SOM (Self Organising Map)

A neural network implementation to multidimensional data into an organized data visualisation.

Features of SOM

- It is motivated from the features of the human brain.
- The neurons are organised in a multi-dimensional lattice.
- Neurons compete among themselves to get activate.
- The weight vector associated with the winning neuron and the associated neighbourhood neuron is only activated – generally referred to as Kohnan SOM.

Types of Neural Network Maps

- One Dimensional :

The neurons are arranged along as a 1Dimentional plane such as a line.

- Two Dimensional :

The Neurons are arranged in a two Dimensional plane format such as a square plane.

- Multi-Dimensional:

The neurons are arranged in a multi dimensional format.

Note: The Neural Network dimension is set as per the depth of dimensional analysis of the Data required.

Properties of Neuron

- Each neuron is associated with an n-dimensional weight vector.

Where n is also the number of dimensions present in the input data.

- The winning neuron is declared based on the minimum distance measure between x_i & w_i .

Here x_i represents the input data of n dimensions & w_i represents the weight vector associated with the respective neuron.

- Where i represents the i'th neuron in the Neural Network.

SOM (Algorithm)

- Initialize the weights in the network.
- There are three processed involved in the functioning of SOM.

➢ Competition – to find the winner.

➢ Co-operation – update the weights of the neighbourhood neurons .

➢ Weight Update.

Competition

- The winner is selected based on the minimum distance between the x_i & w_i .
- In one dimensional lattice normal distance gap is measured ,but in higher dimensional lattices, generally we use Euclidian distance.

$$\text{dist.} = \sqrt{((x_1 - w_1)(x_2 - w_2)(x_3 - w_3)\ldots(x_n - w_n))}$$

Where n is the total number of dimensions available in input x.

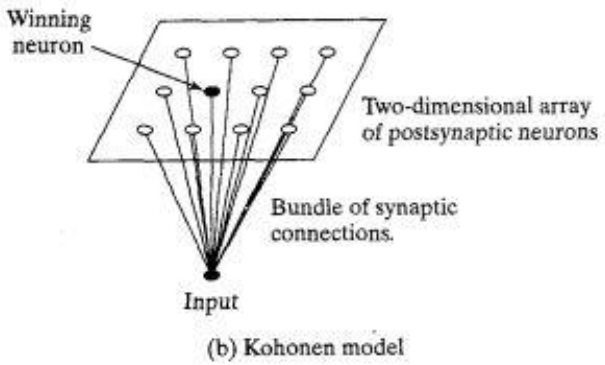

FIGURE 9.1 Two self-organized feature maps.

Co-operation

- Cooperative process
- Adaptive process

Cooperative Process

- The extent to which the neuron's weight is effected is given by , the following function.

$$h_{j,i(x)}(n) = \exp\left(-\frac{d_{j,i}^2}{2\sigma^2(n)}\right), \qquad n = 0, 1, 2, \ldots,$$

where d_{ij} is the Euclidian distance between the winning neuron and the neighbourhood neuron.

- The function reaches it's Maximum value when d_{ij} is minimum.

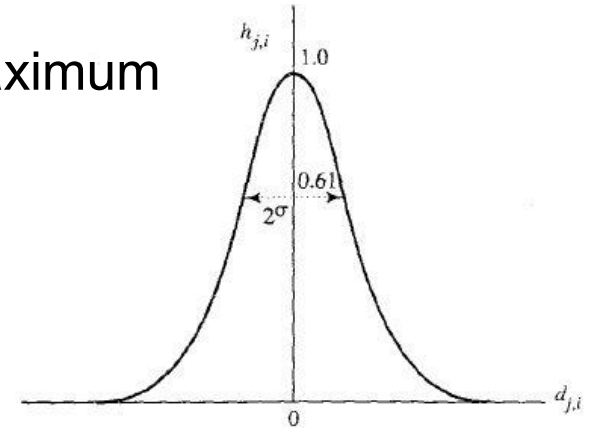

FIGURE 9.3 Gaussian neighborhood function.

- Here sigma is defined as :

$$\sigma(n) = \sigma_0 \exp\left(-\frac{n}{\tau_1}\right) \qquad n = 0, 1, 2, \ldots,$$

Where T_1 : time constant involved;

n : is the total number of iterations

Limitation

- The value of h_{ij} being an ever increasing value would lead to the saturation of the neuron as a whole.
- Hence the modification was introduced , which is reflected as the adaptive process.

Adaptive process

- Introduction of a forgetting function $g(y_j)$, which is initially set as,

$$g(y_j) = 0 \qquad \text{for } y_j = 0$$

- The change in w_j is set as :

  Here eta is a function

$$\Delta \mathbf{w}_j = \eta y_j \mathbf{x} - g(y_j)\mathbf{w}_j$$

  with a maximum number of iterations n.

- Thus making the overall function as a non monotonically increasing function via the introduction of negative term.

Weight update

- Hence the overall function for weight update is given by.

$$\mathbf{w}_j(n+1) = \mathbf{w}_j(n) + \eta(n) h_{j,i(\mathbf{x})}(n)(\mathbf{x} - \mathbf{w}_j(n))$$

- The central tendency of the function is to convert the weight of the neuron towards the value of x as much as possible.

Total procedure

The algorithm is divided into two phases:

- Organizing phase :

The task is to keep adjusting the learning rate with a maximum value of 0.1 at initial and min. above 0.01.

Further to set the suitable value for eta a minimum of 1000 iterations is required with a suitable T_2 value 0f 1000.

N.B: T2 is the time constant associated with the decay of eta.

- Adaptive phase:

The task is to fine tune the weight of the neurons such as to provide maximum accuracy. It is during this phase the adaptive process is incorporated to obtain a suitable visualisation of the input data.

Summary

- SOM is a very useful technique used to provide a suitable visualisation of the data input data into a suitable interpretable format.
- It is highly effective and accurate to a great extent.