frac{1-0.2^4}{4} \right\}$

$= \left\{ \frac{0.9375}{1} + \frac{0.8704}{2} + \frac{0.5904}{3} + \frac{0.9984}{4} \right.$

B = Slightly small $= \left\{ \frac{0.1^{0.5}}{1} + \frac{0.2^{0.5}}{2} + \frac{0.6^{0.5}}{3} + \frac{0.8^{0.5}}{4} \right\}$

$= \left\{ \frac{0.316}{1} + \frac{0.4472}{2} + \frac{0.774}{3} + \frac{0.8944}{4} \right\}$

$\therefore A \cap B = \left\{ \frac{0.316}{1} + \frac{0.4472}{2} + \frac{0.5904}{3} + \frac{0.8944}{4} \right\}$. //

Extension Principale

① **Projection** :- It is use to convert Relation into fuzzy set

Relation ⇒ Fuzzy ⇒ Crisp value [Projection]

$$A = \left\{ \frac{0.1}{x_1} + \frac{0.2}{x_2} \right\} \quad \in x$$

$$B = \begin{array}{c|c} & \begin{array}{cc} y_1 & y_2 \end{array} \\ \begin{array}{c} x_1 \\ x_2 \end{array} & \begin{bmatrix} 0.1 & 0.2 \\ 0.2 & 0.1 \end{bmatrix} \end{array} \quad \in x \, \& \, y$$

$$\begin{array}{c|cc} & y_1 & y_2 \\ x_1 & 0.1 & 0.2 \\ x_2 & 0.2 & \end{array}$$

Find AUB.

$$B = \begin{array}{c|c} & \begin{array}{cc} y_1 & y_2 \end{array} \\ \begin{array}{c} x_1 \\ x_2 \end{array} & \begin{bmatrix} 0.1 & 0.2 \\ 0.2 & 0.1 \end{bmatrix} \end{array} \begin{array}{l} \to \max \\ \to \max . \end{array}$$

Projection of B on x

$$B = \left\{ \frac{0.2}{x_1} + \frac{0.2}{x_2} \right\}$$

crisp

$B = [0.2] = X$.

② **Cylindrical Extension** :- It convert crisp value into a fuzzy set or fuzzy set to a Relation.

C.E of A on y domain

$$A = \begin{array}{c|c} & \begin{array}{cc} y_1 & y_2 \end{array} \\ \begin{array}{c} x_1 \\ 0.1 \\ x_2 \\ 0.2 \end{array} & \begin{bmatrix} 0.1 & 0.1 \\ & \\ 0.2 & 0.2 \end{bmatrix} \end{array}$$

$$A = \left\{ \frac{0.1}{x_1} + \frac{0.2}{x_2} \right\}$$

A [0.1]

C.E on A on x domain

$$A = \left\{ \frac{0.1}{x_1} + \frac{0.1}{x_2} \right\} .$$

4/09/2019.

1. let

high current $= \left\{ \frac{0.6}{1} + \frac{0.7}{2} + \frac{0.8}{3} \right\}$

high voltage $= \left\{ \frac{0.8}{200} + \frac{0.2}{220} + \frac{0.6}{240} \right\}$.

Find Not very high current or Not very very high voltage for the Result obtained 'R' find R∪C.

where flux 'c' $= \left\{ \frac{0.6}{2005} + \frac{0.5}{2209} + \frac{0.8}{2408} \right\}$.

$\longrightarrow$ A = Not very high current $= \left\{ \frac{1-0.6^2}{1} + \frac{1-0.7^2}{2} + \frac{1-0.8^2}{3} \right\}$

$= \left\{ \frac{0.64}{1} + \frac{0.51}{2} + \frac{0.36}{3} \right\}$

B = Not very very high current $= \left\{ \frac{1-0.8^4}{200} + \frac{1-0.2^4}{220} + \frac{1-0.6^4}{240} \right\}$

$= \left\{ \frac{0.5904}{200} + \frac{0.9984}{220} + \frac{0.8704}{240} \right\}$.

∴ R = A∪B =

B \ A	1	2	3
200	0.64	0.590	0.590
220	0.9984	0.998	0.998
240.	0.870	0.870	0.870.

$r = R \cup C$

$R = A \cup B$

$r = R \cup C$

$= A \cup B \cup C \cup A$

R∪C ⇒

Convert fuzzy set to relation using C.E.

C \ B	1	2	3
200	0.6	0.6	0.6
220	0.5	0.5	0.5
240	0.8	0.8	0.8

∴ X = R∪C =

	200	220	240
1	0.64	0.998	0.87
2	6 0.590	0.998	0.878
3	6 0.870	0.98	0.870.

* Composition :-

Let X, Y, Z be the 3 universes where R is the Relation on Domain X & Y, S is the relation on Y & Z using the above information a new fuzzy relation can be form on the domain X, Z using the function composition.

$R = A \times B$ where, $A \in X$

$S = B \times C$ $\quad B \in Y$

$\quad C \in Z$

$$T = \underset{\downarrow}{R \circ S}$$

Composition.

* $(x, z) = (x, y)\,(y, z)$

Types of Composition :-

There are different types of composition.

1> Max-min Composition :-

$$\mu_T(x, z) = \vee(\mu_R(x, y) \wedge \mu_S(y, z))$$

$$= \max(\min(\mu_R(x, y), \mu_S(y, z)))$$

2> Max-max composition :-

$$\mu_T(x, z) = \vee(\mu_R(x, y) \vee \mu_S(y, z))$$

$$= \max(\max(\mu_R(x, y), \mu_S(y, z)))$$

3> Min-max composition :-

$$\mu_T(x, z) = \wedge(\mu_R(x, y) \vee \mu_S(y, z))$$

$$= \min(\max(\mu_R(x, y), \mu_S(y, z)))$$

4> Min-min composition :-

$$\mu_T(x, z) = \wedge(\mu_R(x, y) \wedge \mu_S(y, z))$$

$$= \min(\min(\mu_R(x, y), \mu_S(y, z)))$$

5> Max product composition.

$\mu_T(x, z) = \vee [\mu_R(x, y) \underset{\downarrow}{\bullet} \mu_S(y, z)]$

multiplication.

Examples:-

1> Let A be the fuzzy set on domain of current $A = \{\frac{0.3}{3} + \frac{0.7}{6} + \frac{1}{10} + \frac{0.2}{12}\}$ Let 'B' be the fuzzy on domain of voltage

$B = \{\frac{0.2}{20} + \frac{0.4}{40} + \frac{0.6}{60} + \frac{0.8}{80} + \frac{1}{100} + \frac{0.1}{120}\}$ Let 'C' be fuzzy set on domain speed $C = \{0.33/500 + 0.7/1000 + 1/1500 + 0.15/1800\}$ Find the relation T where T = R·S using max-min composition

→ T = R·S

R = A × B (minmum).

(A × B) (B × C)

A × C

A \ B	20	40	60	80	100	120
3	0.2	0.3	0.3	0.3	0.3	0.1
6	0.2	0.4	0.6	0.7	0.7	0.1
10	0.2	0.4	0.6	0.8	1	0.1
12	0.2	0.2	0.2	0.2	0.2	0.1

→ ①

= R·S (A×B) (B×C)

S = B × C = row x column

B \ C	500	1000	1500	1800
20	0.2	0.2	0.2	0.15
40	0.33	0.4	0.4	0.15
60	0.33	0.6	0.6	0.15
80	0.33	0.7	0.8	0.15
100	0.33	0.7	1	0.15
120	0.1	0.1	0.1	0.1

→ ②

row & column

(×)

→ in min( )

T = R·S ⇒ max-min composition

$\mu_T(3, 500) = \max[\min(0.2, 0.2), \min(0.3, 0.33), \min(0.3, 0.33), \min(0.3, 0.33), \min(0.3, 0.33), \min(0.1, 0.1)]$

$= \max[0.2, 0.3, 0.3, 0.3, 0.3, 0.1]$

$= 0.3$

② $\mu_T(3, 1000) = \max[\min(0.2, 0.2), \min(0.3, 0.4), \min(0.3, 0.6), \min(0.3, \ldots$
$\min(0.3, 0.7), \min(0.1, 0.1)]$
$= \max[0.2, 0.3, 0.3, 0.3, 0.3, 0.1]$
$= 0.3.$

Same!

$T = R \cdot S$
$= (A \times B) \cdot (B \times C)$
$= A \times C$

A \ C	500	1000	1500	1800
3	0.3	0.3	0.3	0.15
6	0.33	0.7	0.7	0.15
10	0.33	0.7	1.	0.15
12	0.2	0.2	0.2.	0.15

09/09/2019

2> A new optical microscope camera uses a look up table to relate voltage Readings (which are related to ilumination) to exposure type to aid in the creation lookup table. We need to determine how much time the camera should expose the picture at certain light level. Define a fuzzy set 'Arround 3V' on universe of voltage Reading in volts $V_{1\times5} = \left\{\frac{0.1}{2.98} + \frac{0.3}{2.99} + \frac{0.7}{3} + \frac{0.4}{3.01} + \frac{0.2}{3.02}\right\}$ Volts. and the fuzzy set arround 1/10 sec. on a universe of exposer type in sec.

$T_{1\times5} = \left\{\frac{0.1}{0.05} + \frac{0.3}{0.06} + \frac{0.3}{0.07} + \frac{0.4}{0.08} + \frac{0.5}{0.09} + \frac{0.2}{0.1}\right\}$ sec.

Find $R = V \times T$.

Now define a third universe of in "stops" in Photography are related to making a picture some degree lighter or darker than "avarage" exposed picture.

∴ The universe of stops = $\{-2, -1.5, -1, 0, 0.5, 1, 1.5, 2\}$

we will define a fuzzy set on the universe on

$Z = \left\{ \frac{0.1}{0} + \frac{0.7}{0.5} + \frac{0.3}{1} \right\}$ = a little bit lighter, Find.

$Z \times T = S$; Find $M = R \cdot S$ using max min composation.

→ $R = V \times T$ (min)

V \ T	0.05	0.06	0.07	0.08	0.09	0.1
2.98	0.1	0.1	0.1	0.1	0.1	0.1
2.99	0.1	0.3	0.3	0.3	0.3	0.2
3	0.1	0.3	0.3	0.4	0.5	0.2
3.01	0.1	0.3	0.3	0.4	0.4	0.2
3.02	0.1	0.2	0.2	0.2	0.2	0.2

$Z = \left\{ \frac{0}{-2} + \frac{0}{-1.5} + \frac{0}{-1} + \frac{0.1}{0} + \frac{0.7}{0.5} + \frac{0.3}{1} + \frac{0}{2} \right\}$.

$S = T \times Z$

row column

$m = R \cdot S = (V \times T)$

T \ Z	-2	-1.5	-1	0	0.5	1	1.5	2
0.05	0	0	0	0.1	0.1	0.1	0	0
0.06	0	0	0	0.1	0.3	0.3	0	0
0.07	0	0	0	0.1	0.3	0.3	0	0
0.08	0	0	0	0.1	0.4	0.3	0	0
0.09	0	0	0	0.1	0.5	0.3	0	0
0.1	0	0	0	0.1	0.2	0.2	0	0

$M = R \cdot S = (V \times T) \cdot (T \times Z) = V \times Z$

V \ Z	-2	-1.5	-1	0	0.5	1	1.5	2
2.98	0	0	0	0.1	0.1	0.1	0	0
2.99	0	0	0	0.1	0.3	0.3	0	0
3	0	0	0	0.1	0.5	0.3	0	0
3.01	0	0	0	0.1	0.4	0.3	0	0
3.02	0	0	0	0.1	0.2	0.2	0	0

11/09/2019

3> Let A & B be the fuzzy sets defined on it's own universe where $A = \left\{ \frac{0.2}{1} + \frac{1}{2} + \frac{0.7}{4} \right\}$ $B = \left\{ \frac{0.5}{1} + \frac{1}{2} \right\}$ Find fuzzy set for the algebric (method) product "approximately four" for A × B defined on the other domain using max - min composation

$$\longrightarrow A \times B = \text{Appx. four} = \left\{ \frac{\max[\min(0.2, 0.5)]}{1\times1} + \frac{\max[\min(0.2, 1)]}{1\times2} + \frac{\max[\min(1, 0.5)]}{2\times1} + \right.$$

$$\left. \frac{\max[\min(1, 1)]}{2\times2} + \frac{\max[\min[0.7, 0.5)]}{4\times1} + \frac{\max[\min(0.7, 1)]}{4\times2} \right\}$$

$$= \frac{0.2}{1} + \max\left[\frac{0.2}{2} + \frac{0.5}{2} \right] + \max\left[\frac{1}{4} + \frac{0.5}{4} \right] + \frac{0.7}{8}$$

$$= \frac{0.2}{1} + \frac{0.5}{2} + \frac{01}{4} + \frac{0.7}{8}$$

Comment :- 4 has 100% degree of truth :

4> Let A be the fuzzy set defined on it's own universe A = appx. 2 = fuzzy set = $\left\{ \frac{0.6}{1} + \frac{01}{2} + \frac{0.8}{3} \right\}$, Let B be another fuzzy set ~~on own~~ defined on it's own universe B = appx. 6 = $\left\{ \frac{0.8}{5} + \frac{1}{6} + \frac{0.7}{7} \right\}$. Find the arithmatic product of max-min composation of appx. 2 & appx. 6

$$\longrightarrow A \times B = \left\{ \frac{\max[0.6]}{1\times5} + \frac{\max[0.6]}{1\times6} + \frac{\max[0.6]}{1\times7} + \frac{0.8}{2\times5} + \frac{1}{2\times6} + \right.$$

$$\left. \frac{0.7}{2\times7} + \frac{0.8}{15} + \frac{0.8}{18} + \frac{0.7}{21} \right]$$

$$= \left\{ \frac{0.6}{5} + \frac{0.6}{6} + \frac{0.6}{7} + \frac{0.8}{10} + \frac{1}{12} + \frac{0.7}{14} + \frac{0.8}{15} + \frac{0.8}{18} + \right.$$

$$\left. \frac{0.7}{21} \right]$$

Comment :- 12 has 100% degree of truth. . . .

12 has higher membership.

In city of ~~caligri~~ belgaum there are significant no. of neighbour hood pound that store overland flow from rain stroms & release the water down steam at a control rate to reduce or eliminating flooding in down steam area. To iuellestrate the ~~ea~~ relation using cartesion. Let us compare the level in the neighbourhood pound system (P1, P2, P3). Based on 1 in 100 year stoome valume capacity with a closest 3 rain ~~load~~ Gauge station that measure total rain fall. Let A = pound system relative depth based on 1 in 100 year capacity (P1, P2, P3, P4).

Let B = total rain fall for event based on 1 in 100 year values from 3 different rain gauge station G1, G2, G3.

Suppose we have following fuzzy set $A = \left\{ \frac{0.2}{P_1} + \frac{0.6}{P_2} + \frac{0.5}{P_3} + \frac{0.9}{P_4} \right\}$

$B = \left\{ \frac{0.4}{G_1} + \frac{0.7}{G_2} + \frac{0.8}{G_3} \right\}$ Find the cartesian product $A \times B$ & explain the result's.

→ Suppose we have relation b/w capacity of 5 more pound within a new pounding system P5, P6, P7, P8 & The rain fall data from the original rain fall Gouge G1, G2, G3. The relation is given by

$$D = \begin{array}{c} \\ G_1 \\ G_2 \\ G_3 \end{array} \begin{array}{c} \begin{array}{ccccc} P_5 & P_6 & P_7 & P_8 & P_9 \end{array} \\ \begin{bmatrix} 0.3 & 0.6 & 0.5 & 0.2 & 0.1 \\ 0.4 & 0.7 & 0.5 & 0.3 & 0.3 \\ 0.2 & 0.6 & 0.8 & 0.9 & 0.8 \end{bmatrix} \end{array}$$

$A \times B$

$E =$

Find the fuzzy relation E using max min composition ($E = C \cdot D$) For the two pounding system when $A \times B = C$.

$$\rightarrow C = A \times B = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} \begin{array}{c} \begin{array}{ccc} G_1 & G_2 & G_3 \end{array} \\ \begin{bmatrix} 0.2 & 0.2 & 0.2 \\ 0.4 & 0.6 & 0.6 \\ 0.4 & 0.5 & 0.5 \\ 0.4 & 0.7 & 0.8 \end{bmatrix} \end{array}$$

$E = C \cdot D = (A \times B) \cdot D$

From the above cartesion product it is clear that higher values indicate design model for controlling the flooding in a reasonable good way, where as lower value's indicate design problem or Non representative gouge ~~AAO~~ location. 23/09/2019

$E = C \cdot D$

$= (A \times B) \cdot D$

$$E = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} \begin{array}{c} \begin{array}{ccccc} P_5 & P_6 & P_7 & P_8 & P_9 \end{array} \\ \begin{bmatrix} 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \\ 0.4 & 0.6 & 0.6 & 0.6 & 0.6 \\ 0.4 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0.4 & 0.7 & 0.8 & 0.8 & 0.8 \end{bmatrix} \end{array}$$

IA, the cartesian product $C = A \times B$, higher values indicate design

Note: The new relation 'E' represents the characteristic of rainfall from the two geometrically separated pounding system.
If the no. in this relation large it means that the rain fall is wide spread. where as if the no's are close to '0' then the rain storm is more localised, & rain gauge's, Not good predicter for both systems.

2) For the above problem. Find out E using max product composition.

$E = max(C \times D)$

$$E = \begin{array}{c} P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} \begin{bmatrix} 0.08 & 0.14 & 0.16 & 0.18 & 0.16 \\ 0.24 & 0.42 & 0.48 & 0.54 & 0.48 \\ 0.20 & 0.35 & 0.40 & 0.45 & 0.40 \\ 0.28 & 0.49 & 0.64 & 0.72 & 0.64 \end{bmatrix}$$

$max(0.2 \times 0.3,\ 0.2 \times 0.4,\ 0.2 \times 0.2)$

$max(0.06,\ 0.08,\ 0.04)$

Theory of Approximate Reasoning. 27/09/2019

1> If ______ then ______

Ex:- If 'x' is 'A' then 'y is B'

Anticedent — consequent.

→ If portion acts as Anticedant & thenpart acts as consequent.

→ Let 'A' be fuzzy set defined by the universe 'x'. B be defined of the universe y.

Ex2:- If tomatoes are red then they are riped.

⇒ Red is an antecedant

Riped → Consequent.

i.e if antecedant then consequent.

The Above rule can be represented in terms of a relation 'R' given by $R = (A \times B) \cup (\bar{A} \times y)$

where,

y = is universe.

A = fuzzy set defined on x

B = fuzzy set defined on universe y.

Problems:-

1) Let x & y be the universes i.e $x = x_1, x_2, x_3$ & $y = y_1, y_2, y_3$. where A is defined on universe 'x'

$$A = \left\{ \frac{0.1}{x_1} + \frac{0.2}{x_2} + \frac{0.6}{x_3} \right\} \in x = \{x_1, x_2, x_3\}$$

$$B = \left\{ \frac{0.3}{y_1} + \frac{0.6}{y_2} + \frac{0.1}{y_3} \right\} \in y = \{y_1, y_2, y_3\}.$$

Find if 'x' is A then 'y' is B

→

$$\bar{A} = \left\{ \frac{0.9}{x_1} + \frac{0.8}{x_2} + \frac{0.4}{x_3} \right\}$$

$$y = \left\{ \frac{1}{y_1} + \frac{1}{y_2} + \frac{1}{y_3} \right\}$$

W.K.t $R = (A \times B) \cup (\bar{A} \times y)$

$A \times B$

A \ B	y_1	y_2	y_3
x_1	0.1	0.1	0.1
x_2	0.2	0.2	0.1
x_3	0.3	0.6	0.1

$\bar{A} \times y$

$\bar{A}$ \ y	y_1	y_2	y_3
x_1	0.9	0.9	0.9
x_2	0.8	0.8	0.8
x_3	0.4	0.4	0.4

$R = (A \times B) \cup (\bar{A} \times y)$

	y_1	y_2	y_3
x_1	0.9	0.9	0.9
x_2	0.8	0.8	0.8
x_3	0.4	0.6	0.4

1> Suppose we are evaluating a new invention to determine its commercial potential we with use two matrix to make our decision regardless the innovation of the idea our matrix are "uniqueness" of the invention denoted by the universe of novelty scale ~~denoted by the universe of mo~~ $x = \{1, 2, 3, 4\}$ & "marketsize" of the inventions commercial market denoted on a universe of scaled market size $y = \{1, 2, 3, 4, 5, 6\}$ in both universes lowest nos are the highest uniqueness & largest market size respectively. A new invention in your group say 'A' compossible liquid of very usefull temperature & viscosity conditionary has just received a score of medium uniqueness denoted by a fuzzy set 'A' & medium market size denoted by Fuzzy set B. we wish to determine the implication of such a result i.e if 'A' then 'B'; we assign the invention the following Fuzzy sets to represent its rating

B = medium market size = $\left\{ \frac{0.4}{2} + \frac{1}{3} + \frac{0.8}{4} + \frac{0.3}{5} \right\}$

A = medium uniqueness = $\left\{ \frac{0.6}{2} + \frac{01}{3} + \frac{0.2}{4} \right\}$

$\longrightarrow$

$$\bar{A} = \left\{ \frac{01}{1} + \frac{0.4}{2} + \frac{0}{3} + \frac{0.8}{4} \right\}$$

$$B = \left\{ \frac{0}{1} + \frac{0.4}{2} + \frac{1}{3} + \frac{0.8}{4} + \frac{0.3}{5} + \frac{0}{6} \right\}$$

$$A = \left\{ \frac{0}{1} + \frac{0.6}{2} + \frac{01}{3} + \frac{0.2}{4} \right\}.$$

$X = A \times B$

A \ B	1	2	3	4	5	6
1	0	0	0	0	0	0
2	0	0.4	0.6	0.6	0.3	0
3	0	0.4	1	0.8	0.3	0
4	0	0.2	0.2	0.2	0.2	0

$$y = \left\{ \frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \frac{1}{6} \right\}$$

$z = \bar{A} \times y$

$\bar{A}$ \ y	1	2	3	4	5	6
1	01	01	01	01	01	01
2	0.4	0.4	0.4	0.4	0.4	0.4.
3	0	0	0	0	0	0
4	0.8	0.8	0.8	0.8	0.8	0.8

$R = (X \cdot Z)$

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	0.4	0.4	0.4	0.4	0.4	0.4
3	0	0.4	1	0.8	0.3	0
4	0.8	0.8	0.8	0.8	0.8	0.8.

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* Let c is equal to defused market size = $\left\{ \frac{0.3}{1} + \frac{0.5}{2} + \frac{0.6}{3} + \frac{0.6}{4} + \frac{0.5}{5} + \frac{0.3}{6} \right\}$ Find if x is A then y is B else y is C

Ex:- if x is A then y is B else y is C

$\Rightarrow (A \times B) \cup (\bar{A} \times C)$

$\bar{A} \times C$

	1	2	3	4	5	6
1	0.3	0.5	0.6	0.6	0.5	0.3
2	0.3	0.4	0.4	0.4	0.4	0.3
3	0	0	0	0	0	0
4	0.3	0.5	0.6	0.6	0.5	0.3

$\therefore R = (A \times B) \cup (\bar{A} \times C)$

	1	2	3	4	5	6
1	0.3	0.5	0.6	0.6	0.5	0.3
2	0.3	0.4	0.6	0.6	0.4	0.3
3	0	0.4	1	0.8	0.3	0
4	0.3	0.5	0.6	0.6	0.5	0.3

Continue with the invention problem suppose the fuzzy relation just developed that is i describe the invention commercial potential. We wish to know what market size would be associated with a uniqueness score of "almost high uniqness". i.e with new ant $A' = \bar{A} =$ Find the conc B' using max-min composition.

A' = almost high uniqness = $\left\{ \frac{0.5}{1} + \frac{1}{2} + \frac{0.3}{3} + \frac{0}{4} \right\}$

$B' = A' \cdot R$

using max-min composition

$$B' = \begin{bmatrix} 0.5 & 1 & 0.3 & 0 \end{bmatrix}_{1\times4} \begin{bmatrix} 0.3 & 0.5 & 0.6 & 0.6 & 0.5 & 0.3 \\ 0.3 & 0.4 & 0.6 & 0.6 & 0.4 & 0.3 \\ 0 & 0.4 & 1 & 0.8 & 0.3 & 0 \\ 0.3 & 0.5 & 0.6 & 0.6 & 0.5 & 0.3 \end{bmatrix}$$

$$= \left\{ \frac{0.3}{1} + \frac{0.5}{2} + \frac{0.6}{3} + \frac{0.6}{4} + \frac{0.5}{5} + \frac{0.3}{6} \right\}$$

From the above fuzzy set, it is clear the market size associated with the product which has uniqueness score of high uniquness is defused in nature. neither high neither low.

4) For reaserch on human vision sly it is sometimes necessary to characterise strength of response to visiual stimulous based on magnetic field measurment's when using magnetic field measurment a typycal expt require necorly 100 of on presentation of stimulous @ one location to obtain usefull data. If the reasercher is attempting to map visiual cortex of brain several stimulous notation used in expt. When working with new sub. the reachrusher will make prelinamary mst to determine the type of stimulous being used ivokes good response in sub. The M.M are interms of femto tesla (10^{-15}) ∴ I/O's measured in magnetic units.

We will define the i/p's on universe $X = \{0, 50, 100, 150, 200\}$ femto tesla. o/p's on universe $y = \{0, 50, 100, 150, 200\}$ femto tesla we will define two fuzzy set 2 different Stimulous on universe X.

W = weak stimulous $= \left\{ \frac{1}{0} + \frac{0.9}{50} + \frac{0.3}{100} + \frac{0}{150} + \frac{0}{200} \right\}$

M = medium " $= \left\{ \frac{0}{0} + \frac{0.4}{50} + \frac{1}{100} + \frac{0.4}{150} + \frac{0}{200} \right\}$

& one more fuzzy set on universe y.

S = seviour response $= \left\{ \frac{0}{0} + \frac{0}{50} + \frac{0.5}{100} + \frac{0.9}{150} + \frac{1}{200} \right\}$

Find the preposition if weak "stimulous ~~Ato~~ then Not seviour" response.

→ A = W = Weak stimulus $= \left\{ \frac{1}{0} + \frac{0.9}{50} + \frac{0.3}{100} + \frac{0}{150} + \frac{0}{200} \right\} \in x$

S = severe Response $= \left\{ \frac{0}{0} + \frac{0}{50} + \frac{0.5}{100} + \frac{0.9}{150} + \frac{1}{200} \right\} \in y.$

$R = (W \times \bar{S}) \cup (\bar{A} \times y)$

$y = \left\{ \frac{1}{0} + \frac{1}{150} + \frac{1}{100} + \frac{1}{150} + \frac{1}{200} \right\}$

$\bar{S} = \left\{ \frac{1}{0} + \frac{1}{50} + \frac{0.5}{100} + \frac{0.1}{150} + \frac{0}{200} \right\}$

$\bar{A} = \left\{ \frac{0}{0} + \frac{0.1}{50} + \frac{0.7}{100} + \frac{1}{150} + \frac{1}{200} \right\}$

$W \times \bar{S}$

	0	50	100	150	200
0	1	0.9	0.3	0	0
50	1	0.9	0.3	0	0
100	0.5	0.5	0.3	0	0
150	0.1	0.1	0.1	0	0
200	0	0	0	0	0

twist

$\bar{A} \times y$

$\bar{A}$ \ y	0	50	100	150	200
0	0	0	0	0	0
50	0.1	0.1	0.1	0.1	0.1
100	0.7	0.7	0.7	0.7	0.7
150	1	1	1	1	1
200	1	1	1	1	1

$R = (W \times S) \cup (\bar{A} \times Y)$

	0	50	100	150	200
0	1	0.9	0.3	0	0
50	1	0.9	0.3	0.1	0.1
100	0.7	0.7	0.7	0.7	0.7
150	1	1	1	1	1
200	1	1	1	1	1

New

9/10/2019

If a new ant M = medium stimulus introduced then Find the cons on the domain y, using max-min compo-sition

$\rightarrow$ $M = \left\{ \frac{0}{0} + \frac{0.4}{50} + \frac{1}{100} + \frac{0.4}{150} + \frac{0}{200} \right\}_{1\times5}$

cons

$B' = M.R$ (max-min).

R.

0	0.1	0.1	0.5	0.1	0
50	0.9	0.9	0.5	0.1	0.1
100	0.7	0.7	0.7	0.7	0.7
150	1	1	1	1	1
200	1	1	1	1	1

5×5

$\therefore B' = \left\{ \frac{0.7}{0} + \frac{0.7}{50} + \frac{0.7}{100} + \frac{0.7}{150} + \frac{0.7}{200} \right\}$.

Note: The results obtained state that it is Not measurable response.

5> Suppose u r soil engineer you wish to trap moment of soil partical & ~~apple~~ under applied loader in an expt apparatus that allow viewing of soil motion. you are bulding pattern recoignization software to enable a computer to monitor & detect motion. However there are some difficulties in teaching your software to view the motion. The track particles can be ~~uploaded~~. occleided obstrick by another partical. the oplugin can occur when track particle is behind another particle, Behind a mark on camera's lens, OR perticularly out off site of camera. We want to establish relation b/w particle occlusion which is poorly known phenomena & lens occlutions which is quire was know in photography Let membership fn

$A = \{ \frac{0.1}{x_1} + \frac{0.9}{x_2} + \frac{0}{x_3} \}$ $\quad B = \{ \frac{0}{y_1} + \frac{1}{y_2} + \frac{0}{y_3} \}$.

describes Fuzzy set for a track particle moderatly occluded behind another particle & len's mark associated with moderate image quality respectively. Fuzzy set A is defined universe of track particle indicator's & Fuzzy set B " on len's ind. obstruction indiser. Find occlusion due to partical occulation moderate thom image quality will be Similar to a moderate len's obstruction. If a new ant A' is introduced in which a track particle is behind ~~a~~ a particle with sligtly more occlusion then the particle expressed in original ant A.

$A' = \{ \frac{0.3}{x_1} + \frac{0.1}{x_2} + \frac{0}{x_3} \}$. Find the associated membership of image quality using max-min composition. $B' = A' \cdot R$.

$(A \times B) \cup (\bar{A} \times y)$

Comment on Result.

$R = (A \times B) \cup (\bar{A} \times y)$ $\quad \bar{A} = \{ \frac{0.9}{x_1} + \frac{0.1}{x_2} + \frac{1}{x_3} \}$

$y = \{ \frac{1}{y_1} + \frac{1}{y_2} + \frac{1}{y_3} \}$

~~A x B~~

A x B

	y_1	y_2	y_3
x_1	0	0.1	0
x_2	0	0.9	0
x_3	0	0	0

$\bar{A} \times y$

	y_1	y_2	y_3
x_1	0.9	0.9	0.9
x_2	0.9	0.1	0.1
x_3	1	1	1

. $R = (A \times B) \cup (\bar{A} \times y)$

0.9	0.9	0.9
0.1	0.9	0.1
1	1	1

$B' = A' \cdot R$

$$B' = \left\{ \frac{0.3}{x_1} + \frac{0.9}{x_2} + \frac{0.3}{x_3} \right\}$$

$$B' = [0.3 \quad 0.9 \quad 0.3]$$

09/10/2019

* Fuzzy preposition :-

It is the short form of Preposition which are used in actual rule

Ex:→ if Tomato is Red then they are riped

if T is R then ~~theo~~ T is Rp

→ If error is negative then change vtg small

If e is N then V is S.

fuzzy preposition need to predefined & stored in the data Bus.

* Types of Inference Rules:-

- Composition Rule of inference
- Generalised modes of Peonens

▷ Generalised modes of peonens :- It uses if then rules to represent explicitely the connection b/w two fuzzy preposition

Ex:- If A is B then A is C.

It is the most commenly used inference Rule, they are very fast & simple to compute.

2> Composition Rule of inference :- This uses a fuzzy relation using composition to represent explicitly the connection b/w two fuzzy preposition.

It is special case of generlized modul of Rule.

Ex:- ① S_1 is Q_1

S_1 R S_2

S_2 is Q_2.

② M is small fuzzy no.

M is some what smaller than N.

→ N is rather small fuzzy no.

① Generalized → uses if then rulse to represent → ~~Relation~~ connection b/w two fuzzy prep

② Composition → uses Fuzzy relation using composition
↳ to represent.