HOW DO ARTIFICIAL NEURAL NETWORKS WORK?

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This paper deals with the definition of artificial neural networks, principles of their operation and practical application. It also describes the basic concepts related to the study of neural networks, as well as identification of development prospects.

Artificial neural networks (ANN) are a modern and very promising computing technology that gives us many opportunities in various fields of science, especially physics, computer science, astronomy and economics. Currently, they are widely used in solving a variety of tasks and are actively used where conventional algorithmic solutions are ineffective or even impossible. Among the tasks that artificial neural networks are trusted to solve are text recognition, contextual advertising on the Internet, spam filtering, checking for suspicious transactions on bank cards, security systems and video surveillance, and that is not a complete list.

Neural networks are the result of research in the field of artificial intelligence, i.e., attempts to reproduce the ability of the biological nervous system to study and correct errors by modeling the structure of the brain at a lower level. The brain consists of a large number of connected neurons (on average, there are thousands of connections per neuron). As indicated in Fig. 1, neurons are special cells that can transmit electrochemical signals. Neurons have branched input structures (dendrites), nuclei and branched outputs (axons). The axons of a cell use synapses to connect to the dendrites of other cells. When activated, neurons send electrochemical signals to their axons. Through synapses, the signal reaches other neurons, which, in turn, can be activated. When the total level of signals from the dendrite to its nucleus exceeds the activation threshold, the neuron is activated.

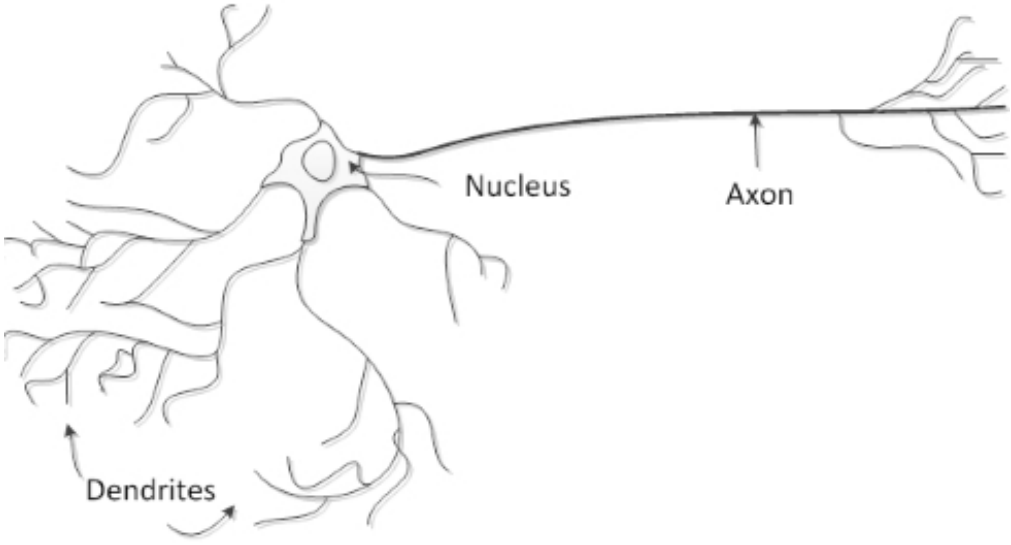

Figure 1 – The natural structure of the human brain

Consequently, artificial neural networks are mathematical models, as well as their software implementation, based on the principles of organization and functioning of biological neural networks in the nerve cells of living organisms [1]. Artificial neurons can be connected to each other in several ways. This gives you the opportunity to create diverse neural networks with different architectures, training methods and skills. The concept is based on the idea that neurons can be modeled using fairly simple automata, and the flexibility of brain functions and other basic characteristics are determined with the use of the connections between neurons. To describe algorithms and devices in neuroinformatics, a special “solution”

was developed in which the basic devices are networked to solve problems. For many beginners, it seems surprising that these elements are not necessarily implemented as separate parts or blocks in the hardware introduction of neural networks or in professional software. The ideal solution used in neuroinformatics is a special language for describing and studying neural networks.

ANN can be also characterized by the ability to learn independently, memorizing past experience. Therefore, the number of errors in the system is getting smaller and smaller every time. Speaking about the similarity with our nervous system, ANN consists of independent neurons located on several layers. The data, which is received at the input, is processed sequentially at each network layer. In this way, ANN consists of nodes that form a layer, namely an input layer, an output layer and several hidden layers (as depicted in Fig. 2). Each node is connected to other nodes with certain weights and thresholds. When a node's output signal exceeds a threshold value, that node is activated and data is sent to the next network layer. Otherwise, the data will not be transferred to the next network layer [1].

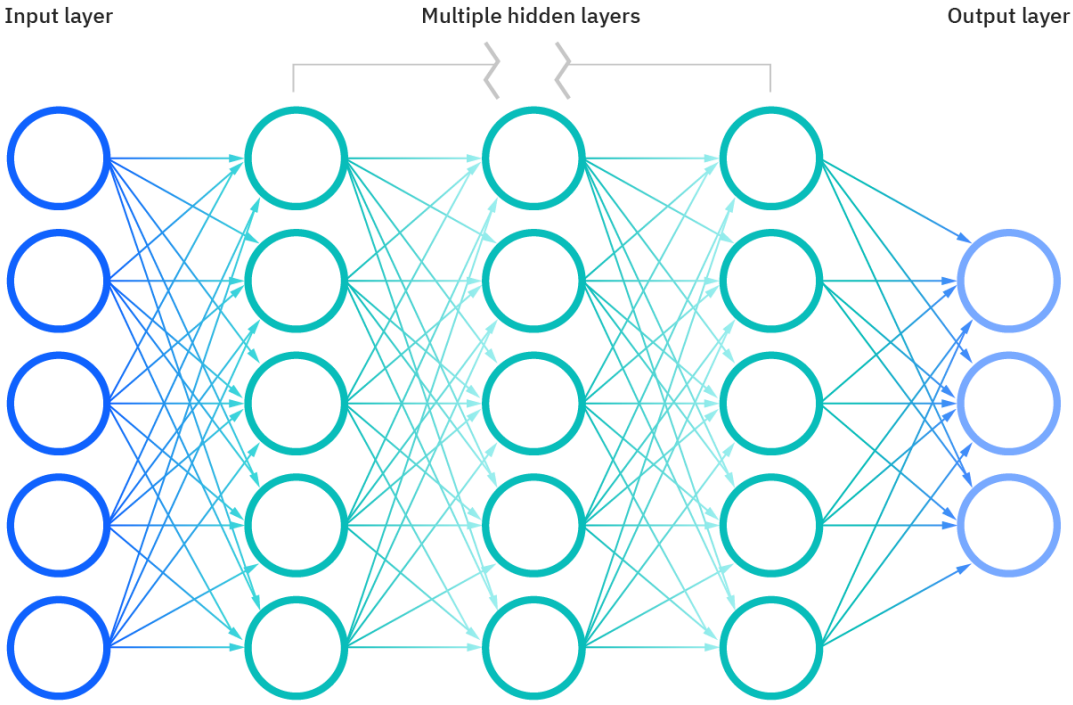

Figure 2 – The natural structure of the deep neural network

Neural networks are trained by establishing connections between neurons, namely weights. As described in the ganglion structure, the scale represents the knowledge of the neural network. Different scales cause the network to produce different results for the same input signal. Hence, neural networks can improve these results by adapting these weights to the learning rules [2].

For example, if you are talking about detection, the input image falls into a network of layers that can be called filters of different sizes and complexity of the detected elements. These filters form their own index or set of attributes, and then fall into the classifier. Biological neural networks are used to recognize objects of varying complexity from images and images. If we look at the example of face recognition, the reception field of our first layer will be very small, then a little bigger, a little bigger, and so on, until we finally can recognize the whole face. The first thing we need to do is run a face detector on the image to find the face. Then we center the face and send it to the neural network for processing. After that, we get a set or a set of feature vectors that clearly describe the characteristics of this person. Then we can compare this feature vector with all the feature vectors stored in our database.

The application I want to talk about is semantic segmentation of 3D images in medicine. Generally speaking, medical imaging is a complex field that is very difficult to deal with because we have very little data. In this case, ANN is used with two threads. One part handles a more normal resolution and the other has a slightly lower resolution to reduce the number of layers we need to train. This will slightly reduce the time for online training. Where to use it: detecting damage after a stroke and searching for tumors in the brain in cardiology to determine how the heart works.

The growth in this field has been foreseen by the big names, companies such as Google, Amazon, etc. This companies have invested in developing products such as libraries, predictive models and intuitive GPUs that support the implementation of neural networks. The question dividing the visionaries is on the

reach of neural networks. To what extent can we replicate the human brain? We have to wait a few more years to give a definite answer.

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