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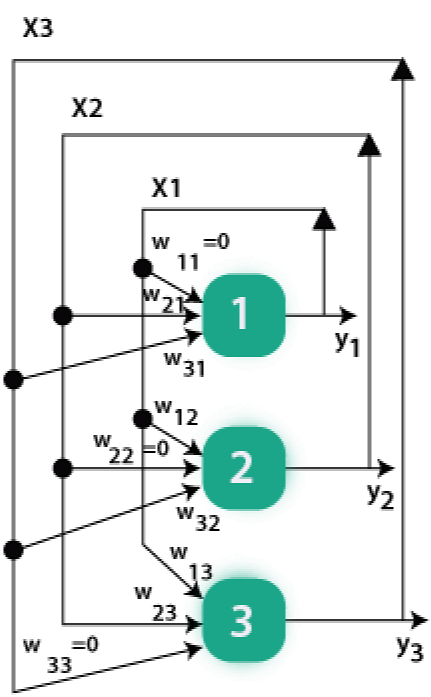
Hopfield Network

Hopfield network is a special kind of neural network whose response is different from other neural networks. It is calculated by converging iterative process. It has just one layer of neurons relating to the size of the input and output, which must be the same. When such a network recognizes, for example, digits, we present a list of correctly rendered digits to the network. Subsequently, the network can transform a noise input to the relating perfect output.

In 1982, **John Hopfield** introduced an artificial neural network to collect and retrieve memory like the human brain. Here, a neuron is either on or off the situation. The state of a neuron(on +1 or off 0) will be restored, relying on the input it receives from the other neuron. A Hopfield network is at first prepared to store various patterns or memories. Afterward, it is ready to recognize any of the learned patterns by uncovering partial or even some corrupted data about that pattern, i.e., it eventually settles down and restores the closest pattern. Thus, similar to the human brain, the Hopfield model has stability in pattern recognition.

A Hopfield network is a single-layered and recurrent network in which the neurons are entirely connected, i.e., each neuron is associated with other neurons. If there are two neurons i and j, then there is a connectivity weight $\mathbf{w}_{ij}$ lies between them which is symmetric $\mathbf{w}_{ij} = \mathbf{w}_{ji}$.

With zero self-connectivity, $\mathbf{W_{ii}}$ **=0** is given below. Here, the given three neurons having values **i = 1, 2, 3** with values $\mathbf{X_i = \pm 1}$ have connectivity weight $\mathbf{W_{ij}}$.



Updating rule:

Consider **N** neurons = **1, ... , N** with values $\mathbf{X_i = +1, -1}$.

The update rule is applied to the node i is given by:

If $\mathbf{h_{i \geq 0}}$ then $\mathbf{x_{i} \rightarrow 1}$ otherwise $\mathbf{x_{i} \rightarrow -1}$

Where **h_i =** $\sum_{j=1}^{N} wijxj$ is called field at i, with b£ R a bias.

Thus, **x_i** $\rightarrow$ **sgn(h_i)**, where the value of **sgn(r)=1, if r ≥ 0**, and the value of **sgn(r)=-1, if r < 0**.

We need to put **b_i=0** so that it makes no difference in training the network with random patterns.

We, therefore, consider **h_i=** $\sum_{j=1}^{N} wijxj$.

We have two different approaches to update the nodes:

Synchronously:

In this approach, the update of all the nodes taking place simultaneously at each time.

Asynchronously:

In this approach, at each point of time, update one node chosen randomly or according to some rule. Asynchronous updating is more biologically realistic.

Hopfield Network as a Dynamical system:

Consider, **K = {-1, 1}** ^{N} so that each state **x £ X** is given by **x_i £ { -1,1 }** for **1 ≤ I ≤ N**