

Optical Character Recognition Using Optimisation Algorithms

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Abstract¹

The purpose of this paper is to present a new method of optical character recognition using hierarchical optimisation algorithms. Mainly, the existing methods and algorithms for optical character recognition are not suitable for using them in industrial systems, i.e. they are not stable to defects and distortions of the recognised characters. Therefore we have developed a new algorithm which is based on the pattern character recognition algorithms and uses hierarchical optimisation. The better recognition results obtained using the proposed algorithm give us a confirmation of a better aptitude of the approach for the industrial environment.

1. Introduction

The existing methods and systems for optical character recognition provide high reliability of the recognition of texts with high and medium print quality. A small number of errors in long texts is usually not a serious problem – one does not notice them at all or corrects them easily.

However such systems are not always able to cope with the task of characters recognition in industrial systems, for example, while recognising serial numbers and inscriptions on components, products, packing etc. The main requirements in this class of problems are reliability and stability, since even single errors in recognition of relatively short inscriptions may produce a serious problem. Algorithms which are used in industrial systems should be stable to different kinds of defects that originate from displacement or deformation of the object, distortion of the image acquired from the camera, image

noises, colour changes under different lighting or pollution etc (see figure 1). In these cases the algorithms for recognition of the printed text give quite poor results.

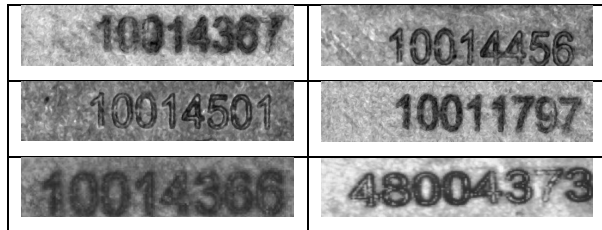


Figure 1 – Samples of the recognised serial numbers

In this paper a new recognition algorithm that has a high precision and is suitable for using in industrial systems is presented. The algorithm provides a high degree of recognition accuracy and is suitable for using in industrial systems.

2. Methods of Optical Character Recognition

The main methods of the character recognition can be divided into the following groups by the used algorithm:

- pattern systems;
- structural systems;
- feature systems;
- neuronal network systems.

Each of the mentioned systems has both advantages and disadvantages which are namely the following:

1. Structural algorithms are very sensitive to the image defects. Besides, in contrast to the pattern and feature systems, effective automated learn procedures for structural systems are not implemented yet [1,2,3].

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2. Feature systems lose important information while calculating the character features and as a consequence make errors on objects classification referring them to the wrong classes [1].
3. Although neuronal networks are able to recognise different fonts taking into consideration their defects and distortions, nevertheless they require complicated multi-layer structure and need a long training using sets of samples [4]. This is not always practicable in industrial environment and at the same time the economic forces are of great importance here.
4. Pattern algorithms are stable to small defects of the image and have sufficiently high recognition velocity. However even minor distortions of the image, which lead to the characters distortion, may influence negatively on the result of recognition [1,2,3].

The task which is to be solved by the described algorithm consists in fast, reliable and stable recognition of the short groups of characters in industrial environment, i.e. when the probability of acquiring distorted and noised images is very high. Therefore implemented recognition algorithm should meet the following requirements:

- stability to defects of the recognised characters;
- high velocity;
- easiness of the tuning and training.

Taking into consideration the existing methods of the optical character recognition and the mentioned above requirements, it was concluded that pattern algorithms are the most suitable for solving this task.

3. Recognition Algorithm

The principle of the pattern algorithms consists in the following: an object which contains the required character is picked out from the original image and is compared to all the patterns from the database; the pattern which has fewer differences from the original image is taken as a result.

It is reasonable that during the comparison between the pattern and the character one of them should be at least shifted vertically or horizontally. Therefore the recognition time depends mainly on the size of the object. Sometimes the rotation of the pattern is needed, which also increases the time of recognition.

The main problem of using the common pattern algorithms for text recognition on distorted and noised (including polluted) images is the large distortion of the characters, which leads to impossibility of their direct comparison with patterns. To solve this problem it was suggested to use the following approaches:

1. Distortion of the template when comparing with the recognised character;

2. Consistent change of the pre-process filters settings and analysis of the recognition results considering the previous recognition results.

Both suggested approaches lead to increasing of the recognition time. Therefore, to improve the algorithm velocity on searching the template which corresponds best to the character on the image, hierarchical probabilistic matching is used. This method consists in the following: when comparing the templates with the character

- not every but only a part of the possible template positions regarding the image is checked using definite algorithm;
- resolution (point number) of templates and search field changed: first few points, then step by step more until all points are used.

In other words, optimisation algorithm searches the optimum (in our case – maximum) of the quality function which reflects how good the correspondence between the template and the character by current resolution is. The side effect of the search is the fast definition of precise position and orientation of the character. It helps to decrease the search area in dynamic and increases the velocity additionally. Multidimensional optimisation with Powell's method was chosen as an optimisation algorithm.

While searching the following variables can be changed independently from each other (by each resolution):

- translation along the x- and y-axes;
- translation in the directions (x, y) , (-x, y) etc.;
- rotation around the x- and y-axes;
- rotation around the z-axis;
- scaling (=translation along the z-axis).

Hence, the optimisation by each resolution is carried out in 8-dimensional space.

According to the optimisation algorithm the position of the template for the next iteration is defined on the basis of the quality criterion, which is calculated by the following formulas:

$$QC_1 = \sum_{i=0}^N d_i^k, \quad (1)$$

where N is the amount of the template points, d_i is the distance from the i-point of the template to the nearest point of the recognised character, k may be 1/2, 1 or 2.

$$QC_2 = \frac{N_e}{N_t} \cdot \frac{N_e}{N_c}, \quad (2)$$

where N_e is the amount of the template points which are coincident to the points of the recognised character; N_t is

the total amount of the template points, N_c is the amount of the points of the image area which is bounded by the applied template.

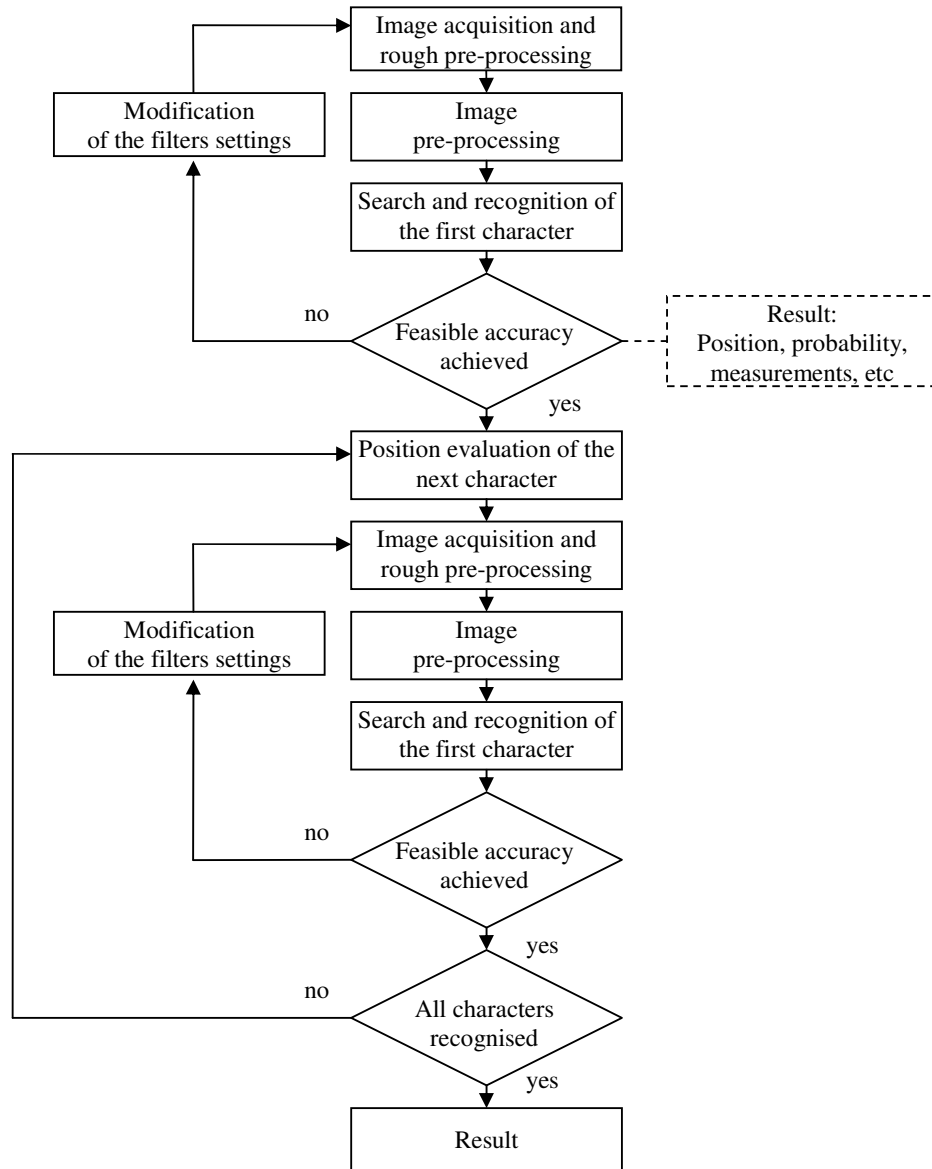


Figure 2 – Common algorithm of the character recognition

Figure 2 represents the common character recognition algorithm which uses probabilistic matching.

As it was mentioned before, one of the solutions of the character recognition problem on the distorted and noised images is the hierarchical iterative character recognition algorithm. On all hierarchic levels and each of the iterations definite pre-processing filter settings are used (for example, binarisation threshold, iterations number and radius of the anisotropic diffusion filter, radius of the voting binary hole filling filter, kernel size of the morphological filters, etc.). Each of the iterations is followed by the recognition results analysis, which is carried out considering the results that were obtained on

the previous steps. On reaching the results with feasible accuracy another hierarchical level (with more precision) can be used or the process of filter settings changing is stopped.

The main idea of this method consists in following: different characters on one image can be recognised correctly on pre-processing of this image using filters with different parameters (see figure 5). For example, if one of the characters is recognised correctly using the binarisation threshold T_{B1} , and the other using T_{B2} ($T_{B1} \neq T_{B2}$), it is impossible to find the parameter value, at which both of the characters can be recognised with feasible accuracy.

One of the important steps of the recognition algorithm is the quality criterion calculation which represents the

quality of the template application on the recognised character (see figure 3).

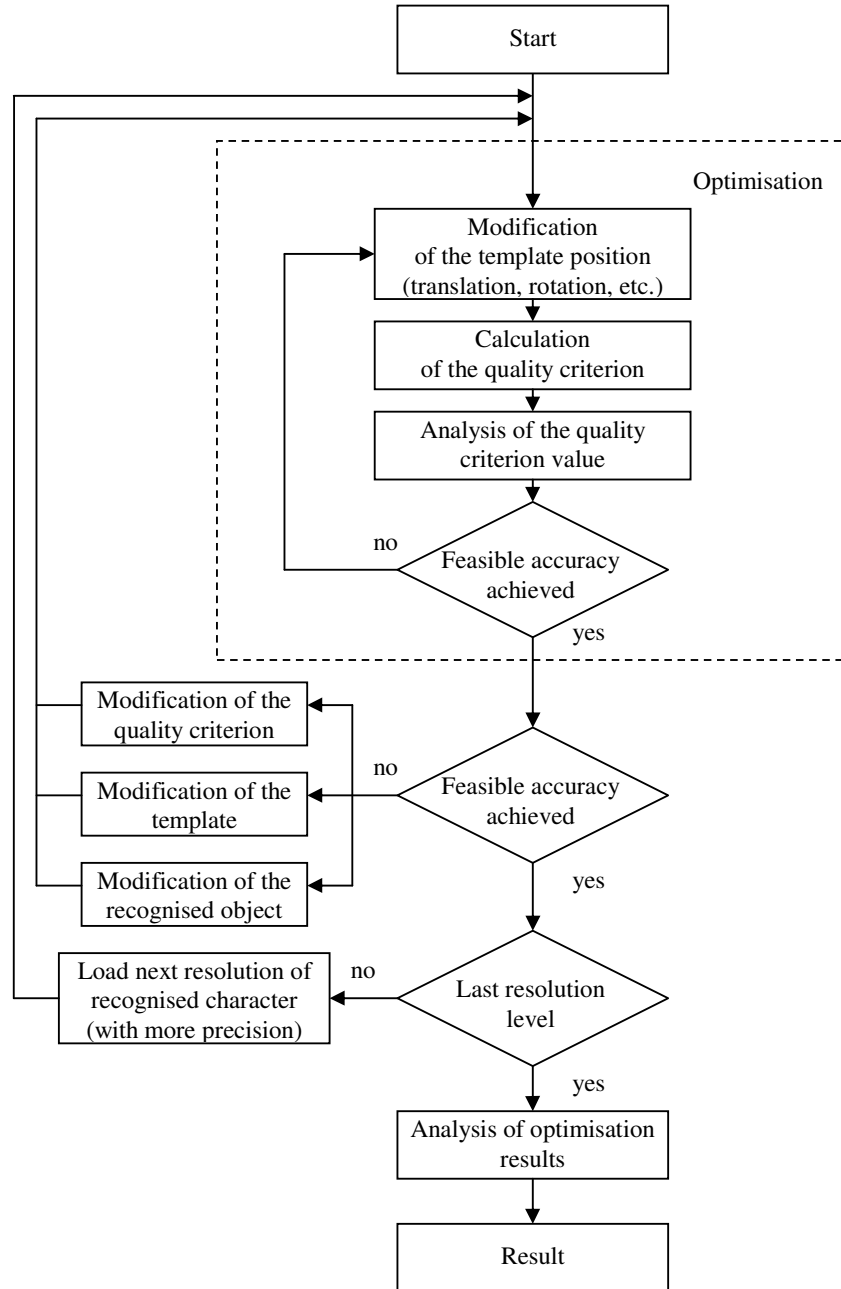


Figure 3 – Algorithm of the quality criterion calculation

By character recognition on distorted and noisy images the template can be also distorted when comparing it to the recognised character. This distortion is carried out both on the step of the quality criterion calculation (template scaling, rotation around the x- and y-axes) and later, after the step of optimised quality criterion analysis (optical distortion of the template, etc.). Furthermore, to increase the recognition accuracy on the step of comparison of the template with the recognised character

the following modifications are carried out taking into consideration the calculated quality criterion:

- changing the resolution;
- modification of the search area (for example, limitation of the image area which contains the recognised character);
- modification of the quality criterion (for example, on the first step of optimisation the

sum of squared distances is used (see formula 1) and on the next step – the amount of the template points which differ from the points of the recognised character (see formula 2).

optical character recognition software such as TOCR, SimpleOCR, GOCR, OpenOCR, TopOCR, Readiris Pro, ScreenOCR etc. Almost all systems (except TOCR) are not able to provide an acceptable result of character recognition even using the clean object (see figure 4).

4. Experimental Results

To estimate the quality of the implemented algorithm many experiments were carried out using the modern

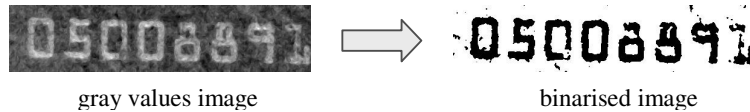


Figure 4 – Example of the recognised object

All the mentioned systems are not able to recognise the group of the characters with uneven pollution (see figure 5).

The application which uses the algorithm presented in this paper can provide correct results in more than 99% cases on real industrial images.

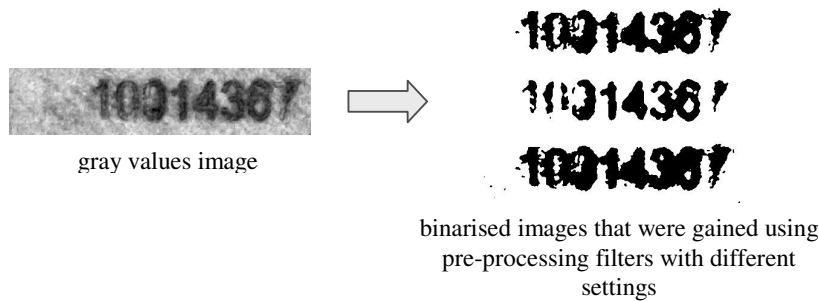


Figure 5 – Example of the recognised object with uneven pollution

5. Conclusions

In this paper a new hierarchical character recognition algorithm is presented which uses optimisation methods on the basis of patterns with different resolutions. The presented algorithm is insensible to the image defects, possesses a high recognition accuracy and a high velocity which enables to use it in industrial systems.

References

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