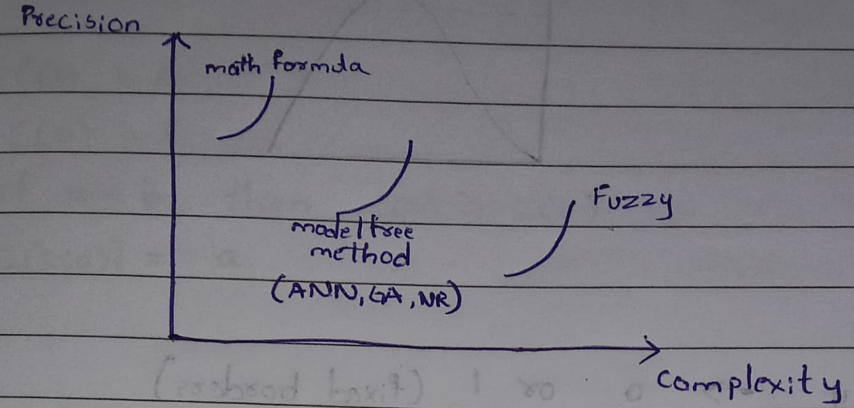
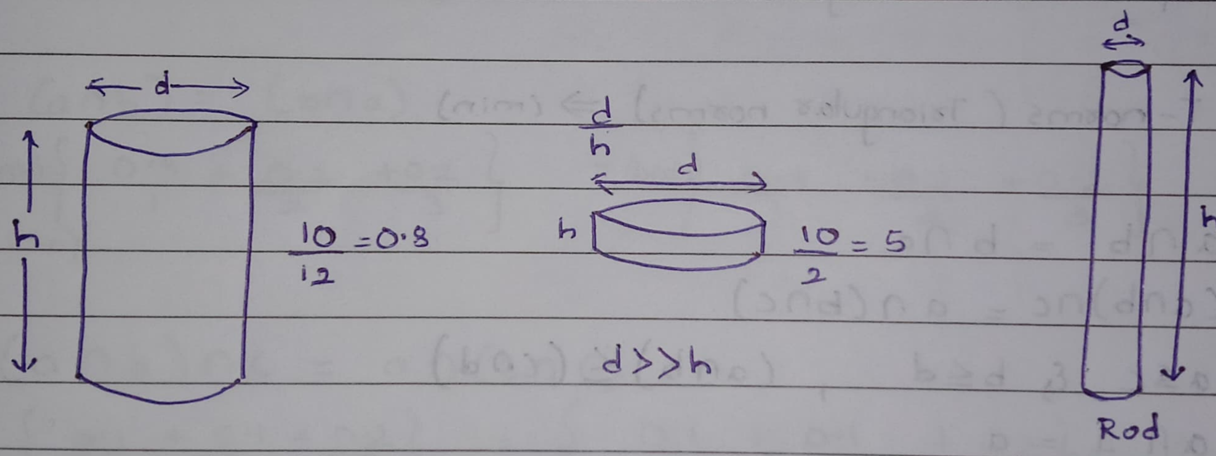
* Application Area

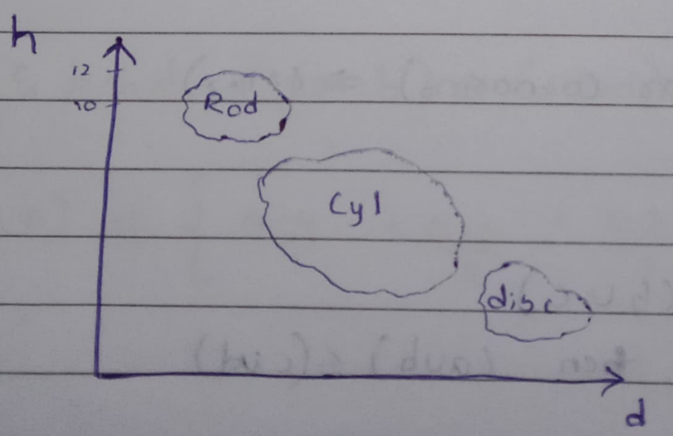


Uncertain ambiguous info → Fuzzy S/M → Certain information

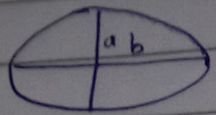


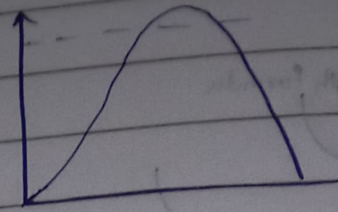
$\frac{10}{12} = 0.8$ $\frac{d}{h}$ $\frac{10}{2} = 5$ $\frac{1}{10} = 0.1$

$d \approx h$ $d >> h$ $h >> d$



* Ecllipse





1) Classical Theory → 0 or 1 (fixed borders)

2) Fuzzy S/m → 0 to 1 (flexible borders)

absent

* Properties of Fuzzy Set

1) T-norms (Triangular norms) ⇒ (min)

1) $a \cap b = b \cap a$
2) $(a \cap b) \cap c = a \cap (b \cap c)$
3) $a \le c$ & $b \le d$, $(a \cap b) \le (c \cap d)$
4) $a \cap 1 = a$
5) $a \cap 0 = 0$

2) S-Norms (Triangular co-norms) ⇒ (Max)

1) $a \cup b = b \cup A$
2) $(a \cup b) \cup c = a \cup (b \cup c)$
3) if $a \le c$ & $b \le d$, then $(a \cup b) \le (c \cup d)$
4) $a \cup 1 = 1$
5 $a \cup 0 = a$

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3) C - norms (complimentary norms)

1) $C(1) = 0$
2) $C(0) = 1$
3) if $a < b$, then $C(a) > C(b)$
4) $C(C(a)) = a$

Ex. $c = \left\{ \frac{0.4}{1} + \frac{0.2}{2} + \frac{0.3}{3} \right\}$, $d = \left\{ \frac{0.5}{1} + \frac{0.6}{2} + \frac{0.2}{3} \right\}$

$a = \left\{ \frac{0.1}{1} + \frac{0.1}{2} + \frac{0.2}{3} \right\}$, $b = \left\{ \frac{0.4}{1} + \frac{0.3}{2} + \frac{0.1}{3} \right\}$

Prove prop of fuzzy set

$\Rightarrow$ $(a \cap b) = (b \cap a)$

$(a \cap b) = \left\{ \frac{0.4}{1} + \frac{0.2}{2} + \frac{0.2}{3} \right\}$ (min) $= (b \cap a) = \left\{ \frac{0.4}{1} + \frac{0.2}{2} + \frac{0.2}{3} \right\}$

$(a \cap b) \cap c = a \cap (b \cap c)$

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

$a \leq c$ & $b \leq d$, $(a \cap b) \leq (c \cap d)$

$(a \cap b) \leq \left\{ \frac{0.4}{1} + \frac{0.2}{2} + \frac{0.2}{3} \right\}$

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$A/B = A \cap \bar{B}$

$B/A = B \cap \bar{A}$

$\overline{(A \cup B)} = (\bar{A} \cap \bar{B})$

2) $a = \left\{ \frac{0.6}{x_1} + \frac{0.4}{x_2} + \frac{0.6}{x_3} + \frac{0.5}{x_5} \right\} \in X$

$b = \left\{ \frac{0.3}{x_1} + \frac{0.2}{x_3} + \frac{0.4}{x_4} + \frac{1}{x_5} \right\} \in X$

$X = [x_1, x_2, x_3, x_4, x_5]$

Find $A \cap B$, $A \cup \bar{B}$, $\bar{A} \cap B$, A/B, B/A, demorgans law

$A \cap B = \left\{ \frac{0.3}{x_1} + \frac{0}{x_2} + \frac{0.2}{x_3} + \frac{0}{x_4} + \frac{0.5}{x_5} \right\}$

$\bar{B} = \left\{ \frac{0.7}{x_1} + \frac{1}{x_2} + \frac{0.8}{x_3} + \frac{0.6}{x_4} + \frac{0}{x_5} \right\}$

$A \cup \bar{B} = \left\{ \frac{0.6}{x_1} + \frac{0.4}{x_2} + \frac{0.6}{x_3} + \frac{0.4}{x_4} + \frac{1}{x_5} \right\}$

$A \cup \bar{B} = \left\{ \frac{0.7}{x_1} + \frac{1}{x_2} + \frac{0.8}{x_3} + \frac{0.6}{x_4} + \frac{0.5}{x_5} \right\}$

$\bar{A} \cap B = \left\{ \frac{0.3}{x_1} + \frac{0}{x_2} + \frac{0.2}{x_3} + \frac{0.4}{x_4} + \frac{0.5}{x_5} \right\}$

$\bar{A} = \left\{ \frac{0.4}{x_1} + \frac{0.6}{x_2} + \frac{0.4}{x_3} + \frac{1}{x_4} + \frac{0.5}{x_5} \right\}$

* Zadeh Implication

T-norm $\Rightarrow \min(a,b)$

S-norm $\Rightarrow \max(a,b)$

c-norm $\Rightarrow (1-a), (1-b)$

* Youger's family Implication

T-norms

$$Y_q(a,b) = 1-\min\left(1, \left((1-a)^q + (1-b)^q\right)\right)$$

Assume $q=1$

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

$$B = \left\{ \frac{0.9}{1} + \frac{0.2}{2} + \frac{1}{3} + \frac{0.7}{4} \right\} \in x$$

Find ~~A∪B~~ $A \cap B$ using Zadeh, Youger's

$$A \cap B = \left\{ \frac{0}{1} + \frac{0.2}{2} + \frac{0.6}{3} + \frac{0.7}{4} \right\}$$

$$\begin{aligned} Y(1,1) &= 1-\min\left(1, \left((1-0)' + (1-0.9)\right)\right) \\ &= 1-\min(1, 1.1) \\ &= 0 \end{aligned}$$

$$\begin{aligned} Y(2,2) &= 1-\min\left(1, \left((1-0.2)' + (1-0.2)'\right)\right) \\ &= 1-\min(1, 1.6) \\ &= 0 \end{aligned}$$

$$\begin{aligned} Y(3,3) &= 1-\min\left(1, (1-0.6)' + (1-1)'\right) \\ &= 1-\min(1, 0.4) \\ &= 0.6 \end{aligned}$$

$$y(4,4) = 1 - \min\left(1, \left((1-1)^{1} + (1-0.7)^{1}\right)\right)$$
$$= 1 - \min(1, 0.3)$$
$$= 0.7$$

$$A \cap B = \left\{ \frac{0}{1} + \frac{0}{2} + \frac{0.6}{3} + \frac{0.7}{4} \right\}$$

* Dubos & Prodan Implementation

$$T_\alpha(a,b) = \frac{a \cdot b}{\max(a,b,\alpha)}$$ assume $\alpha = 1$

$$A = \left\{ \frac{0.2}{1} + \frac{0.4}{2} + \frac{0.9}{3} + \frac{1}{4} \right\} \in X$$

$$B = \left\{ \frac{0.9}{1} + \frac{0.5}{2} + \frac{0.1}{3} + \frac{0.7}{4} \right\} \in X$$

$$T_\alpha(1,1) = \frac{1.8}{\max(0.2, 0.9, 1)} = 1.8$$

$$T_\alpha(2,2) = \frac{0.2}{\max(0.4, 0.5, 1)} = 0.2$$

$$T_\alpha(3,3) = \frac{0.09}{\max(0.9, 0.1, 1)} = 0.09$$

$$T_\alpha(4,4) = \frac{0.7}{\max(1, 0.7, 1)} = 0.7$$

$$A \cup B = \left\{ \frac{0.1.8}{1} + \frac{2}{2} + \frac{0.9}{3} + \frac{0.7}{4} \right\}$$

Zadeh method:

$$A \cup B = \left\{ \frac{0.9}{1} + \frac{0.5}{2} + \frac{0.9}{3} + \frac{1}{4} \right\}$$

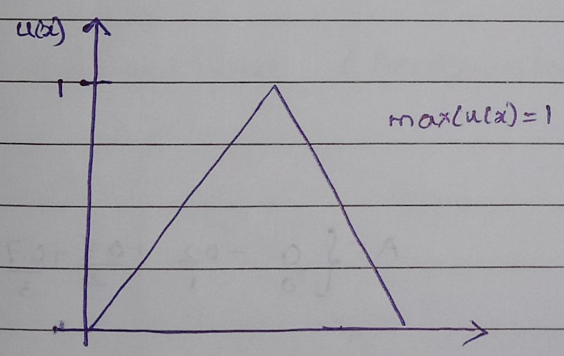
Yougers method:

$$Y_1(1,1) = 1 - \min(1, ((1-0.2)' + (1-0.9)'))$$
$$= 1 - \min(1, 0.9)$$
$$= 0.1$$

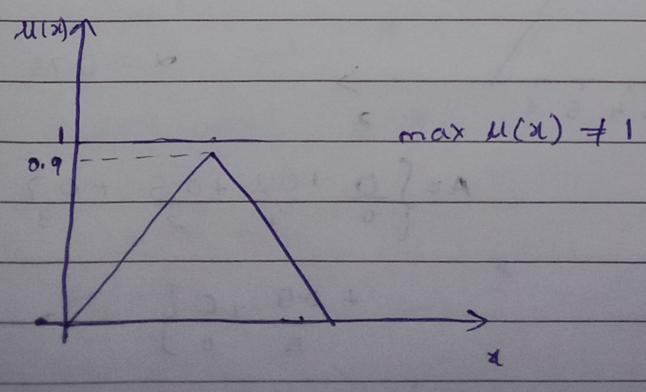
$$Y(2,2) = 1 - \min(1, (1-0.4)' + (1-0.5)'))$$
$$= 1 - \min(1, 0.9)$$
$$= 0.1$$

* Types of fuzzy function

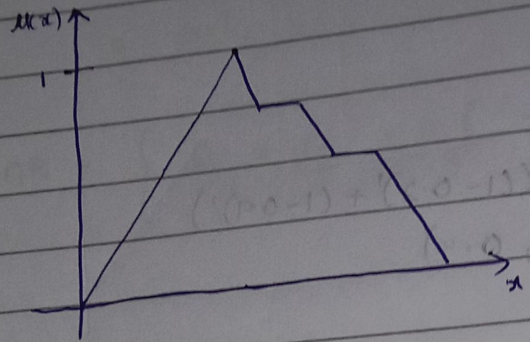
1) Normal fuzzy set



2) Sub-normal fuzzy set

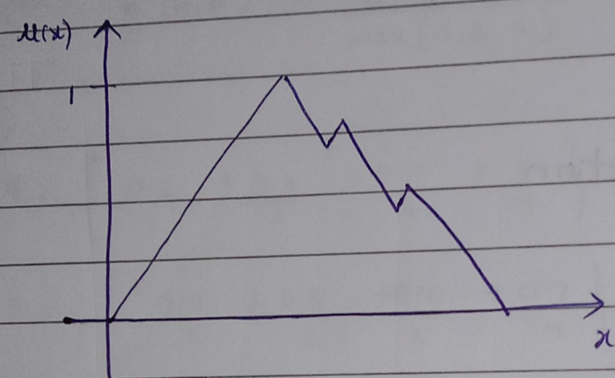


3) Convex fuzzy set



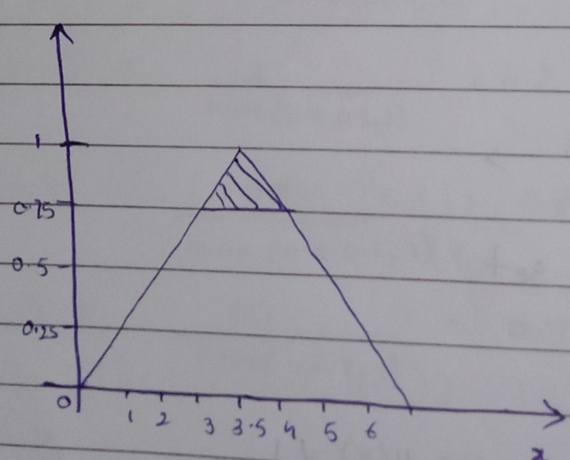
no dips

4) Non-convex fuzzy set



Dip

* λ-cut or α-cut



$$A = \left\{ \frac{0}{0} + \frac{0.2}{1} + \frac{0.5}{2} + \frac{0.7}{3} + \frac{1}{3.5} + \frac{0.7}{4} + \frac{0.5}{5} + \frac{0}{6} \right\}$$

$\alpha = 0.75$

$$A = \left\{ \frac{0}{0} + \frac{0.2}{1} + \frac{0.5}{2} + \frac{0.7}{3} + \frac{0.7}{3.5} + \frac{0.7}{4} + \frac{0.5}{5} + \frac{0}{6} \right\}$$

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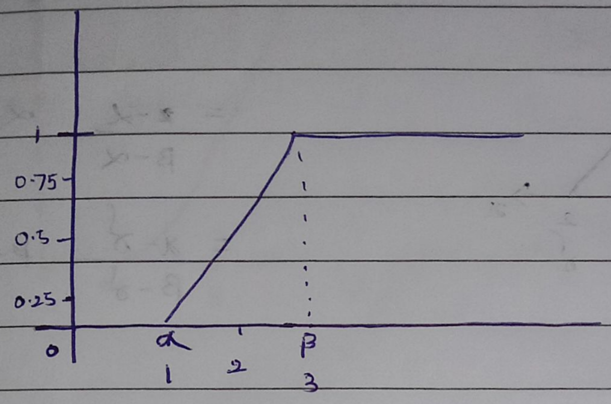
* Shapes of membership funct^{n}

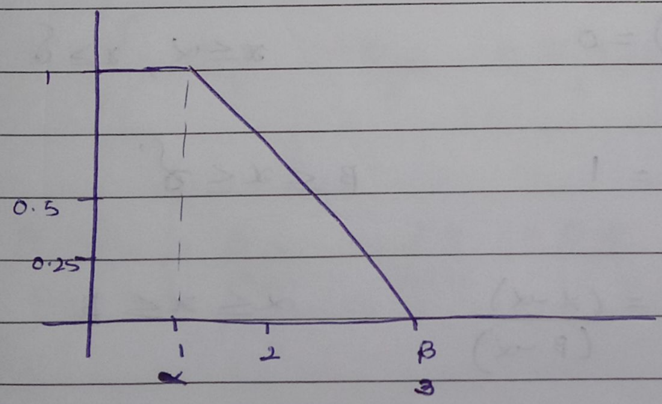
1) T- Function (Incremental f^{n})



$\alpha = 1, \ \beta = 3$

$$\Gamma(x, \alpha, \beta) = 0 \qquad x \le \alpha$$
$$= 1 \qquad x \ge \beta$$
$$= \frac{(x-\alpha)}{(\beta-\alpha)} \qquad \alpha \le x \le \beta$$

2) L- function : (Decrimental



$$\mu(x, \alpha, \beta) = 0 \qquad x \ge \beta$$
$$= 1 \qquad x \le \alpha$$
$$= \frac{x-\beta}{\alpha-\beta} \qquad \alpha \le x \le \beta$$

Let $\alpha = 1, \ \beta = 3$

$x = \alpha \Rightarrow 1$

$x = \beta \Rightarrow 0$

$x = 2 = 0.5$

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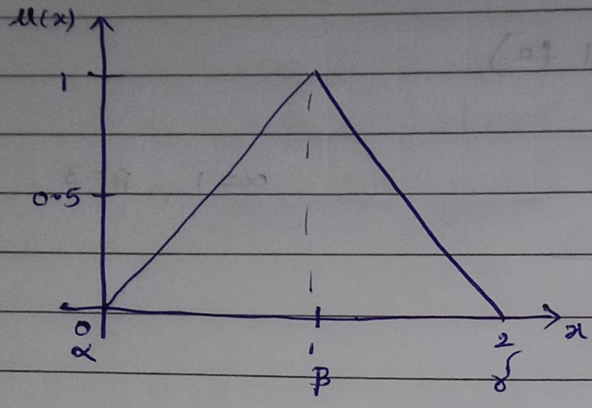
3) Λ - function



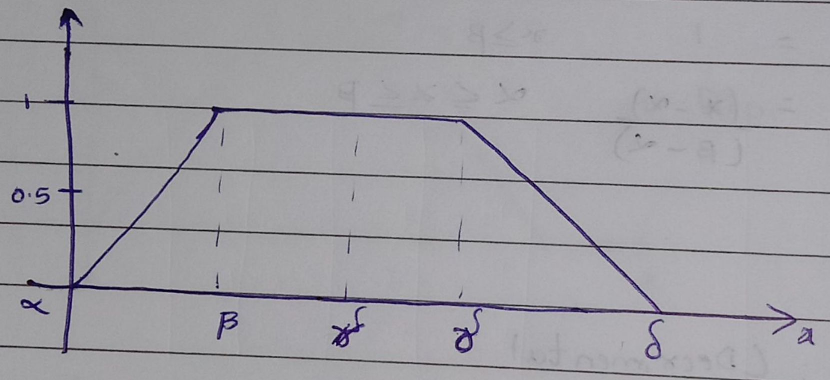
$$\mu(x,\alpha,\beta,\gamma) = 0 \qquad x \le \alpha,\ x \ge \gamma$$

$$= 1 \qquad x = \beta$$

$$= \frac{x-\alpha}{\beta-\alpha} \qquad \alpha \le x \le \beta$$

$$= \frac{x-\gamma}{\beta-\gamma} \qquad \beta \le x \le \gamma$$

4) Π - function



$$\mu(x,\alpha,\beta,\gamma,\delta) = 0$$

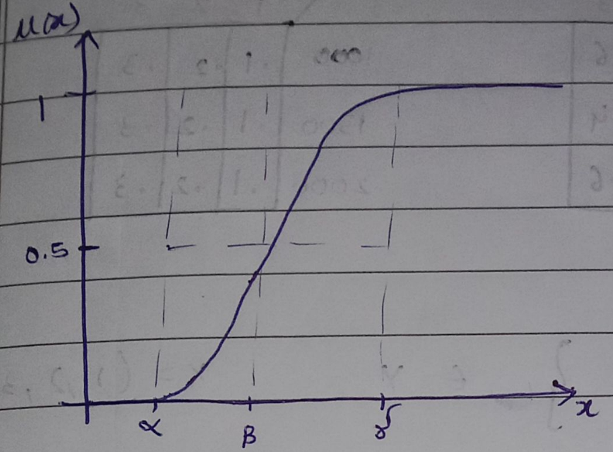
$$x \le \alpha,\ x \ge \delta$$

$$= 1 \qquad \beta \le x \le \gamma$$

$$= \frac{(x-\alpha)}{(\beta-\alpha)} \qquad \alpha \le x \le \beta$$

$$= \frac{(x-\delta)}{(\gamma-\delta)} \qquad \gamma \le x \le \delta$$

5) S-function



$$\mu(x, \alpha, \beta, \gamma) = 0 \qquad x \le \alpha$$

$$= 1 \qquad x \ge \gamma$$

$$= 2\left(\frac{x-\alpha}{\gamma-\alpha}\right)^2 \qquad \alpha \le x \le \beta$$

$$= 1 - 2\left(\frac{x-\gamma}{\gamma-\alpha}\right) \qquad \beta \le x \le \gamma$$

* 1) $A = \left\{ \frac{0.1}{1} + \frac{0.2}{2} + \frac{0.3}{3} \right\} \in x$ Find AUB

$B = \left\{ \frac{0.6}{1000} + \frac{0.4}{1500} + \frac{0.6}{2000} \right\} \in Y$

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→ A ∪ B (max)

	1	2	3
1000	·6	·6	·6
1500	·4	·4	·4
2000	·6	·6	·6

A ∩ B

	1	2	3
1000	·1	·2	·3
1500	·1	·2	·3
2000	·1	·2	·3

Q $A = \left\{ \frac{0.1}{1} + \frac{0.6}{2} + \frac{0.4}{4} \right\} \in X$ $X = (1, 2, 3, 4)$

$B = \left\{ \frac{0.3}{1} + \frac{0.9}{2} + \frac{0.8}{4} \right\} \in Y$ $Y = (1, 2, 3, 4)$

A ∪ B

	1	2	3	4
1	0·3	0·6	0·3	0·4
2	0·9	0·9	0·9	0·9
3	0·1	0·6	0	0·4
4	0·8	0·8	0·8	0·8

A ∩ B

	1	2	3	4
1	0·1	0·3	0	0·3
2	0·1	0·6	0	0·4
3	0	0	0	0
4	0·1	0·6	0	0·4

Your are asked to select & implet a technology for a numer process. Computation throughput is directly related to clock speed assume that all implementations will be in the same family. (CMOS). You are consedring weather the design should be implemented using medium scale integration. (MIS) with discrete parts, field programing array (FPGA) or multichip model (MCM), A universe of potential clock frequency is X = [1, 10, 20, 40, 80, 100] MHz and define MIS, FPGA, MCM as fuzzy sets of clock frequency that should be implemented with each of these technologies.

Table I defines the membership values of the above fuzzy sets

Representing 3 fuzzy sets as MSI = M, FPGA = F, MCM = C
Find the following, ~~A∪B~~, $M \cap F$, $\bar{F}$, $C \cap \bar{F}$, $\overline{M \cap C}$, M/F → $M \cap \bar{F}$
$M \cup F$,

	M	F	C
→ check freq (Mhz)	MIS	FPGA	MCM
	1		
1	1 ~~0.7~~	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

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

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

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

$M \cup F = \left\{ \frac{1}{1}, \frac{1}{10}, \frac{1}{20}, \frac{0.5}{40}, \frac{0.2}{80}, \frac{0}{100} \right\}$

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

$\bar{F} = \left\{ \frac{0.7}{1}, \frac{0}{10}, \frac{0}{20}, \frac{0.5}{40}, \frac{0.8}{80}, \frac{1}{100} \right\}$

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

$M \cap C = \left\{ \frac{0}{1}, \frac{0}{10}, \frac{0.4}{20}, \frac{0}{40}, \frac{0}{80}, \frac{0}{100} \right\}$

$\overline{M \cap C} = \left\{ \frac{1}{1}, \frac{1}{10}, \frac{0.6}{20}, \frac{1}{40}, \frac{1}{80}, \frac{1}{100} \right\}$

* linguistic variables:
are the values interms of words or statement

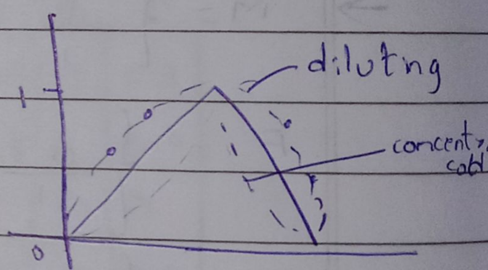
ex. ~~very~~ small, large, good,

* linguistic headges:
These are adjective associated with linguistic variables in order to concentrate or dilute the system
Very Verygood slightly

1) Very = $\alpha = \int_0^n \left[\frac{(u(x))^2}{x} \right]$

2) Very Very = $\alpha = \int_0^n \left[\frac{(u(x))^4}{x} \right]$

3) Plus = $\alpha = \int_0^n \left[\frac{(u(x))^{1.5}}{x} \right]$



4) Slightly = $\alpha = \int_0^n \left[\frac{(u(x))^{0.5}}{x} \right]$

5) minus = $\alpha = \int_0^n \left[\frac{(u(x))^{0.75}}{x} \right]$

1, 2, 3 are used concentrate & 4, 5 to dilute

Date: / /

Q $\text{Small} = \left\{ \frac{1}{1} + \frac{0.8}{2} + \frac{0.5}{3} + \frac{0.2}{4} \right\} \in X$

$\text{large} = \left\{ \frac{0.1}{1} + \frac{0.3}{2} + \frac{0.8}{3} + \frac{1}{4} \right\} \in X$

Find : Very Very Small and Not very large $\approx A \cap B$

$A \cap B = \left\{ \frac{0.1}{1} + \frac{0.3}{2} + \frac{0.5}{3} + \frac{0.2}{4} \right\}$

$VVS = \left\{ \frac{1}{1} + \frac{0.4096}{2} + \frac{0.0625}{3} + \frac{0.0016}{4} \right\}$

$VL = \left\{ \frac{0.01}{1} + \frac{0.09}{2} + \frac{0.64}{3} + \frac{1}{4} \right\}$

$NVL = \left\{ \frac{0.99}{1} + \frac{0.91}{2} + \frac{0.36}{3} + \frac{0}{4} \right\}$

$= \left\{ \frac{0.99}{1} + \frac{0.4096}{2} + \frac{0.0625}{3} + \frac{0}{4} \right\}$

* $\text{Cold} = \left\{ \frac{0.1}{10} + \frac{0.2}{20} + \frac{0.6}{30} \right\} \in X$

$\text{Hot} = \left\{ \frac{0.4}{10} + \frac{0.1}{20} + \frac{1}{30} \right\} \in X$

Find "Not very cold or slightly Hot"

(max)

$VL = \left\{ \frac{0.01}{10} + \frac{0.04}{20} + \frac{0.36}{30} \right\}$

$SH = \left\{ \frac{0.632}{10} + \frac{0.316}{20} + \frac{1}{30} \right\}$

$NVL = \left\{ \frac{0.99}{10} + \frac{0.96}{20} + \frac{0.64}{30} \right\}$

$NVL \cup SH = \left\{ \frac{0.99}{10} + \frac{0.96}{20} + \frac{1}{30} \right\}$

$\in X$
$\in Y$

	10	20	30
10	0.99	0.99	1
20	0.96	0.96	1
30	0.64	0.64	1

* Cylindrical Extention:

* Projection: Projection operation converts a relation to a fuzzy set or fuzzy set to a single crisp value

$$R = \begin{array}{c|ccc} & y_1 & y_2 & y_3 \\ x_1 & 0.1 & 0.2 & 0.4 \\ x_2 & 0.5 & 0.2 & 0.6 \\ x_3 & 0.8 & 0.3 & 1 \end{array}$$

Proj on x domain

Max $[(x_1, y_1)\ (x_1, y_2)\ (x_1, y_3)]$

Max $[0.1 \quad 0.2 \quad 0.4]$

0.4

$$A = \left\{ \frac{0.4}{x_1} + \frac{0.6}{x_2} + \frac{1}{x_3} \right\}$$

$$B = \left\{ \frac{0.8}{y_1} + \frac{0.3}{y_2} + \frac{1}{y_3} \right\}$$

Date: / /

cylindrical extenstion is used to convert single crisp value into a fuzzy or a fuzzy set into a relation

$$A = \left\{ \frac{0.1}{x_1} + \frac{0.2}{x_2} + \frac{0.3}{x_3} \right\} \in X$$

$$Y = \{ y_1, y_2, y_3, y_4 \}$$

A on domain x

	y_1	y_2	y_3	y_4
x_1	0.1	0.1	0.1	0.1
x_2	0.2	0.2	0.2	02
x_3	0.3	0.3	0.3	0.3

* Composition
1) Max-Min composition
2) Max-product "
3) Min-max "
4) Max-max "
5) Min-min "

1) $$A = \left\{ \frac{0.1}{10} + \frac{0.2}{20} + \frac{0.3}{30} \right\} \in X$$

$$B = \left\{ \frac{0.6}{100} + \frac{0.5}{200} + \frac{0.6}{300} + \frac{0.4}{500} \right\} \in Y$$

$$C = \left\{ \frac{0}{1000} + \frac{0.5}{1500} + \frac{1}{2000} \right\} \in Z$$

* Cartation Product : $(\times) \rightarrow (\min)$

$\underset{(x)}{A} \times \underset{(y)}{B} = A \cap B$

$T = R \cdot S$

$R = A \times B$

$S = B \times C$

$R = A \cap B$

	100	200	300	~~400~~ 500
10	0.1	0.1	0.1	0.1
20	0.2	0.2	0.2	0.2
30	0.3	0.3	0.3	0.3

$S = B \cap C$

	1000	1500	2000
100	0	0.5	0.6
200	0	0.5	0.5
300	0	0.5	0.6
500	0	0.4	0.4

Find $T = R.S$ using max min composition

R.S

A×B B×C

~~A×C~~

$$
\begin{array}{c|ccc}
 & 1000 & 1500 & 2000 \\
\hline
10 & 0 & 0.1 & 0.1 \\
20 & 0 & 0.2 & 0.2 \\
30 & 0 & 0.3 & 0.3
\end{array}
$$

$T(10, 1500) = \text{Max}(\min(0.1, 0.5), \min(0.1, 0.5), \min(0.1, 0.5), \min(0.1, 0.4)$

$= \text{Max}(0.1, 0.1, 0.1, 0.1)$

$= 0.1$

$T(20, 1000) = \text{Max}(\min(0.2, 0)$

$=$

$= 0$

$T(20, 1500)$

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1) $A = \left\{ \frac{0.6}{x_1} + \frac{0.5}{x_2} + \frac{0.8}{x_3} + \frac{0.2}{x_5} \right\} \in X$

$B = \left\{ \frac{1}{y_1} + \frac{2}{y_2} + \frac{3}{y_3} \right\} \in Y$

$C = \left\{ \frac{0.8}{z_1} + \frac{1}{z_2} + \frac{0.3}{z_3} + \frac{1}{z_5} \right\} \in Z$

where $X = [x_1\ x_2\ x_3\ x_4\ x_5]$

$Y = [Y_1\ Y_2\ Y_3]$

$Z = [Z_1\ Z_2\ Z_3\ Z_4\ Z_5]$

find $T = R \cdot S$ using max min composition

$R = A \times B$ $S = B \times C$

$R = A \times B$

	y_1	y_2	y_3
x_1	0.6	0.6	0.6
x_2	0.5	0.5	0.5
x_3	0.8	0.8	0.8
x_4	0	0	0
x_5	0.2	0.2	0.2

$S = B \times C$

	z_1	z_2	z_3	z_4	z_5
Y_1	0.8	1	0.3	0	1
Y_2	0.8	1	0.3	0	1
Y_3	0.8	1	0.3	0	1

$R \cdot S$

$(A \times B)\ (B \times C)$

$T = R \cdot S$

$= (A \times B)\ (B \times C)$

$= A \times C$

$$T = \begin{array}{c|c|c|c|c|c|}
 & z_1 & z_2 & z_3 & z_4 & z_5 \\
x_1 & 0.6 & 0.6 & 0.3 & 0 & 0.6 \\
x_2 & 0.5 & 0.5 & 0.3 & 0 & 0.5 \\
x_3 & 0.8 & 0.8 & 0.3 & 0 & 0.8 \\
x_4 & 0 & 0 & 0 & 0 & 0 \\
x_5 & 0.2 & 0.2 & 0.2 & 0 & 0.2
\end{array}$$

$(x_1, z_1) = \max(\min(0.6, 0.8)\ \min(0.6, 0.8)\ \min(0.6, 0.8))$

$= \max(0.6, 0.6, 0.6)$

$= 0.6$

* Rules

Theory of approximate Reasoning

- Rules in fuzzy

i) If ___ Then ___

If x is A then Y is B

where A & B are fuzzy sets on universe x & Y respectively.

ex. If tomatoes are red then tomates are riped

here "tomatoes are red" is an anticident whereas "tomatoes are riped" is a consquient. There can't be a consiquient without an anticident.

ex. If motor speed is low then increase the voltage

anticident — motor speed is low

consiquient — increase the voltage

In fuzzy If ___ then ___ is represented as

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

$(A \times B)$ — Cart. Product

Y — Universe

ii) If x is A then y is B else y is C.

In fuzzy it is represented as

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

here x is A acts as an anticident for consiquent y is B also for consiquent y is C

ex. If tomatoes are red they are riped else not riped

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$A = \left\{ \frac{0}{1} + \frac{1}{2} + \frac{1}{3} + \frac{0}{4} \right\} \in X$

$B = \left\{ \frac{0}{1} + \frac{0}{2} + \frac{1}{3} + \frac{1}{4} + \frac{0}{5} + \frac{0}{6} \right\} \in Y$

Find if x is A then y is B

where $X = [1, 2, 3, 4]$

$y = [1\ 2\ 3\ 4\ 5\ 6]$

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

A X B

	y_1	y_2	y_3	y_4	y_5	y_6
x_1	0	0	0	0	0	0
x_2	0	0	1	1	0	0
x_3	0	0	1	1	0	0
x_4	0	0	0	0	0	0

$\bar{A} \times Y$

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	1	1	1	1	1	1

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

1	1	1	1	1	1
0	0	1	1	0	0
0	0	1	1	0	0
1	1	1	1	1	1

Date: / /

→ $X = [1, 2, 3, 4] \Rightarrow$ uniqueness
$Y = [1, 2, 3, 4, 5, 6] \Rightarrow$ Market size

$A =$ Medium uniquiness $= \left\{ \frac{0.6}{2} + \frac{1}{3} + \frac{0.2}{4} \right\}$

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

$C =$ diff used market size $= \left\{ \frac{0.3}{1} + \frac{0.5}{2} + \frac{0.6}{3} + \frac{0.6}{4} + \frac{0.5}{5} + \frac{0.3}{6} \right\}$

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

	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

$\bar{A} = \left\{ \frac{1}{1} + \frac{0.4}{2} + \frac{0}{3} + \frac{0.8}{4} \right\}$ $Y = \left\{ \frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \frac{1}{6} \right\}$

$\bar{A} \times Y =$

	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	0	0	0	0
4	0.8	0.8	0.8	0.8	0.8	0.8

$R =$

	1	2	3	4	5	6
1	1	1	1	1	1	1
2	0.4	0.4	0.6	0.6	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

also find the logical conditional implication in the compound form i.e "If medium uniqueness then medium market size else defused market size." If A then B else C.

a. Continuing with problem no 1, suppose that the fuzzy relation just develop i.e R describe the inventions commercial potential. We wish to know what market size to be associated with the uniqueness score of "almost high uniquiness" i.e with the new anticident A' find the consequent B' using max-min composition.

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

$$B' = A' \cdot R$$

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

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

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Q w = weak stimulus = $\left\{ \frac{1}{0} + \frac{0.9}{50} + \frac{0.3}{100} + \frac{0}{150} + \frac{0}{200} \right\}$ C X

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

S = Severe Response = $\left\{ \frac{0}{0} + \frac{0}{50} + \frac{0.5}{100} + \frac{0.9}{150} + \frac{1}{200} \right\}$ C Y

Find, "if weak stimulus then Not severe Response"

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

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

$W \times \bar{S}$ =

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

$\bar{W} \times Y$ =

	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

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

	0	50	100	150	200
0	1	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

Q) Now using the new antcident for the input M = medium stimulus. Find the consiquent on the universe of to relate the appoximately to the new stimulus M using max-min composition. i.e Find M.R

$$\rightarrow \begin{bmatrix} 0 & 0.4 & 1 & 0.4 & 0 \end{bmatrix} \cdot \begin{bmatrix} 1 & 1 & 0.5 & 0.1 & 0 \\ 0.9 & 0.9 & 0.5 & 0.1 & 0.1 \\ 0.7 & 0.7 & 0.7 & 0.7 & 0.7 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$$= \left[\frac{0.7}{0} + \frac{0.7}{50} + \frac{0.7}{100} + \frac{0.7}{150} + \frac{0.7}{200} \right]$$

Q. Suppose we have distillation process where objective is to seperate the components of mixture in the input Scehme, the process is pictured in the fig. The relation b/w the input variable, temp & output variable, distillation fractions is not precise, but human operated of this process has developed an intitive understanding of the Relation. The universe of each of varible is

$X = [\text{temp} = \{160, 165, 170, 175, 180, 185, 190, 195\}]$

Y = distillation (%) fraction $= \{77, 80, 83, 86, 89, 92, 95, 98\}$.

A = temp of i/p stem $= \left\{ \frac{0}{175} + \frac{0.7}{180} + \frac{1}{185} + \frac{0.4}{190} \right\}$

B = Seperation of mixture is good $= \left\{ \frac{0}{89} + \frac{0.5}{92} + \frac{0.8}{95} + \frac{1}{98} \right\}$

a) Find "if temp is hot then separation of mixture is good"

b) Let $A' = \left\{ \frac{1}{170} + \frac{0.8}{175} + \frac{0.5}{180} + \frac{0.2}{185} \right\}$

For the new rule "if A' then B'", find B' using max-product