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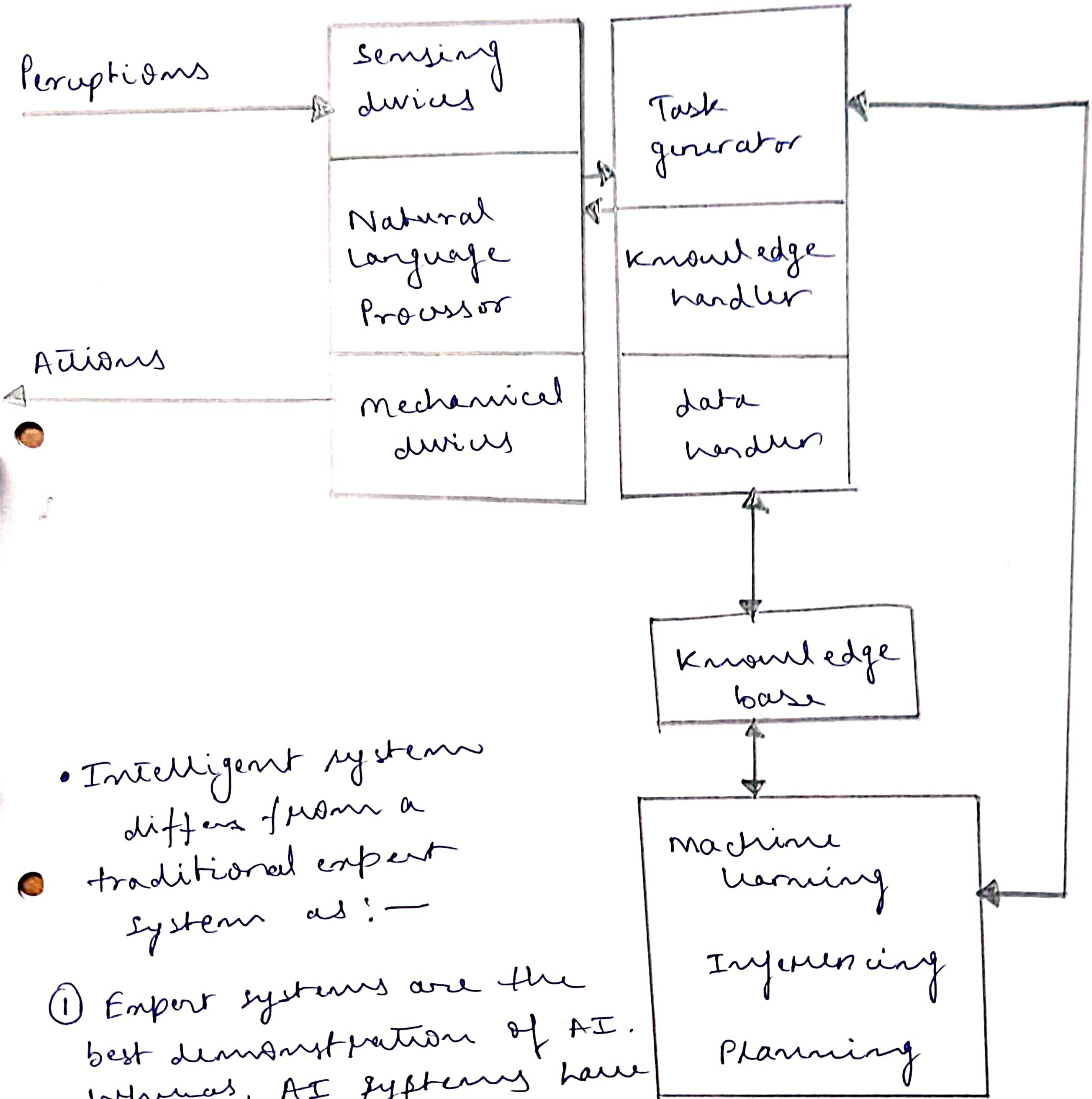
Computational Intelligence Activity - 01

Ans1) • Computational intelligence is the theory, design, application and development of biologically and linguistically motivated computational paradigms. The 3 main pillars of CI are neural networks, fuzzy systems and evolutionary computation.

• Differences between AI and CI :-

	AI	CI
1	Study of intelligent behaviour demonstrated by machines.	Study of adaptive mechanisms to enable or facilitate intelligent behaviour.
2	Goal of AI is to create intelligent machines which can exhibit intelligent behaviour.	Goal of CI is to understand the paradigms that make intelligent behaviour possible.
3	Common applications of AI are speech recognition, optical recognition & NLP	Common applications of CI are intelligent household application, medical diagnosis & optimization applications

Ans 2) Schematic diagram of an intelligent system :-



- Intelligent system differs from a traditional expert system as :-

① Expert systems are the best demonstration of AI. whereas, AI systems have the ability to think, work, learn & react.

② Expert systems are used to solve complex decision problems whereas AI systems are used to simulate intelligent behaviour.

Ans 3) Difference between Soft computing & hard computing :-

Soft computing	Hard computing
It incorporates stochasticity	① It is deterministic
Can deal with noisy & ambiguous data.	② Requires exact input data
Allows parallel computation	③ It is strictly sequential
It can yield approximate answers	④ Produces precise answers
Has characteristics of approximation & dispositionality	⑤ Has characteristics of prediction & precision & categoricity

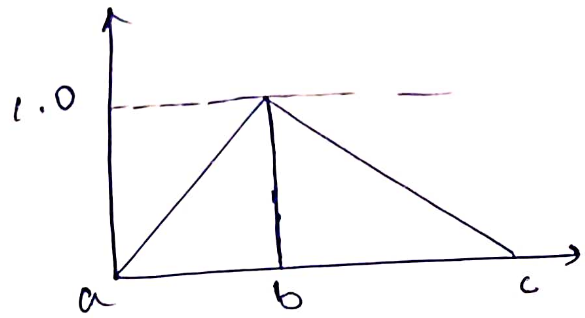
Ans 4) If X is a universe of discourse and $x \in X$, then a fuzzy set 'A' in X is defined as a set of ordered pairs, that is

$A = \{(x, \mu_A(x)) \mid x \in X\}$ where $\mu_A(x)$ is called the membership function for the fuzzy set 'A'.

Various types of one dimensional membership functions are :-

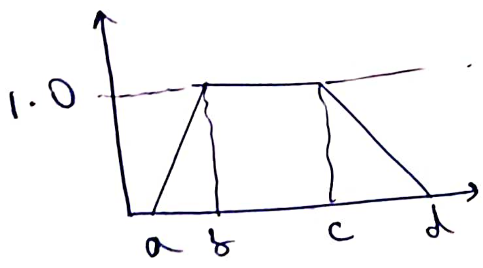
① Triangular MF :-

$$\text{triangle}(x; a, b, c) = \begin{cases} 0 & \text{if } x \le a \\ \dfrac{x-a}{b-a} & \text{if } a \le x \le b \\ \dfrac{c-x}{c-b} & \text{if } b \le x \le c \\ 0 & \text{if } c \le x \end{cases}$$



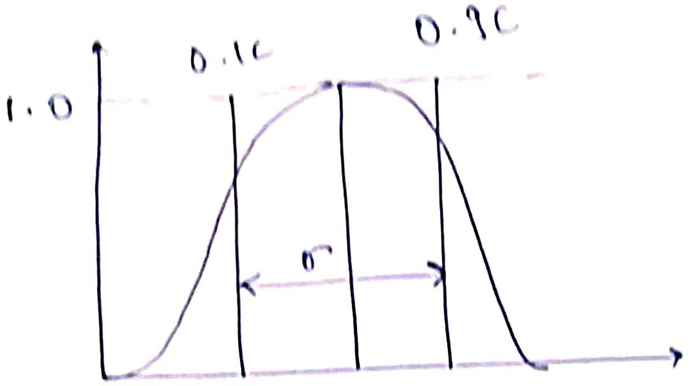
② Trapezoidal MF :-

$$\text{trapezoid}(x; a, b, c, d) = \begin{cases} 0 & \text{if } x \le a \\ \dfrac{x-a}{b-a} & \text{if } a \le x \le b \\ 1 & \text{if } b \le x \le c \\ \dfrac{d-x}{d-c} & \text{if } c \le x \le d \\ 0 & \text{if } d \le x \end{cases}$$



(3) Gaussian MF :-

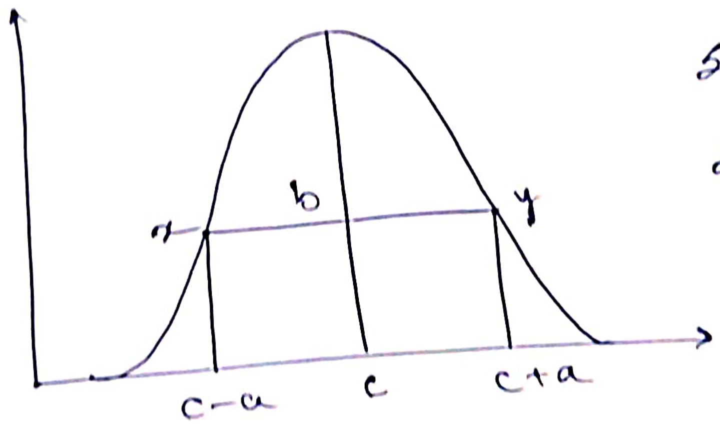
$$\text{gaussian}(x; c, \sigma) = e^{-\frac{1}{2}\left(\frac{x-c}{\sigma}\right)^2}$$



(4) Generalized bell MF :-

Also called cauchy MF. Specified by 3 parameters.

$$\text{bell}(x; a, b, c) = \frac{1}{1 + \left|\frac{x-c}{a}\right|^{2b}}$$

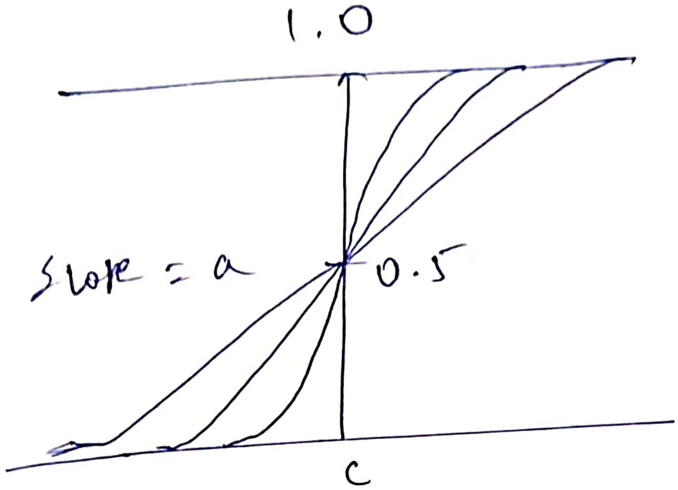


Slope at $x = \frac{b}{2a}$

Slope at $y = -\frac{b}{2a}$

(5) Sigmoid MF :-

$$\text{sigmoid}(x; a, c) = \frac{1}{1 + e^{-\left[\frac{a}{x-c}\right]}}$$



Ans 5) The 3 types of universe of discourse are :-

(1) Fuzzy set with a discrete non ordered universe of discourse :-

→ Universe of discourse may contain discrete non-ordered pairs or objects.

ex : The fuzzy set "desirable city to live in" may be described as :-

A = {(mumbai, 0.9), (Pune, 0.8), (Delhi, 0.6)}

(2) Fuzzy set with a discrete ordered universe of discourse :-

→ Let X = {0, 1, 2, 3, 4, 5, 6} be the set of no. of children a family may chose to have.

- Then a fuzzy set "sensible number of children in a family" may be described as :-

A = {(0, 0.1), (1, 0.3), (2, 0.7), (3, 1), (4, 0.7), (5, 0.3), (6, 0.1)}

③ Fuzzy set with a continuous universe of discourse :—

→ Let, $X = R^+$ be the set of possible ages for human beings. Then the fuzzy set B = "about 50 year old" may be expressed as

$B = \{ x, \mu_B(x)) \mid x \in X \}$

where, $\mu_B(x) = \dfrac{1}{1 + \left(\dfrac{x-50}{10}\right)^4}$

x	40	42	44	46	48	50	52	56	58	60	62
$\mu_B(x)$	0.5	0.71	0.94	0.99	1	0.99	0.89	0.74	0.71	0.5	

Ans.6) 0.4 cut on A i.e. $A_{0.4}$

$A_{0.4} = \{(-3, 0.6), (-2, 0.5), (0, 1), (3, 0.5), (4, 0.4)\}$

$A_{0.4}' = \{(-3, 0.6), (-2, 0.5), (0, 1), (3, 0.5)\}$

Ans7) <i> Support : Support of a fuzzy set "A" is the set of all points such that $\mu_A(x) > 0$.

<ii> Core : core of a fuzzy set "A" is the set of all points x in X such that $\mu_A(x) = 1$.

<iii> Normality : A fuzzy set "A" is normal if it's core is non empty. A point such that $\mu_A(x) = 1$; $x \in X$

<iv> Crossover point : Crossover point of a fuzzy set "A" is a point $x \in X$ such that $\mu_A(x) = 0.5$.

<v> Fuzzy singleton : Fuzzy set whose support is a single point in X with $\mu_A(x) = 1$ is called a fuzzy singleton.

<vi> α - cut : The α-cut of a fuzzy set A is a crisp set defined by

$$A_\alpha = \{x \mid \mu_A(x) \geq \alpha\}$$

<vii> Strong α-cut : Strong α-cut is defined by

$$A_\alpha' = \{x \mid \mu_A(x) > \alpha\}$$

<viii> Convexity : A fuzzy set "A" is convex if and only if for any x_1 and $x_2 \in X$ and any $\lambda \in [0,1]$.

$$\mu_A(\lambda x_1 + (1-\lambda)x_2) \geq \min(\mu_A(x_1), \mu_A(x_2))$$

<ix> Bandwidth : for a normal & convex fuzzy set, the bandwidth (or width) is defined as the distance the 2 unique crossover points :

$$\text{Bandwidth}(A) = |x_1 - x_2|$$

where $\mu_A(x_1) = \mu_A(x_2) = 0.5$

<x> Symmetry : A fuzzy set A is symmetric if its membership function around a certain point $x = c$, namely

$$\mu_A(x+c) = \mu_A(x-c) \text{ for all } x \in X$$

Ans 8) Suppose that the fuzzy A = "(x, y) is near (3,4)" is depicted by :

$$\mu_A(x,y) = \exp\left[-\left(\frac{x-3}{2}\right)^2 - (y-4)^2\right]$$

$$= \exp\left[-\left(\frac{x-3}{2}\right)^2\right]\exp\left[-\left(\frac{y-4}{1}\right)^2\right]$$

$$= g(x;3,2) * g(y;4,1)$$

This 2 dimensional MF is composite, the fuzzy set "A" is composed of 2 statements "x is near 3" and "y is near 4".

$\therefore$ defined as $\mu_{near\,3}(x) = g(x;3,2)$

$\mu_{near\,4}(x) = g(y;4,1)$

$$\mu_A(x,y) = \frac{1}{1+|x-3||y-4|^{2.5}}$$; it is non composite

Ans 9) $A = \{(x_1, 0.5), (x_2, 0.4), (x_3, 0.7), (x_4, 1), (x_5, 0.6)\}$

$B = \{(y_1, 0.5), (y_2, 0.3), (y_3, 0.8), (y_4, 1), (y_5, 0.6)\}$

→ Cartesian product of A & B.

	y_1	y_2	y_3	y_4	y_5
x_1	0.5	0.3	0.5	0.5	0.5
x_2	0.4	0.3	0.4	0.4	0.4
x_3	0.5	0.3	0.7	0.7	0.6
x_4	0.5	0.3	0.8	1	0.6
x_5	0.5	0.3	0.6	0.6	0.6

Co-cartisan product of A & B :-
"yet to be discussed"

Ans 10) $\mu_A(x) = trapezoid(x; 10, 20, 40, 70)$

$$= \begin{cases} 0 & x \le 10 \\ \frac{x-10}{10} & 10 \le x \le 20 \\ 1 & 20 \le x \le 40 \\ \frac{40-y}{30} & 40 \le x \le 70 \\ 0 & 70 \le x \end{cases}$$

For P_1 :-

$$0.5 = \frac{P_1 - 10}{10}$$

$\Rightarrow 5 = P_1 - 10$

$P_1 = 15$

For P_2 :-

$$0.5 = \frac{70 - P_2}{30}$$

$\Rightarrow 15 = 70 - P_2$

$55 = P_2$

Bandwidth $= P_2 - P_1$

$= 55 - 15$

$= 40$

$\therefore$ width $= 40$