

Human Neural Network and Artificial Neural Networks: analogy review

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Abstract: Nature is considered as a great source of inspiration as birds inspired humans to fly, ants showed us worth of team-work, similarly human brains architecture inspired to build intelligent machines. Human Nervous System working organization is very complex. It comprises of Peripheral and Central Nervous System. Input information is generated at receptors and transmitted towards brain for detailed analysis and final output is made which is thereby sent to different effectors organs. However, it is very well coordinated and resilient system. Neuron is structural and functional unit of our nervous system. Neurons comprised of cell body containing nucleus, multiple branching extensions dendrites, a long-elongated axon and junction between two neurons called synapse. Neurons produce short electrical impulses or action potential which propagates through neurons to neurons through synaptic communications. Artificial Neuron Networks (AANS) are the machine learning models inspired by the networks of biological neurons found in our brains. ANNS, base of deep learning, application areas are classification of images, speech recognition, video recommendations, complex decision making in gaming and many more. Authors discuss Artificial Neural Networks (ANNS) its analogy to human nervous system and different types of Artificial Neural Networks (ANNS) and its current applications. AANS is also termed as Neural Network or Simple Neural Nets.

Keywords: Artificial Neural Networks, Human Nervous System, Artificial Intelligence, Analogy

Introduction: Human brain is an extremely complex and highly evolved organ ^[1, 2] Neurons are considered to be the basic units of the nervous system. Sensory input received through sensory neurons from the receptors end, act as input process and further brain processes these input information and finally output is created and subsequently output is sent to different organs of body like visual, skeletal muscles, and effectors organs. Neurons are usually interlinked with complex arrangements with junctions known as synapse. In analogy, ANNS comprised of artificial neurons called unit. These units are arranged in turn into complex layers. Given layer can typically contain variable numbers of neuron and may vary between fifteen to millions units depending on nature and need of system requirement. ANNS has

three layers, first being input layer, second being hidden layer structure while third is output layer. ^[3] Input layer functions as data receiver and subsequently data passes through hidden layers causing transformation into valuable output layer. Finally output layers releases as output known as response.

In majority of ANNS, units remain interconnected amongst one layer to another. Each connections typically carry weights that can place influence one over another unit. As data gets further transferred from one to another unit, carry learning process. ^[4]

Authors also discuss about different ANNS including Feed Forward Network, Convolutional Network, Modular Network, Recurrent Network and its application areas in different domains.

Architecture of typical ANNS

Anatomical structures and physiological function of human neurons is basis for ANNS program. ANNS has three layers, input layer being first act as receiver of data input and sends second layer being hidden layer, ^[1,2] processing in hidden layer, each successive neuron receives its input from the predecessor layer located neurons, computing done to get weighted sums, which gets passed to next layer.

Relationship between Artificial Neurons versus Human Neurons

ANNS concept is analogues to human Neurons in structure as well as function. ^[2]

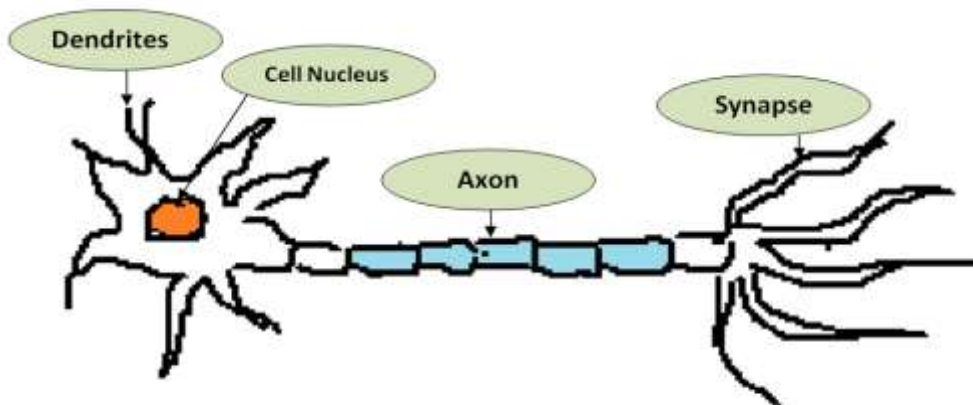


Figure 1: Human Neuron

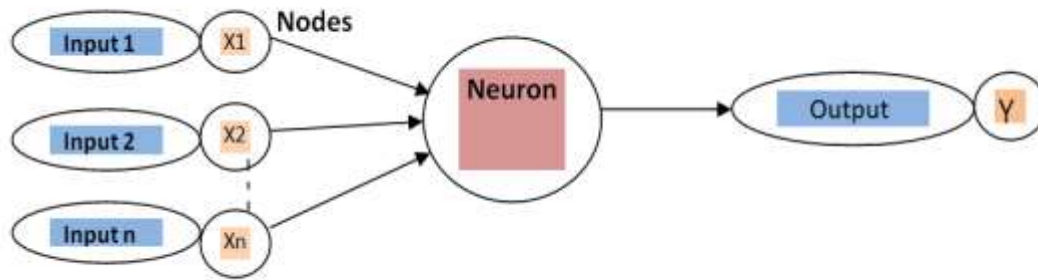


Figure 2: Simple Artificial Neural Network model

Table 1 showing similarity between artificial neuronal network and human neurons.

Human neurons Structure: A typical neuron contains body to process the impulses derived from dendrites, which act receiver, while axon part carry information towards another neuron. As ANNs input nodes receive input information and passed to hidden layer nodes for computation of signals, and later passed on to output layer nodes using activation functions.

Table 1: Analogy between Human Neuron and Artificial Neuron (Perceptron)

S. No.	Human Neuron	Artificial Neuron (Perceptron)	Function
1	Dendrite	Input	Receives information from outer world.
2	Cell body	Nodes	Processing
3	Axon	Output	Final output
4	Synapse	Weight	It is junction between two neurons

Synapse: Synapse is junction between biological neurons causing facilitation of transmission of impulses to cell body. Analogically to synapses are the weights in ANNS that join nodes of one-layer to the next-layer. Its strength is determined by assigned value of given weight.

Process of Learning: In biological neurons learning occur at cell body causing production of new action potential which travels via axon. In ANNS, learning occurs via back propagation.

Activation process: In neurons activation means generation of action potential and later on it propagates. In ANNS, mathematical function called as activation function is related to mapping action of input to output and thereby performing of activation process.

Types of Artificial Neuronal Network (ANNS)

Important types are:

1. Feed Forward Neural Network: It is one of most basic ANNS here input data is guided to travel in single direction only, it does not have looping nodes so all information is only passed in forward direction, also referred as multi-layer neural network.⁶

Information moves through input layer to final output layer. It finds application in pattern recognition, image recognition tasks, where input and output are not dependent, however networks inability of retaining previous inputs makes lesser and lesser useful for sequential data analysis .

2. Convolutional Neural Networks: Convolutional Neural Networks is inspired with visual cortex area of brain. It can identify and classify specific characteristic of an images so accordingly widely used for study of visual images and largely finds applications in image and video recognition, classification of image, analysis of medical image like Computed Tomography scan, computer vision and natural language processing in addition to voice analysis.^[7,8]

It finds application related to computer Vision as offers extremely high accuracy, useful in phone, security, recommendation systems, etc. It is also used in voice recognition.

3. Modular Neural Network: comprised of a group of neural networks linked together via an intermediate, which work independently to give output, however, no interaction takes place amongst themselves. Hence every network is assigned separate sub- task and capable of handling complex management and more basic neural network systems. Multiple neural networks acting as module, with each module solve a part, while role of integrator is subcategorized to multiple modular units and finally integration parts of solution to create final output.it is used in Robotics and autonomous systems and to solve complex problems.

4. Recurrent Neural Networks: based on the principle stating history repeats itself. It is special model characterized by output of a given particular layer is saved and again fed back to ongoing step to yield better outcome prediction. In contrary, traditional ANN , input and outputs are not dependent .

This special layer Hidden Layer of RNNS seems closer to human neural working principle as it remembers information about a sequence. So aptly referred as Memory State for memorizing predicts input and provided for each input as it performs the same task on all inputs or hidden to give result and minimizes parameters complexity, unlike other network. RNNS works better in sequential data like Time-Series data and text data. ^[11]

The fundamental processing unit is Recurrent Unit, as having unique ability to promoting a hidden state, allowing the network to capture sequential dependencies by remembering previous inputs during processing of data. Long Short-Term Memory, Gated Recurrent Unit versions improve the RNN's ability to handle long-term dependencies.

To overcome the problems like vanishing gradient and exploding gradient descent several new advanced versions of RNNs are formed ^[10, 11]

- i. Memory of Long term- Short term
- ii. Two- way Neural Network

i. Memory of Long term- Short term

It's working principle read-write-and-forget as input network reads and writes important information but not relevant information is forgotten thereby allow selected information passage in network. ^[10]

ii. Two-way Neural Network

Considered as modification of Recurrent Neural Networks, input flow in bi-direction and output of bi-directions are again combined together treated as input and useful for context of input constitute vitals like Time-Series analysis.

Conclusion: Artificial neuronal network knowledge is improving with a rapid pace but still needs a significant strive and continuous meaningful concentrated efforts and pace as neurosciences is also advancing very speedily. All stakeholder of Artificial intelligence needs to work in synchrony so that it may mimic human neuronal networks. Globally advent of newer computing system, various model's developmental stages with diverse specifications, modalities and efficacy are evolving. As future growth of ANN will definitely prove to be greatest scientific boon for humanity across globally as it will holistically improve screening of diseases, early diagnosis, personalized treatment, advancement in diagnostic, therapeutic and rehabilitative measure. It will also improve social interaction, mental health, emotional health, financial activity, entertainment activity almost every aspect of human being. Authors are hopeful that sooner ANNS will match HNNS not only in analysis but also in stronger reasoning and other capability also.

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Abbreviations:

AANS: Artificial Neural Networks

HNNS: Human Neuronal Networks

CNNS: Convolutional Neuronal Networks

RNNS: Recurrent Neural Networks