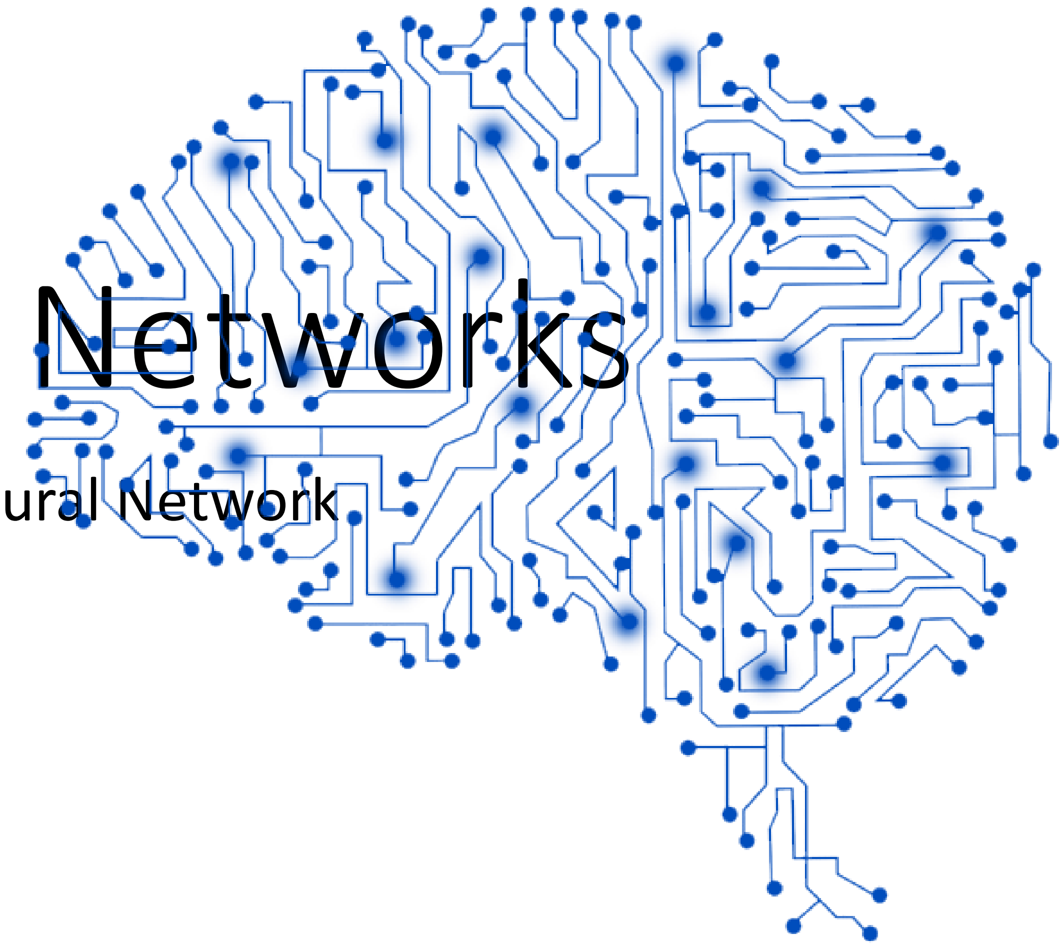
Artificial Neural Networks

Introduction to Artificial Neural Network



Arie Satia Dharma, S.T., M.Kom
Dosen Informatika

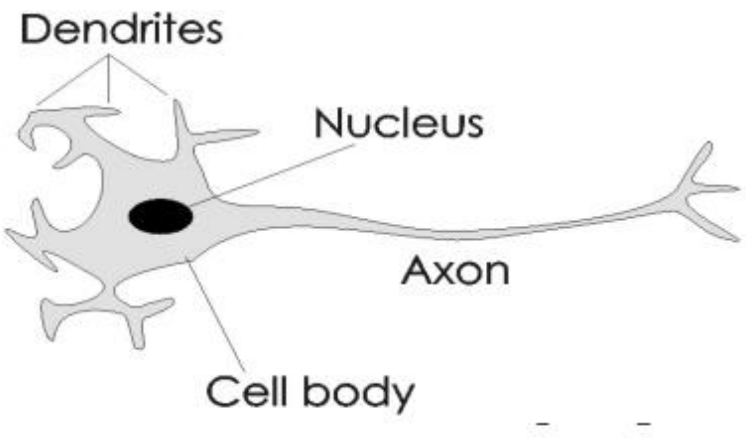
Topics

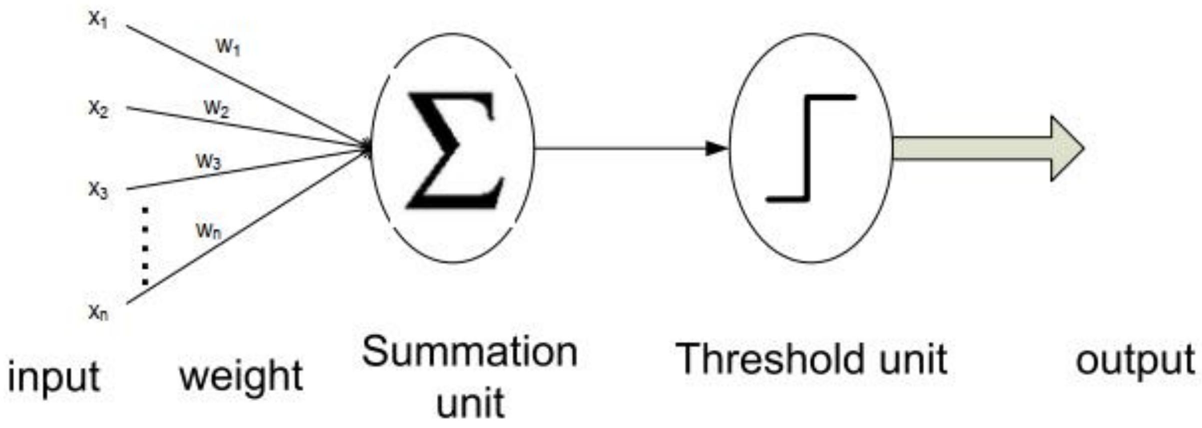
- ❑Artificial Neural Networks
- ❑Transformation Functions
- ❑Advantages of ANN

Artificial Neural Networks (ANN)

- In fact, the human brain is a highly complex structure viewed as a massive, highly interconnected network of simple processing elements called neurons.
- Artificial neural networks (ANNs) or simply we refer it as neural network (NNs), which are simplified models (i.e. imitations) of the biological nervous system, and obviously, therefore, have been motivated by the kind of computing performed by the human brain.

Artificial Neural Networks (ANN)

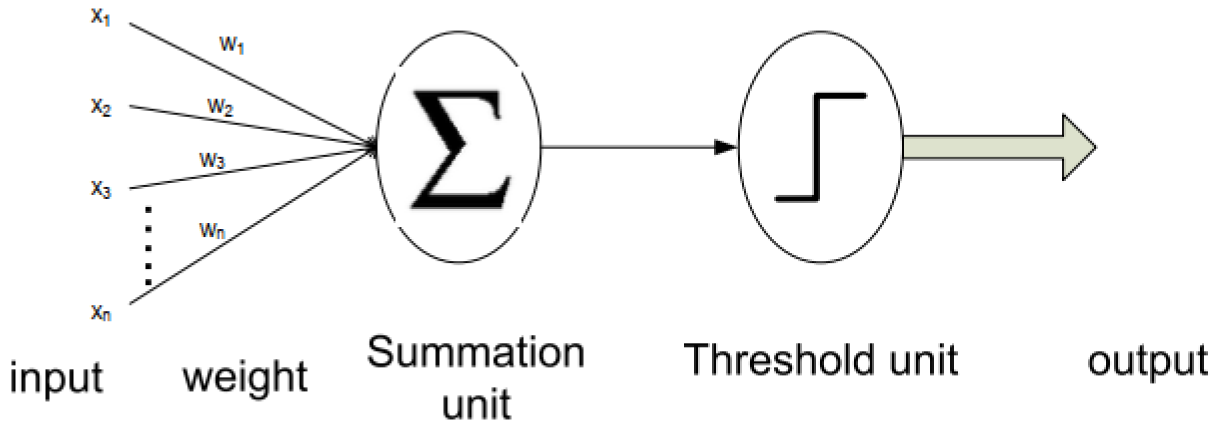




Artificial Neural Networks (ANN)

- Basic Idea: A complex non-linear function can be learned as a composition of simple processing units
- ANN is a collection of simple processing units (nodes) that are connected by directed links (edges)
  - Every node receives signals from incoming edges, performs computations, and transmits signals to outgoing edges
  - Analogous to human brain where nodes are neurons and signals are electrical impulses
  - Weight of an edge determines the strength of connection between the nodes
- Simplest ANN: Perceptron (single neuron)

Artificial Neural Networks (ANN)



- Here, x1; x2; · · · ; xn are the n inputs to the artificial neuron.
- w1; w2; · · · ; wn are weights attached to the input links.

Artificial Neural Networks (ANN)

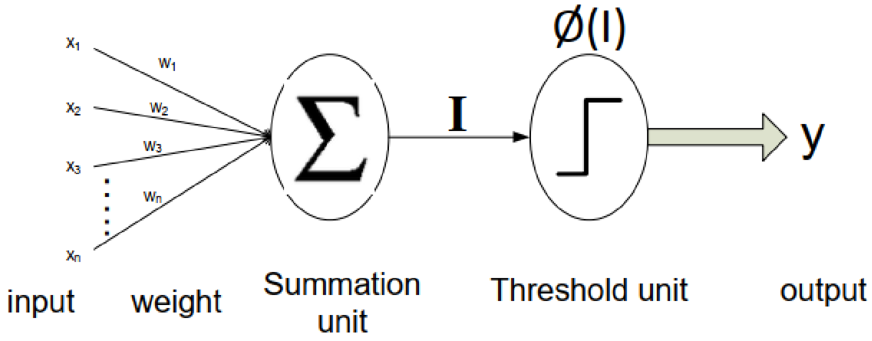
- Note that, a biological neuron receives all inputs through the dendrites, sums them and produces an output if the sum is greater than a threshold value.
- The input signals are passed on to the cell body through the synapse, which may accelerate or retard an arriving signal.
- It is this acceleration or retardation of the input signals that is modeled by the **weights**.
- An effective synapse, which transmits a stronger signal will have a correspondingly larger weights while a weak synapse will have smaller weights.
- Thus, weights here are multiplicative factors of the inputs to account for the strength of the synapse.

Artificial Neural Networks (ANN)

- Hence, the total input say I received by the soma of the artificial neuron is

$$I = w_1 x_1 + w_2 x_2 + \cdots + w_n x_n = \sum_{i=1}^{n} w_i x_i$$

- To generate the final output y, the sum is passed to a filter ϕ called transfer function, which releases the output.
- That is, y = ϕ(I)



Artificial Neural Networks (ANN)

- A very commonly known transfer function is the **thresholding function**.
- In this thresholding function, sum (i.e. I) is compared with a threshold value θ.
- If the value of I is greater than θ, then the output is 1 else it is 0 (this is just like a simple linear filter).
- In other words, $y = \phi(\sum_{i=1}^{n} w_i x_i - \theta)$

  where

$$\phi(I) = \begin{cases} 1 & , \text{if } I > \theta \\ 0 & , \text{if } I \leq \theta \end{cases}$$

Transformation Functions

- **Hard-limit transfer function** : The transformation we have just discussed is called hard-limit transfer function. It is generally used in perception neuron.

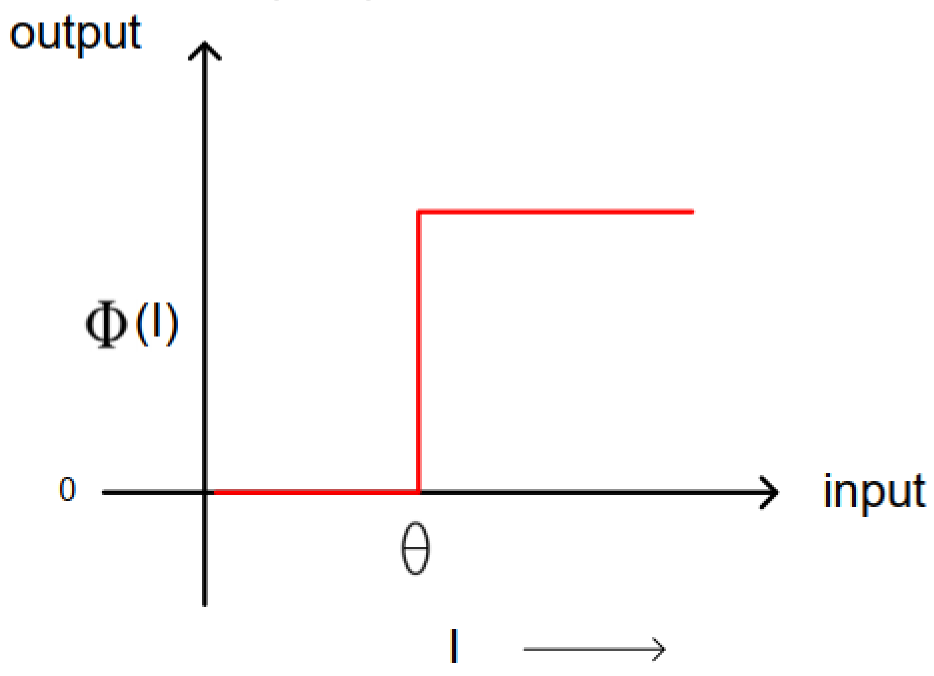
$$\phi(I) = \begin{cases} 1 & , \text{if } I > \theta \\ 0 & , \text{if } I \leq \theta \end{cases}$$

- **Linear transfer function** : The output of the transfer function is made equal to its input (normalized) and its lies in the range of −1.0 to +1.0. It is also known as Signum or Quantizer function and it defined as

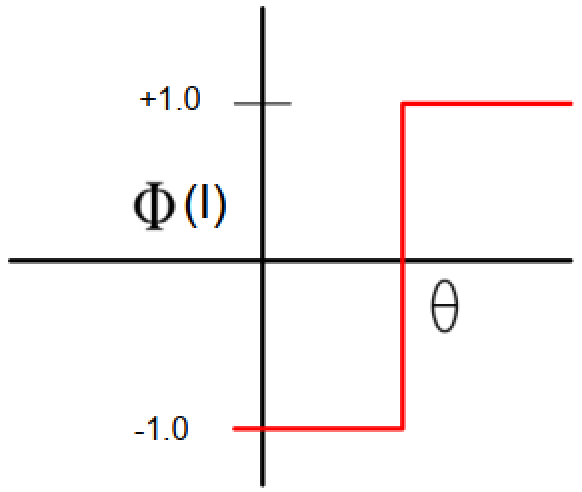
$$\phi(I) = \begin{cases} +1 & , \text{if } I > \theta \\ -1 & , \text{if } I \leq \theta \end{cases}$$

Transformation Functions

- Following figures illustrates two simple thresholding functions.



(a) Hard-limit transfer function



(b) Signum transfer function

Other Transformation Functions

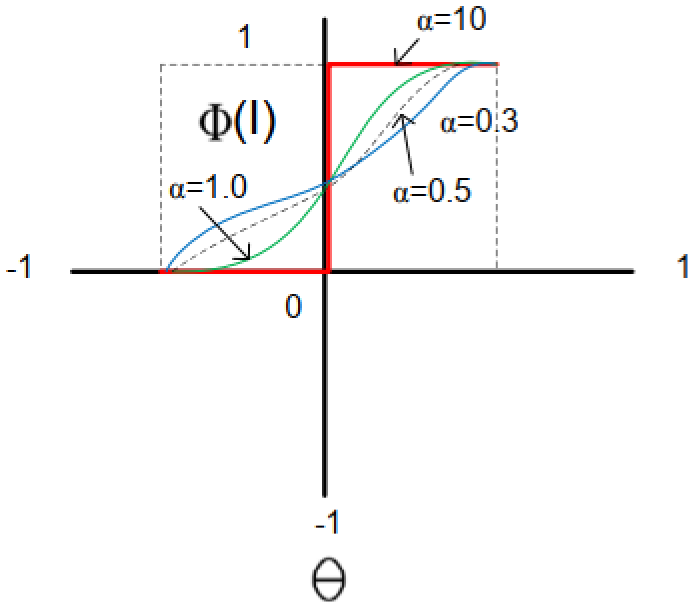
- **Sigmoid transfer function** : This function is a continuous function that varies gradually between the asymptotic values 0 and 1 (called log-sigmoid) or -1 and +1 (called Tan-sigmoid) threshold function and is given by

$$\phi(I) = \frac{1}{1+e^{-\alpha I}} \text{ [log-Sigmoid]}$$

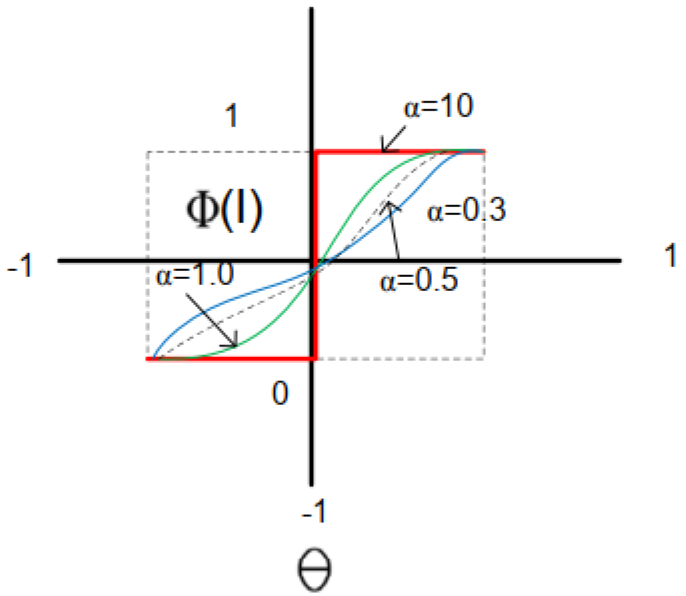
$$\phi(I) = tanh(I) = \frac{e^{\alpha I}-e^{-\alpha I}}{e^{\alpha I}+e^{-\alpha I}} \text{ [tan-Sigmoid]}$$

- Here, α is the coefficient of transfer function.

Other Transformation Functions



(a) Log-Sigmoid transfer function



(b) Tan-Sigmoid transfer function

Advantages of ANN

- ANNs exhibits mapping capabilities, that is, they can map input patterns to their associated output pattern.
- The ANNs learn by examples. Thus, an ANN architecture can be trained with known example of a problem before they are tested for their inference capabilities on unknown instance of the problem. In other words, they can identify new objects previous untrained.
- The ANNs posses the capability to generalize. This is the power to apply in application where exact mathematical model to problem are not possible.

Advantages of ANN

- The ANNs are robust system and fault tolerant. They can therefore, recall full patterns from incomplete, partial or noisy patterns.
- The ANNS can process information in parallel, at high speed and in a distributed manner. Thus a massively parallel distributed processing system made up of highly interconnected (artificial) neural computing elements having ability to learn and acquire knowledge is possible.