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Artificial Neural Networking and Human Brain

Poonam Gupta
Department of Mathematics, Hindu Girls College, Sonipat
Poonammittal2207@gmail.com

Parveen Mehta
Department of Computer Science, Hindu Girls College, Sonipat
Parveen_amb25@rediffmail.com

Abstract :- Neural Network technology performs "intelligent" tasks. ANN(Artificial Neural Network) can be employed to solve a wide spectrum of problems as optimization , Parallel Computing , Matrix Algebra and Signal Processing . ANN is an information processing paradigm inspired by the way biological nervous System , such as brain , process information ANN is an interconnected web of neurons which a building block of neural network . Neurons receives inputs from other sources, combines them in some way performs a generally non linear operation and then outputs the final results. This paper gives overview of working of Neurons for basic understanding how electronic model of ANN are work for problem solving.

Keyword: *ANN, Neuron , Perceptron,Dendrites,Synapse.*

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Introduction to Neural Networks

Neural network is referred to as an 'artificial' neural network (ANN).The inventor of one of the first neurocomputers is Dr. Robert Hecht-Nielsen. The general idea behind artificial neural networks arose from the psychologist Donald O. Hebbs famous theory (1949). ANN are computers whose architecture is modelled after the brain. They consist of 100s of simple processing units (neurons) which are wired together in a complex communication network[15]. An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain information system[14].

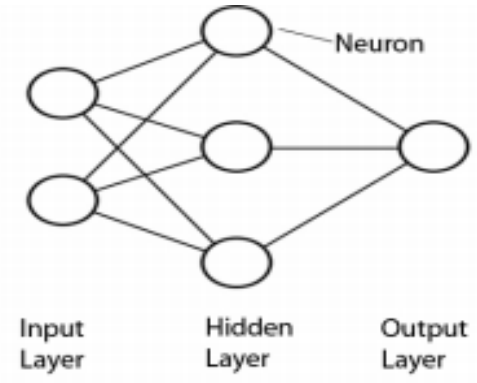
Neurons : Basic Building blocks of Neural networks .

Perceptron :- In ANN neuron also referred to as the perceptron.

An ANN is configured for solving artificial intelligence problems without creating a model of real biological system such as pattern recognition or data classification, through a learning process.

Structure & working of ANN

Artificial neural networks consist of several neurons. These neurons, also called Units. These neurons can be clustered together. This clustering occurs in human mina in such a way that information can be processed in a interactive, dynamic and self organizing way. Basically, all artificial neural network have a similar structure as shown below. Network contain three type of layers -input, hidden and output. Information is received by the layer of input neurons from neurons of the previous layer and pass them on to others. The intensity of the connection between two neurons is represented by a weight value and this weight value stores the knowledge of the neural network. If bigger the absolute value of the weight is, the bigger is the influence for an error[6]. The weight values passed to the hidden layer which contain an internal representation and output units pass the output signal to environment.



How the Human Brain Learns

To process information extremely large interconnected networks of neurons are used by the human brain. A neuron collects signals from others through a fine structures called *dendrites*. The neuron effectively sums all of these inputs from dendrites and if the resulting value is greater than

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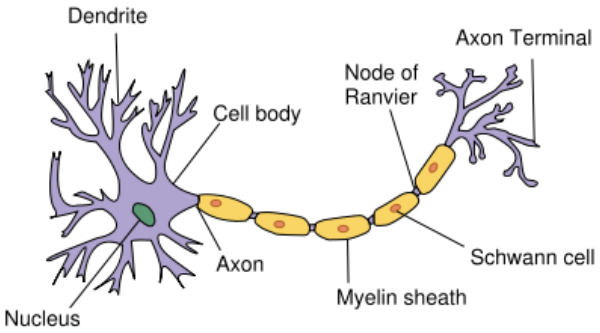
its firing threshold, the neuron fires and sends out spikes of electrical activity through a long, thin stand known as an *axon* to its boutons. Axon splits into thousands of branches and at the end of each branch, a structure called a *synapse* converts the activity from the axon into electrical effects that excite activity in the connected neurons[14]. In human brain there are about 100 billion neuron each with about 1000 synaptic connections. These synapses are wired in the efficient way that give our brain the ability to process the information.



How Neural Network Learn

An artificial neural network follow a dynamic computational structure and do not abide by a simple process to drive a desired output. The basis of these networks originated from biological neurons and neural structures. In neural networks different inputs are processed and modified by a weight. The network then combines these different weighted inputs with reference to a certain threshold and activation function and gives out the final value.

Artificial Neuron function

$$f_{AN}: R^{I} \rightarrow [0,1] \quad \text{or}$$

$$f_{AN}: R^{I} \rightarrow [-1,1]$$

I:- Number of input signals to AN

Artificial Network receives a vector of I input signals

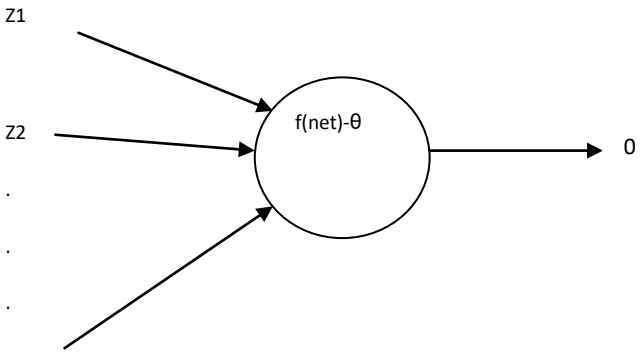
$$Z = \{Z_1, Z_2, \ldots\ldots\ldots\ldots, Z_I\}$$

Either from environment or from other ANs

-Each is associated with a weight vi to strengthen or deplete the input signal

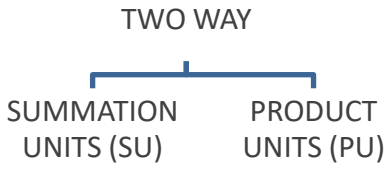
The AN computes the net input signal and uses an activation function f_{AN} to compute the output signal zero

By given the input value $Z_1, Z_2, Z_3, \ldots\ldots Z_I$, the strength of the output signal is further influenced by a threshold value (θ) also referred to as the bias.



Calculation of the Net input signal

There are two way of calculation of the net input signal for getting values



Summation Unit (SU):- The net input signal to an AN is usually computed as the weighted sum of all input signals. It is called summation unit.

$$net = \sum_{i=1}^{n} Z_i V_i$$

Product Units(PU):- Artificial neurons that compute the net input signal is to use products units (PU)

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$$net = \prod_{i=1}^{n} Z_i^{V_i}$$

Products units allow higher order combinations of inputs , having the advantage of increased information capacity.

Activation Function

f_{AN} :- It receives input signal and bias and determines the output or firing strength of the neuron . This function is referred to as the activation function. It has monotonically increasing mappings where (excluding the linear function)

$f_{AN}(-\infty) = 0$ **and** $f_{AN}(-\infty) = 1$ **and**

$f_{AN}(\infty) = 1$

Frequently used function

1. **Linear function (for** θ=0):-

   $f_{AN}(net-\theta) = \lambda(net-\theta)$ where λ is the slope of the function. It produces a linearly modulated output, where λ is constant.

2. **Step Function(for** θ>0):-

$$f_{AN}(net-\theta) = \begin{cases} r_1 \text{ if } net \geq \theta \\ r_2 \text{ if } net < \theta \end{cases}$$

   This function produce two scalar output values depending on the value of threshold usually.
   Binary output is produced for which r1=1 and r2=0
   Bipolar output is also sometimes used where r1=1 and r2=-1.

3. **Ramp Function (for** θ>0) combination of step and linear function

$$f_{AN}(net-\theta) = \begin{cases} r \text{ if } net-\theta \geq \varepsilon \\ net-\theta \text{ if } -\varepsilon < net-\theta < \varepsilon \\ -r \text{ if } net-\theta \leq -\varepsilon \end{cases}$$

4. **Sigmoid Function(for** θ=0)

   It is continuous version of ramp function with f_{AN} (net) , $f_{AN}(net) \in (0,1)$ .The parameter λ controls the steepness of the function usually $\lambda = 1$

$$f(net-\theta) = \frac{1}{1+e^{-\lambda(net-\theta)}}$$

5. **Hyperbolic tangent(for** θ=0)

$$f_{AN}(net-\theta) = \frac{e^{\lambda(net-\theta)} - e^{-\lambda(net-\theta)}}{e^{\lambda(net-\theta)} + e^{-\lambda(net-\theta)}}$$

   Or

$$f_{AN}(net-\theta) = \frac{2}{1+e^{-\lambda(net-\theta)}} - 1$$

   The output of this function is in the range (-1,1)

6. **Gaussian Function(for** θ=0):-

$$f_{AN}(net-\theta) = e^{-(net-\theta)^2/\sigma^2}$$

   $net-\theta \rightarrow is the mean$

   $\sigma \longrightarrow$ **Standard deviation of the Gaussian distribution**

Artificial Neuron Geometry

Linearly Separable Functions

Single neurons can be used to realize linearly separable functions without any error. Linearly separable means that the neuron can separate the space of I-dimensional input vectors yielding an above threshold response from those

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having a below threshold response by an I-dimensional hyper plane.

The hyper plane forms the boundary between the input vectors associated with the two output values.

The hyper plane separate line input vectors for which $\sum_i z_i v_i - \theta > 0$ from the input vectors for which $\sum_i z_i v_i - \theta < 0$.

Two Boolean Function

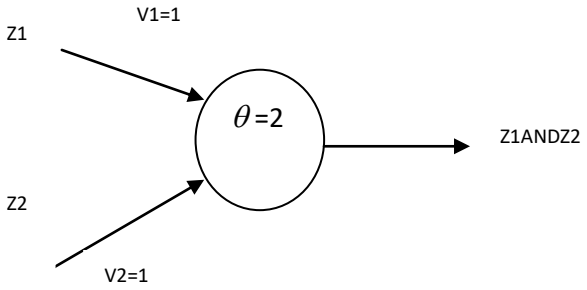
AND and OR can be implemented using a single perceptron Example Of linearly separable functions for such simple functions , It is easy to manually determine values for the bias and the Weights.

Given input signals and value of threshold θ the weight values V_i can easily be calculated by solving

VZ= θ where Z is the matrix of input patterns are given in the truth tables.

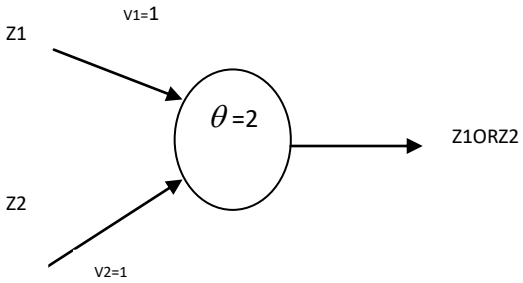
AND

Z1	Z2	Z1ANDZ2
0	0	0
0	1	0
1	0	0
1	1	1



OR

Z1	Z2	Z1 OR Z2
0	0	0
0	1	1
1	0	1
1	1	1



Non Linearly Separable

A single perceptron cannot implement .this function .If a single perceptron is used , then the best accuracy that can be obtained is 75% .To be able to learn functions that are not linearly separable.

A layered Neural Network of several neutrons is requires

XOR Boolean function are required . It has 2 inputs , 2 hidden layers and one output Units

Z1	Z2	Z1 XOR Z2
0	0	0
0	1	1
1	0	1
1	1	0

Artificial Neuron Learning

Artificial neural networks are inspired by the biological nervous system, in particular the human brain. Interesting characteristics of the human brain is it's learning power. Brain's neural structure is altered during the learning process. Artificial neural network can model this learning process by adjusting the weighted connections between neurons in the

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network. Once a network has been structured for a particular application that network is ready to be trained. There are two approaches to learning – supervised and unsupervised. Learning algorithms are extremely useful when it comes to certain problems that either can't be practically written by a programmer or can be done more efficiently by a learning algorithm[7].

A learning algorithms consists of adjusting weight(V_i) and threshold values(θ) until a certain criterion (or several criteria) are satisfied.

Supervised Learning:

Both the inputs and outputs are provided in this learning. The neural network processes the input and calculate an error based on its target output and actual output and that error is used for making the corrections by updating its weight i.e. the aim of supervisor training is the to adjust the weight values so at the error between the real output $\theta = f(net - \theta)$ of the neuron and the target output is minimized.

Unsupervised Learning or Adaptive Training

In unsupervised training only inputs are given to the network and then neural network it self decide what feature would be used to combine the input data provided without any external aid. This type of learning paradigm is often used in data mining and is also used by many recommendation algorithms due to their ability to predict a user's preferences based on the preferences of other similar users it has grouped together.

Conclusion

In this paper we discussed about the Artificial neural network, working of ANN. Comparison of the neural networks with the human brain. Various functions discussed above provide a mathematical approach to conventional techniques which are often limited by strict assumptions of normality, linearity, variable independence etc. ANN has various real time applications. Application areas of ANN include system identification, process control, game playing, decision making, pattern recognition, medical diagnosis etc. Today, neural networks discussions are occurring everywhere. Their promise seems very bright as nature itself is the proof that this kind of thing works. Yet, its future, indeed the very key to the whole technology, lies in hardware development.

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