

## **Handwriting Recognition Methods and Approaches**

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**Abstract.** The paper analyzes the existing methods and approaches for character recognition. The subject area and its problems are considered. The best method for solving the handwriting recognition task is the convolutional neural network method. Features of software implementation of convolutional neural network, implementation of data storage model for training are considered.

**Keywords:** Character recognition, neural network, recognition methods, convolutional network, data models.

The task of recognizing handwriting characters is one of the most complex and demanding tasks facing developers of modern software systems. This task requires a large amount of computing resources to solve, and existing software solutions work with a certain level of character recognition, which makes the work relevant.

Using neural networks to solve the character recognition task will improve existing software solutions, automating the process of translating human-written information into digital form.

Existing software methods are not always effective enough - recognition or inaccurate or long-lasting, which is especially true when using computing devices.

There is a problem with the imperfection of character recognition modern methods, which do not provide high quality and speed of recognition.

There are the following existing recognition approaches:

1. Comparison with the sample. The geometric normalization is applied and the distance to the prototype is calculated. The most obvious use of this method in the recognition of text. The disadvantage of this method is the inaccuracy of recognizing the manuscript character due to the large number of letters variations.
2. Statistical methods. Distribution for each class is built and classify it by Bayes rule. The distribution can be built using a training collection.
3. Structural and syntactic methods. The object is broken down into elements. Rules are made depending on the occurrence of individual elements and their sequences.

There are three methods of pattern recognition.

The first is the search method. In this case, a comparison is made with the database, where each type of object is represented by different display modifications. For example, for optical pattern recognition, you can use the method of sorting an object at different angles, scales, displacements, deformations, etc. For letters, it is necessary to iterate over the font, font properties, etc. In the case of audio pattern recognition, respectively, comparison with some well-known patterns (for example, a word spoken by several people).

The second approach is to conduct a deeper analysis of the image characteristics. In the case of optical recognition, this can be a definition of different geometric characteristics. The audio sample in this case is subjected to frequency, amplitude analysis, etc. [1, p. 20].

The third method is the use of artificial neural networks (ANN). This method requires either a large number of examples for learning recognition tasks, or a special neural network structure that takes into account the specificity of the task. The method is more efficient and productive [2].

The fourth method is genetic algorithms. A genetic algorithm is a heuristic search algorithm that is used to solve optimization and modeling problems by randomly selecting, combining, and varying the desired parameters using mechanisms similar to natural selection in nature. There are a variety of evolutionary computations that solve optimization problems using natural evolution methods, such as inheritance, mutations, selection, and crossover. A distinctive feature of the genetic algorithm is the emphasis on the use of the "crossing" operator, which produces the operation of recombination of candidate solutions, the role of which is similar to the role of crossing in the wild [3]. The genetic algorithm is slower and is characterized by a stepwise error improvement.

In order to solve the problem of handwriting character recognition, the method of convolutional neural networks was chosen because of its versatility and noise immunity in the input data (Fig. 1).

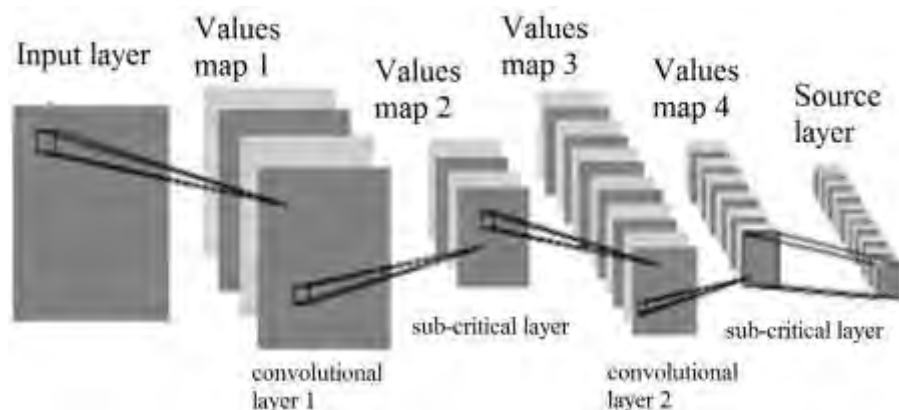


Fig. 8. Structure of the convolution network

The most important steps in the recognition process are:

1. Image perception.
2. Pre-treatment. Noise removal, black and white image representation, trimming of unnecessary image parts;
3. Characterization (indexing). At this stage, the characteristic properties of the object are measured.
4. Classification (decision making).

Thus, handwriting recognition is not an unfinished task, which has many flaws and does not have a finite algorithm for recognizing with minimal error.

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