

1a) Characteristics of supervised learning is labelled data and characteristics of unsupervised learning requires redundancy in data.

1b) Examples of artificial neural networks that perform supervised learning are

- i) perceptron
- ii) associative net

Examples of artificial neural networks that perform unsupervised learning are

- i) Kohonen
- ii) elastic net

1c) Examples of supervised and unsupervised learning in the brain are

- i) associative net / associative memory and
- ii) visual cortex respectively
i.e topographic maps in brain respectively.

1d) Different types of neural code are rate coding and temporal coding.

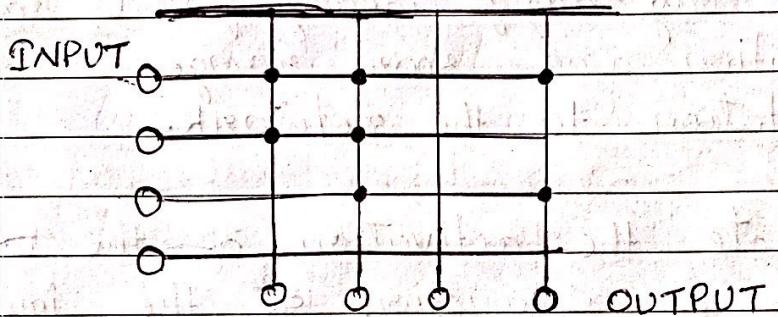
Application of rate coding is measurement of joint angle.

Application of temporal coding is echo location bat.

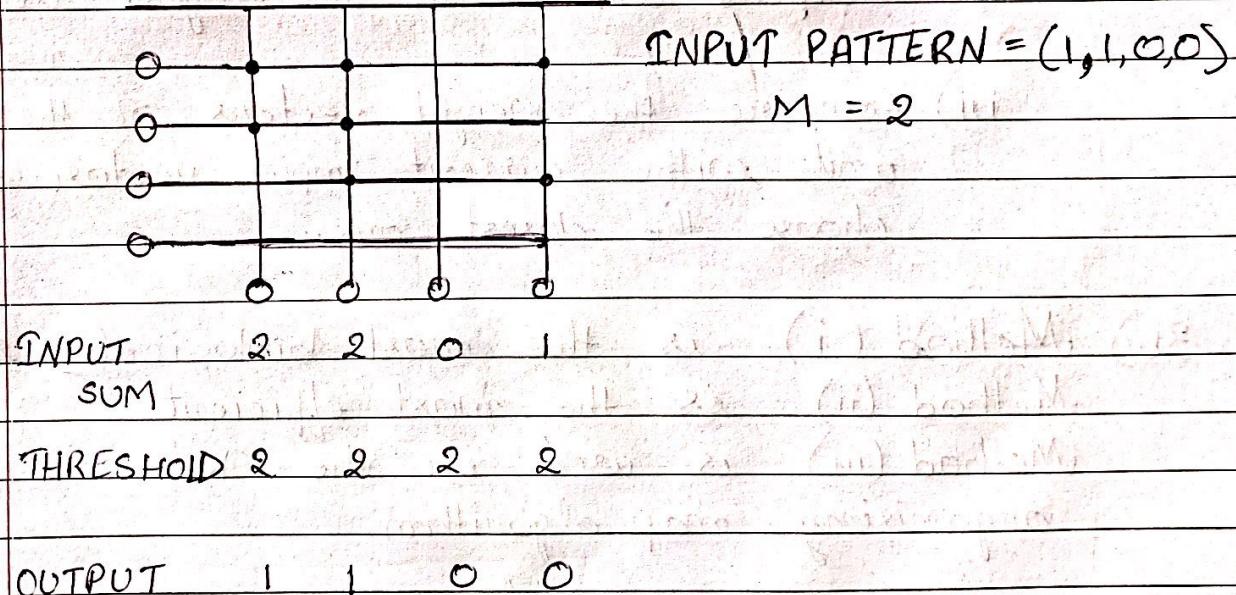
- 2a) The input association stored in this net is (1,0,0,0).
- 2a) The association in input pattern stored in this net is (1,0,0,0).

The association in output pattern stored in this net is (0,1,0,0)

2b)



2c)



- 2d) When some synapses are missing : each output unit needs to know the maximum input it can receive.

2e) To change the connectivity of the associative net from hetero-associative memory to an auto associative memory we need to change the connectivity from feed-forward to recurrent.

3a) The three methods are

i) add long-range (ideally, global) lateral inhibition and short range (or self) excitation to the network.

ii) calculate the activation of the output units as a function of the inputs and weights and hand-pick the output unit with the largest activation

iii) compare the weight vectors of the output units with the current input vector and choose the closest one.

3b.) Method (i) is the most biologically realistic
Method (ii) is the most efficient
Method (iii) is used in the Kohonen self-organising map algorithm

3c) Phonetic typewriter

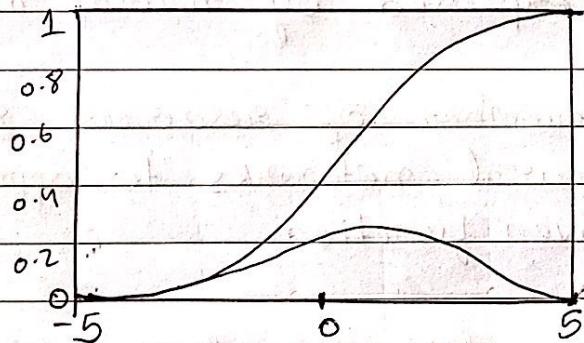
Travelling Salesman problem

Learning similarities between animals

3d) Examples of

- i) 1D input space onto 2D output space is
bat auditory cortex
- ii) 2D input space onto 2D output space is
mapping random input vectors
- iii) higher dimensional input space onto 2D
output space is somatosensory map.

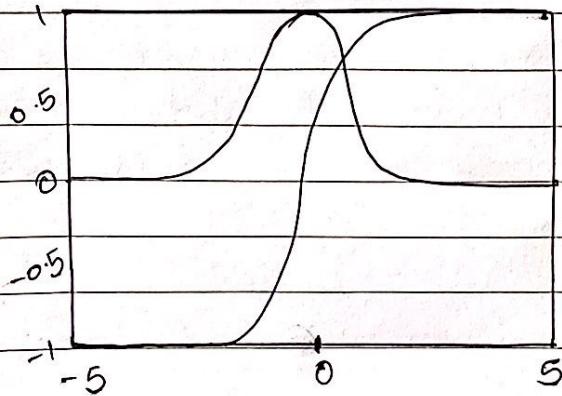
4a) i) Sigmoid function



$$g(z) = \frac{1}{1+e^{-z}}$$

$$g'(z) = g(z)(1-g(z))$$

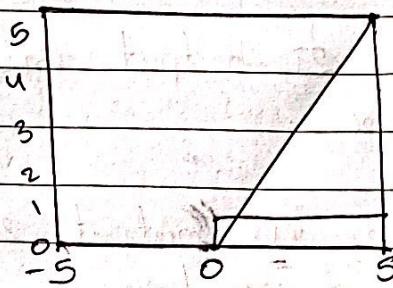
ii) Hyperbolic Tangent



$$g(z) = \frac{e^z - e^{-z}}{e^z + e^{-z}}$$

$$g'(z) = 1 - g(z)^2$$

iii) Rectified Linear Unit



$$g(z) = \max(0, z)$$

$$g'(z) = \begin{cases} 1, & z > 0 \\ 0, & \text{otherwise} \end{cases}$$

4b) i) Expressibility :- what classes that can be expressed by neural networks

ii) Efficiency :- The number of resources required by neural networks to approximate a given function.

iii) Learnability :- The learning speed with which neural networks learn good parameters for approximating a function.

- 4c)
- i) False
 - ii) True
 - iii) False

- 5a)
- i) True
 - ii) False
 - iii) True

5b) Two examples are

- i) cat and dog classification
- ii) facial recognition.

$$5c) i) F_1 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{pmatrix}$$

$$A = \begin{bmatrix} 2 & 0 & 10 & 0 & 7 \\ 3 & 0 & 10 & 0 & 7 \\ 3 & 0 & 10 & 0 & 3 \\ 3 & 0 & 10 & 0 & 3 \\ 3 & 8 & 10 & 7 & 3 \end{bmatrix}$$

$$\left[\begin{array}{l} 2 \times 0 + 0 \times 0 + 10 \times 0 + \\ + 5 \times 0 + 0 \times 0 + 10 \times 0 = 13 \\ + 3 \times 1 + 0 \times 1 + 10 \times 1 \end{array} \right] \dots$$

$$\text{Answer} = \begin{bmatrix} 13 & 10 & 13 \\ 13 & 10 & 13 \\ 21 & 25 & 20 \end{bmatrix}$$

$$ii) F_2 = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\text{Answer} = \begin{bmatrix} 30 & 0 & 17 \\ 30 & 0 & 13 \\ 30 & 7 & 9 \end{bmatrix}$$

$$iii) F_3 = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\text{Answers} = \begin{bmatrix} 33 & 10 & 27 \\ 33 & 10 & 23 \\ 41 & 25 & 26 \end{bmatrix}$$

- iv) The first filter selects features with less sparsity, second filter selects features with high pixel value and third filter selects features with high density.