Research on Transmission Light and Recognition Algorithms of Invoice Check Code

Jintao Zhang[1, a], Jianyi Kong[1, b], Xingdong Wang[1, c], Wei Sun[1, d, *]
[1]Key Laboratory of Metallurgical Equipment and Control, Ministry of Education, Wuhan University of Science and Technology, Hubei Wuhan 430081, China

Keywords: Invoice recognition; Reverse transmission illumination; double threshold segmentation; machine vision.

Abstract: Invoice checking code is one of the key factors affecting invoice reimbursement, but some invoice checking codes are covered by red seal, resulting in lack of information. In order to solve the identification problem of defect invoice check code, in this paper, the color distribution in the check code region and the interaction between color and light are studied, and the scheme of invoice monochrome light reverse transmission is formulated. By analyzing the gray histogram of R, G and B three-channel images, a three-channel weighted graying method for invoice images is proposed. After locating the region by vertical horizontal projection of the check codes, the binarization of the check codes is realized by double threshold segmentation, and the single character segmentation is obtained by vertical projection. Finally, character recognition is carried out by template matching method. The experimental results show that the above method can eliminate the influence of red seals and improve the accuracy of the identification of check codes for defective invoices.

1 INTRODUCTION

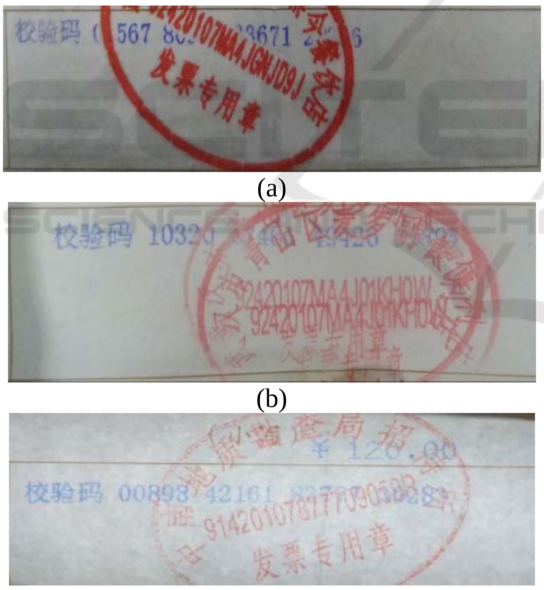
Invoice Check Code is one of the important bases for checking the authenticity of invoices. In the process of invoicing, various uncertainties lead to various degrees of corruption of invoice check codes (as shown in Figure 1, the check codes are covered by red seals). It is impossible for businesses to distinguish the authenticity of invoices and bring great difficulties to invoice reimbursement. Therefore, the research on automatic recognition of check codes covered by red seals will help to reduce the investment of manpower and material resources (Sonka M, Hlavác V, Boyle R, 2014).

In order to solve the problem of character recognition in complex situations such as character being covered by seals, some scholars have studied it at present.To solve the problem of image decolorization, H. Du et al. (Du H , He S , Sheng B , et al, 2015). Proposed a color-gray conversion method based on regional saliency model. S. Liu (Liu, SF, 2017) and others proposed to use Gabor filter and S Obel operator to extract features first, then K-means algorithm to segment regions, and compare the characters to be recognized with standard fonts. Finally, two character recognition parameters, stroke cross-section and energy density, were designed to increase recognition. Other adaptability and robustness. (A Namane et al, 2010). Proposed the method of using complementary similarity measure (CSN) as classifier and feature extractor to recognize degraded characters, which enhanced the recognition ability of characters with poor print quality. For non-uniform illumination image, (Vo G et al, 2016). Proposed a robust matrix decomposition method to solve the problem of robust regression for binarization of images in strong noise inhomogeneous background. This method automatically segments binary images into foreground and background regions in the case of high observation noise level and uneven background intensity. The experimental results show that the method is more robust to high image noise and uneven background. In order to improve the efficiency of binarization, (Soua M et al, 2014) proposed a hybrid binarization Keymens method (HBK) parallel to Nvidia GTX 660 graphics processing unit (GPU) (Soua et al. at the International Symposium on Communication, Control and Signal Processing, 2014). Our implementation combines fine-grained and coarse-

Zhang, J., Kong, J., Wang, X. and Sun, W.
Research on Transmission Light and Recognition Algorithms of Invoice Check Code.
DOI: 10.5220/0008869804350443
In *Proceedings of 5th International Conference on Vehicle, Mechanical and Electrical Engineering (ICVMEE 2019)*, pages 435-443
ISBN: 978-989-758-412-1

grained parallel strategies to achieve the best. Good GPU usage and efficient memory.

In summary, at present, the main method of character recognition is to obtain images by front illumination, and then design an algorithm to extract characters from overlapping parts of characters and seals. However, the examples in the above literature do not include the cases of badly occluded characters in seals as shown in Figure 1. In this paper, the problem of identification of check codes directly covered by red seals is studied. The color distribution of the check code region and the interaction between color and light are analyzed. A scheme of imaging monochrome red light reverse transmission is proposed, and the gray level of the check code image is realized by three-channel weighting method. Then the check code region is located by two-way projection, and double thresholds are carried out according to the characteristics of the histogram of the gray image. Value binarization, using vertical projection for single character segmentation, and finally using template matching method for character recognition.



(a)

(b)

(c)

Figure 1. Sample invoice with a check code covered by a seal.

2 INVOICE IMAGING SCHEME

The color of opaque object imaging is determined by the diffuse reflection and absorption properties related to wavelength. The color of transparent object or translucent object is determined by the transmission properties related to wavelength. The monochrome light can be used to illuminate the color object to enhance the contrast of the corresponding features of the detected object. (Carsten Steger, et.al, 2017) Because of the three colors of red (seal), blue (check code) and white (invoice paper), RGB is used to illuminate the target area, highlighting the characteristics of the target area.

Figure 2 is an experimental platform for invoice imaging. The RGB color camera has a resolution of 2592 1944 and a frame rate of 15 fps. The light source is a monochrome strip light source. The optional color light is red light with a wavelength of 600-700 nm, green light with a wavelength of 500-550 nm and blue light with a wavelength of 400-480 nm, respectively

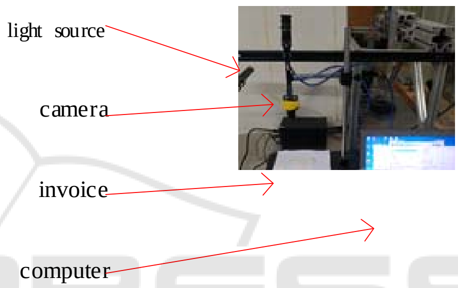


Figure 2. Invoice image collection experiment platform.

2.1 Forward Lighting

The color of an object's forward illuminated image is determined by the reflection property of its surface. In order to understand the color distribution of the invoice surface image, it is necessary to study its reflection property. Fig. 3 is a schematic diagram of the invoice forward illumination model. The camera and light source are arranged on the front of the invoice. In the vertical direction, there are three layers of structure: red seal, blue check code and invoice paper. In order to facilitate analysis, the positive surface of invoice is divided into uncovered area (A), covered area (B), only seal area (C) and invoice blank area (D).

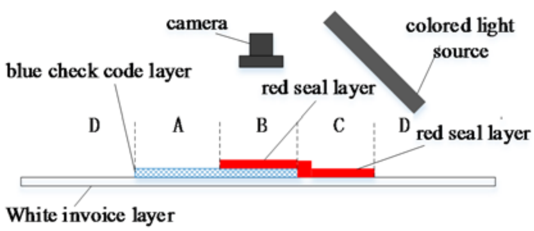
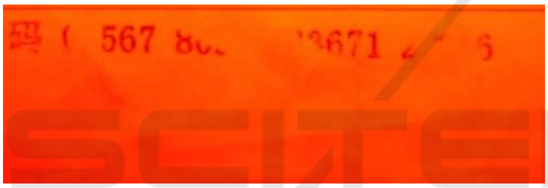


Fig 3. Forward illumination imaging schemati diagram.

The invoice of Fig. 1 (a) is illuminated by red light. The imaging effect is shown in Fig. 4 (a). Because the blue calibration codes in Area A absorb red light, the red seal and the white paper surface reflect red light, so the calibration codes show black color and obvious contrast; the red seal and the white paper surface in the top layer of Area B, C and D all reflect red light, and the blue calibration codes in the bottom layer of the seal are not illuminated, so they can not be displayed.

The invoice of Fig. 1 (a) is illuminated by green light. The imaging effect is shown in Fig. 4 (b). Because the red and blue check codes absorb green light and the white paper reflects green light, the image background is green and the seal and check codes are black.

The invoice of Fig. 1 (a) is illuminated by blue light. The imaging effect is shown in Fig. 4 (c). Because both the check code and the white paper surface reflect blue light, the seal absorbs blue light, and the background of the image is blue, the check code disappears and the seal highlights



(a) Results of red light illumination

(b) Results of green light illumination

(c) Results of blue light illumination

Fig 4. Forward illumination imaging result (for Fig. 1(a).

The experimental results show that the forward irradiation imaging can not effectively eliminate the influence of the seal, nor can it highlight the blue check codes covered by the seal. Similar results can be obtained for the invoices of Figure 1 (b) and (c).

2.2 Reverse Transmission

Reverse transmission imaging is suitable for transparent or translucent objects. As the invoice paper is carbon-free copy paper (Guanhao Gaoxin, 2013), when the backlight intensity is large enough, it presents the characteristics of translucent objects, so it can be imaged by the way of reverse transmission illumination shown in Fig. 5. The camera is on the front of the invoice and the light source is on the back of the invoice.

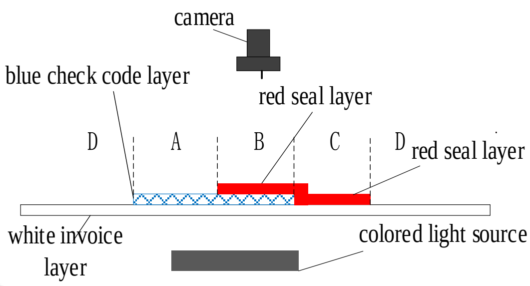


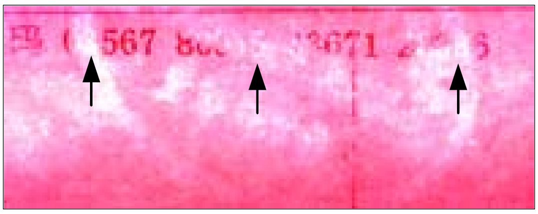
Fig 5. Reverse transmission imaging schematic diagram.

For Fig. 1 (a), the results of red light transmission imaging are shown in Fig. 6 (a). White paper will pass through red light, D area background will appear red; Blue check code will absorb red light, A area blue check code will appear black, contrast is obvious; Red seal will pass through red light, so the seal outline of B and C area will appear red, although the blue check code covered by red seal in B area will absorb part of red light. However, the backlight has a large luminous surface, and the seal ink increases the transparency of the invoice itself to a certain extent. The red light will still pass through the blue check code and the overlap area of the seal, so that the red part of the seal (including the cover check code indicated by the solid arrow in Fig. 6 (a) is highlighted as a whole, and it is slightly brighter than the background red.

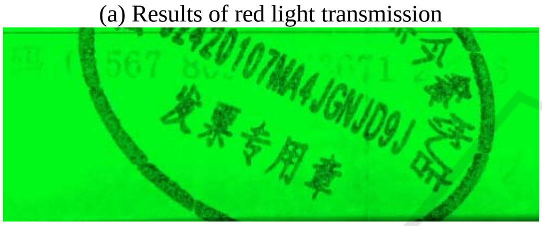
The green light transmission imaging effect is shown in Fig. 6 (b). White paper absorbs green light through green light, seal and check code. The whole image presents a green background. The check code and seal are black, and the covered part is not prominent.

Using blue light transmission imaging effect as shown in Figure 6 (c), white paper and blue check codes all penetrate blue light; the seal absorbs blue light, showing black, and the check codes are submerged in the overall blue background.

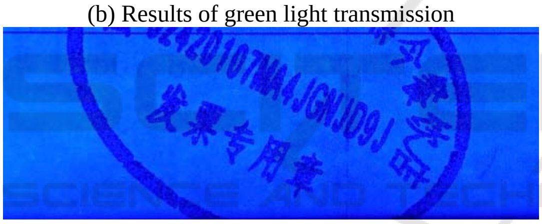
Comparing the two irradiation models, we can see that: (1) reverse transmission imaging needs stronger light; (2) forward irradiation imaging can not highlight the characteristics of coverage check codes in area B; (3) reverse red light transmission can highlight the background, red seal and blue check codes covered by seals, and it is advantageous to enhance the contrast to a certain extent. For further image recognition. Therefore, the invoice image is obtained by the illumination method of reverse transmission of red light.



(a) Results of red light transmission



(b) Results of green light transmission



(c) Results of blue light transmission

Fig 6. Result of reverse transmission imaging.

3 BINARIZATION OF CHECK CODE IMAGE

After imaging with the above method, the covered part of the check code can be displayed, but it is still weak compared with the uncovered part. In order to obtain the complete invoice check code, binarization is needed to achieve the complete segmentation of the check code.

In this paper, according to the color information of the image, the three-channel gray value is weighted to realize the image gray level, the two-way projection is used to locate the check code area, and the double threshold is used to binarize the gray level image. In order to verify the effectiveness of the algorithm, this paper uses the visual module Visio Assistant of MATLAB and Labview.

3.1 Grayscale Image

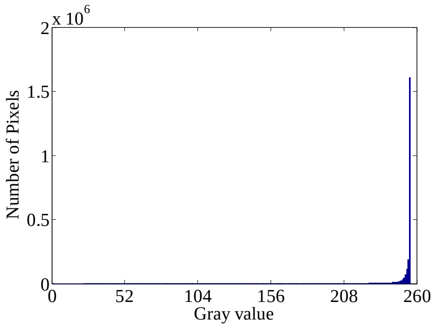
In the color image acquired by the reverse transmission of red light (Fig. 6 (a)), the check codes show two colors: the uncovered check codes show black color, and the seal-covered check codes show bright white color, which shows the difference of the check codes to a certain extent, but the strong background color also reduces the contrast of the check codes. The data of each channel should be integrated and grayed to improve the contrast of the target. Each pixel of a color image is the corresponding red, green and blue components of the color image in a specific spatial position. The common gray-scale method is to weigh the RGB images in each channel, and its formula is shown in Formula (1).

$$f(x,y)=a_1\times r(x,y)+a_2\times g(x,y)+a_3\times b(x,y) \quad (1)$$

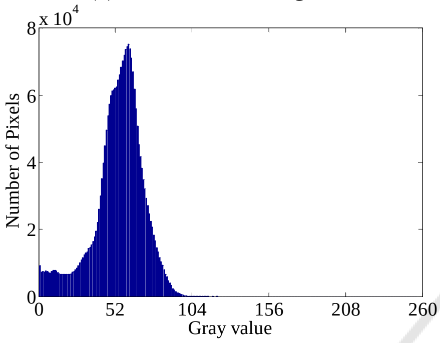
In the formula: x, y is the position of the pixel in the image, $f(x,y)$ is the grayscale image; a_1, a_2, a_3 are weighted coefficients, they are all non-negetive numbers and satisfy $a_1+a_2+a_3=1$, $r(x,y)$, $g(x,y)$, $b(x,y)$ are the image components of the red channel, the green channel and the blue channel of the image.

In order to select a reasonable grayscale function, it is necessary to calculate the grayscale distribution of each RGB channel image, and then determine the weighted value according to the statistical characteristics. Histogram is the most common method of pixel statistics.

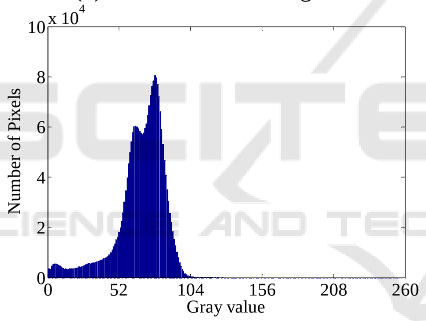
Figure 7 (a), (b) and (c) are gray image histograms of red, green and blue channels respectively, which express the number of gray value pixels in each channel image. As can be seen from Figure 7, the gray value of the red channel is concentrated, which reduces the image contrast, while the gray distribution of the other two channels is relatively wide, which can show a better brightness difference.



(a) Red channel histogram;



(b) Green channel histogram



(c).Blue channel histogram

Fig 7. RGB three-channel image.

Because the background color of the image is red, in order to maximize the suppression of the background color and reduce the interference of the red channel, let $a_1 = 0$, the coefficients of the other two channels $a_2 = 0.7$, $a_3 = 0.3$ the result of weighted graying is shown in Fig. 8. It can be seen from the figure that the contrast between the overwritten check codes and the uncovered check codes has been greatly improved.

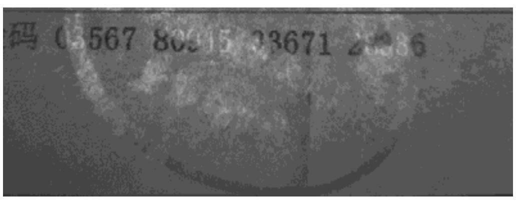


Fig 8. Grayscale results.

3.2 Regional Positioning

Binarization is the most direct way to extract targets, but due to the uneven illumination and background, direct binarization will bring a lot of interference. The interference can be greatly reduced by localizing the parity-check code region and then processing it. In order to locate the region, the method of maximum inter-class variance (Liu J, 1993) is used to binarize figure 8. The result is shown in Figure 9. The uncovered parity-check codes and the lines above the parity-check codes are extracted, and most of the background interference is filtered out, which is conducive to the next projection positioning.

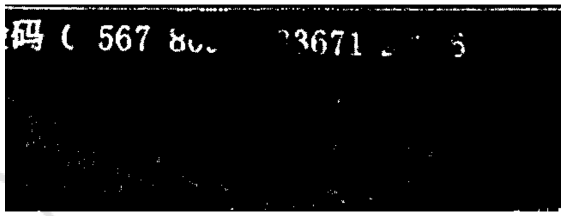


Fig 9. Otsu binarization results.

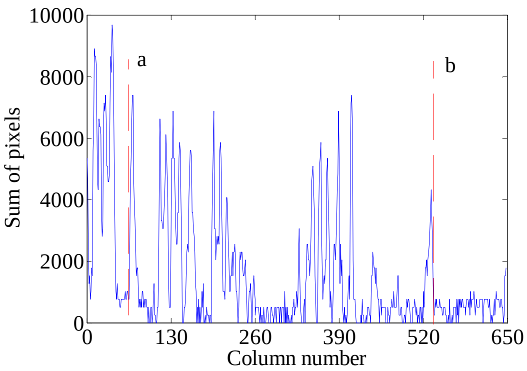
Vertical and horizontal projection refers to the sum of gray levels along the vertical and horizontal directions of the image. If the image size is M * N (M is the number of rows of the image and N is the number of columns of the image), the vertical and horizontal bidirectional projections are carried out by using formulas (2), (3).

$$F_y(x) = \sum_{y=1}^{M} F(x, y) \tag{2}$$

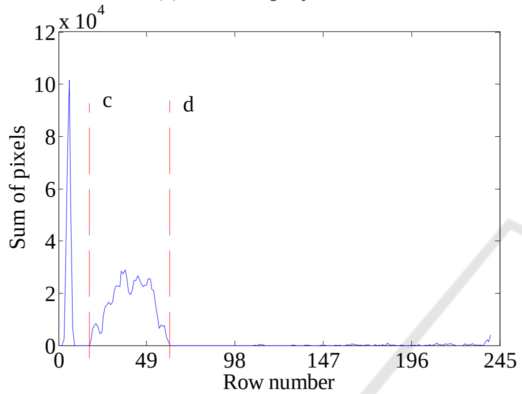
$$F_x(y) = \sum_{x=1}^{N} F(x, y) \tag{3}$$

In the formula: $F(x, y)$ is the pixel value of image 9 at the point (x, y), $F_y(x)$ is the vertical projection vector, $F_x(y)$ is the horizontal projection vector. The range of values of x and y is divided into $x \in [1, N]$, $y \in [1, M]$.

The result of bidirectional projection of Figure 9 is shown in Figure 10. In this paper, N = 648, M = 240.



(a) Vertical projection



(b) Horizontal projection

Fig 10. Bidirectional Projection Results.

Vertical projection (Fig. 10 (a)) is used to determine the left and right boundaries of the parity code region. The algorithm steps are as follows:

(1) Set a valley threshold T_1 , and traverse the histogram from small to large. When the value is less than T_1 , record the gray level of the position as a candidate valley.

(2) Setting a width threshold T_2 , when the number of gray levels continuously less than the threshold T_1 is greater than the threshold T_2 , it is marked as a continuous trough.

(3) Search from left to right (for Fig.10 (a), T_1 = 766, T_2 = 20) to find the column corresponding to the end of the first continuous trough (point a in the figure, its abscissa is 67), that is the left boundary of the check code; search from right to left, the position of the end of the first reverse continuous trough (point B in the figure, its abscissa is 538), which corresponds to the check. Code right boundary.

Fig 11. Location result.

3.3 Binarization

In the gray image, the invoice check code is divided into two parts: the low gray level part which is not covered and the high gray level part which is covered. The number of gray level pixels in these two parts is much less than that in the background. The histogram of this kind of gray image presents a single peak, so it is difficult to find the valley by traditional methods, which makes it difficult to segment the check code.

In this paper, according to the characteristics of high and low distribution of target pixels in gray image, a double threshold method is used to binarize the image. The algorithm steps are as follows:

(1) The gray histogram $T(r)$ of the image is acquired, and the maximum peak $T_{\max}$ and its corresponding gray value r_m are determined by traversal from the gray histogram.

(2) With the maximum peak value as the demarcation line, the maximum gray value of gradient is searched from left and right sides to the middle respectively, and two thresholds r_1 and r_2 are obtained by using formulas (4) and (5).

$$T'(r_1) = \max\{T'(r) | r \le r_m\} \tag{4}$$

$$T'(r_2) = \max\{T'(r) | r \ge r_m\} \tag{5}$$

(3) Using r_1 and r_2 as double thresholds, image 11 is binarized according to formula (6).

In formula: $F_1(x, y)$ and $f(x, y)$ are binary image and gray image respectively. After binarization of image 11, the median filter with 3 *3 sliding window is used to remove the particle noise. The result is shown in Figure 12.

Fig 12. Binary results.

From Figure 12, we can see that the binary image is obtained by the above method, and the uncovered check codes are extracted completely. For the overwritten check codes, the extraction effect is also good, which lays a good foundation for the recognition of the subsequent check codes.

4 CHARACTER SEGMENTATION AND RECOGNITION

4.1 Single Character Segmentation

As shown in Figure 12, the binary characters are fractured and cohesive. In this case, the method based on character width and eigenvalue projection can be used to segment the binary characters. If the eigenvalue is used to represent the peak judgment threshold T_4, the first valley value that satisfies the width limitation condition is found after passing through a peak beyond the eigenvalue from any segmentation point, that is, the location of the next segmentation point. As shown in Figure 13, the red line in the vertical projection is the eigenvalue T_4 = 514.

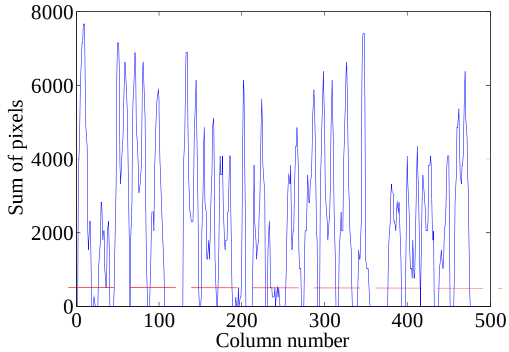


Fig 13. Vertical projection.

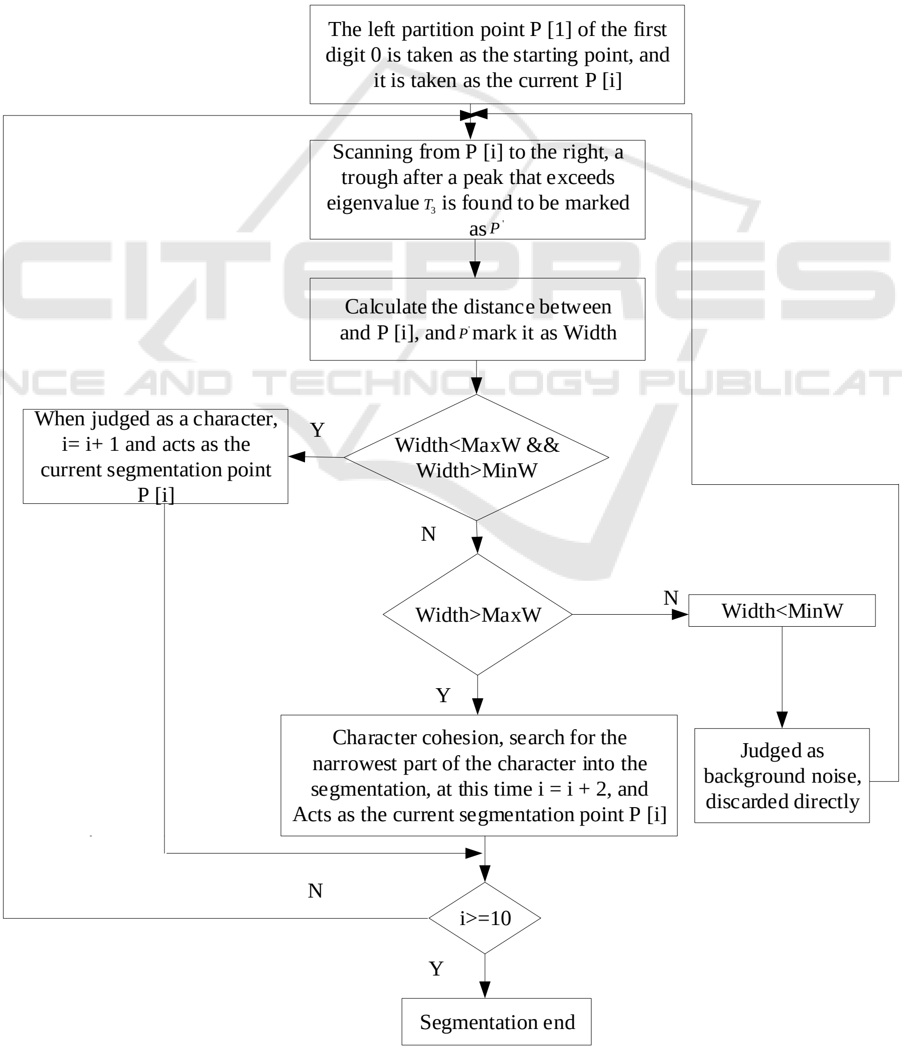


Fig 14. Separation flow char.

As shown in Figure 12, the parity code region will have three largest interval regions (e.g. between the fifth character and the sixth character). The parity code is divided into four parts, and their search and segmentation methods are similar.

According to the prior knowledge such as the overall width of the check code region and the width of a single character, the segmentation points of each group of numbers can be searched by combining the threshold of the continuous trough. Then, the minimum width of the character MinW = 8 and the maximum width MaxW = 19 are used as the thresholds of the character width for single character segmentation. Taking the first group of figures in Figure 12 as an example, there are five figures, forming 10 segmentation points P. With the initial segmentation position P (Sonka M, Hlavác V, Boyle R, 2014) as the starting point, search right. The flow chart of the algorithm program is shown in Figure 14.

After vertical segmentation, the upper and lower positions of characters have more or less space, and then horizontal projection segmentation is carried out to determine the upper and lower boundary positions of characters. The result of segmentation is shown in Fig. 15. The graph completely divides every number of check codes and can be used as input for next processing.

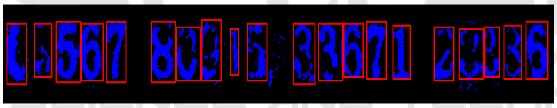


Fig 15. Segmentation results.

4.2 Character Recognition

Because the style of the check code is relatively fixed, this paper uses the template matching method (Wei L, He X, Chao T, et al, 2017) with higher recognition rate to recognize. The template and the character to be recognized are both black and white characters. Before recognition, the character to be recognized is normalized into 34 x 60 pixels by bilinear interpolation method, and then matched with the template. The specific steps are as follows:

(1) Calculate the number of white pixels T and U of the character to be recognized, and then calculate the number of white pixels V of image 1 by logical "and" operation of template image and character image to be recognized.

(2) The character image to be recognized and image 1 are processed by logic XOR operation to get image 2 and calculate the number of white pixels X in image 2.

(3) The template character image and image 1 are processed by logic XOR operation to get image 3, and the number of white pixels W in image 3 is calculated.

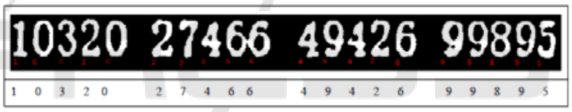
(4) Computation of similarity coefficient Y according to formula (6)

$$Y = \frac{V}{\frac{W}{T} \times \frac{X}{U} \times \sqrt{\frac{(T-TUV)^2 + (U-TUV)^2 + (V-TUV)^2}{2}}} \qquad (6)$$

In the formula: $TUV = \dfrac{T+U+V}{3}$

For each specific character, the similarity coefficients of 10 templates are calculated, and the template corresponding to the maximum similarity coefficient is taken as the recognition result of the character to be recognized. According to the above algorithm, the recognition results of some images in this paper are shown in Figure 16.

(a)



(b)

(c)

Fig 16. Partial Sample Recognition Results.

The experimental results show that the method can eliminate the influence of red stamps and get better recognition results for invoices with less serious red stamps, as shown in Fig. 16 (b), (c). But for Figure 1 (a), because the red seal is very serious, and part of the blue check code fades, there are some flaws in the recognition effect part, resulting in the second digit to be recognized, which is also what this algorithm needs to be further studied.

In conclusion, the proposed model and image processing algorithm can recognize the check codes covered by logarithmic seals. The experimental results show the effectiveness of the algorithm.

5 CONCLUDING REMARKS

Aiming at the problem of recognition of blue check codes covered by red seals on ordinary VAT invoices, this paper studies and analyses the three steps of image acquisition, image binarization and character recognition. In the phase of image acquisition, considering the color distribution of the check code area, monochrome red light is used to transmit the image from the back of the invoice to highlight the cover check code. In the binarization stage, according to the gray histogram of R, G and B channels, the weighted method is proposed to gray the image, and the two-way projection method is used to locate the check code region, and a double threshold binarization method is proposed. In the character recognition stage, a single character is segmented according to the width of vertically projected characters. Finally, a template matching method is used for character recognition. The experimental results show that this method can solve the problem of extraction and recognition of check codes when the check codes of invoices are covered by red seals, and improve the accuracy of identification of such defective check codes.

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