**Tutorial on artificial neural network**

Loc Nguyen

Loc Nguyen’s Academic Network, Vietnam

Email: ng\_phloc@yahoo.com

Homepage: www.locnguyen.net

# Abstract

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# 1. Introduction

Artificial neural network (ANN) is the mathematical model based on biological neural network but neural network (NN) in this research always indicates artificial neural network. NN consists of a set of processing units which communicate together by sending signals to each other over a number of weighted connections (Kröse & Smagt, 1996, p. 15). Each *unit* is also called neuron, cell, node, or variable which is quantified by a real variable. Each weighted connection, which is considered a neural cord, is often quantified by a real number called *weight*. According to Kröse & Smagt, each unit is responsible for receiving input from neighbors or external sources and using this input to compute an output signal which is propagated to other units (Kröse & Smagt, 1996, p. 15). The most important thing here is that the signal propagation is done by the means of weighed connections which are imitated as biological neurotransmission with neurons and neural cords. According to Kröse & Smagt (Kröse & Smagt, 1996, pp. 15-16), there are three types of units:

* *Input units* receive data from outside the network. These units structure the *input layer*.
* *Hidden units* own input and output signals that remain within the neural network. These units structure the hidden layer. There can be one or more *hidden layers*.
* *Output units* send data out of the network. These units structure the *output layer*.

Units in NN are also considered variables. The figure (Wikipedia, Artificial neural network, 2009) below shows the simplest structure of an artificial neural network with three layers such as input layer, hidden layer, and output layer. The structure of neural network is often called the topology.

Diagram

Description automatically generated

**Figure 1.1.** Simplest topology of neural network with three layers such as input layer, hidden layer, and output layer

Note that the main reference of this research report is the book “An Introduction to Neural Networks” by Ben Kröse and Patrick van der Smagt (Kröse & Smagt, 1996).

According to Daniel Rios (Rios), there are two main topologies (structures) of neural network:

* *Feed-forward NN* is directed acyclic graphic in which flow of signal from input units to output units is one-way flow and so, there is no feedback connection.
* *Recurrent NN* is the one whose graph (topology) contains cycles and so, there are feedback connections.

It is necessary to evolve NN by modifying the weights of connections so that they become more accurate. In other words, such weights should not be fixed by experts. NN should be trained by feeding it teaching patterns and letting it change its weights. This is learning process or training process. According to Daniel Rios, there are three types of learning methods (Rios):

* *Supervised learning*: According to Daniel Rios (Rios), the network is trained by matching its input and its output patterns. These patterns are often known as classes which can be represented by binary values, integers for nominal indices, or real numbers.
* *Unsupervised learning*: The network is trained in response to clusters of patterns behind the input. According to Daniel Rios (Rios), there is no a priori set of categories into which the patterns are to be classified.
* *Reinforcement learning*: The learning algorithms receive partially information along with input from environments and then, adjust partially and progressively the weighted connections by adaptive way to such input. According to Daniel Rios (Rios), reinforcement learning is the intermediate form between supervised learning and unsupervised learning.

This introduction section focuses on supervised learning in which input and output are realistic quantities (real numbers). For NN, the essence of supervised learning is to improve weighted connections by matching input and output.

# References

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