Section-A

1.a: List any five applications of neural networks.

1. Face Recognition
2. Stock Market Prediction
3. Signature Verification and Handwriting recognition
4. Weather forecasting
5. Speech and Text Procesing

1.b: List any one real-life application for each of supervised learning, unsupervised learning and reinforcement learning techniques.

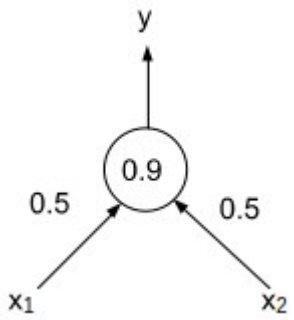
1. Supervised Learning – Face Recognition
2. Unsupervised Learning – Recommender System
3. Reinforced Learning – Autonomous Driving

1.c: How does the learning rate (α) and bias (b) parameter impact in artificial neural networks?

(a) Learning Rate: The learning rate controls how quickly the model is adapted to the problem. Smaller learning rates require more training epochs given the smaller changes made to the weights each update, whereas larger learning rates result in rapid changes and require fewer training epochs.

(b) bias: It is an additional parameter in the Neural Network which is used to adjust the output along with the weighted sum of the inputs to the neuron. Therefore Bias is a constant which helps the model in a way that it can fit best for the given data.

1.d: Compute the result Y of a single neuron when input $X_1 = X_2 = 1$ and threshold is 0.9 as given in figure below.



Answer: W1X1+W2X2= 1*0.5+1*0.5=1>0.9=1

1.e: Differentiate fuzzy set and crisp set with the help of example of each.

Crisp set defines the value is either 0 or 1. Fuzzy set defines the value between 0 and 1 including both 0 and 1.

It is also called a classical set. It specifies the degree to which something is true.

It shows full membership It shows partial membership.

Crisp Example: She is 18 years old Vs Fuzzy set example: Rahul is 1.6m tall

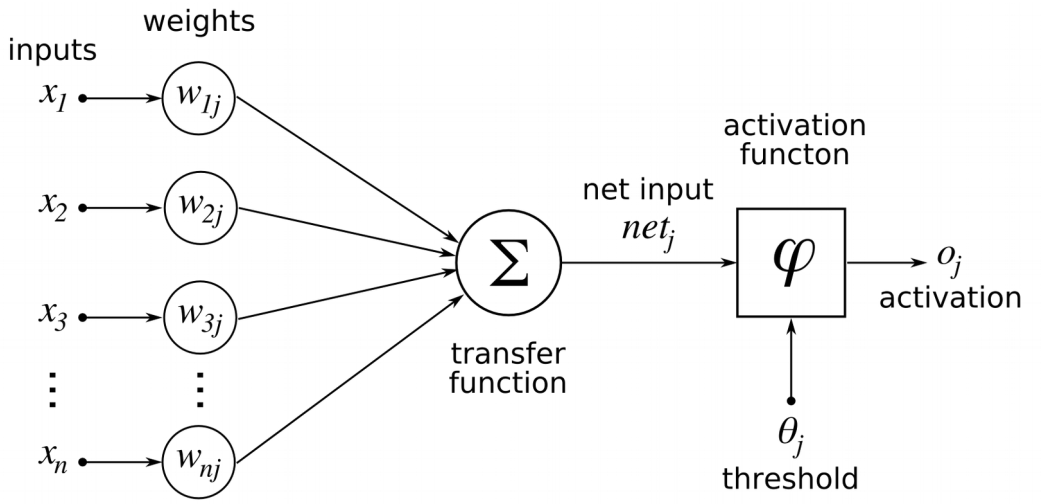
Crisp Example: She is about 18 years old.Vs Fuzzy set example: Rahul is about 1.6m tall.

Section-B

2.a: 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. Compute the output Y.

Answer: (1*4+2*10+3*5+4*20)*2=238

2.b Design a single artificial neuron model and explain each component with neat and clean diagram.



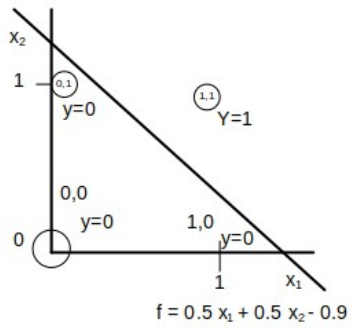
3.a Explain the concept of linearly seperable and linearly nonseperable tasks with the help of examples of AND and XOR problem.

x_1 Inputs x_2		Output (y)
0	0	0
0	1	0
1	0	0
1	1	1

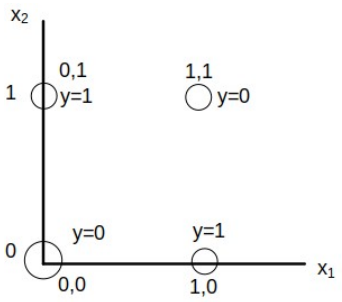
AND Problem

x_1	x_2	Output (y)
0	0	0
0	1	1
1	0	1
1	1	0

XOR Problem



AND-problem is linearly separable



XOR-problem is non-linearly separable

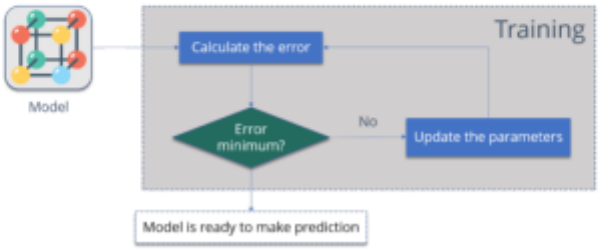
3.b Summarize the steps of backpropagation error correction method in multilayer feed forward network. Also explain the significance of gradient direction in order to optimize the loss function.

Answer: The positive gradient tells that error is increasing and we should move opposite towards the weights in order to minimize the error whereas the negative gradient tells that error is decreasing and continuin in the same direction could help us to find optimal weights.

Backpropagation is a supervised learning algorithm, for training Multi-layer Perceptrons (Artificial Neural Networks).
To summarize the steps:

1. Calculate the error – How far is your model output from the actual output.
2. Minimum Error – Check whether the error is minimized or not.
3. Update the parameters – If the error is huge then, update the parameters (weights and biases). After that again check the error. Repeat the process until the error becomes minimum.

Model is ready to make a prediction – Once the error becomes minimum, you can feed some inputs to your model and it will produce the output.



4.a: What are the advantages and disadvantages of fuzzy logic?

Answer:

Fuzzy Logic Advantages:

- Fuzzy logic is more likely to reflect real-world problems than classical logic.
- Fuzzy logic algorithms have lower hardware requirements than classical boolean logic.
- Fuzzy algorithms can produce accurate results with imprecise or inaccurate data.

Fuzzy Logic Disadvantages:

- Fuzzy algorithms require broad validation and verification.
- Fuzzy control system are dependent on human expertise and knowledge.

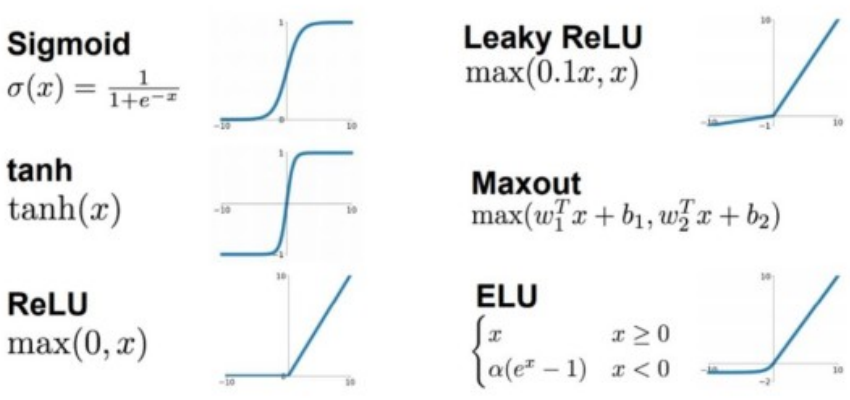
4.b: Differentiate fuzzyfication and defuzzification process with the help of an example..

Fuzzification: It is the method of transforming a crisp quantity(set) into a fuzzy quantity(set). This can be achieved by identifying the various known crisp and deterministic quantities as completely nondeterministic and quite uncertain in nature. This uncertainty may have emerged because of vagueness and imprecision which then lead the variables to be represented by a membership function as they can be fuzzy in nature. For example, when I say the temperature is 45° Celsius the viewer converts the crisp input value into a linguistic variable like favorable temperature for the human body, hot or cold.

Defuzzification: It is the inverse of fuzzification. The former one was used to convert the crisp results into fuzzy results but here the mapping is done to convert the fuzzy results into crisp results. This process is capable of generating a non-fuzzy control action which illustrates the possibility distribution of an inferred fuzzy control action. Defuzzification process can also be treated as the rounding off process, where fuzzy set having a group of membership values on the unit interval reduced to a single scalar quantity.

Section-C

5.a Define activation function and it's importance in Artificial neural network. Explain and illustrate any five activation function with their mathematical formula and plotting (Diagram).



Answer: Activation function decides, whether a neuron should be activated or not by calculating weighted sum and further adding bias with it. The purpose of the activation function is to introduce non-linearity into the output of a neuron.

5.b Calculate the weights of a single neural network which computes the following function. Construct the neural network and show the weight computations. The training set is given below:

	x_1	x_2	x_3	$o(x_1, x_2, x_3)$
1.	1	1	1	1
2.	1	1	0	1
3.	1	0	0	1
4.	0	1	1	0
5.	0	0	1	0
6.	0	1	0	0
7.	1	0	1	1

Answer: w1=w2=1, w3=0

6.a: Train a hetroassociative memory network using Hebb rule to store input row vector s=(s1,s2,s3,s4) to output row vector t=(t1,t2), the vector pair given in table bellow.

S1	S2	S3	S4	T1	T2
1	0	1	1	1	0
1	0	0	1	1	0
1	1	1	1	0	1
0	0	0	0	0	1

Inputs and Targest	s1	s2	s3	s4	t1	t2
1st	0	1	1	1	1	0
2nd	1	1	0	1	1	0
3rd	1	1	1	1	0	1
4th	0	1	0	0	0	1

Step 0: Initialize the weights by zero.

Step 1: For the first pair 0111: 10

Step 2: Update the weights: $w_{ij}(new) = w_{ij}(old) + x_i y_i$

Similarly, for 1st Input pair 1011:10			Similarly, for 3rd Input pair 1111: 01		
$w_{11}(new)=w_{11}(old)+x_1y_1=$	0+1*1=	1	$w_{11}(new)=w_{11}(old)+x_1y_1=$	0+1*0=	0
$w_{21}(new)=w_{21}(old)+x_2y_1=$	0+0*1=	0	$w_{21}(new)=w_{21}(old)+x_2y_1=$	0+1*0=	0
$w_{31}(new)=w_{31}(old)+x_3y_1=$	0+1*1=	1	$w_{31}(new)=w_{31}(old)+x_3y_1=$	0+1*0=	0
$w_{41}(new)=w_{41}(old)+x_4y_1=$	0+1*1=	1	$w_{41}(new)=w_{41}(old)+x_4y_1=$	0+1*0=	0
$w_{12}(new)=w_{12}(old)+x_1y_2=$	0+1*1=	1	$w_{12}(new)=w_{12}(old)+x_1y_2=$	0+1*1=	1
$w_{22}(new)=w_{22}(old)+x_2y_2=$	0+1*1=	1	$w_{22}(new)=w_{22}(old)+x_2y_2=$	0+1*1=	1
$w_{32}(new)=w_{32}(old)+x_3y_2=$	0+1*1=	1	$w_{32}(new)=w_{32}(old)+x_3y_2=$	0+1*1=	1
$w_{42}(new)=w_{42}(old)+x_4y_2=$	0+1*1=	1	$w_{42}(new)=w_{42}(old)+x_4y_2=$	0+1*1=	1
Similarly, for 2nd Input pair 1001:10			Similarly, for 4th Input pair 0000: 01		
$w_{11}(new)=w_{11}(old)+x_1y_1=$	0+1*1=	1	$w_{11}(new)=w_{11}(old)+x_1y_1=$	0+0*0=	0
$w_{21}(new)=w_{21}(old)+x_2y_1=$	0+0*1=	0	$w_{21}(new)=w_{21}(old)+x_2y_1=$	0+0*0=	0
$w_{31}(new)=w_{31}(old)+x_3y_1=$	0+0*1=	0	$w_{31}(new)=w_{31}(old)+x_3y_1=$	0+0*0=	0
$w_{41}(new)=w_{41}(old)+x_4y_1=$	0+1*1=	1	$w_{41}(new)=w_{41}(old)+x_4y_1=$	0+0*0=	0
$w_{12}(new)=w_{12}(old)+x_1y_2=$	0+1*0=	0	$w_{12}(new)=w_{12}(old)+x_1y_2=$	0+0*1=	0
$w_{22}(new)=w_{22}(old)+x_2y_2=$	0+0*0=	0	$w_{22}(new)=w_{22}(old)+x_2y_2=$	0+0*1=	0
$w_{32}(new)=w_{32}(old)+x_3y_2=$	0+0*0=	0	$w_{32}(new)=w_{32}(old)+x_3y_2=$	0+0*1=	0
$w_{42}(new)=w_{42}(old)+x_4y_2=$	0+1*0=	0	$w_{42}(new)=w_{42}(old)+x_4y_2=$	0+0*1=	0

Step 3: $\sum W_{ij}$

$W=$

w_{11}	w_{12}
w_{21}	w_{22}
w_{31}	w_{32}
w_{41}	w_{42}

$=$

2	2
0	2
1	2
2	2

6.b: What do you understand by the concept of computing? What are the charecteristics of hard and Soft Computing?

The concept of computing suggests that there should be a formal method or algorithm to solve a problem which could be represented as $Y=f(x)$, where f is a mapping function or formal method.

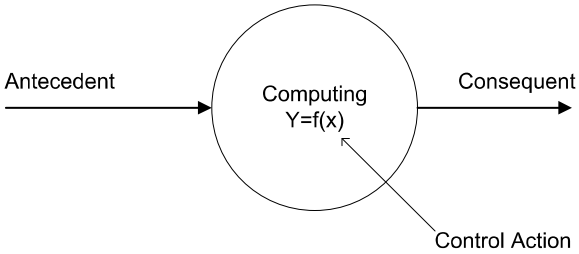


Figure: Concept of Computing

Hard Computing Charecteristics:

- Precise result is guaranteed.
- Control action is unambiguous.
- Control action is formally defined (i.e. with mathemetical model)

examples: Solving numerical problems. (root of polynomials, integration or differentiation), searching and sorting techniques etc.

Soft Computing Charecteristics:

- Doesn't require any mathemetical modelling of problem solving.
- It may not yield a precise solution. (Tolerance of imprecision)
- Algorithms are adaptive (can adjust to the change of dynamic environment: Robustness)
- Use some biological inspired methodologies such as genetics, evolutions, Ant's behavior, particle swarming, human nervous systems etc.

7.a For a given input vector X=[1,0,1,-1,2], weight vector W=[0,-1,-1,-1,1] and biase B=+2, computer the output of a single neuron having following activation function.
a) Linear b) threshold (0.5) c) Rectified Linear Unit (ReLU) d) sigmoid and e) tanh (tansigmoid).

Answer:

a) Linear or identity: 1*0+0*(-1)+ 1*(-1)+(-1)*(-1)+2*1+2=4

b) Threshold: 1*0+0*(-1)+ 1*(-1)+(-1)*(-1)+2*1+2= 4 > 0.5 ⇒ 1

c) ReLU: max ($w_i x_i$,0) ⇒ 1*0+0*(-1)+ 1*(-1)+(-1)*(-1)+2*1+2⇒4

d) sigmoid: sigmoid ⇒ 1 / 1+e^-x ⇒ 0.982

e) tanh: 0.999

7.b Train a hetroassociative memory network using Outer product rule to store input row vector s=(s1,s2,s3,s4) to output row vector t=(t1,t2), the vector pair given in table bellow.

S1	S2	S3	S4	T1	T2
1	0	1	1	1	0
1	0	0	1	1	0
1	1	1	1	0	1
0	0	0	0	0	1

Inputs and Targest	s1	s2	s3	s4	t1	t2
1st	1	0	1	1	1	0
2nd	1	0	0	1	1	0
3rd	1	1	1	1	0	1
4th	0	0	0	0	0	1

Step 1: Transpose the input matrix

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

Step 2: Compute $S^T(P)*T$

$S^T(1)*T$

1	0
0	0
1	0
1	0

$S^T(2)*T$

1	0
0	0
0	0
1	0

$S^T(3)*T$

0	1
0	1
0	1
0	1

$S^T(4)*T$

0	0
0	0
0	0
0	0

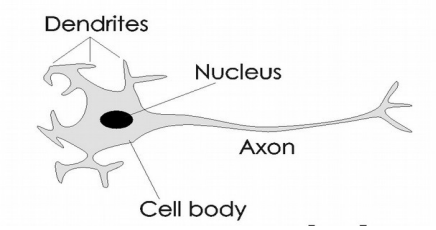
Step 2: $\Sigma S^T(P)*T$

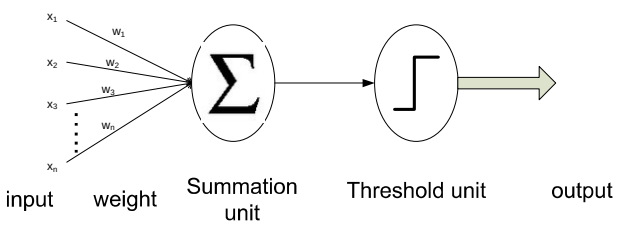
2	1
0	1
1	1
2	1

8.a: We may note that a neuron is a part of an interconnected network of nervous system and serves the following.

- Compute input signals
- Transportation of signals (at a very high speed)
- Storage of information
- Perception, automatic training and learning

We also can see the analogy between the biological neuron and artificial neuron. Truly, every component of the model (i.e. artificial neuron) bears a direct analogy to that of a biological neuron. It is this model which forms the basis of neural network (i.e. artificial neural)





8.b Develop a perceptron training algorithm. Write the pseudocode also.

Abswer:

Step-1

In the first step first, multiply all input values with corresponding weight values and then add them to determine the weighted sum. Mathematically, we can calculate the weighted sum as follows:

∑wi*xi = x1*w1 + x2*w2 +…wn*xn

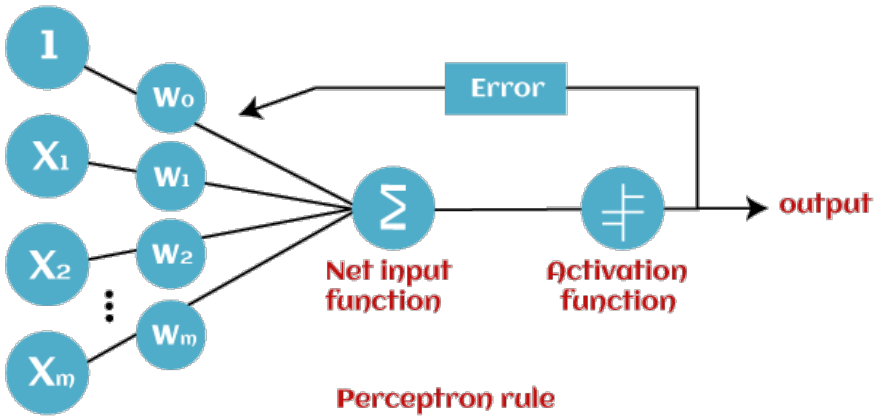
Add a special term called **bias 'b'** to this weighted sum to improve the model's performance.

∑wi*xi + b

Step-2:

In the second step, an activation function is applied with the above-mentioned weighted sum, which gives us output either in binary form or a continuous value as follows:

Y = f(∑wi*xi + b)



9.a Consider the following real variables from everyday life.
- Income measured in INR. **Answer: High, middle, low**
- Speed measured in meters per second. **Answer: High, normal, low**
- A TV show measured in how much you are interested watching it. **Answer: Exquisite, Interesting, okay, boring.**
- A meal measured in how much you like to eat it. Sumptous, delicious, tasty, normal, inedible.
- A traffic light measured in what colour is on. **Answer: Red, Green, Orange,**

In each case, suggest a fuzzy variable corresponding to these real variables.
For which of these five variables the use of a fuzzy variable is not really necessary and why?
Use of fuzzy variable for traffic light seems unnecessary because it is always going to have the definite answer among only these three colors: Red, green and orange.

9.b: If two fuzzy sets A and B are given with membership functions μA(x) = {0.2, 0.4, 0.8, 0.5, 0.1} μB(x) = {0.1, 0.3, 0.6, 0.3, 0.2} Then compute the value of complement of A Intersection B which is represented as μ (A∩B)'.
Answer:

μA(x) = {0.2, 0.4, 0.8, 0.5, 0.1}
μB(x) = {0.1, 0.3, 0.6, 0.3, 0.2}
μ (A∩B) = min (A∩B) ⇒ {0.1,0.3,0.6,0.3,0.1}
finally μ (A∩B)' ⇒ {0.9,0.7,0.4,0.7,0.9}

END