Model Question Paper

QP CODE:

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 444

Course Name: Soft Computing

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Explain the architecture of a simple Artificial Neural network? Compare it with a biological neuron.

2. A 4-input neuron has weights 1, 2, 3 and 4. The transfer function is linear with the constant of proportionality being equal to 2. The inputs are 4, 10, 5 and 20 respectively. Predict the output?

3. Explain the Widrow-Hoff learning rule for supervised learning in neural networks with help of an example. Why is it sometimes called the LMS learning rule?

4. Implement one epoch of Adaline algorithm for AND logic function with binary inputs and bipolar outputs. Initial weights are w1=0.2, w2=0.1 and learning rate parameter η=0.2.

5. Consider two fuzzy sets $A = \left\{\frac{0.2}{0} + \frac{0.3}{1} + \frac{1}{2} + \frac{0.1}{3} + \frac{0.5}{4}\right\}$ $B = \left\{\frac{0.1}{0} + \frac{0.25}{1} + \frac{0.9}{2} + \frac{0.7}{3} + \frac{0.3}{4}\right\}$ Find the following: (a) Algebraic sum (b) Algebraic product(c) Bounded sum.

6. Using your own intuition and definition of universe of discourse, plot membership

functions for liquid level (Empty, very less, less, full, very full) in a tank.

7. Explain Stochastic Universal Sampling with an example.

8. Explain any two mutation methods.

9. Differentiate between linear and nonlinear Multi Objective Optimization Problem.

10. What are the characteristics of neuro fuzzy hybrid systems?

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Implement XOR function using M-P Neuron Model (with binary input).Why M-P neuron is widely used in processing binary data? **(8)**

(b) Using Hebb Network calculate the weight required to perform the following classification of given input pattern. **(6)**

L □belongs to the members of the class(+)□target value +1

U□does not belongs to members of class(.)□target value -1

+	.	.
+	.	.
+	+	+

L

+	.	+
+	.	+
+	+	+

U

OR

12. (a) Compare the three learning approaches in Artificial Neural Network. How is the critic information used in learning process. **(8)**

(b) Define Hebb Law. Design a Hebb Network to implement logical AND function. Use bipolar input and targets. **(7)**

13. (a) Discuss the training algorithm and explain the weight updates in back propagation networks. **(10)**

(b) Implement one epoch of Perceptron training algorithm for OR logic function with binary input and bipolar output. **(4)**

OR

14. (a) Explain how synaptic weights are adapted iteration by iteration using error correction rule in Perceptron convergence algorithm for an OR gate with bipolar inputs and outputs. Initial weights are all zero and learning rate parameter η=0.1. **(10)**

(b) Explain Perceptron convergence theorem and discuss Perceptron algorithm based on XOR logic function. **(4)**

15. (a) Three fuzzy sets are defined as follows: **(10)**

$A = \left\{\frac{0.1}{30} + \frac{0.2}{60} + \frac{0.3}{90} + \frac{0.4}{120}\right\}, B = \left\{\frac{1}{1} + \frac{0.2}{2} + \frac{0.5}{3} + \frac{0.7}{4} + \frac{0.3}{5} + \frac{0}{6}\right\},$

$$C = \left\{\frac{0.33}{100} + \frac{0.65}{200} + \frac{0.92}{300} + \frac{0.21}{400}\right\}$$

Find: (i)$R = A \times B$ (ii)$S = B \times C$ (iii)$T = RoS$, using Max-Min composition (iv)$T = RoS$, using Max-Product composition.

(b) For the fuzzy sets given $A = \left\{\frac{0.5}{x_1} + \frac{0.2}{x_2} + \frac{0.9}{x_3}\right\}$ and$B = \left\{\frac{1}{y_1} + \frac{0.5}{y_2} + \frac{1}{y_3}\right\}$. Find relation R by performing Cartesian product over the given fuzzy sets. **(4)**

OR

16. (a) Using inference approach, find the membership values for each of the triangular shapes (I, R, IR, T) for a triangle with angles 120°, 50°, 10°. **(8)**

(b) Using Zadeh's notation, determine the ʎ - cut sets for the given fuzzy sets: **(6)**

$$S_1 = \left\{\frac{0}{0} + \frac{0.5}{20} + \frac{0.65}{40} + \frac{0.85}{60} + \frac{1.0}{80} + \frac{1.0}{100}\right\}$$

$$S_2 = \left\{\frac{0}{0} + \frac{0.45}{20} + \frac{0.6}{40} + \frac{0.8}{60} + \frac{0.95}{80} + \frac{1.0}{100}\right\}$$

Express the following for $\lambda = 0.5$: a) $S_1 \cup S_2$ b) $\acute{S_2}$ c) $S_1 \acute{\cap} S_2$

17. (a) Differentiate between value encoding and permutation encoding. **(8)**

(b) Explain the stopping conditions for genetic algorithm. **(6)**

OR

18. (a) Apply Mamdani fuzzy model to design a controller to determine the wash time of a domestic washing machine. Assume input is dirt and grease of the cloth. Use three descriptors for input variable and five descriptors for output variables .Derive the set of rules for controller action and defuzzification. Design should be supported by figure wherever possible. **(10)**

(b) Explain Single-Point Crossover and Two-Point Crossover with example. **(4)**

19. (a) Explain convex and non convex MOOP? How to find a non dominated set. **(10)**

(b) What are the properties of dominance relation? **(4)**

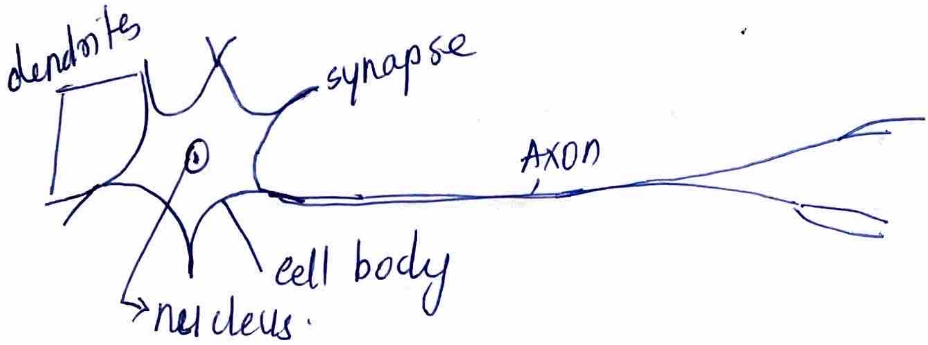
OR

20. (a) Explain Genetic Neuro-Hybrid System with block diagram. Also write the advantages of Genetic- Neuro Hybrid systems. **(8)**

(b) Discuss the classification of Neuro-Fuzzy Hybrid System. **(6)**

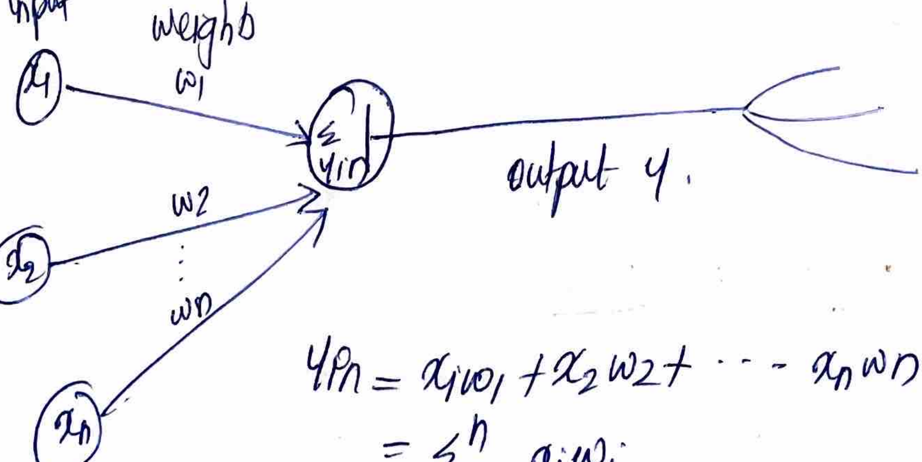
1. Explain the architecture of simple Artificial neural network? Compare it with a biological neuron.

ans: human brain consist of large number of neurons. a biological neuron can be structured as:



consists of 3 parts:

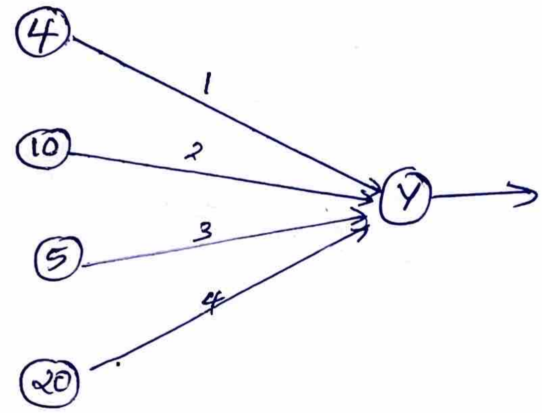
- cell body (soma): where cell neucleus is located
- dendrite: where nerve is connected to cell body.
- Axon - which carries impulse of neuron



$$y_{in} = x_1w_1 + x_2w_2 + \cdots x_nw_n$$
$$= \sum_{i=1}^{n} x_iw_i$$

2) A 4 input neuron has weights 1, 2, 3, and 4. The transfer function is linear with the constant of proportionality being equal to 2. The inputs are 4, 10, 5, and 20 respectively. Predict the output.

Ans)



~~Y_{in}~~ Weights = 1, 2, 3, 4

Inputs = 4, 10, 5, 20

constant of proportionality = 2

$$Y_{in} = (4 \times 1) + (10 \times 2) + (5 \times 3) + (20 \times 4)$$

$$= 119$$

$$\text{output} = 2 \times Y_{in}$$

$$= 2 \times 119 = \underline{\underline{238}}$$

3. Explain the widrow hoff learning rule for supervised learning in neural networks with the help of an example. Why is it sometimes called the LMS learning rule.

Ans: The Widrow-Hoff learning rule, also known as the Least Mean Squares (LMS) learning rule, is a widely used algorithm for training neural networks in supervised learning tasks. It is a gradient descent-based method that adjust the weight of the network to minimize the mean squared error between the predicted output and desired output.

Example,

Implement OR function with bipolar input and target value using adaline network,

x_1	x_2	t
1	1	1
1	-1	1
-1	1	1
-1	-1	-1

$$y_{in} = b + w_1 x_1 + w_2 x_2$$
$$w_i(new) = w_i(old) + \alpha(t - y_{in})x_i$$
$$b_i(new) = b(old) + \alpha(t - y_{in})$$
$$\text{Error}, E_i = \sum (t - y_{in})^2$$

x_1	x_2	t	y_{in}	$t-y_{in}$	w_1	w_2	b	$(t-y_{in})^2$	MSE
1	1	1	0.3	0.7	0.17	0.17	0.17	0.49	3.02
1	-1	1	0.17	0.83	0.253	0.087	0.253	0.69	
-1	1	1	0.087	0.913	0.1617	0.1783	0.343	0.83	
-1	-1	-1	0.0043	-1.0043	0.2021	0.2787	0.243	1.01	

In the next epoch the mean error, become less than first epoch.

Q.4) Implement one epoch of Adaline algorithm for AND logic function with binary inputs & bipolar outputs. Initial weights are $w1 = 0.2$, $w2 = 0.1$ and learning rate parameter $\eta = 0.2$.

Answer) Initially, $w_1 = 0.2$, $w_2 = 0.1$, $b = 0.1$

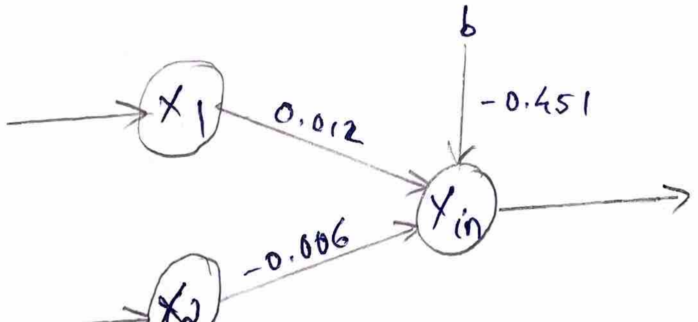
and $\alpha = 0.2$

then, $y_{in} = b + \sum x_i \cdot w_i$

$w_i(new) = w_i(old) + \alpha(t - y_{in})x_i$

$b_i(new) = b_i(old) + \alpha(t - y_{in})$

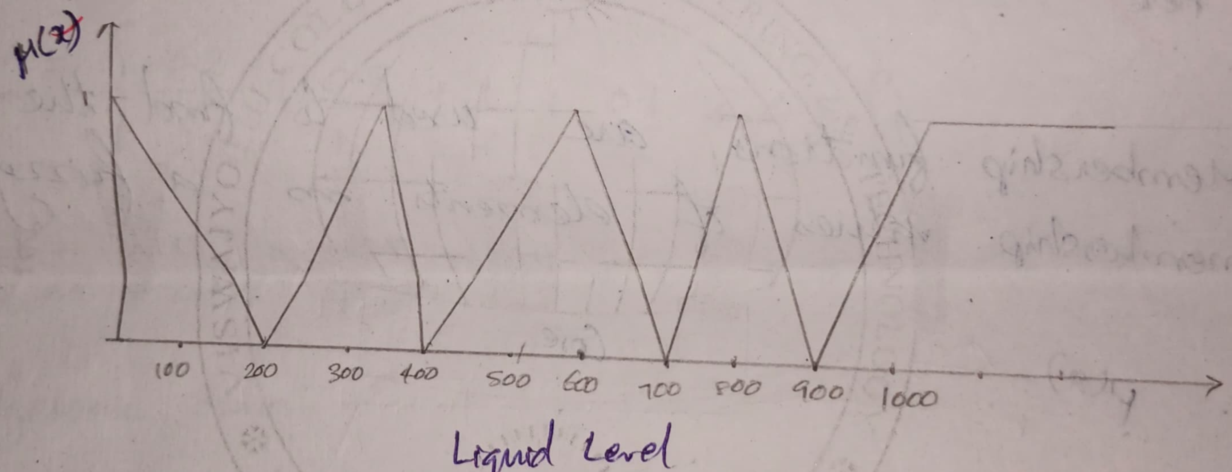
x_1	x_2	t	y_{in}	$t - y_{in}$	$(t-y_{in})^2$	w_1	w_2	b	MSE
1	1	1	0.4	0.6	0.36	0.32	0.22	0.22	
1	0	-1	0.54	-1.54	2.37	0.012	0.22	-0.088	4.48
0	1	-1	0.132	-1.132	1.28	0.012	-0.006	-0.314	
0	0	-1	-0.314	-0.686	0.47	0.012	-0.006	-0.451	



5

1) Assume that the tank has a capacity of 1000L.

	Liquid Level
Empty (E)	0-200L
Very Less (VL)	200-400L
Less (L)	400-700L
Full (F)	700-900L
Very Full (VF)	>900 L



6 $\underset{\sim}{A} = \left\{ \frac{0.2}{0} + \frac{0.3}{1} + \frac{1}{2} + \frac{0.1}{3} + \frac{0.5}{4} \right\}$

$\underset{\sim}{B} = \left\{ \frac{0.1}{0} + \frac{0.25}{1} + \frac{0.9}{2} + \frac{0.7}{3} + \frac{0.3}{4} \right\}$

(a) Algebraic Sum

$$\underset{\sim}{A} + \underset{\sim}{B} = \{ \mu_{\underset{\sim}{A}}(x) + \mu_{\underset{\sim}{B}}(x) - \mu_{\underset{\sim}{A}}(x) * \mu_{\underset{\sim}{B}}(x) \}$$

$$= \left\{ \frac{0.28}{0} + \frac{0.475}{1} + \frac{1}{2} + \frac{0.73}{3} + \frac{0.65}{4} \right\}$$

(b) Algebraic product

$$\underset{\sim}{A} \cdot \underset{\sim}{B} = \{ \mu_{\underset{\sim}{A}}(x) \cdot \mu_{\underset{\sim}{B}}(x) \}$$

$$= \left\{ \frac{0.02}{0} + \frac{0.075}{1} + \frac{0.9}{2} + \frac{0.07}{3} + \frac{0.15}{4} \right\}$$

(c) Bounded sum

$$\underset{\sim}{A} \oplus \underset{\sim}{B} = \min\left[1, \mu_{\underset{\sim}{A}}(x) + \mu_{\underset{\sim}{B}}(x)\right]$$

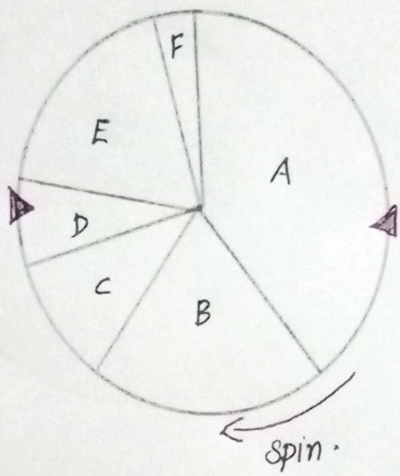
$$= \left\{ \frac{0.3}{0} + \frac{0.55}{1} + \frac{1}{2} + \frac{0.8}{3} + \frac{0.8}{4} \right\}$$

7) Explain Stochastic Universal Sampling with an example.

ans) Stochastic Universal Sampling is quite similar to Roulette wheel
* selection, however instead of having just one fixed point, we have multiple fixed points as shown in the image.

* Therefore, all the parents are chosen in just one spin of the wheel

* Also, such a step encourages the highly fit individuals to be chosen at least once.



Chromosome	Fitness Value
A	8.2
B	3.2
C	1.4
D	1.2
E	4.2
F	0.3

8) Explain any two mutation methods.

* Flipping

~~Fill~~ Flipping of a bit involves changing 0 to 1 and 1 to 0 based on a mutation chromosome generated. A parent is considered and a mutation chromosome is randomly generated.

Parent 1 0 1 1 0 1 0 1

Mutation chromosome 1 0 0 0 1 0 0 1

child 0 0 1 1 1 1 0 0

0 0 1 $\boxed{1}$ 0 1 0 0 1 0 $\Longrightarrow$ 0 0 1 $\boxed{0}$ 0 1 0 0 1 0

* Reversing.

A random position is chosen and the bits next to that position are reversed and child chromosome is produced.

Parent : 1 0 1 1 0 1 0 1

child : 1 0 1 1 0 1 1 0

0 1 $\boxed{2}\boxed{3}\boxed{4}\boxed{5}\boxed{6}$ 7 8 9 $\Longrightarrow$ 0 1 $\boxed{6}\boxed{5}\boxed{4}\boxed{3}\boxed{2}$ 7 8 9

9 Differentiate between linear and non-linear multi objective optimization problems.

Linear Multi Objective Optimization Problems:

Both the objective functions and constraints are linear. The goal is to find the set of optimal solutions that simultaneously minimize or maximize multiple linear objective functions, subject to linear constraints. The solution space forms a convex polyhedron and the Pareto frontier lies on the edges and vertices of this polyhedron.

Non-Linear Multi Objective Optimization Problems

At least one of the objective functions or constraints is non-linear. The objective functions and constraints may involve non linear equations, inequalities or both. The solution space may exhibit non-convexity and the Pareto frontier may contain curved or discontinuous regions.

10Q. What are the characteristics of neuro fuzzy hybrid systems?

A neuro fuzzy hybrid system (or fuzzy neural hybrid) is a learning mechanism that utilizes the training and learning algorithms from neural networks to find parameters of a fuzzy system.

- It can handle any kind of information (neumeric, linguistic, logical etc)
- It can manage imprecise, partial, vague or imperfect information
- It can resolve conflicts by collaborations and aggregation
- It has self-learning, self-organizing and self-tuning capabilities
- It doesnt need prior knowledge of relationships data

11a Implement XOR function using M-P Neuron model (with binary input). Why MP-neuron is widely used in processing binary data?

MP neuron model is used due to its simplicity and ability to represent binary logic functions. Some of the reasons include:

- Binary representation
- Simplified model
- Logical interpretability
- Boolean logic functions
- Classification tasks
- Computationally efficient
- Learning rules

XOR

x_1	x_2	y
1	1	0
1	0	1
0	1	1
0	0	0

XOR function can't be represented by simple and single logic functions. It is represented as $y = x_1\bar{x}_2 + \bar{x}_1 x_2$

$= z_1 + z_2$ where $z_1 = x_1\bar{x}_2$

$z_2 = \bar{x}_1 x_2$

$z_1 = x_1 \bar{x_2}$

x_1	x_2	y
0	0	0
0	1	0
1	0	1
1	1	0

Assume $w_{11} = 1$, $w_{21} = -1$

$(0,0)$ $z_{in} = 0$

$(0,1)$ $z_{in} = -1$

$(1,0)$ $z_{in} = 1$

$(1,1)$ $z_{in} = 0$

$$f(y_{in}) = \begin{cases} 1 & \text{if } y_{in} \geq \theta \\ 0 & \text{if } y_{in} < \theta \end{cases}, \text{ where } \theta = 1$$

$z_2 = \bar{x_1} x_2$

x_1	x_2	y
0	0	0
0	1	1
1	0	0
1	1	0

Assume $w_{12} = -1$, $w_{22} = 1$

$(0,0)$ $z_{in} = 0$

$(0,1)$ $z_{in} = 1$

$(1,0)$ $z_{in} = -1$

$(1,1)$ $z_{in} = 0$

$$f(y_{in}) = \begin{cases} 1, & \text{if } y_{in} \geq \theta \\ 0 & \text{if } y_{in} < \theta \end{cases}$$

where $\theta = 1$

$y = z_1 + z_2$

z_1	z_2	y
0	0	0
0	1	1
1	0	1
0	0	0

Assume $v_1 = 1$ & $v_2 = 1$

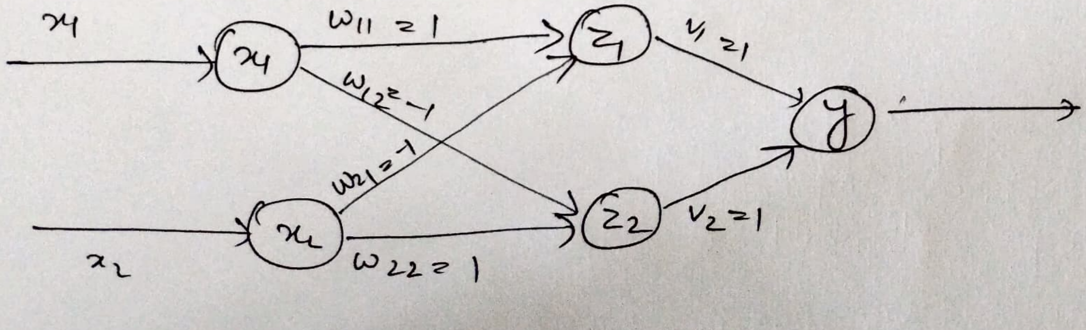
$(0,0)$ $y_{in} = 0$

$(0,1)$ $y_{in} = 1$

$(1,0)$ $y_{in} = 1$

$(1,1)$ $y_{in} = 0$

$$f(y_{in}) = \begin{cases} 1, & \text{if } y_{in} \geq \theta \\ 0, & \text{if } y_{in} < \theta \end{cases} \text{ with } \theta = 1$$



11. b.) Using Hebb Network calculate the weight required to perform the following classification of given input pattern

L belongs to the members of the class(+) target value +1

V does not belongs to members of class (.) target value -1

+	.	.
+	.	.
+	+	+

L

+	.	+
+	.	+
+	+	+

V

ans: ~~Arranging~~ The input pattern

Pattern	Inputs										Target
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	b	y
L	1	-1	-1	1	-1	-1	1	1	1	1	1
V	1	-1	1	1	-1	1	1	1	1	1	-1

$w_1 = w_2 = w_3 = w_4 = w_5 = w_6 = w_7 = w_8 = w_9 = b = 0$

Applying Hebb rule, $w_i(new) = w_i(old) + x_i y$

Pattern L

$w_1(new) = 0 + 1 \times 1 = 1$

$w_2(new) = 0 + -1 \times 1 = -1$

$w_3(new) = 0 + -1 \times 1 = -1$

$w_4(new) = 0 + 1 \times 1 = 1$

$w_5(new) = 0 + -1 \times 1 = -1$

$w_6(new) = 0 + -1 \times 1 = -1$

$w_7(new) = 0 + 1 \times 1 = 1$

$w_8(new) = 0 + 1 \times 1 = 1$

$w_9(new) = 0 + 1 \times 1 = 1$

$b(new) = 0 + 1 \times 1 = 1$

Pattern U

$w_1(new) = 1 + 1 \times -1 = 0$

$w_2(new) = -1 + -1 \times -1 = 0$

$w_3(new) = -1 + 1 \times -1 = -2$

$w_4(new) = 1 + 1 \times -1 = 0$

$w_5(new) = -1 + -1 \times -1 = 0$

$w_6(new) = -1 + 1 \times -1 = -2$

$w_7(new) = 1 + 1 \times -1 = 0$

$w_8(new) = 1 + 1 \times -1 = 0$

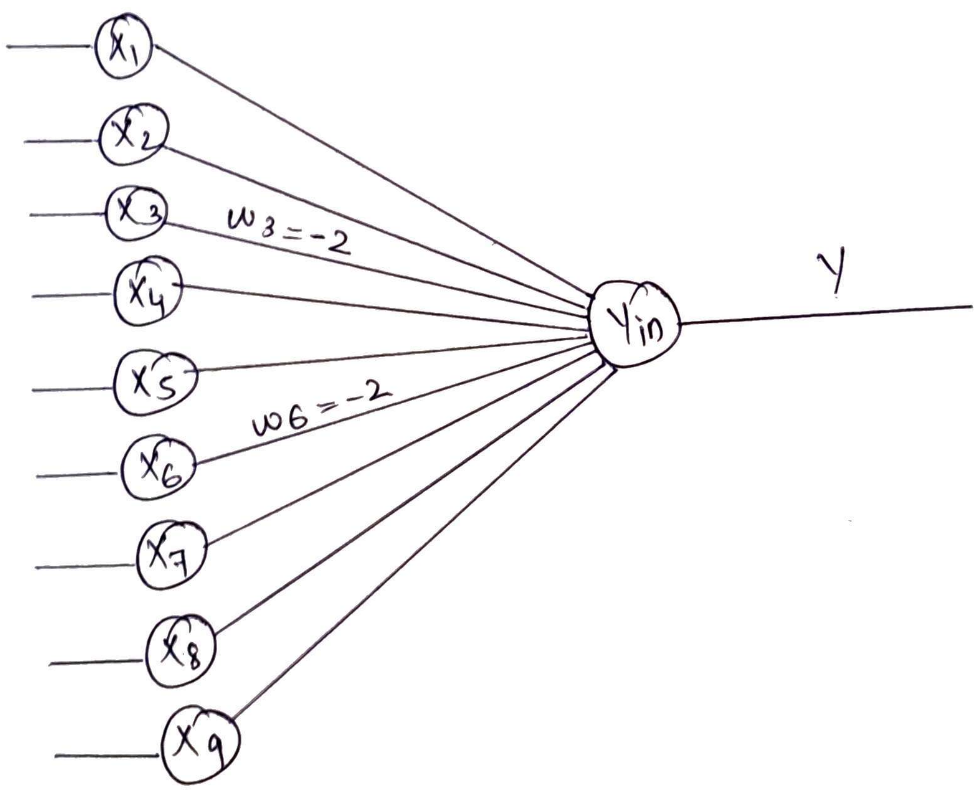
$w_9(new) = 1 + 1 \times -1 = 0$

$b(new) = 1 + 1 \times -1 = 0$

So the final weights are:

Pattern	Inputs										Target	Weights									
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	b	y	w_1	w_2	w_3	w_4	w_5	w_6	w_7	w_8	w_9	b
L	1	-1	-1	1	-1	-1	1	1	1	1	1	1	-1	-1	1	-1	-1	1	1	1	1
U	1	-1	1	1	-1	1	1	1	1	1	-1	0	0	-2	0	0	-2	0	0	0	0

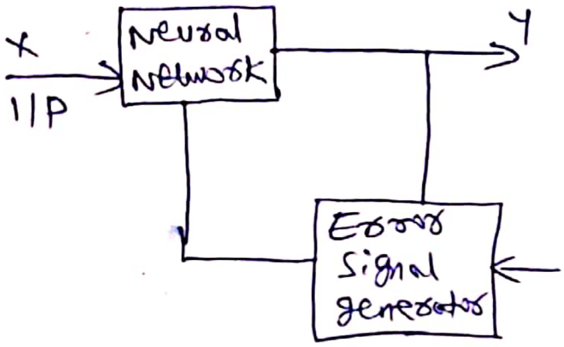
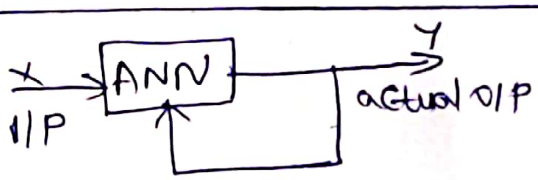
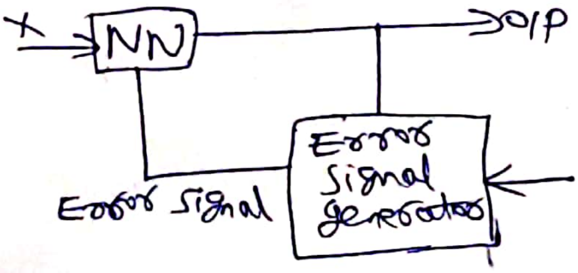
Hebb network



12

Q) Compare the three learning approaches in Artificial Neural Network. How is the critic information used in learning process.

ans:-

Supervised		The ANN is trained using labeled Data, where the input is presented along with the desired output.
Unsupervised		The ANN learns to identify the Patterns or Structures in the input data without labeled examples.
Reinforcement Network		The ANN learns to interact with an environment and receives feedback in the form of rewards or Penalties, based on its action.

* In Supervised learning, unlabeled data is not used directly. Also it does not utilize the explicit feedback or reward as the desired O/P

unknown in advance.

* Unsupervised learning does not employ explicit feedback or rewards during the learning process. The learning object is usually defined based on unsupervised criterias.

2) Define Hebb law. Design a Hebb Network to implement logical AND function. Use bipolar input and targets.

ans:- * Hebb or Hebbian learning rule comes under Artificial Neural Network (ANN) which is an architecture of a large number of interconnected elements called neurons.

* These neurons process the input to received to give the desired output.

* The nodes are linked with inputs $(x_1, x_2, \ldots x_n)$ connection weights $(w_1, w_2, \ldots, w_n)$ and activation functions (a function that defines the output of a node).

* Updates weight and bias.

$$\boxed{\begin{aligned} w_i(new) &= w_i(old) + x_i \cdot y \\ b(new) &= b(old) + y \end{aligned}}$$

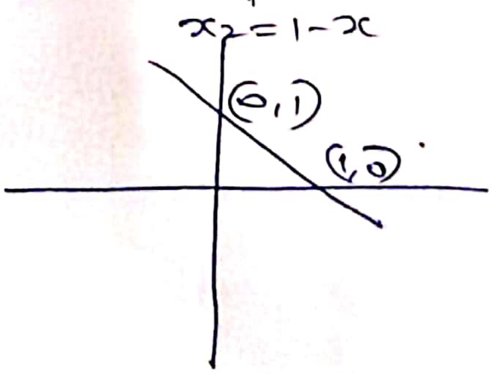
x_1	x_2	b	y
1	1	1	1
1	-1	1	-1
-1	1	1	-1
-1	-1	1	-1

$w_i(new) = w_i(old) + x_i y$

$b(new) = b(old) + y$

$w_1 = 0, \; w_2 = 0, \; b = 0.$

x_1	x_2	b	y	w_1	w_2	b
1	1	1	1	1	1	1
1	-1	1	-1	0	2	0
-1	1	1	-1	1	1	-1
-1	-1	1	-1	2	2	-2



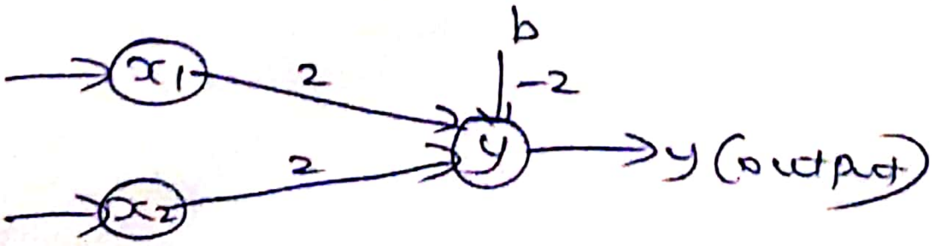
$$x_2 = -\frac{w_1}{w_2} \cdot x_1 - \frac{b}{w_2}$$

$1,1,1 \Rightarrow x_2 = -x_1 - 1$

$0,2,0 \Rightarrow x_2 = 0$

$1,1,-1 \Rightarrow x_2 = -x_1 + 1$

$2,2,-2 \Rightarrow x_2 = -x_1 + 1$



13(a) Discuss the training algorithm and explain the weight updates in back propagation networks.

(b) Implement one epoch of Perceptron training algorithm for OR logic function with binary input and bipolar output

Answer

(a) step 0 : Initialize weights

step 1 : While stopping condition is false, do steps 2 to 9

step 2 : For each training pair, do steps 3-8

Feed forward

step 3 : Input unit recieves input signal and propagates it to all units in the hidden layer

step 4 : Each hidden unit sum its weighted input signals

step 5 : Each output unit sums its weighted input signals and applied its activation function to compute its output signal

Back Propagation

step 6 : Each output unit receives a target pattern corresponding to the input training pattern, computes its error information term

$$\delta_k = (t_k - y_k) f'(y_{-ink})$$

calculates its bias correction term

$$\Delta w_{0k} = \alpha \delta_k$$

And sends δ_k to units in the layer below step 7 : Each hidden unit sums its delta inputs

$$\delta\_in_j = \sum_{k=1}^{m} \delta_k w_{jk}$$

Multiplies by the derivative of its activation function to calculate its error information term

$$\delta_j = \delta\_in_j f'(z\_in_j)$$

calculates its weight correction term $\Delta v_{ij} = \alpha \delta_j x_i$

And calculates its bias correction term $\Delta v_{0j} = \alpha \delta_j$

Update weights and biases

step 8 : Each output unit updates its bias and weights

$$w_{jk}(new) = w_{jk}(old) + \Delta w_{jk}$$

Each hidden unit updates its bias and weights

$$v_{ij}(new) = v_{ij}(old) + \Delta v_{ij}$$

step 9 : Test stopping condition. The stopping condition may be certain number of epochs reached or when the actual output equal to target value

(b) <u>OR</u>

x_1	x_2	t
0	0	-1
0	1	1
1	0	1
1	1	1

Assume,

$b = w_1 = w_2 = 0 \qquad \theta = 0$

$\alpha = 1 \qquad (0 < \alpha < 1)$

$y_{in} = b + x_1 w_1 + x_2 w_2$

$$y = f(y_{in}) \cdot \cdot \begin{cases} 1 & \text{if } y_{in} > 0 \\ 0 & \text{if } y_{in} = 0 \\ -1 & \text{if } y_{in} < 0 \end{cases}$$

If $y \neq t$ then $w_i(new) = w_i(old) + \alpha t x_i$

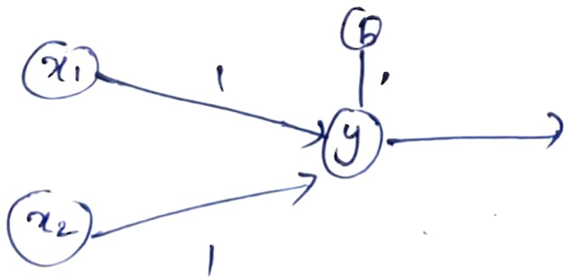
$b_i(new) = b_i(old) + \alpha t$

else $w_i(new) = w_i(old)$.

$b_i(new) = b_i(old)$

<u>1 epoch</u>

x_1	x_2	t	y_{in}	y	w_1	w_2	b
0	0	-1	0	0	0	0	-1
0	1	1	-1	-1	0	1	0
1	0	1	0	0	1	1	1
1	1	1	3	1	1	1	1



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Q.(a) Explain how synaptic weights are adapted iteration by iteration using error correction rule in perceptron convergence algorithm for an OR gate with bipolar inputs & outputs. Initial wts are all zero and learning rate parameter $\eta = 0.1$

(b) Explain Perceptron convergence theorm & discuss Perceptron algorithm based on XOR logic function

Ans: (a) x_1, x_2 : Input values
y : Desired output
w_1, w_2 : Weights
$\hat{y}$: Calculated output
e : Error
$\Delta w_1, \Delta w_2$: Weight updates
η : Learning rate (0.1)

Iteration	x_1	x_2	y	w_1	w_2	$\hat{y}$	e	Δw_1	Δw_2	New w_1	New w_2
1	-1	-1	-1	0	0	-1	0	0	0	0	0
2	-1	1	1	0	0	-1	2	-0.2	0.2	-0.2	0.2
3	1	-1	1	-0.2	0.2	-1	2	0.2	-0.2	0	0
4	1	1	1	0	0	-1	2	0.2	0.2	0.2	0.2

Iteration 1:
Input : (-1, -1)
Desired output : -1
Calculated o/p : $\hat{y} = \text{Sign}(w_1 x_1 + w_2 x_2) = \text{Sign}(0 * -1 + 0 * -1) = \underline{\underline{-1}}$
Error: $e = y - \hat{y} = -1 - (-1) = 0$
$\Delta w_1 = 0.1 * 0 * -1 = 0$
$\Delta w_2 = 0.1 * 0 * -1 = 0$

Updated wts, $w_1 = w_1 + \Delta w_1 = 0 + 0 = 0$
$w_2 = w_2 + \Delta w_2 = 0 + 0 = 0$

Iteration 2:
Input : $(-1, 1)$ Output : 1
$\hat{y} = \text{sign}(0 * -1 + 0 * 1) = -1$
$e = y - \hat{y} = 1 - (-1) = 2$
$\Delta w_1 = 0.1 * 2 * -1 = -0.2$ $\Delta w_2 = 0.1 * 2 * 1 = 0.2$
New wts, $w_1 = 0 + (-0.2) = -0.2$
$w_2 = 0 + 0.2 = 0.2$

Iteration 3:
Input : $(1, -1)$ Output : 1
$\hat{y} = \text{sign}((-0.2) * 1 + 0.2 * -1) = -1$
$e = y - \hat{y} = 1 - (-1) = 2$
$\Delta w_1 = 0.1 * 2 * 1 = 0.2$
$\Delta w_2 = 0.1 * 2 * -1 = -0.2$
New wts, $w_1 = (-0.2) + 0.2 = 0$ $w_2 = 0.2 + (-0.2) = 0$

Iteration 4:
Input : $(1, 1)$ Output : 1
$\hat{y} = \text{sign}(0 * 1 + 0 * 1) = -1$
$e = 1 - (-1) = 2$
$\Delta w_1 = 0.1 * 2 * 1 = 0.2$ $\Delta w_2 = 0.1 * 2 * 1 = 0.2$
New wts, $w_1 = 0 + 0.2 = 0.2$ $w_2 = 0 + 0.2 = 0.2$

(b) Perceptron Convergence Theorm : States that if the training data is linearly seperable, the Perceptron algorithm will find a seperating hyperlane in a finite number of iterations.

The theorm assumes the following:
→ Linear seperability : Training data perfectly seperated into two classes by a hyperlane in the input space

→ Learning rate: learning rate used in Perceptron algorithm Is fixed and positive. Determines step size for wt updates & control rate of convergence.

This theorm guarentees convergence by showing that the algorithm progresses towards finding a solution with each iteration.

Perceptron Algorithm based on XOR:

- The XOR logic function takes two binary i/p and return 1 if it the inputs are different and 0 if the i/p are same. The XOR function cannot be modeled accurately by a single perceptron because it is not linearly seperable.

The Perceptron algorithm works by iteratively adjusting the wts and bias based on the difference b/w the predicted o/p and target o/p. It aims to find a decision boundary that seperates the two classes. However, the XOR logic fn cannot be linearly seperated by a single perceptron since it requires a non-linear decision boundary.

15) a) $A = \left\{ \frac{0.1}{30}, \frac{0.2}{60}, \frac{0.3}{90}, \frac{0.4}{120} \right\}$

$B = \left\{ \frac{1}{1}, \frac{0.2}{2}, \frac{0.5}{3}, \frac{0.7}{4}, \frac{0.3}{5}, \frac{0}{6} \right\}$

$C = \left\{ \frac{0.33}{100}, \frac{0.65}{200}, \frac{0.92}{300}, \frac{0.21}{400} \right\}$

(i) $A \times B =$

$$\begin{array}{c|cccccc} & 1 & 2 & 3 & 4 & 5 & 6 \\ \hline 30 & .1 & .1 & .1 & .1 & .1 & 0 \\ 60 & .2 & .2 & .2 & .2 & .2 & 0 \\ 90 & .3 & .2 & .3 & .3 & .3 & 0 \\ 120 & .\overset{4}{\cancel{33}} & .\cancel{2}4 & .4 & .4 & .3 & 0 \end{array}$$

(ii) $B \times C =$

$$\begin{array}{c|cccc} & 100 & 200 & 300 & 400 \\ \hline 1 & .33 & .65 & .92 & .21 \\ 2 & .2 & .2 & .2 & .2 \\ 3 & .33 & .5 & .5 & .21 \\ 4 & .33 & .65 & .7 & .21 \\ 5 & .3 & .3 & .3 & .21 \\ 6 & 0 & 0 & 0 & 0 \end{array}$$

(iii) $T = R \circ S$

$$= \begin{array}{c|cccc} & 100 & 200 & 300 & 400 \\ \hline 30 & .1 & .1 & .1 & .1 \\ 60 & .2 & .2 & .2 & .2 \\ 90 & .3 & .3 & .3 & .21 \\ 120 & .33 & .4 & .4 & .21 \end{array}$$

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(IV) $T = R \circ S$

$$= \begin{array}{c|cccc} & 100 & 200 & 300 & 400 \\ \hline 30 & .033 & .055 & .092 & .021 \\ 60 & .066 & .13 & .184 & .042 \\ 90 & .099 & .195 & .276 & .063 \\ 120 & .132 & .26 & .368 & .084 \end{array}$$

15.b) For the fuzzy sets given $A=\left\{\frac{0.5}{x_1}+\frac{0.2}{x_2}+\frac{0.9}{x_3}\right\}$ & $B=\left\{\frac{1}{y_1}+\frac{}{y_2}+\frac{}{y_3}\right\}$. Find Relation R by performing Cartesian Product over given fuzzy sets.

Ans :-

$$A=\left\{\frac{0.5}{x_1},\frac{0.2}{x_2},\frac{0.4}{x_3}\right\} \qquad B=\left\{\frac{1}{y_1}+\frac{0.5}{y_2}+\frac{1}{y_3}\right\}$$

$$\tilde{R}=\tilde{A}\times\tilde{B} \Rightarrow \mu_{(\tilde{A}\times\tilde{B})}=\min(\mu_{\tilde{A}},\mu_{\tilde{B}})$$

$$= \begin{array}{c c} & \begin{array}{ccc} y_1 & y_2 & y_3 \end{array} \\ \begin{array}{c} x_1 \\ x_2 \\ x_3 \end{array} & \begin{bmatrix} 0.5 & 0.5 & 0.5 \\ 0.2 & 0.2 & 0.2 \\ 0.9 & 0.5 & 0.9 \end{bmatrix} \end{array} = \underline{\underline{\tilde{R}}}$$

16) Using inference approach find the membership values for each of the triangular shapes (I, R, IR, T) for a triangle with angles $120^\circ, 50^\circ, 10^\circ$.

$A > B > C$.

$A = 120^\circ \quad B = 50^\circ \quad C = 10^\circ$

1) Isosceles. $\mu_I(A,B,C) = 1 - \frac{1}{60}\min(A-B, B-C)$

$\mu_I(120, 450, 10) = 1 - \frac{1}{60}\min(70, 40)$

$= 0.333$

2) Right triangle $\mu_R(AB, C) = 1 - \frac{1}{90}|A-90|$

$\mu_R(120, 50, 10) = 1 - \frac{1}{90}|120-90|$

$= 0.666$

IR). Isosceles and Right

$\mu_{IR}(A,B,C) = 1 - \max\left[\frac{1}{60}\min(A-B, B-C), \frac{1}{90}|A-90|\right]$

$\mu_{IR}(120, 50, 10) = 1 - \max\left[\frac{40}{60}, \frac{30}{90}\right]$

$= 1 - \frac{2}{3} = 0.333$

Other triangles $\mu_T(A,B,C) = \frac{1}{180} \min(3(A-B), 3(B-C), 2|A-90|, A-C)$

$$\mu_T(120, 50, 10) = \frac{1}{180} \min(210, 120, 60, 110)$$

$$= \frac{1}{180} \times 60 = \frac{1}{3}$$

$$= 0.333$$

16 b. Using Zadeh's notation, determine the λ-cut set for the given fuzzy sets:

$$S_1 = \left\{ \frac{0}{0} + \frac{.5}{20} + \frac{.65}{40} + \frac{.85}{60} + \frac{1.0}{80} + \frac{1.0}{100} \right\}$$

$$S_2 = \left\{ \frac{0}{0} + \frac{.45}{20} + \frac{.6}{40} + \frac{.8}{60} + \frac{.95}{80} + \frac{1.0}{100} \right\}$$

Express the following for $\lambda = 0.5$,

a) $S_1 \cup S_2$ b) $\bar{S}_2$ c) $S_1 \cap S_2$

a) $\underset{\sim}{S_1} \cup \underset{\sim}{S_2} = \max\left[\mu_{\underset{\sim}{S_1}}(x), \mu_{\underset{\sim}{S_2}}(x)\right]$

$$= \left\{ \frac{0}{0} + \frac{.5}{20} + \frac{.65}{40} + \frac{.85}{60} + \frac{1.0}{80} + \frac{1.0}{100} \right\}$$

$$(S_1 \cup S_2)_{0.5} = \left\{ \frac{0}{0} + \frac{1}{20} + \frac{1}{40} + \frac{1}{60} + \frac{1}{80} + \frac{1}{100} \right\}$$

Cut set $= \{20, 40, 60, 80, 100\}$

b) $\bar{S}_2 = 1 - \mu_{\underset{\sim}{S_2}}(x)$

$$= \left\{ \frac{1}{0} + \frac{.55}{20} + \frac{.4}{40} + \frac{.2}{60} + \frac{.05}{80} + \frac{0}{100} \right\}$$

$$(\bar{S}_2)_{0.5} = \left\{ \frac{1}{0} + \frac{1}{20} + \frac{0}{40} + \frac{0}{60} + \frac{0}{80} + \frac{0}{100} \right\}$$

$$\lambda \text{ set} = \{0, 20\}$$

c) $$\overline{\underset{\sim}{S_1} \cap \underset{\sim}{S_2}} = 1 - \mu_{\bar{S}_1 \cap \bar{S}_2}$$

$$S_1 \cap S_2 = \min \left[\mu_{S_1}(x), \mu_{S_2}(x) \right]$$

$$= \left\{ \frac{0}{0} + \frac{.45}{20} + \frac{.6}{40} + \frac{.8}{60} + \frac{.95}{80} + \frac{1.0}{100} \right\}$$

$$\overline{S_1 \cap S_2} = \left\{ \frac{1}{0} + \frac{.55}{20} + \frac{.4}{40} + \frac{.2}{60} + \frac{.05}{80} + \frac{0}{100} \right\}$$

$$(\overline{S_1 \cap S_2})_{0.5} = \left\{ \frac{1}{0} + \frac{1}{20} + \frac{0}{40} + \frac{0}{60} + \frac{0}{80} + \frac{0}{100} \right\}$$

$$\lambda \text{ set} = \{0, 20\}$$

17. a) Differentiate b/w value encoding and permutation encoding

b) Explain the stopping conditions for genetic algorithms

b) • Best individual: A best individual convergence criterion stops the search once the minimum fitness in the population drops below the convergence value. This brings the search to a transfer conclusion guaranteeing at least one good solution.

• Worst individual: worst individual terminates the search when the least fit individuals in the population have fitness less than the convergence criteria. This guarantees the entire population to be of minimum standard, although the best individual may not be significantly better than the worst. In this case, a stringent convergence value may never be met, in which case the search will terminate after the maximum has been exceeded.

• Sum of fitness: In this termination scheme, the search is considered to have satisfaction converged when the sum of the fitness in the entire population is less than or equal to the convergence value in the population record.

• Median Fitness: Here at least half of the individuals will be better than or equal to the convergence value, which should give a good range of solutions to choose from.

a) Permutation Encoding

Permutation encoding can be used in ordering problems, such as travelling salesman problem or task ordering problems.

In permutation encoding, every chromosome is a string of number that represent a position in a sequence.

chromosome A	1 5 3 2 6 4 7 9 8
chromosome B	8 5 6 7 2 3 1 4 9

Permutation encoding is useful for ordering problems. For some types of crossover and mutation corrections must be made to leave the chromosome consistent (i.e have real sequence in it) for some problems.

Example : Travelling salesman problem (TSP)

The problem: There are cities and given distance b/w them.

Travelling salesman has to visit all of them, but he doesnot want to travel more than necessary. Find a sequence of cities with a minimal travelled distance

Encoding : chromosome describes the order of cities, in which the salesman will visit them.

Value Encoding

Direct value encoding can be used in problems where some more complicated values such as real numbers are used. Use of binary encoding for this type of problems would be difficult.

In the value encoding, every chromosome is a sequence of some values. values can be anything connected to the problem, such as (real) numbers, chars or any objects

Chromosome A	1.2324 5.3243 0.4556 2.3293 2.4545
Chromosome B	ABDJEIFJDHDIERJFDLDFLFEGT
Chromosome C	(back), (back), (right), (forward), (left)

Value encoding is a good choice for some special problems. However, for this encoding it is often necessary to develop some new crossover and mutation specific for the problem

Example of problem: Finding weights for a neural network.

The problem: A neural network is given with defined architecture Find weights b/w neurons in the neural network to get the desired output from the network.

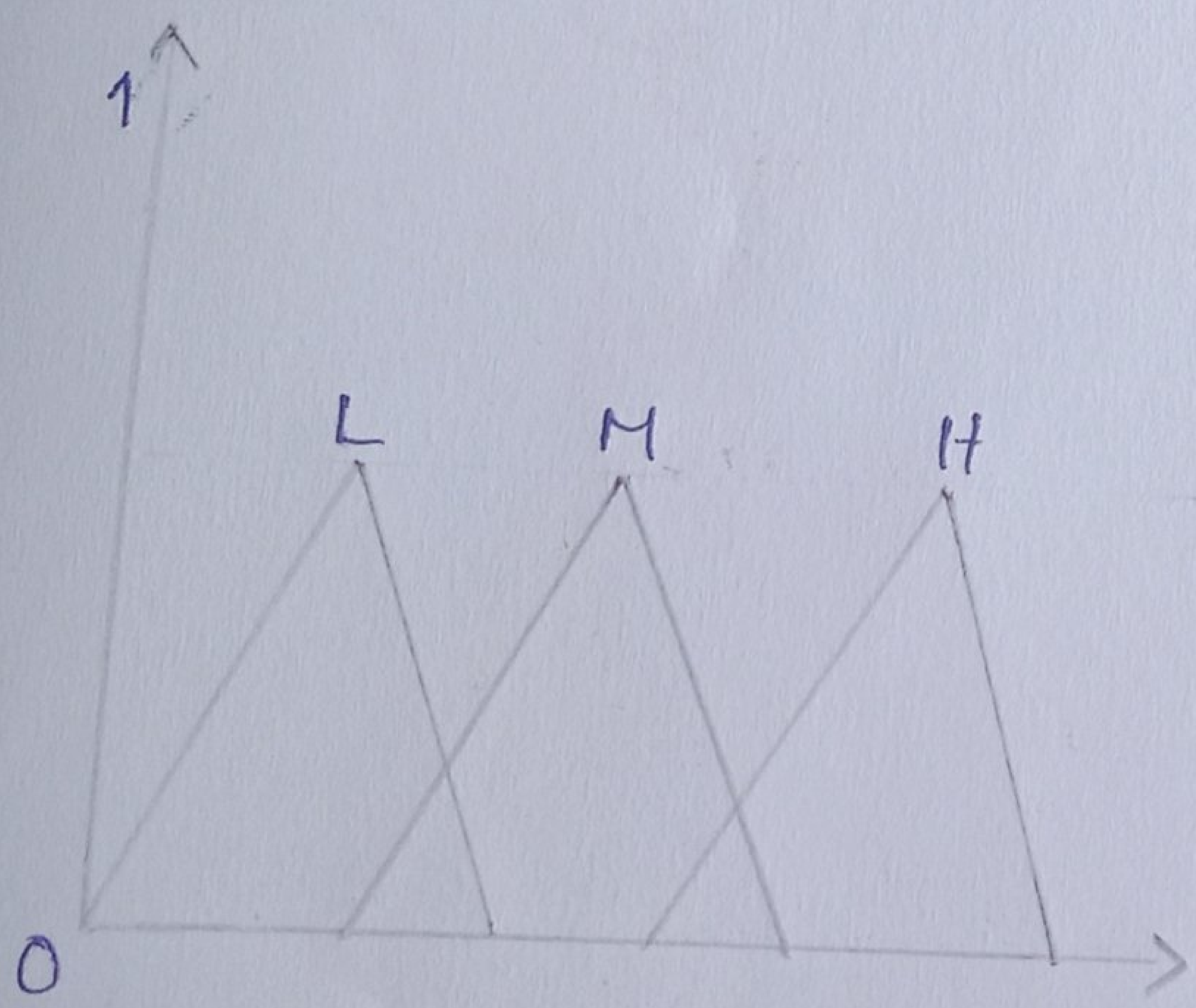
Encoding: Real values in chromosomes represent weights in the neural network.

Qn) 18 Apply Mamdani fuzzy model to design a controller to determine the wash time of a domestic washing machine. Assume input is dirt and grease of the cloth. Use three descriptors for input variable and five descriptors for output variables. Derive the set of rules for controller action and defuzzification. Design should be supported by figure wherever possible.

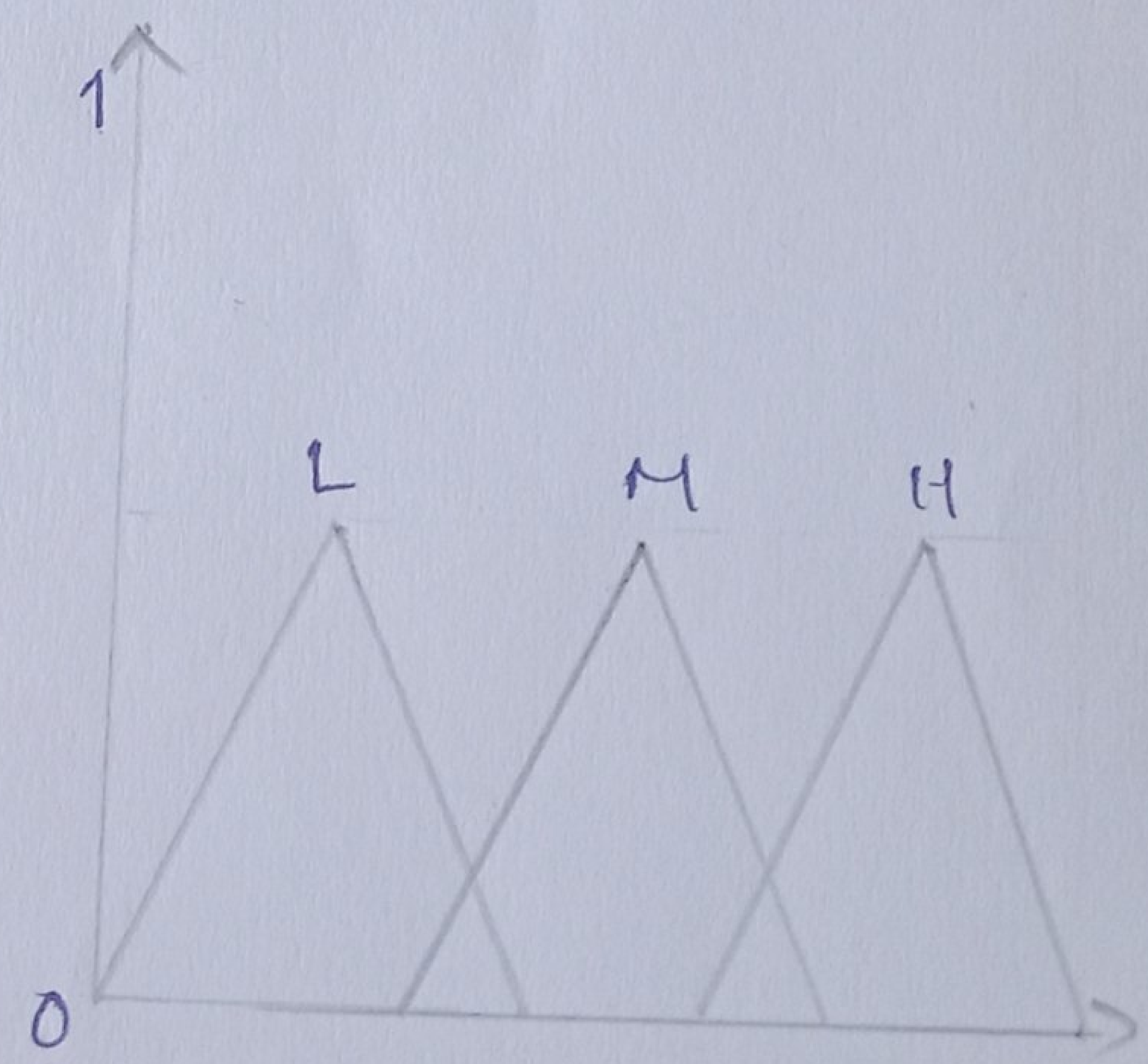
Ans: Input : Dirt and grease
[3 descriptors : Low , Medium, High]

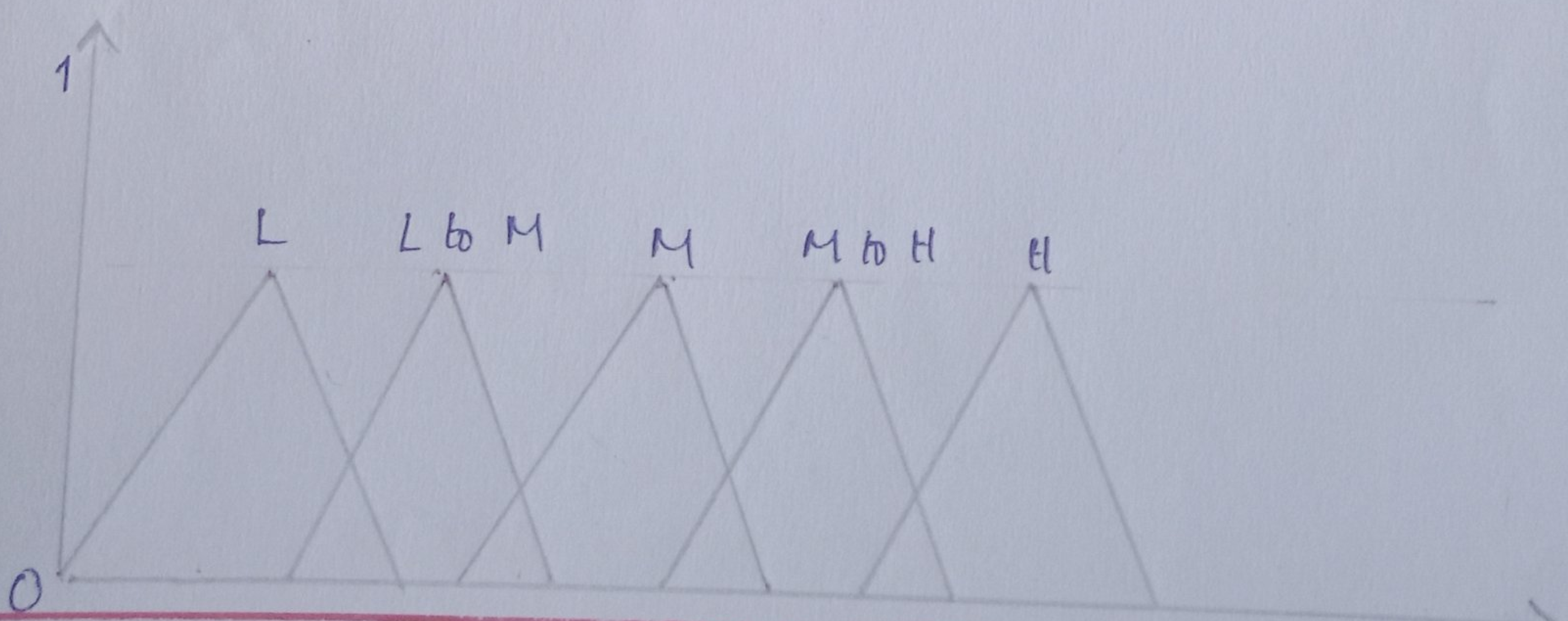
Output : Wash time (5 descriptors : Low, Low to Medium , Medium, Medium to High, High)

Dirt



Grease





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Rules.

① if dirt is low AND
Grease is low then wash time is Lo

② if dirt is low AND
Grease is Medium then wash time is L to M

③ if dirt is Medium AND
Grease is Medium then wash time is M.

④ if dirt is high AND
Grease is medium then wash time is
M to H.

⑤ if dirt is high AND
Grease is high then wash time is high (H)

Explain Single point crossover and two point crossover with example.

→ Single point crossover.

Single point crossover is a widely used genetic operator in evolutionary algorithms. It involves selecting a random crossover point along the chromosomes of 2 parent individuals and exchanging genetic material beyond that point to create offspring. The crossover point is usually determined by a randomly generated integer within the range of chromosome length.

Example.
Consider two parent individuals with binary chromosomes

Parents	10110 : 010 10101 : 111
Offsprings.	10110 : 111 10101 : 010

The genetic material beyond the crossover point is exchanged between the parents, resulting in 2 new offsprings.

Two point Crossover

Two point crossover is another commonly used genetic operator. It involves selecting two random crossover point along the chromosome of parent individuals and exchanging the genetic material between these points to create offspring. Similar to single point crossover, the crossover points are typically determined by randomly generated integers within the chromosome length.

Example.

Parent	0 1 2	3 4 5	6 7 8 9
	5 8 9	4 2 3	5 7 5 8
Offsprings	0 1 2	4 2 3	6 7 8 9
	5 8 9	3 4 5	5 7 5 8

The genetic material between the two crossover points is exchanged between the parents, resulting in 2 new offsprings. 4
The genetic material outside these points remains unaffected.

19. (a) Explain Convex and non-convex MOOP?

How to find a non dominated set.

Answer

- Multi-objective optimization problems involve more than one objective function that are to be minimized or maximized.
- Answer is set of solutions that define the best trade off between competing objectives.

Mathematically.

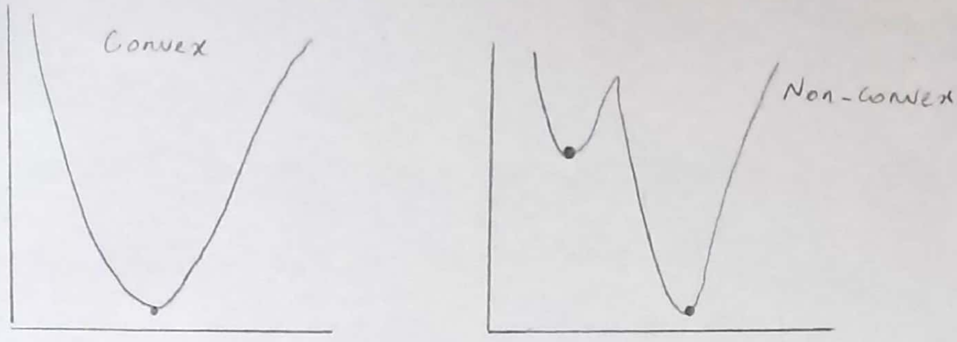
$$\min/\max f_m(x), \quad m = 1, 2, \ldots, M$$

$$\text{subject to } g_j(x) \geq 0, \quad j = 1, 2, \ldots, J$$

$$h_k(x) = 0, \quad k = 1, 2, \ldots K$$

$$\underbrace{x_i^{(L)}}_{\text{Lower bound}} \leq x_i \leq \underbrace{x_i^{(U)}}_{\text{upper bound}}, \quad i = 1, 2, \ldots n$$

MOOP is classified into two types



Convex and non convex functions

Non-Dominated set can be identified by kung's method.

Step 1 : Sort population in descending order of importance of the first objective function and name population as P.

Step 2 : Call recursive function Front (P)

Front (P)

```
IF |P| = 1,
   Return P
ELSE
   T = Front (P(1: [|P|/2]))
   B = Front (P([|P|/2 + 1] : |P|))
   IF the i-th non-domenated solution of B is not
   dominated by any non-dominated solution of T,
   M = T U {i}
   Return M
END
END
```

19.b) What are the properties of dominance relation?

Solution:

Dominance: In single objective optimization problem, the superiority of a solution over other solutions is easily determined by comparing their objective function values.
In multi-objective optimization problem, the goodness of a solution is determined by the dominance.

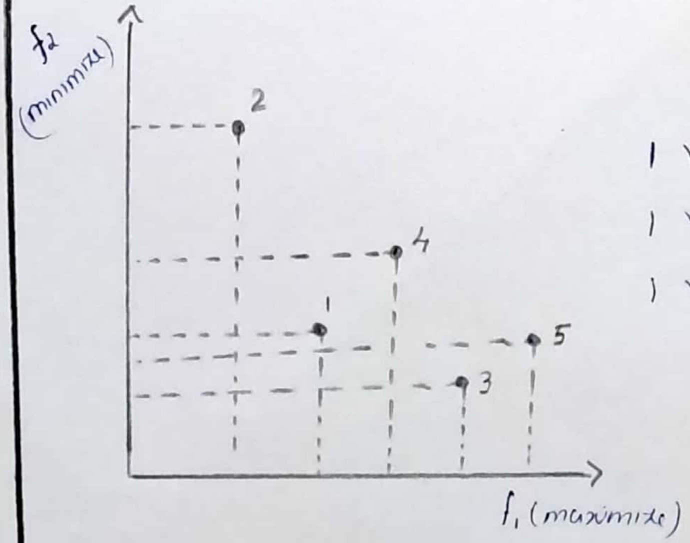
Dominance Test:

x_1 dominates x_2 if,

- Solution x_1 is no worse than x_2 in all objectives
- Solution x_1 is strictly better than x_2 in at least one objective.

x_1 dominates $x_2 \Longleftrightarrow x_2$ is dominated by x_1

Example of dominance test

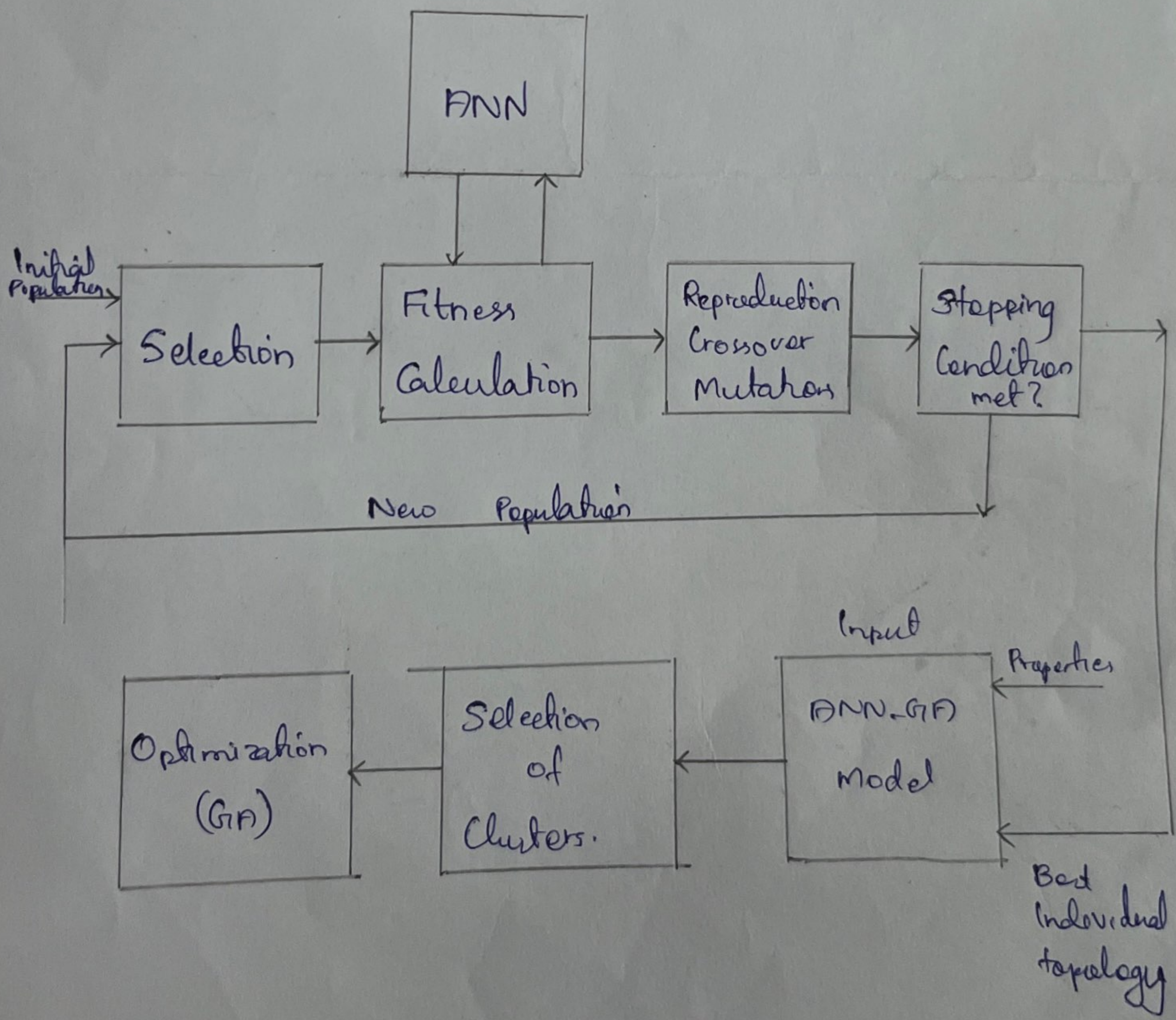


1 Vs 2: 1 dominates 2

1 Vs 5: 5 dominates 1

1 Vs 4: Neither solution dominates.

20 Genetic Neuro Hybrid System is one in which a neural network employs a genetic algorithm to optimize its structural parameters that define its architecture. In general neural networks and genetic algorithm refers to a different methodologies. Neural network learn and execute different task using examples, classify and model relationships. On the other hand genetic algorithm present themselves as a potential solution for the optimization of parameters



* The parameters of neural networks are encoded by genetic algorithms as a string of properties of network.

* Neural Network or GANN has the ability to locate the neighborhood of optimal solutions quickly, compared to other strategies.

* The steps in BPN Algorithm are;
  1) Coding
  2) Weight Extraction
  3) Fitness ~~Eval~~ Function
  4) Reproduction of Offspring
  5) Convergences.

Advantages

* GA performs optimization of neural network with simplicity, ease of operation and minimal requirements

* GA helps to find out complex structure of ANN. by using its learning rule as a fitness function.

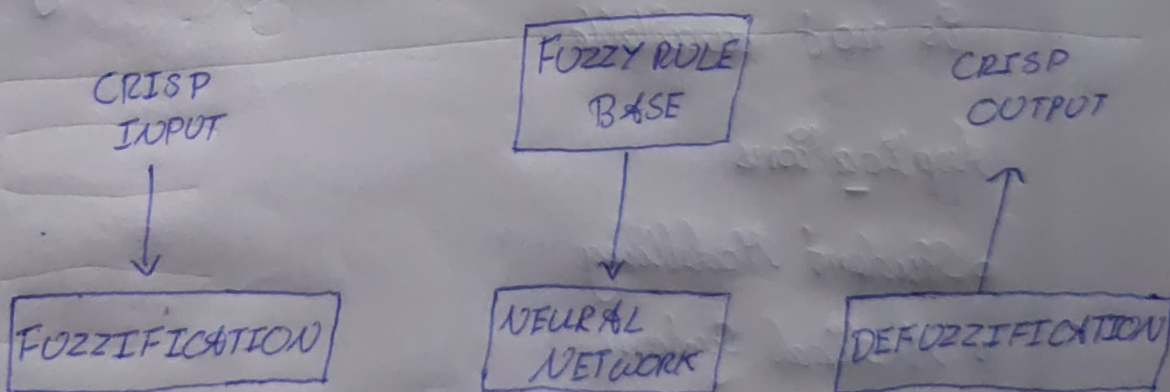
* Hybrid approach ensembles a powerful model that could significantly improve the predictability of the system under construction

20 b. Discuss the classification of Neuro-Fuzzy Hybrid system.

Answer

The Neuro-fuzzy system is based on fuzzy system which is trained on the basis of the working of neural network theory. The learning process operates only on the local information and causes only local changes in underlying fuzzy system. It can be seen as a 3-layer feedforward neural network.

- First layer - Input Variables
- Middle layer - Fuzzy rules
- Third layer - Output variables.



- In the input layer, each neuron transmits external crisp signals directly to next layer.
- Each fuzzification neuron receives a crisp input and determines the degree to which the input belongs.
- The fuzzy rule layer receives neurons that represent fuzzy sets.

- An output neuron combines all inputs using fuzzy operation UNION
- Each defuzzification neuron represents the single output of neuro-fuzzy system

Advantage

- It can handle numeric, linguistic etc. kind of information
- It has self-learning, self organizing and self-tuning capabilities
- It can mimic the human decision making process.

Disadvantage

- Hard to develop a model from fuzzy system
- Neural networks cannot be used if training data is not available.

Applications

- Student Modelling
- Medical System
- Traffic control systems.