UDC 004.032.26

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THE CONCEPT OF DEEP LEARNING: RECOGNIZING ELEMENTS IN CARTOGRAPHIC IMAGES

Abstract: In the process of digitizing archives, there is a problem of transferring the obtained data to a vector image to further work with the obtained result, for example, take the cartographic schemes of hydraulic structures. To solve this problem, consider deep learning. Deep learning, in turn, is a class of machine learning algorithms that uses a multilayer system of nonlinear filters to separate the required characteristics with transformations. Consider how deep learning works, on the example of recognizing elements in a cartographic image.

Keywords: vector image, image recognition, deep learning, cartographic schemes

Formulation of the problem

Nowadays, a large amount of data is stored in non-digitized form. This is a big problem, because such data cannot be worked with, cannot be edited, and over time, their condition deteriorates and thus information is lost. Today there are some methods to solve this problem. With the help of certain software it is possible to digitize cartographic schemes, but the quality of the result will be unsatisfactory, because after digitization, the image must be manually processed, and this is a lot of time. Alternatively, to solve this problem, it is proposed to use a neural network for image recognition, namely deep learning.

A neural network is a mathematical model in the form of a software and hardware embodiment based on the principles of functioning of biological neural networks. Today, such networks are actively used for practical purposes due to the possibility of not only development but also learning. The main priority was to solve the problem according to the model of how the human brain copes with it. Thanks to the large amount of data, it is possible to train the neural network to recognize all the elements of hydraulic structures depicted in the cartographic diagram.

Deep learning, in turn, is a class of machine learning algorithms that uses a multilayer system of nonlinear filters to separate the required characteristics with transformations.

Methodology

Machine learning is a part of artificial intelligence, which is not aimed at direct problem solving, but at learning, using a large amount of data to solve similar problems. Simply put, it is an attempt to teach computers to learn on their own, instead of following clear rules. This is made possible by the computing power of modern technology, which can easily handle even huge amounts of data.

Artificial intelligence specialists distinguish controlled and uncontrolled learning [1]. Supervised learning means the use of labeled data sets that contain input data and expected outputs. When learning a neural network through controlled learning, you provide both input and expected output. If the neural network generates an erroneous result, it adjusts its calculations. This process will stop when the network stops making mistakes.

Unsupervised learning means using data sets without a specific structure. When you train a neural network uncontrollably, it conducts its logical classification of data (Fig. 1).
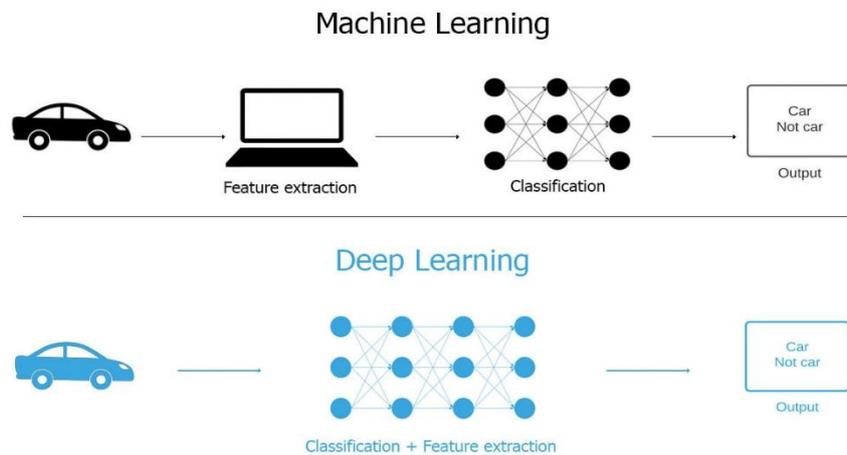

Figure 1. Comparison deep learning and machine learning

Deep learning, in its turn, is a class of machine learning algorithms that uses a multilayer system of nonlinear filters to separate the required characteristics with transformations. At the beginning of each subsequent layer, the data obtained as a result of the previous layer are taken. Deep learning provides an opportunity to teach the model to predict the outcome, only on the input data set. Both controlled and uncontrolled training can be used to teach such a network.

Recognizing elements

Let us consider how deep learning works using the example of recognizing elements in a cartographic image. The training will be controlled. We need the program to detect on the handwritten map, for example, the symbol "shrub" according to the following input data:
-color
-height
-width
An artificial neural network consists of interconnected neurons (Fig. 2):

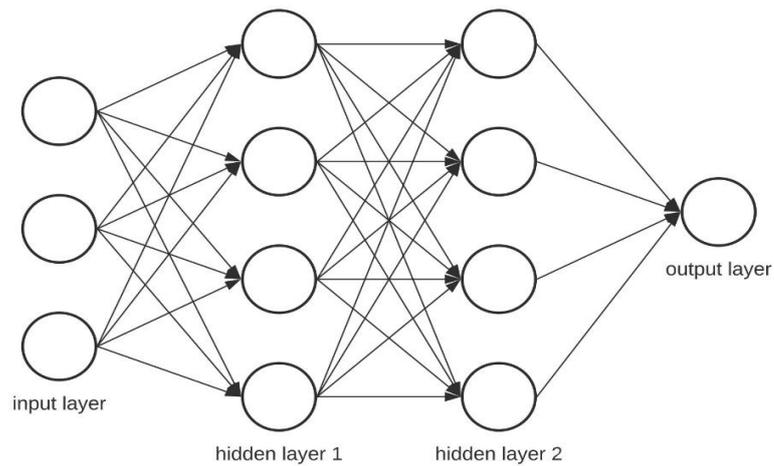*Figure 2*. Deep neural network (2 hidden layers)

Neurons are grouped into three different types of layers:

• input;

• hidden layer (layers);

• output.

The input layer receives data. In our case, there are four neurons: a dam, a river, a bush, and a settlement. Then they are transferred to the first hidden layer.

Hidden layers perform mathematical calculations with input data.
The presence of more than one hidden layer indicates the "depth" of learning.

The output layer shows the result. In our case, these are the symbols found on the map illustrated by Fig. 3.
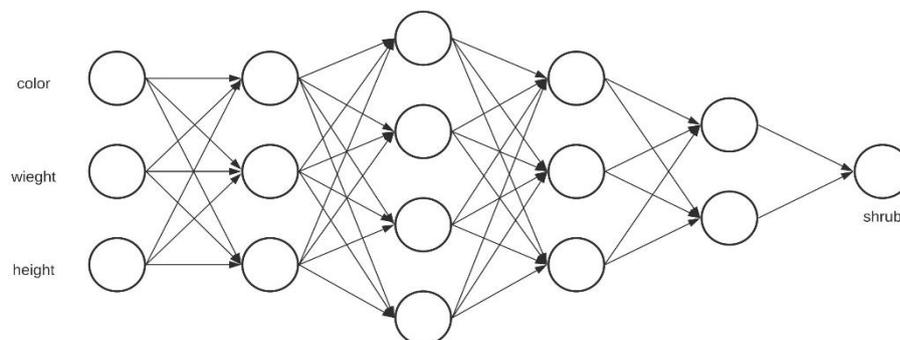

Figure 3. Structure of input and output layer

So how are the elements recognized? This is where deep learning takes place. Interconnected neurons have a certain weight. It is this weight that determines the value of the input element [2]. The initial weight is indicated randomly.

To read the elements, "color" is one of the most important criteria in determining this symbol. This means that the connections of the neuron "color" should have the biggest weight (Fig. 4).
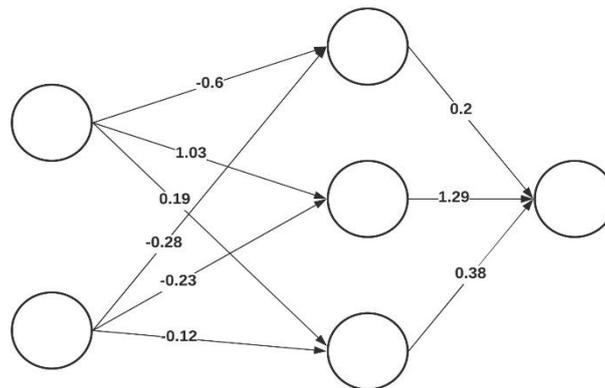

Figure 4. connections of the neuron "color"

The most complicated part of deep learning is neural network learning. Because you need to have a lot of data and a lot of computing power.

To recognize the elements in the image, you need to find many examples of maps with the symbols we need. To teach a network, it is necessary to offer it all the prepared data and compare the initial results generated by it with the data of our set. Until the network is trained, the results will be erroneous.

After processing all the data, we can define a function that will show us how the results of the algorithms differ from reality. This is a function of losses. For a perfect picture, it needs to be zero. This will mean that the initial results of the network completely coincided with our data set.

To reduce the value of the loss function, you need to change the weight between the neurons [3]. This can happen by accident, but it is not an effective enough way.

You can use the gradient descent method. This method allows finding a minimum of functions [4]. The bottom line is that you need to change the weights little by little after each iteration. By calculating the derivative of the loss function, with a specific set of weights, we will determine in which direction the minimum is (Fig. 5).

It is important to repeatedly go through the data to minimize the loss function. That is why this process will require large computing power. Weight change using the gradient descent method is automatic [5].

Upon completion of the training, the network will allow the recognition of the symbols "bush" illustrated by cartographic images.
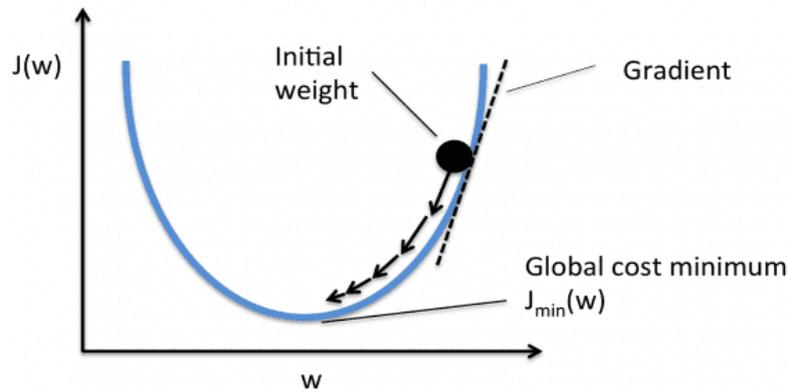
Figure 5. Gradient descent method

Conclusion

The ability to learn based on information obtained from the environment is a major feature of artificial neural networks. As a result of training, networks can increase their productivity. This happens over time and in accordance with the rules. In general, deep learning of the neural network occurs through the process of changing the weights of neurons. In the correct course, the neural network receives data from the environment at each iteration of its learning process. Thus, to solve the problem of recognizing elements in cartographic images, it is possible to use methods of deep learning of neural networks. However, the problem of deep learning in the aspect mentioned above is extremely complex and cannot be fully resolved in this study, which necessitates its further development.

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