Use of artificial intelligence for automated map updating

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Abstract. Nowadays the tasks to quickly update the cartographic material are prevailing due to the fact that every year the landscape changes around the world are accelerating. The amount of houses change, forests turn into cities, etc. Since updating the material is a rather large and time-consuming task and there are few specialists, the solution lies in the maximum automation of this process. In the past ten years, artificial intelligence systems have reached a lot in the recognition of various patterns, which we can use to recognize certain objects or vegetation in images, followed by their vectorization and placement in GIS.

1. Introduction

Deep learning and machine learning based on layered representations of variables called neural networks made speech understanding practical on our phones and other devices and its algorithms can be widely applied to a great variety of applications [1-5]. Natural Language Processing (NLP), through the rapid presentation of knowledge and thoughts opened up new possibilities for web search.

It became possible to solve the problems of the automation of cartographic materials updating with the modern development of technologies for storing and processing of data using artificial intelligence.

If maps are updated promptly and correctly, they convey spatial information precisely and quickly.

There are two ways to perform the process of creating and updating a map [6]. First, users make a map from some datasets using appropriate software such as geographic information systems (GIS) [7]. Otherwise, a map server is required as the final tool for the visualization of data sets, as, for example, in the automated control of technological parameters of stationary equipment [8]. In both cases, a set of knowledge of the operation in these systems is required.

The purpose is to solve the decision problems in topic mapping to make the perfect map using an intelligent user management system. Key decision-making issues related to the topic design of a map should be clearly analyzed at the start of the development of a good smart system.

There are more than 10 well-known types of topic maps, namely: point chart maps, line chart maps, monochromatic mosaic maps, contour maps, stereoscopic perspective methods, nominal point symbol maps, proportional symbol maps, point methods (dot mapping), method of classification ratio, statistical maps (methods of area graphs), methods of cartographic arrow and triangular diagram. Different geographic data have different data structures [9-11] (Figure 1).
2. **Choice of network class**

As it is mentioned earlier, neural networks are most useful for the solution of automated recognition problems, since they are able to solve the following range of tasks for GIS:

- Identification of objects;
- Semantic definition of the boundaries of objects (allows leaving only the boundaries of objects in a picture);
- Semantic segmentation (allows splitting an image into various separate objects);
- Selection of surface normals (allows converting two-dimensional images into three-dimensional images).

It is necessary to note that the problem of image recognition has an important character and the solution of this problem is a complex and extraordinary process.

This study will consider the algorithm for creating and training the recognition of terrain objects of a neural network. The images will be read by one of the inputs of neural network and one of the outputs will be used to output the result.

At this stage, it is necessary to briefly dwell on the classification of neural networks. Nowadays, there are 3 main types of them:

- convolutional neural networks (CNN);
- recurrent networks (deep learning);
- reinforcement learning (RL).

According to all the results of a detailed analysis of the main neural networks, the convolutional principle of the construction of neural networks was developed. The idea of this principle was to implement the functioning of the neural network, the alternation of convolutional layers, usually denoted as C - Layers, subsampling layers S - Layers, and fully connected F - Layers at the output from the neural network.

In the basis of such a network there are three paradigms - the paradigm of local perception, the paradigm of shared weights and the paradigm of subsampling.

3. **Implementation of neural network training**

The existing networks are divided into 3 classes of the architecture in terms of learning:
• Learning with a teacher (perceptron);
• Learning without a teacher (networks of adaptive resonance);
• Blended learning (networks of radial-basis functions).

One of the most important criteria for the evaluation of the performance of a neural network in the case of image recognition is the quality of image recognition. It is necessary to note that for a quantitative assessment of the quality of image recognition using a neural network, the root-mean-square error (RMSE) algorithm is most often used:

$$E^p = \frac{1}{2}(D^p - 0(I^p, W))^2$$

In this relation $E^p$ – the $p$th recognition error for a pair of neurons, $D^p$ – the expected output result of the neural network (usually the network should strive for 100% recognition, but this is not yet happening in practice), and the construct $O(I^p, W)^2$ – the square of the network output, which depends on the $p$th input and the set of weight coefficients $W$.

This construct includes both convolution kernels and weight coefficients of all layers. The error calculation consists in the calculation of the arithmetic mean for all pairs of neurons (Figure 2).

![Figure 2. An example of learning](image)

The main idea of the method is to disseminate information, in the form of error signaling, from output neurons to input neurons, that is, in the direction opposite to the propagation of signals through the neural network [12, 13].

In addition, it is necessary to note that the training of the network is carried out on specially prepared databases of images classified into a large number of classes and takes quite a long time. Today, the largest databases are ImageNet and TensorFlow. Both of them have free access to academic institutions. However, the images in these databases are focused on other tasks, such as: finding and recognizing people and objects in ordinary images. In our case, aerial and space photography are used in cartography. Accordingly, the databases of this kind must be collected independently from the images available on the network and carrying out manual preliminary recognition using special software.

As a result, it is necessary to note that neural networks and algorithms, based on the principle of their functioning, can find their application in fingerprint card recognition systems for internal affairs
bodies. Usually it is the software component of a software and hardware complex aimed at the recognition of such a unique complex image as a drawing, which is an identification data that does not fully solve the tasks assigned to it. A program based on the algorithms built on a neural network will be much more efficient.

Today further research of neural networks seems to be a promising area of research that will be successfully applied in an even larger number of branches of science and technology, as well as in human activities (Figure 3). One of these areas is the creation of an intelligent information system for automated trading on the stock, currency or cryptocurrency markets. To increase the learning speed of neural networks, it is proposed to implement a distributed algorithm based on the use of the main application as the central node of a distributed system in conjunction with an arbitrary number of auxiliary nodes [14].

![Figure 3. An example of automated building search](image)

The main emphasis in the development of modern recognition systems is now put to the field of semantic segmentation of 3D images in geodesy, medicine, prototyping and other areas of human activity. These are rather complex algorithms and this is due to:

- Lack of a sufficient number of databases of reference images;
- Lack of a sufficient number of free experts for the initial training of the system;
- Images are not stored in pixels, which require additional resources from both a computer and developers.

4. Conclusion
To conclude with, we can summarize the following:

- Neural networks can find application, both in the issue of image recognition of both buildings and vegetation objects in aerial photographs;
- Neural networks can be trained, which indicates the possibility of the optimization of the process from functioning.
- There are mechanisms for the adjustment of the parameters to the required value, calculating the required weight coefficients.
It is necessary to note that today there are a large number of standard architectures to construct neural networks, which greatly facilitates the task to construct a neural network from scratch and reduces it to the selection of a network structure suitable for a specific task.

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