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THE ALGORITHM OF IMAGE RECOGNITION TO POSTAL APPLICATION

Summary. In this article we presented the algorithm for postal code recognition. The main objective of this article is to use the of the Radon Transform and Rough Set methods to obtain a set of invariant features, on basis of which postal code will be recognized. The reported experiments results prove the effectiveness of the proposed method. Moreover article contains basic image processing for instance filtration binarization and normalization of the character.

Keywords: postal code recognition, Radon transformation

ZASTOSOWANIE ALGORYTMU ROZPOZNAWANIA OBRAZÓW W APLIKACJACH POCZTOWYCH

Streszczenie. Metoda rozpoznawania znaków z wykorzystaniem transformaty Radona umożliwia rozwiązanie podstawowych problemów aplikacji rozpoznających znaki, które charakteryzują się dużą liczbą zniekształceń procesu akwizycji (np. szumy) oraz przekształceń liniowych, takich jak obrót, zmiana skali czy przesunięcie. Zaletą przedstawionej metody jest mała wrażliwość na zakłócenia w obrazie, sprawdza się ona przede wszystkim tam, gdzie nie jest znana cała wiedza o rozpoznawanym znaku.

Słowa kluczowe: rozpoznawanie kodów pocztowych, transformata Radona

1. Introduction

Today most important role play electronic message (e-mail, SMS, MMS etc.), but traditional mail like postcard is not death. In 2008 in Poland Poczta Polska served 1.6 billion parcel post [2]. In lot of them the address wrote freehand. To fast deliver parcel post the segregation must be automatic.

For many years many systems will be proposed. The typical system of sorting consists of the image acquisition unit, video coding unit and OCR[1] unit. The image acquisition stage sends the image of mail piece to the OCR module for address data recognition. If the OCR unit is able to provide the sort of information required, it sends this data to the sorting system, otherwise the image of the mail pieces is sent to the video coding unit, where the group of operator's writes down the information about mail pieces.

The main problem of this scenario is that operators of the video coding unit have lower throughput than an OCR and induce higher costs [3]. Therefore the OCR module is improving, particularly in the field of recognition of the handwritten characters.

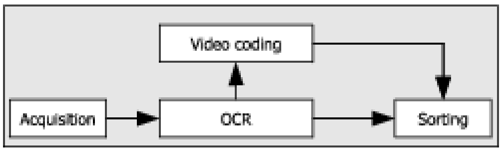

Fig. 1. The automatic sorting system - mail flow
Rys. 1. Schemat systemu sortowania

Although, these satisfactory results were received for printed writing, the handwriting is still difficult to recognize. Taking into consideration the fact, that manually described mail constitutes a large part of the whole mainstream, it is important to improve the possibility of segment recognizing the hand writing. This paper presents the proposal of a system for recognition of handwritten characters, for reading post code from mail pieces.

2. Proposed system overview

The whole process of post code characters recognition can be divided into several stages: preprocessing, Radon transform calculating, feature vector building, and character recognition stage. The part of preprocessing consists of stages: filtration, binarization and normalization (see on fig. 2).

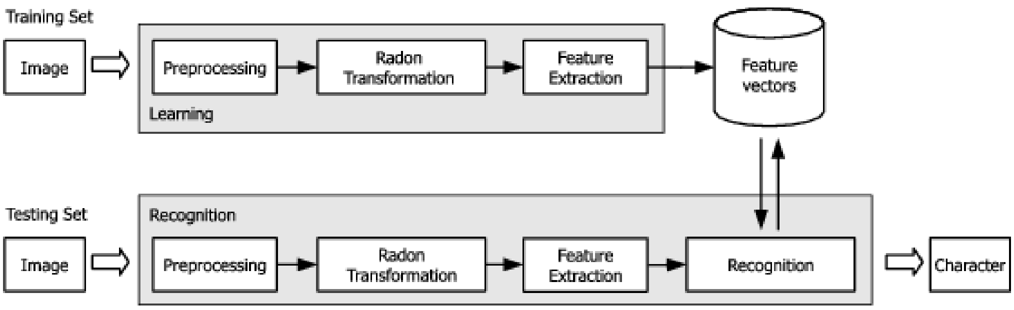

Fig. 2. The proposed method of character recognition
Rys. 2. Schemat metody rozpoznawania znaków

[1] Optical Character Recognition

2.1. Preprocessing

The first step of the malipiece image processing is color image to grayscale conversion. Typically the image is represented by 3 coefficients (Red, Green and Blue) taken from the acquisition unit, and have to be transformed into image with 256 levels of grey scale. After that the digital filtration is applied on the image of mail piece. The filtration is used for improving the quality of the image, emphasizing details and making processing of the image easier. The filtration of digital images is obtained by convolution operation. The new value of point of image is counted on the basis of neighbouring points value. Thus every value is classified and it has influence on new value of point of the image after filtration.

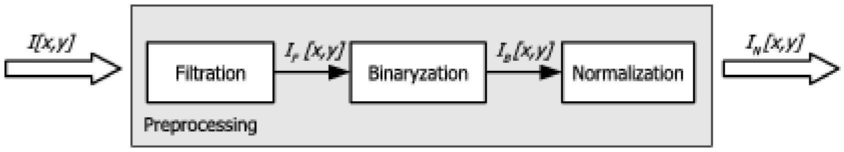

Fig. 3. Preprocessing scheme
Rys. 3. Schemat przetwarzania wstępnego

In this part non-linear filtration was applied. The statistical filter separates the signal from the noise, but it does not destroy useful information. The applied filter is median filter, with mask 3x3.

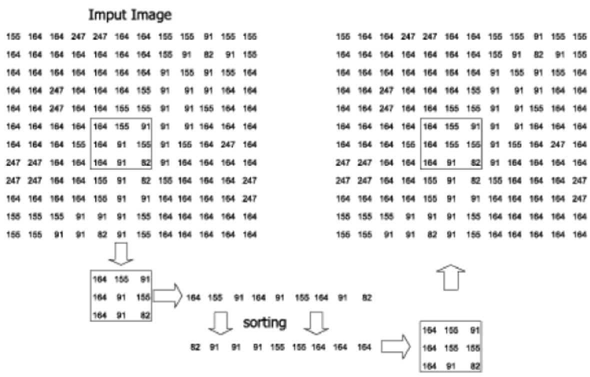

Fig. 4. Median filtration
Rys. 4. Filtracja medianowa

The image of character received from the acquisition stage have different distortion such as: translation, rotation and scaling. The character normalization is applied for standardization size of the character. Images there are translated, rotated and expanded or decreased. The typical solutions takes into consideration the normalization coefficients and calculate the new coordinates given by:

$$[x, y, 1] = [i, j, 1]\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -I & -J & 1 \end{bmatrix} \times \begin{bmatrix} m_i & 0 & 0 \\ 0 & m_j & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \cos\beta & \sin\beta & 0 \\ \sin\beta & \cos\beta & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{1}$$

where: I,J is a center of gravity given by:

$$I = \frac{\sum_i \sum_j i f(i,j)}{\sum_i \sum_j f(i,j)} \qquad J = \frac{\sum_i \sum_j j f(i,j)}{\sum_i \sum_j f(i,j)} \tag{2}$$

We use new coordinate system where center is equals to center of gravity of the character. The value of angle rotation is according to main axes of the image. The value of scale coefficient is calculated by mean value of variation of the character. So the center of gravity of the character is good candidate point of the center of image as a product of normalization stage.

2.2. Radon Transformation

In recent years the Radon transform have received much attention. This transform is able to transform two dimensional images with lines into a domain of possible line parameters, where each line in the image will give a peak positioned at the corresponding line parameters. This have lead to many line detection applications within image processing, computer vision, and seismic [1,17]. The Radon Transformation is a fundamental tool which is used in various applications such as radar imaging, geophysical imaging, nondestructive testing and medical imaging [9,14,4].

The Radon transform computes projections of an image matrix along specified directions. A projection of a two-dimensional function *f(x,y)* is a set of line integrals. The Radon function computes the line integrals from multiple sources along parallel paths, or beams, in a certain direction. The beams are spaced 1 pixel unit apart. To represent an image, the radon function takes multiple, parallel-beam projections of the image from different angles by rotating the source around the centre of the image. The Fig.5 shows a single projection at a specified rotation angle.

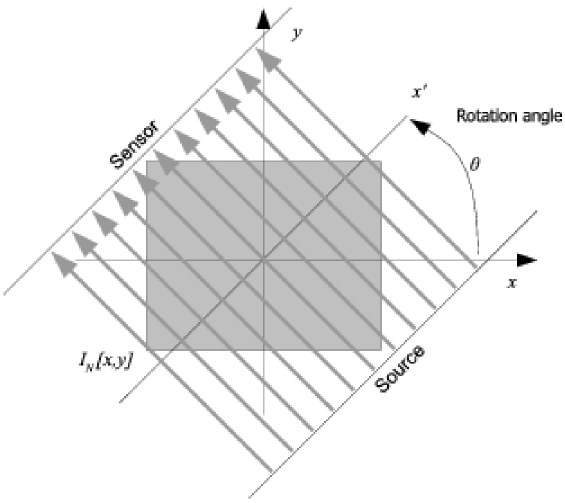

Fig. 5. Single projection at a specified rotation angle
Rys. 5. Projekcja dla wybranego kąta

The Radon transform is the projection of the image intensity along a radial line oriented at a specific angle. The radial coordinates are the values along the x'-axis, which is oriented at *theta* degrees counter clockwise from the x-axis. The origin of both axes is the center pixel of the image.

For example, the line integral of $f(x,y)$ in the vertical direction is the projection of $f(x,y)$ onto the x-axis; the line integral in the horizontal direction is the projection of $f(x,y)$ onto the y-axis.

Projections can be computed along any angle *theta*, by use general equation of the Radon transformation [5, 11, 12] :

$$R_{\Theta}(x') = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x,y)\delta(x\cos\Theta + y\sin\Theta - x')dxdy \tag{3}$$

where:

$$\delta(x\cos\Theta + y\sin\Theta - x') \tag{4}$$

$\delta(\cdot)$ is the *delta* function with value not equal zero only for argument equal 0, and:

$$x' = x\cos\Theta + y\sin\Theta \tag{5}$$

x' is the perpendicular distance of the beam from the origin and *theta* is the angle of incidence of the beams.

The very strong property of the Radon transform is the ability to extract lines (curves in general) from very noise images. Radon transform has some interesting properties relating to the application of affine transformations. We can compute the Radon transform of any translated, rotated or scaled image, knowing the Radon transform of the original image and the parameters of the affine transformation applied to it.

This is a very interesting property for symbol representation because it permits to distinguish between transformed objects, but we can also know if two objects are related by an affine transformation by analyzing their Radon transforms [13]. It is also possible to generalize the Radon transform in order to detect parameterized curves with non-linear behavior [17, 14, 15].

2.3. Feature extraction

Reduct rendering feature vector we can do to many ways. One of the ways is based on rough set [18, 19]. Consider a simple knowledge representation scheme in which a finite set of objects is described by using a finite set of attributes (features vector). The data received from the Rough set discretize operation are used to create vector of features of character. The amount of information mainly depends from the image of character size. For example, we use image with size 128x128 pixels and step *phi* equals one degree. With those parameters we can retrieve accumulator matrix with 180 width and 185 height cells. To produce feature vector we don't use all values from the accumulator. The reduction the accumulator data is possible by the matching Rough set discretization. As a result is a vector of significant parameters from the accumulator.

2.4. Recognition and classification

The classification in the recognition module compared features from the pattern to model features sets obtained during the learning process. The proposed classification system is supported by preliminary classification stage.

The main aim of that is to reduce the number of possible candidates for an unknown character, to a subset of the total character set. For this purpose, the selected domain is categorized into nine groups with number of local maximum. The preliminary classification is based on the amount of local maximum calculating in the Feature extraction stage. Based on the feature vector recognition, the main classification stage attempts to identify the character based on the calculation of Euclidean distance between the features of the character and of the character models [10].

The distance function is given by:

$$D(C_i,C_r)=\sum_{j=1}^{N}[R(j)-A(j)]^2 \tag{6}$$

where: Ci is the predefined character, Cr is the character to be recognized, R is the feature vector of the character to be recognized, A is the feature vector of the predefined character, N is the number of features.

2.5. Experiment results

Especially for evaluation experiments, we extracted some digit data from various paper documents from different sources e.g. mail pieces post code, bank cheque etc. The character samples were scanned with 600dpi in color and stored in special data collections [16] in form 24 bit RGB and 8 bit grayscale images. It is important that in the case of images with heterogeneous background to perform directional filtering for 0, 45 and 90 degrees. Character image is normalized according to specification of the section 2.1. Based on geometric and central moments, can be achieve center of gravity and main axis angle. For experimental purposes, the character image sizes are ranged from 16x16, 32x32, 64x64, 128x128 to 256x256 pixels. Optimal results have been obtained for 128x128 pixels. Similar scenario was carried out for grayscale levels, where 2, 4, 8, 16, 32 and 64 levels were tested. On this stage each pattern is represented by a Radon transformation table. Also for this part is critical parameter number of discretization levels of accumulator table. We use 4, 8, 16, 32 and 64 levels of the accumulator. Before Rough set descretization, the accumulator data is sorted by Hilbert Curve. Finally, each pattern can be represented as a feature vector with 63 elements. In our experiment we obtain recognition rate 91%. These results obtained for testing 5 sets defined in ratio 32:68 of all samples (testing set:learning set). For similar character sets from MNIST database, the results were about 7% less (due to a lower resolution).

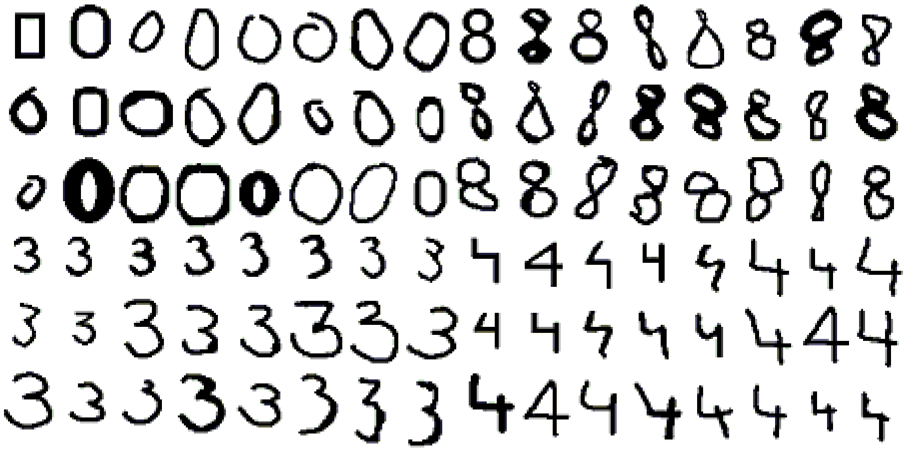

Fig. 6. The examples of database digit data
Rys. 6. Przykłady cyfr z bazy znaków

The minimum distance *D* (equ.5) between unknown character feature and predefined class of the characters is the criterion choice of the character [5].

Table 1

Results of experiments by train and test metod for 64x64 and 128x128 size images

character	0	1	2	3	4	5	6	7	8	9
31 feature elements	80%	87%	100%	100%	87%	73%	73%	100%	80%	86%
63 feature element	100%	100%	100%	73%	71%	80%	100%	100%	93%	100%

2.6. Conclusion

The paper describes often used the character image processing such as image filtration, binaryzation, normalization and the Radon Transformation calculating. For evaluation experiments, we extracted some digit data from various paper documents from different sources e.g. mail pieces post code, bank cheque etc. In total, the training datasets contain the digit patterns of above 130 writers. Collected 920 different digits patterns for training set and 300 digits for test set. The selecting of the features for character recognition can be problematic. Moreover fact that the mail pieces have different sizes, shapes, layouts etc. this process is more complicated.

The task of comparing the results for handwritten character with other researches [10, 6, 7, 8] is a difficult work because are differences in experimental methodology, experimental settings and handwriting databases, therefore, generally they are treated as lab results. The main advantages of the method are: finding geometric relations of the character by Radon transform, invariance to background noise, low computational complexity, working with grayscale images. Disadvantages: low value of the rejections, need to use preprocessing. Further work will include Wavelet Transformation tools to obtain more distinctive invariant features. Moreover the data set will be upgraded to all alphanumerical signs.

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Omówienie

Stosowane obecnie systemy automatycznego sortowania przesyłek pocztowych wykorzystują mechanizmy optycznego rozpoznawania pisma, jednak rozpoznawanie adresów, w szczególności tych pisanych ręcznie, jest w obecnej chwili niewystarczające. Prowadzone są zatem prace, w celu podniesienia skuteczności modułu OCR w dziedzinie odczytywania pisma ręcznego. Pomimo że uzyskano zadowalające rezultaty z rozpoznawaniem pisma drukowanego, to pismo ręczne jest nadal trudne do interpretacji.

Zaproponowana metoda rozpoznawania znaków z wykorzystaniem transformaty Radona wydaje się obiecującym rozwiązaniem podstawowych problemów aplikacji rozpoznających znaki, które charakteryzują się dużą liczbą zniekształceń procesu akwizycji (np. szumy) oraz przekształceń liniowych, takich jak obrót, zmiana skali czy przesunięcie. Zaletą przedstawionej metody jest mała wrażliwość na zakłócenia w obrazie, sprawdza się ona przede wszystkim tam, gdzie nie jest znana cała wiedza o rozpoznawanym znaku oraz występują niekompletne dane wejściowe albo dane są silnie zakłócone.

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