Deriving Intelligent Systems via Application of Neural Networks across Generic Data

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ABSTRACT

In this research project, the features of an artificial neural network were studied and contrasted with the biological neural network. The metrics such as structures, layers, size and functional capabilities of neurons, learning capabilities, processing elements, processing speed, style of computation, connections, strength, information transmission, information storage, communication media selection, signal transduction and fault tolerance were used as basis for comparison. A major finding in the research establishes that artificial neural networks served as the platform for neuro-computing technology and as such are a major driver for the development of neuron-like computing systems. It was also discovered that Information processing of the future computer systems will largely be influenced by the adoption of artificial neural network model.

Keywords: Artificial, Biological, Network, Neurons, Architecture, Speech Recognition

1. BIOLOGICAL NEURAL NETWORKS

Biological neural networks can perhaps be best defined as, the nervous system as a network of cells differentiated for the reception, transmission and integration of information. This System comprises the brain and spinal cord (the central nervous system, CNS), sensory and motor nerve fibres which enter and exit the Central Nervous System (CNS), or are completely outside the CNS (the peripheral nervous system; PNS). The fundamental unit of the nervous system being, the neuron, whose cell bodies tend to aggregate into concise groups (nuclei, ganglia) or into sheets that lie within the grey matter of the central nervous system (CNS) or are present in specialized ganglia in the peripheral nervous system (PNS).

Groups of nerve fibres transmitting in a common direction usually form a compact bundle (nerve, tract, peduncle, brachium, and pathway). Many of these nerve fibres are girdled by sheaths of lipid material called myelin which gives rise to the characteristic appearance of the white matter. Along with neurons, there are glial cells which play a supporting role and are about 10 times the number of neurons, occupying approximately half the volume of the brain.

Abstractly neurons are specialized;
1. to receive information from the external and internal environment;
2. to convey signals to other neurons and to effector organ;
3. to process information (integration) and
4. to determine or modify the distinction of sensory receptor cells and effector cells.
2. ARTIFICIAL NEURAL NETWORKS

The artificial neuron is a grossly simplified model of the biological specimen incorporating the four basic elements: synapses, soma, dendrites, and axon. The dendrites and synapses of the artificial neurone act as inputs to the processing element, soma. Each of these inputs have an associated connection weight, which simulates the strength of a specific synaptic connection. The processing element multiplies each input with its connection weight, usually summing these products, which is then passed onto the transfer function to derive a result which is then transmitted through the output path. The transfer function dictates the firing of the neurone, this could be based on a certain threshold level, a linear, or a sigmoid function where the threshold varies for output. Neurones can be classified as excitatory or inhibitory dependent on the effect their output inflicts on the output of a target neurone.

Artificial Neural systems do exact their own demands, they do require their implementer to meet a number of conditions, such as:

- a data set which houses the information which can characterize the problem.
- an adequately sized data set to both, test and train the network.
- an understanding of the basic nature of the problem to be solved, so that basic first-cut decision on creating the network can be made. These decisions include the activation as well as transfer functions, and the learning methods.
- Familiarity with the development tools.
- adequate processing power (certain applications demand real-time processing that exceeds what is available in the standard, sequential processing hardware. The evolution of hardware is the key to the future of neural networks).

Once these conditions are met, neural networks offer the opportunity of solving complex problems.

3. LEARNING

Neural networks are trained towards specific outputs by imposing a learning scheme. Learning occurs, where a network alters the weights of its constituent connections, so as to bring it closer to a aspired output or problem solution. Three learning schemes are used:
3.1 UNSUPERVISED LEARNING
The hidden layers organise the weights of their connections with influence from outside the network.

3.2 REINFORCEMENT/SUPERVISED LEARNING
Here the weights of the connections in the hidden layers are randomised, and the resultant output is graded by an instructor or target data set as to how close the desired output it is.

3.3 BACK PROPAGATION
A highly successful method for training multi-level networks where not only feedback on proximity to the target outputs is returned to the hidden layers, but also the information on error levels.

1) OFF-LINE
In off-line methods of learning once the network is in operation its connection weights are fixed. Most networks are off-line.

2) ON-LINE
On-line or real-time learning is where the system continues to learn whilst being employed as a decision tool, such as in a decision support system. This type of learning method requires a complex architecture.

4. LEARNING LAWS
Learning laws are mathematical algorithms that instruct as to how the connection weights of a neural network will be varied after learning. This, again is a crude approximation of biological function as our knowledge of biological learning systems is still incomplete. Some of these major laws that help us understand variance in such networks are:

- **HEBB’S RULE** - If a neuron receives input from another neuron, and if both are highly active, the weight between the neurones should be strengthened.

- **HOPFIELD LAW** - If the desired output and input are both active or inactive, increment the connection weight by the learning rate (traditionally a positive number between zero and 1).

- **THE DELTA RULE/LEAST MEAN SQUARED RULE/WINDROW – HOFF RULE** - A rule where the input connection weights are constantly modified to reduce the difference (delta) between the actual output and the desired output of the neuron. This rule aims to minimise the mean squared error of the network, and this error data is then back-propagated through the layers in the sequence until the first layer is reached.

- **KOHENON’S LEARNING LAW** - A law where neurons compete for the opportunity to alter their connection weights. The neuron with the largest output is given the power to inhibit its competitors and excite its neighbours.

5. APPLICATIONS ON GENERIC DATA- SPEECH RECOGNITION
Speech is probably the most efficient way to communicate with one another. This also implies that speech could be a useful interface to communicate with machines. Speech recognition, has been justifying ground for neural networks. As in neural networks, the challenge is specific to placement of appropriate weights in the connection. In several speech recognition systems, both Markov Model and the Neural Network, techniques are implemented together and they work in a symbiotic relationship. Neural networks perform very efficiently at learning phoneme probability from highly parallel audio inputs, while Markov models can employ the phoneme observation probabilities that neural networks provide to generate the likeliest phoneme sequence, or word. This is at the core of a hybrid approach to understanding natural language.

Multilayer feed forward network, one of the most popular neural network, this consists of an input layer, a hidden layer and an output layer. Here, a set of Mel Frequency Cepstrum coefficients is used as input for the neural network. As we only need ten to twenty of them to represent a word, the neural network will only have 10 to 20 inputs. For each input neuron this parameter is set, hence we install all these input ranges in an 'InputLayer' variable matrix. The hidden layer consists of, non-linear sigmoidal activation function neurons using, 'tansig' MATLAB NN Toolbox function. The amount of neurons depends on certain factors like the
amount of input data, output layer neuron number, the required generalization capacity of the network and the size of the training set. The output layer comprises of linear activation function elements. Once the network is created, it can be trained for a specific problem, by presenting the training inputs and their corresponding targets (also, supervised training). A set of 100 samples of every word can is used as training data, the network is trained in batch mode which mean, that the weights and biases of the network are updated only after the complete training set has been applied to the network.

When the number of words that have to be figured out increases, the number of hidden layer neurons also has to be increased. The amount of neurons required is almost equal to the amount of words to recognize. Increasing the number of hidden layer units, causes the training time to grow sensitively. The performance of the network is mainly dependent on, the quality of the signal pre-processing.

6. APPLICATIONS

Most applications of neural networks can be categorised by five functions:

- **Classification** - The use of input values to categorize objects, pattern recognition is an important application area of neural networks. This can also include tasks such as handwriting recognition, text to speech conversion, diagnosis of disease, optical quality control, and chemical analysis among other things.

- **Data association** - Similar to the classification of objects, but inculcating feedback on errors in the system. Could be found in fault tolerant systems.

- **Prediction** - Using some input values to predict an output, examples of the same can be seen in cardiovascular disease prediction, airline booking systems and stock market prediction.
Data conceptualisation - Analyse inputs so that grouping relationships can be exacted. This finds use in the creation of market demographics, data management.

Data filtering - The use of the neural network to minimise errors or noise in an input. This capability is established in image processing, and enhancing signal to noise ratio in communication systems.

7. CONCLUSIONS
Following are the conclusions drawn from the study:

- Neural Networks attempt to bring computers a bit closer to the brain’s capabilities by imitating aspects of information in the brain in a very simplified way. Although neural networks as they are installed on computers, were inspired by the function of biological neurons, many of the designs have become far detached from biological reality.
- The understanding of biological nervous systems kindled the concept of Artificial Neural Networks (ANN), which are a form of information processing. Usually developed for specific applications, neural networks are optimal for data classification and pattern recognition problems.
- Simple feed-forward systems behave like biological neurons and focuses on pattern recognition. Once the input layer values of the neurons are installed, the neuron derives the output, layer by layer. The dependence output values on input values requires adjusting, every weight and threshold, which can be often complex and time consuming. After training is complete, the network is able to provide reasonable outputs for any type of input, even if it does not resemble the training data. In that case, it attempts to estimate the best output depending on, training method. Learning algorithms are present that accept the inputs, adjust the weights and produce the required output.
- The key idea behind neural network is that they can take in a lot of data, process the same in parallel, and supply accurate output, much as the human brain does. For example, when you see a car, you know straight away that it is a car. You don’t have to stop and gaze at the, shape and colour. You process all data at the same instant to confirm that you see a car, this is what an artificial neural network does for a computer system.

8. REFERENCES: