Neural Networks

Lecture 17

Unsupervised Learning Network (1)

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Chapter Contents

- **This chapter covers the following topics:**
  - **Introduction to Unsupervised Learning Networks**
  - **Hamming Network**
  - **Max Net**
  - **Competitive Learning in ANN**
  - K-means Clustering Algorithm
  - Self- Organizing Feature Map

Unsupervised Learning Networks…

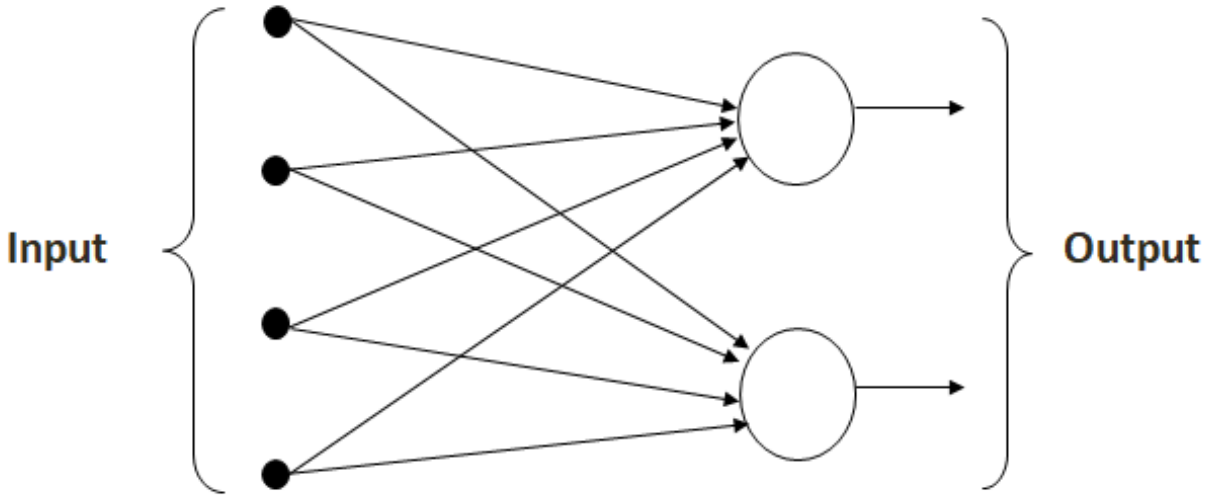
- As the name suggests, this type of learning is done without the supervision of a teacher. This learning process is independent.
- During the training of ANN under unsupervised learning, the input vectors of similar type are combined to form clusters. When a new input pattern is applied, then the neural network gives an output response indicating the class to which input pattern belongs.
- In this network, there would be no feedback from the environment as to what should be the desired output and whether it is correct or incorrect.
- Hence, in this type of learning the network itself must discover the patterns, features from the input data and the relation for the input data over the output.

Unsupervised Learning Networks

- These kinds of networks are based on the competitive learning rule and will use the strategy where it chooses the neuron with the greatest total inputs as a winner.
- The connections between the output neurons show the competition between them and one of them would be 'ON' which means it would be the winner and others would be 'OFF'.
- Following are some of the networks based on this simple concept using unsupervised learning:
  - Hamming Network
  - Max Net
  - Competitive Network
  - Self- Organizing Feature Map

Hamming Network…

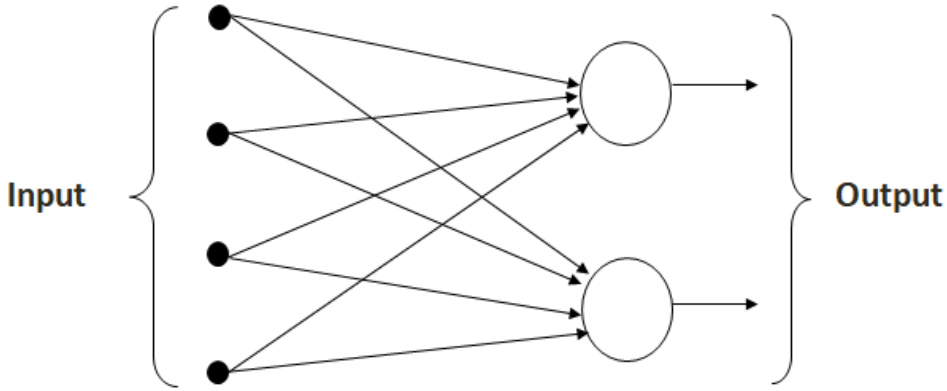
- In most of the neural networks using unsupervised learning, it is essential to **compute the distance and perform comparisons**. This kind of network is Hamming network, where for every given input vectors, it would be **clustered into different groups**.
- The following is a single layer hamming network:



Hamming Neural Network

Hamming Network…

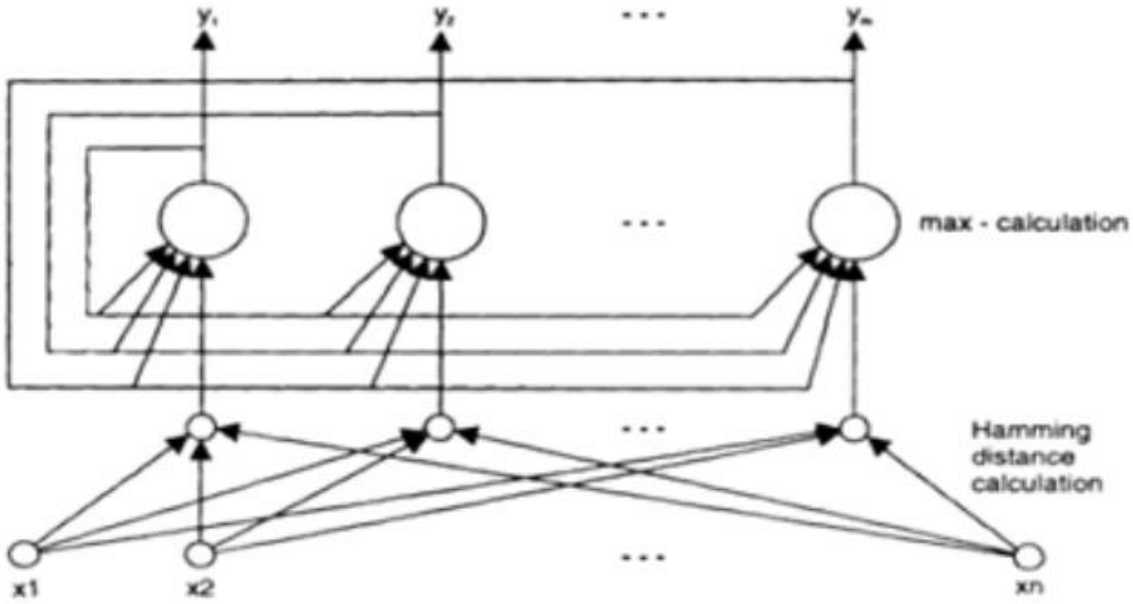
- Following are some important features of Hamming Networks −
  - Lippmann started working on Hamming networks in 1987.
  - It is a single layer network. It clusters the inputs.
  - The inputs can be either binary {0, 1} of bipolar {-1, 1}.
  - The weights of the net are calculated by the exemplar vectors.
  - It is a fixed weight network which means the weights would remain the same even during training.



Hamming Neural Network

Hamming Network…

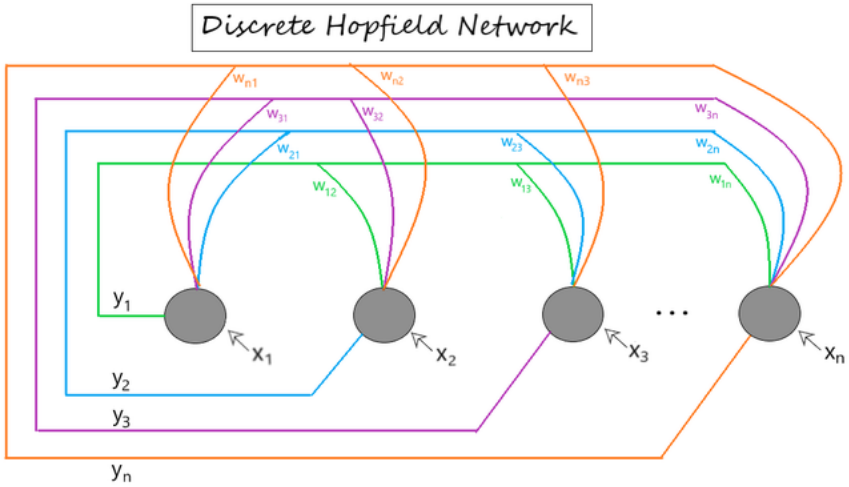
- The Hamming network performs the task of pattern association, or classification, based on measuring the **Hamming distance**. The network is a pattern associate of n-dimensional binary vectors labeled with m-class labels (m-class patterns).
- A new vector x' is associated with class pattern xi with the minimum Hamming distance, a Hamming distance being the number of different bits in the two patterns.

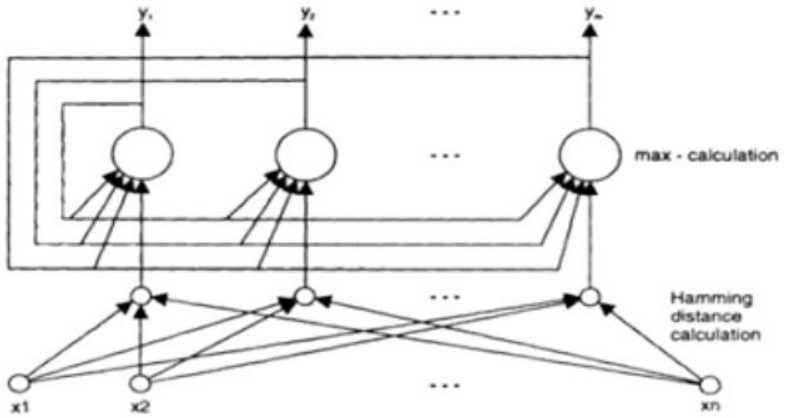


A Hamming associative neural network.

Hamming Network…

- The Hamming network is similar to the Hopfield network, but it has two layers of connections.
  - The first layer contains connections between all the n inputs, and all the m outputs.
  - The second layer is a fully connected recurrent network with m neurons (similar to the Hopfield network).

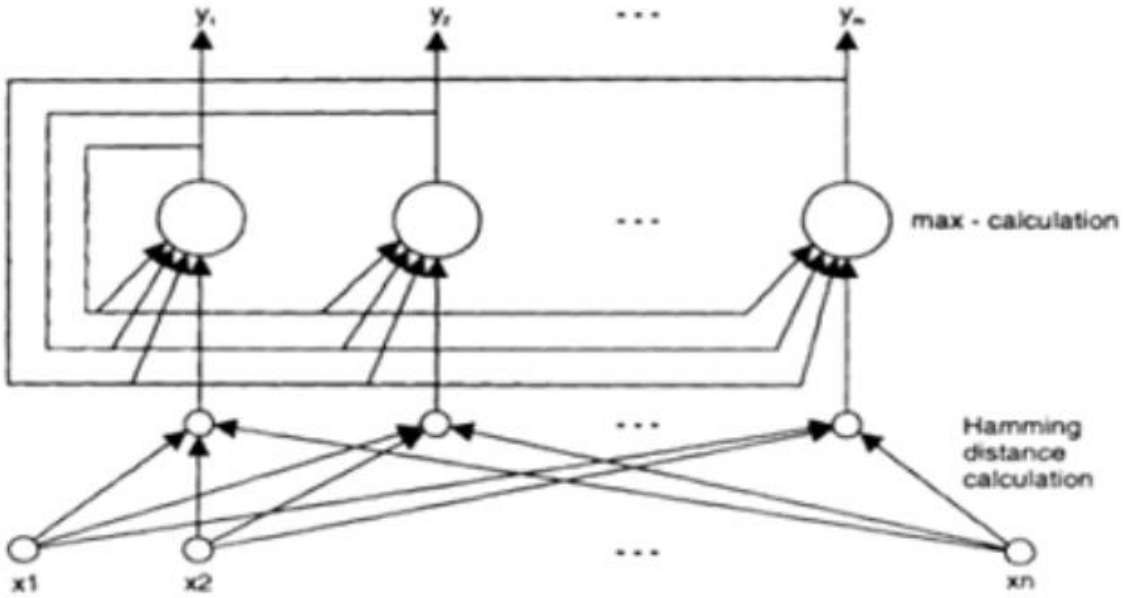




A Hamming associative neural network.

Hamming Network…

- Two layers of connections in Hamming network:
  - **Layer-1:** Connections between all the n inputs, and all the m outputs.
  - **Layer-2:** A fully connected recurrent network with m neurons (similar to the Hopfield network).



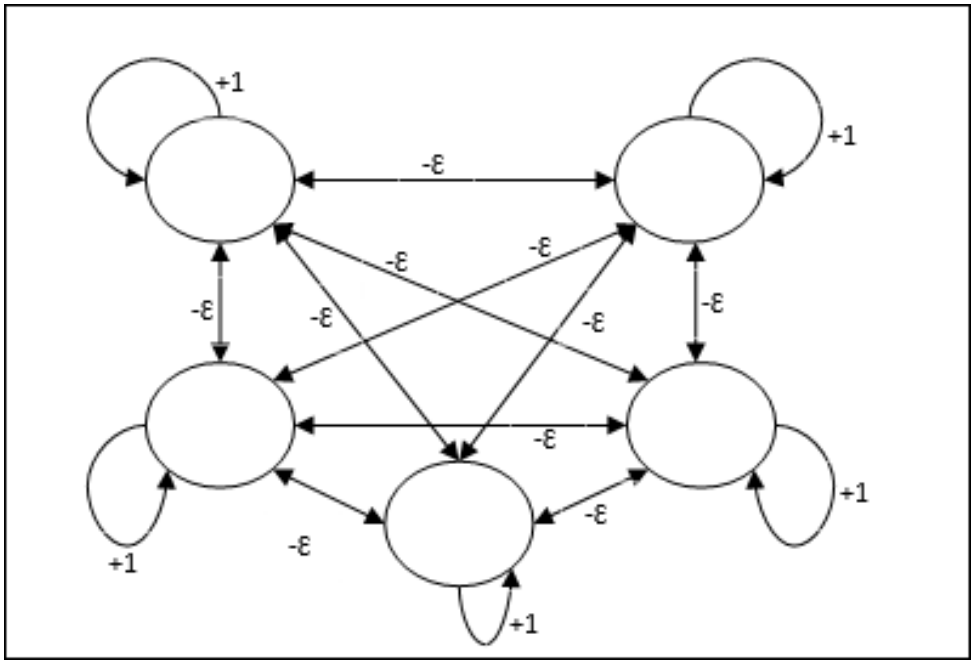
A Hamming associative neural network.

Hamming Network

- All nodes use linear threshold activation functions.
- The first layer of connections is finding the difference between the number n and the Hamming distance between the input pattern x' and each of the m-class patterns used to calculate the connection weights in advance.
- The second layer of connections is calculating the maximum of these values for finding the best matched- class pattern.
- Using a Hamming network has several advantages: it requires fewer connections than the Hopfield network, and it implements the "optimum minimum error classifier when bit errors are random and independent", that is, the network always converges and finds the output node with the maximum value.

Max Net…

- This is also a fixed weight network, which serves as a subnet for selecting the node having the highest input.
- All the nodes are fully interconnected and there exists symmetrical weights in all these weighted interconnections.

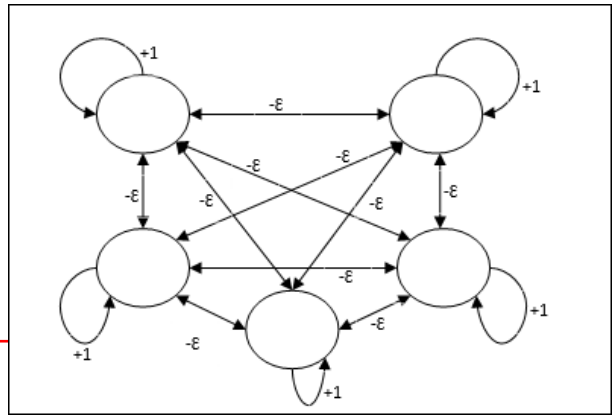


Max Net

- It uses the mechanism which is an iterative process and each node receives inhibitory inputs from all other nodes through connections.
- The single node whose value is maximum would be active or winner and the activations of all other nodes would be inactive.
- Max Net uses identity activation function with-

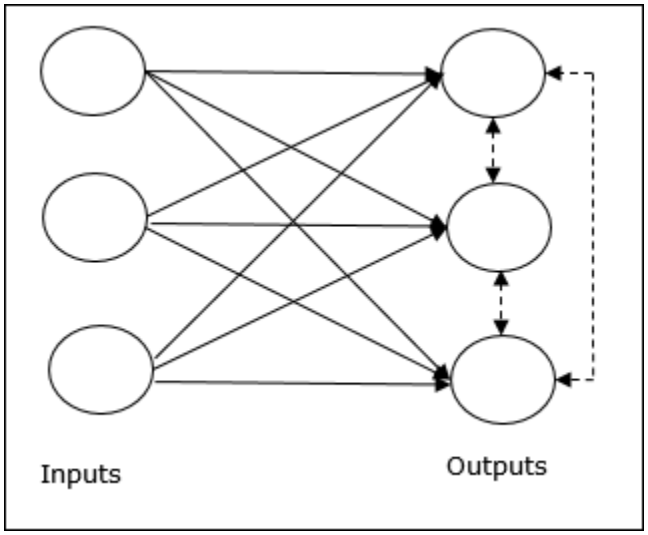
$$f(x) = \begin{cases} x & if\ x > 0 \\ 0 & if\ x \leq 0 \end{cases}$$

The task of this net is accomplished by the self-excitation weight of +1 and mutual inhibition magnitude, which is set like [$0 < \varepsilon < \frac{1}{m}$] where **"m"** is the total number of the nodes.



Competitive Network…

- It is concerned with unsupervised training in which the output nodes try to compete with each other to represent the input pattern.
- This network is just like a single layer feed-forward network having feedback connection between the outputs.
- The connections between the outputs are inhibitory type, which is shown by dotted lines, which means the competitors never support themselves.



Competitive Network…

Basic Concept of Competitive Learning Rule

- As said earlier, there would be competition among the output nodes so the main concept is - during training, the output unit that has the highest activation to a given input pattern, will be declared the winner.
- This rule is also called **Winner-takes-all because only the winning neuron is updated** and the rest of the neurons are left unchanged.

Competitive Network…

Mathematical Formulation:

- Following are the three important factors for mathematical formulation of this learning rule −
  1. Condition to be a winner
  2. Condition of the sum total of weight
  3. Change of weight for the winner

Competitive Network…

Mathematical Formulation:

1. **Condition to be Winner:** Suppose if a neuron y_k wants to be the winner, then there would be the following condition:

$$y_k = \begin{cases} 1 & if\ v_k > v_j\ for\ all\ j,\ j \neq k \\ 0 & otherwise \end{cases}$$

It means that if any neuron, say, y_k wants to win, then its induced local field **the output of the summation unit**, say v_k, must be the largest among all the other neurons in the network.

Competitive Network…

Mathematical Formulation:

2. **Condition of the sum total of weight:** Another constraint over the competitive learning rule is the sum total of weights to a particular output neuron is going to be 1.

For example, if we consider neuron k then-

$$\sum_k w_{kj} = 1 \quad for\ all\ k$$

Competitive Network

Mathematical Formulation:

3. **Change of weight for the winner:** If a neuron does not respond to the input pattern, NO learning takes place in that neuron.

   However, if a particular neuron wins, then the corresponding weights are adjusted as follows-

$$\Delta w_{kj} = \begin{cases} -\alpha(x_j - w_{kj}), & if\ neuron\ k\ wins \\ 0 & if\ neuron\ k\ losses \end{cases}$$

   Here, α is the learning rate.

- This clearly shows that we are favoring the winning neuron by adjusting its weight and if a neuron is lost, then we need NOT bother to re-adjust its weight.

UNSUPERVISED LEARNING
NETWORK PARADIGMS

To be continued…