

Hybrid system for recognition of handwritten symbols on the base of structural methods and neural networks

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Abstract

The problem of handwritten symbol recognition has been investigated. An algorithm of approximation and breaks elimination has been developed. This approach allows to simplify the description of symbols and remove available errors. A method of structural recognition based on the description of a structure for handwritten symbols with the help of primitive sequences, robust to geometrical distortions has been used. A structural classifier has been used in a combination with the specified method of the description. The technique for the analysis and optimization of a choice of feature extraction algorithm and its parameters based on an estimation of clusterization quality of training sample with the help of self-organizing neural networks has been implemented. Computation algorithm of Legendre moments is presented. A new method for training RBF-neural network is represented. Classification results for binary images (handwritten Arabic numerals) are presented. On the base of classification results the recommendations for choice of maximal order Legendre moments and various classifiers are given.

1. Introduction

The system consists from two parts: structural recognition subsystem, and neural recognition subsystem [6, 7]. Methods of structural recognition have more potential when it is necessary to achieve high recognition quality at significant modifications and distortions in recognized objects in comparison with an ideal one. We suggest the structure of recognition system on the basis of comparison with the standard. The structural methods, permitting to select and recognize structure, are characterized by a stability to the distortions peculiar to handwritten symbols: variations of a size, proportions, an angle of declination, thickness of a line. The possibility of training allows to adjust a system to various types of symbols (numerals,

letters of various languages, other symbols).

The structural subsystem operates according to the following stages:

- filtration and thinning;
- approximation of the symbol on the base of graph representation;
- elimination of the break-downs;
- exposition of a symbol structure via primitive sequences;
- recognition of an image by the search close ideal description via the base of standards.

Neural subsystem performs feature extraction task from the image on the basis of Legendre moments and classifies them with the help of RBF network. So, real output of the system is based on the best result of two subsystems. Both subsystems has been trained on the same data set of grayscale images.

2. Break-down elimination

The basic direction of the feature extraction (compression) in a structural recognition of handwritten numerals is selection of symbol structure with the help of thinning [1], graph extraction and approximation. The serious problem is the break-downs that takes place because of the errors of spelling and scanning, and causes the large modifications in description of a symbol structure. The break-downs of handwritten symbols have been investigated, and the fast heuristic algorithm of their elimination has been developed. The break-downs can be divided into three types. Figure 1 shows them.

It should be noted that the characteristic case is the "point-line" break-down. It is appropriate to such situation when square of distance between vertex of graph and the nearest point of some edge, not incident to vertex and not connected with it, is less than threshold P . The threshold is usually defined by percentages from geometrical size of a symbol that makes algorithm insensitive to symbol

