Binarizing the Courtesy Amount Field on Color Chinese Bank Check Images

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***Abstract*—A novel binarization method for courtesy amount recognition of color Chinese checks is proposed in this paper. It includes two steps: background removal and seal removal. In the first step, two complementary binarization methods (Otsu method and Niblack method) are combined. In the second step, a multi-stage method for seal removal is proposed. All the seal-like pixels whose colors are similar to red in HSI color space are extracted first. Then the covered strokes which are extracted in the first stage are brought back to the left image by thresholding in RGB color space. Experiments show that the proposed method performs very well with little noise and can be used to remove background and seals for courtesy amount recognition of Chinese checks.**

Keywords-courtesy amount field pre-processing; background removal; seal removal; binarization;courtesy amount recognition

I. INTRODUCTION

Automatic bank check image processing has been intensively investigated for many years. The recognition of courtesy amount is one of the most important parts in a bank check image processing system. For the checks used in China, an automatic courtesy amount recognition system usually contains three procedures: (1) binarization; (2) column line (as shown in Fig. 1) detection and removal; (3) digit string segmentation and recognition. Binarization is the initial step and the quality of binarized results has a great impact on the performance of the whole optical character recognition (OCR) system.

A typical image of courtesy amount area on Chinese bank check images is shown in Fig. 1. The white rectangle in Fig. 1 indicates the exact location of courtesy amount field and the image quality within this area is most concerned. The goal of our binarization method is to remove the pre-printed background and possible red seals which may cover some parts of the courtesy amount field. The handwritten numerals and vertical lines within which the digits are written should be reserved as complete as possible for localization, segmentation and recognition in the following OCR steps.

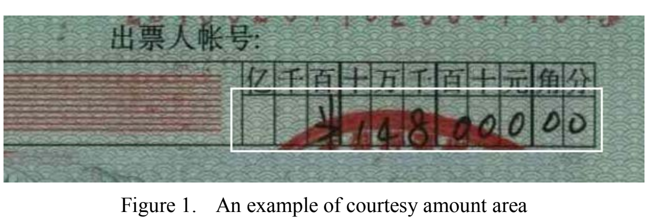

Figure 1. An example of courtesy amount area

Many former research on Chinese check binarization is based on gray-scale image by the limitation of image acquisition device [1][2]. It is very difficult to tell characters from seals in gray-scale images especially when the seals are thick in color and cover part of the characters. And most research related to seals focuses on seal extraction but not removal [3][4][5]. Seals are usually extracted in color space as complete as possible. Some strokes covered by seals are also extracted with incomplete characters left, which is just opposite to our desired result.

In this paper, a novel binarization method for courtesy amount recognition of color Chinese bank check images is proposed. It consists of two steps: background removal and seal removal. In the first step, a global binarization method (Otsu method [6]) and a local one (Niblack method [7][8]) are efficiently combined to remove pre-printed check background on gray-scale images. In the second step, a multi-stage seal removal method based on color images is proposed. All the seal-like pixels whose colors are similar to red in HSI color space are extracted first, and the covered strokes which are extracted in the previous stage are recovered by thresholding in RGB color space. The seals are removed with complete characters left and final result is got.

This paper is organized as follows: Section 1 is the introduction; In section 2, two binarization methods and their combination are discussed for background removal; In section 3, a multi-stage seal removal method is described; Some experimental results will be given in section 4; Section 5 is the summary of this paper.

II. BACKGROUND REMOVAL

Gray-scale image is used in this step. So color images are converted to gray-scale ones first. Then the combination of two binarization methods described below is carried out.

A. Otsu method

The Otsu method is a global binarization method. It is non-parametric and a threshold is selected automatically and stably for the whole image. It deals directly with the problem of evaluating the goodness of thresholds from a gray level histogram. The optimal threshold is selected by maximizing the measure of separability of the resultant classes in gray levels, which is defined by the variance between classes in the following form:

$$\sigma_B^2(k) = \omega_0(k)(\mu_0(k) - \mu_T)^2 + \omega_1(k)(\mu_1(k) - \mu_T)^2 \qquad (1)$$

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ω_0, ω_1 and μ_0, μ_1 are the probabilities of class occurrence and the class mean levels, respectively. They are determined by threshold k. And μ_T is the total mean level of the original picture. The optimal threshold k* is defined as (suppose the range of gray level is [0, L]):

$$\sigma_B^2(k^*) = \max \sigma_B^2(k),\ 0<k<L \qquad (2)$$

The Otsu method takes the gray levels of all the area into consideration and selects an optimal threshold for separating background from characters. The uniform background with high gray level will be removed with little noise. But in the local area which connects background and characters, the global threshold is not precise enough to separate characters cleanly and clearly from background.

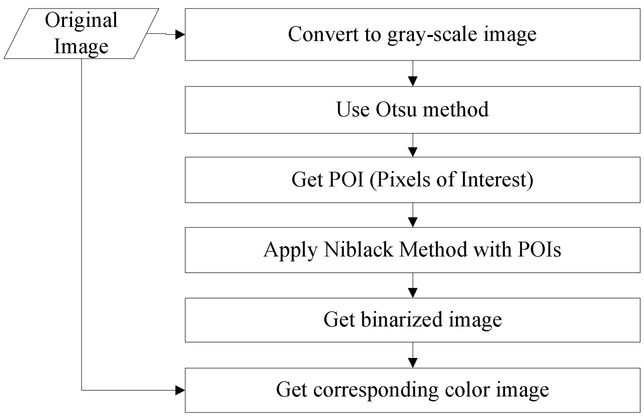


Figure 2. Workflow of proposed background removal method

B. Niblack method

The Niblack method is a local binarization method. It calculates a threshold for each pixel adaptively from the local area of a window size w*w around the pixel. The threshold T (i, j) for pixel (i, j) is calculated according to the mean m (i, j) and standard deviation σ (i, j) within a local window and can be expressed as:

$$T(i, j) = m(i, j) + k*\sigma(i, j) \qquad (3)$$

The constant k is a parameter as well as the window size w, and their recommended values are -0.2 and 15 respectively.

The Niblack method uses both mean and standard deviation to determine the threshold for each pixel. In the local area of a check image with characters, standard deviation is relatively high. So thresholds in stroke area are appropriate low. And this is helpful to binarize characters clearly from background with little noise. But in the area of background, the standard deviation is extremely low. The thresholds for pixels in this area are almost the same as the average gray-scale values. So some pixels may be binarized into foreground, and it results in a lot of noise in the binarization of background area.

In short, Niblack method has the advantage of thresholding characters cleanly and clearly but it causes a lot of noise in background area without characters. These features are just opposite to the ones described in Otsu method. Obviously, these two methods are complementary to each other.

C. Combination of two binarization methods

We combine these two complementary binarization methods aiming to overcome the limitations of either one. The flow chart of proposed combination method for background removal is shown in fig. 2.

For the input color image of courtesy amount area, it is first converted into gray-scale. Otsu method is carried out to remove most background areas without characters. Small components whose areas are less than t (3 in our system) are removed as noise and others are set to be POI (pixel of interest). After all the POIs are got, Niblack method is applied with the original gray-scale image but on the POIs only. Pixels that are not among the POIs are removed directly.

The use of POI combines both Otsu and Niblack method. And it also has the following benefits:

(1) The POIs cover the area of characters. So after Niblack method is used on POIs, clean and clear characters can be got with sharp edges in binary image compared to Otsu method.

(2) The POIs do not include the areas with background only. So background noise from Niblack method can be avoided.

(3) Only the thresholds of POIs are calculated in the Niblack step. So a lot of computation effort can be saved compared to the Niblack method used for each pixel of the whole image.

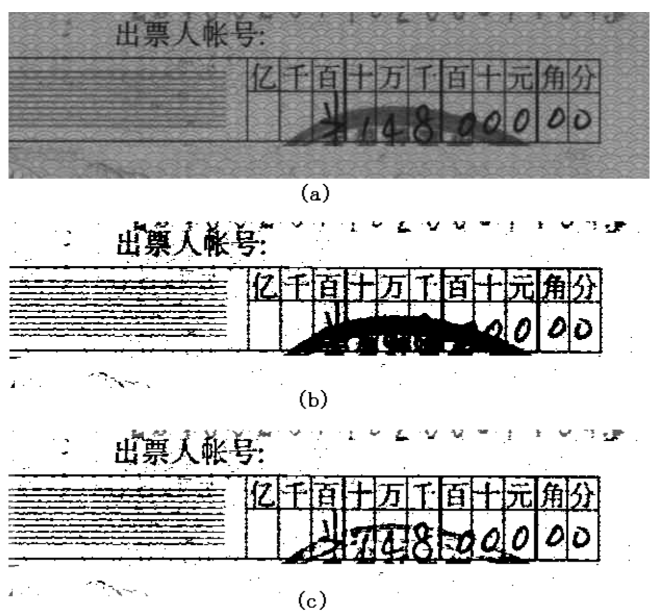


Figure 3. (a)Original image (b)POIs got by Otsu method (c)Niblack result on POIs

Some intermediate results from the key steps of removing background are shown in Fig. 3. The procedure of how Otsu and Niblack are combined is easily seen and the disadvantages of each single algorithm are avoided.

Finally, the binary result generated from the combined binarization method is used as a mask. All the blank areas in the mask are removed from the original color image. Then a color image with background removed is got.

III. SEAL REMOVAL

After the background removal step, the characters and pre-printed forms are got. Some seals which cover part of the characters are also left in the image. More work should be done to remove them.

Most former research related to seals focuses on seal extraction but not removal. A commonly used method is to set thresholds in HSI color space. Pixels are extracted as seals if some conditions are satisfied. Some strokes which are covered by seals are always extracted as seals and the left characters are broken.

Our proposed method removes seals stage by stage in both HSI and RGB color spaces. HSI stand for hue, saturation, and intensity. The values in HSI model are more intuitive than the RGB ones. It is easier to extract seal pixels with red color in HSI color space. For the pure seal pixels and stroke pixels covered by seals, the contrast is higher in R channel than the other two channels and it is easier to separate the covered strokes in RGB color space. Our method is based on these two features and the flowchart is shown in Fig. 4.

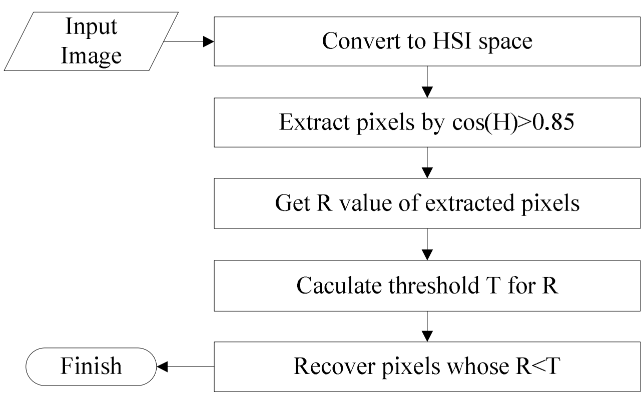


Figure 4. Workflow of proposed seal removal method

The input image is converted to HSI color space first. The conversion from RGB to HSI is extremely easy by using the following formula:

$$H = \cos^{-1}\left\{\frac{\left((R-G)+(R-B)/2\right)}{\sqrt{(R-G)^2+(R-B)(G-B)}}\right\}$$

$$(H = 360 - H, \quad \text{if} \quad B > G)$$

$$S = 1 - 3\left\{\frac{\min(R,G,B)}{R+G+B}\right\} \tag{4}$$

$$I = (R+G+B)/3$$

Then all the pixels satisfying cos(H)>0.85 are extracted as seal-like pixels. Pixels with red color whose hue are around 0 degree are selected by using cos(H). So all the red seals, strokes covered by seals (if any) and other red areas are extracted no matter what saturation and intensity they have.

The RGB color space is used in the next stage. R values of all the seal-like pixels are extracted as a data set. And a threshold T is calculated according to the data set. All the pixels with a lower R value than T are regarded as strokes and brought back to the original image.

The threshold T is defined as

$$T = \min(T_{Otsu}, T'), \ (T' = \text{minimum} + k^*\sigma) \tag{5}$$

σ is standard deviation and k is a constant parameter (3 is used in our experiment).

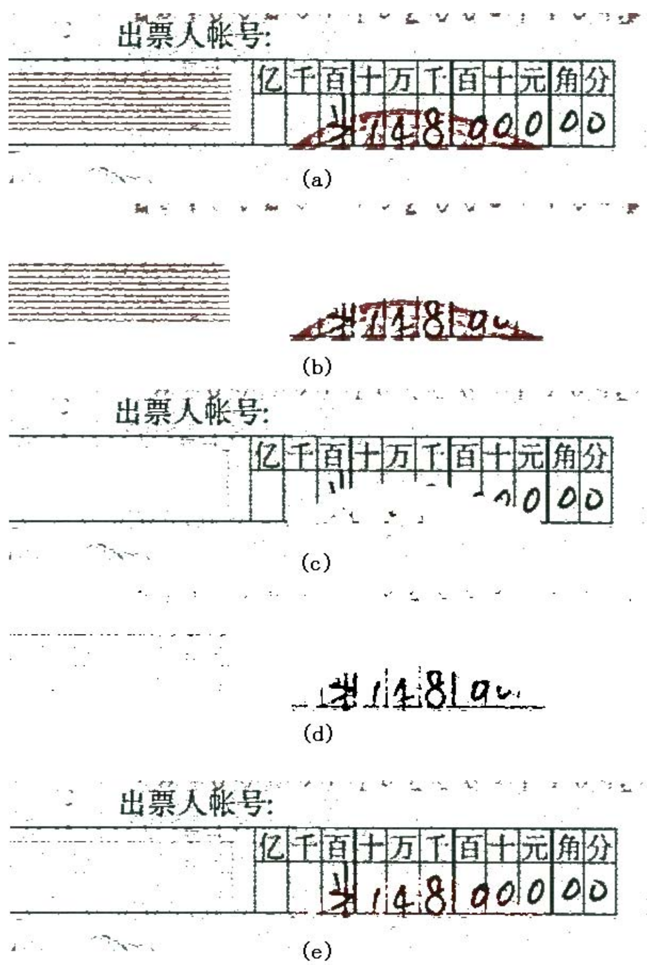


Figure 5. (a)Input image (b)Extracted seal-like pixels (c)Image left after extraction (d)Stroke pixels got by threshold T (e)Final Result

The definition of T considers both the threshold calculated by Otsu method and the standard deviation of the whole data set. It makes our method adaptive for different situations and has the following advantages:

(1) If many stroke pixels exist in the extracted data set (such as the case shown in Fig. 6 (3a)), the standard deviation is relatively high. Threshold calculated by Otsu method is suitable for this typical two-class problem. But T' is always very high as a result of the high standard deviation. T is always assigned by the value calculated using Otsu method, which is an optimal threshold.

(2) If only a few stroke pixels exist in the data set (such as the case shown in Fig. 6 (2a)), the standard deviation is low. Threshold obtained by Otsu method is always too high to separate the stroke pixels for the number of them is too small. T' gives a relatively low threshold and performs better than Otsu method in this situation. And T' is naturally used for the final T by the definition.

(3) When no stroke pixels exist in the data set (such as the case shown in Fig.6 (1a)), the recover stage is still carried on. Although the threshold is very low according to the definition, some seal pixels are still regarded as covered strokes so noise is brought back to the final result. But the noises are not within the exact courtesy amount field in this situation and the characters remain clean after processing.

Finally, seals are removed and the digits of courtesy amount and the pre-printed forms remain. Fig. 5 shows how our method works.

IV. EXPERIMENTS

1000 images of real Chinese checks from banks are used to test our method in the experiment. They are processed using the proposed background and seal removal method and some of the results are shown in Fig. 6. Some results got by other traditional binarization and seal extraction methods are also presented for comparison.

The samples shown in Fig. 6 are selected to cover the three most commonly happened situations in courtesy amount area: no seal pixels, a few seal pixels and many seal pixels. As can be seen from the results, the proposed method can clearly binarize characters and pre-printed forms from background and covered seals without broken strokes. The results of proposed method are better than many traditional algorithms. It is useful and adaptive no matter how many strokes are covered by seals.

All the results are evaluated with the criterion proposed in [2]. If all the background pixels and seals are removed with no strokes broken, the binarization result is considered as a good one. The rate of good results by our method and two other methods proposed in [2] are shown in the following table.

TABLE 1 PERFORMANCE OF DIFFERENT METHODS

Method	Rate of Good Results
Recursive Threshold	77.0%
Gray-MDE Histogram	79.5%
Proposed Method	96.9%

Advantages of the proposed method can be obviously seen from table 1. Our algorithm outperforms the best compared to the method proposed in [2] by about 17 percent. It is proved to be useful by experiment and is a promising algorithm for constructing a courtesy amount recognition system with high performance.

According to our experiments, the proposed method seldom fails in the background removal step. But unsuccessful seal removal results are produced in two situations:

(1) When the color of seal is very dark, some seal pixels are likely to be brought back to the final result as covered stroke pixels. An example is shown in Fig. 7(a).

(2) If the digits of courtesy amount are typed with very thin ink, there is little difference between real seal pixels and character stroke pixels covered by seals. All the seal-like pixels are likely to be removed, as shown in Fig. 7(b).

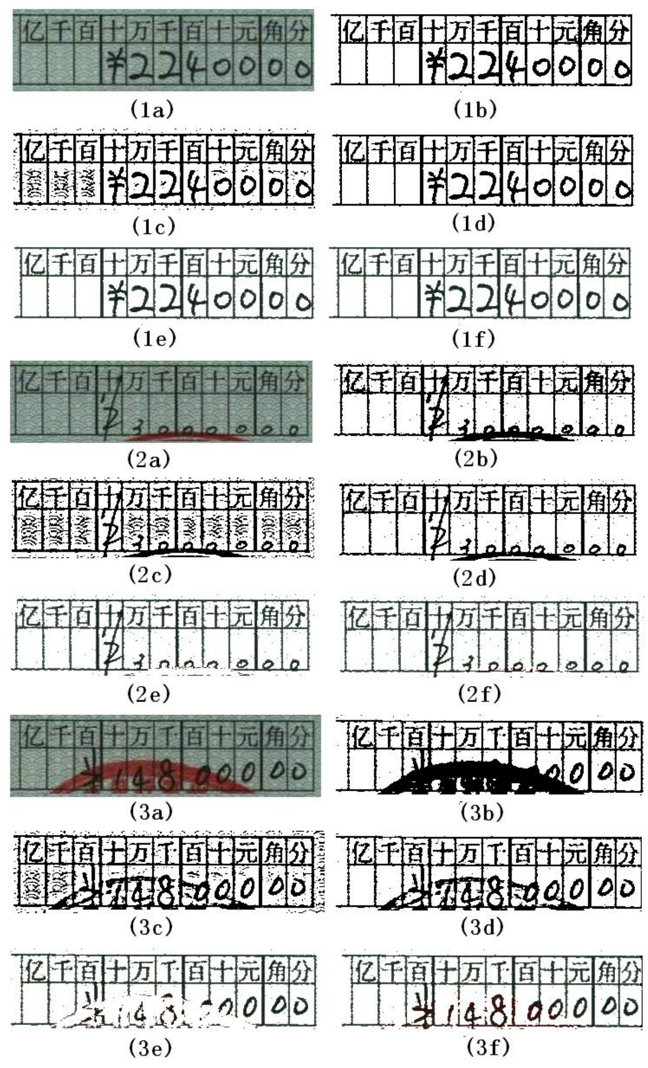
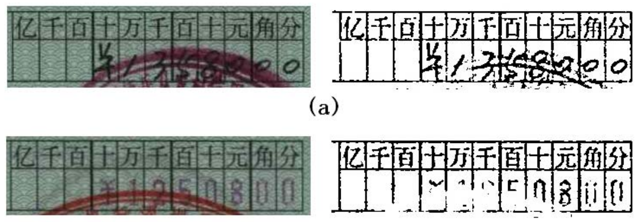


Figure 6. (1a-3a)Original images (1b-3b)Results of Otsu method (1c-3c)Results of Niblack method with recommended parameters (1d-3d)Results of proposed background removal method (1e-3e)Results of traditional seal removal method with thresholds $T_{cos(H)}$=0.94, T_S=0.1, T_I=0.1 (1f-3f)Results of proposed seal removal method



(a)

(b)

Figure 7. (a)Failure example when seal color is very dark (b)Failure example when character ink is very thin

V. SUMMARY

Our proposed method binarizes courtesy amount field with two major steps: background removal and seal removal. In the first step, Otsu method is used to get POIs. Then Niblack method is applied with these POIs to remove background and then clean characters are got. The combination of Otsu and Niblack methods by POIs makes use of both methods' advantages while avoiding their shortcomings. It is also very efficient because Niblack method is used only on POIs and a lot of computation efforts can be saved. In the second step, a multi-stage method is proposed and both RGB and HSI color spaces are used to remove seal pixels covering the courtesy amount field characters. All the seal-like pixels whose colors are similar to red in HSI color space are extracted first. And the covered strokes are picked up and recovered by thresholding in RGB color space in the following stage. An image with background and seal removed is got as the final result.

This novel binarization method has demonstrated very promising results according to our experiments on real Chinese bank check images and outperforms many other methods reported so far. Compared with other methods, our proposed method can always get better results by using both gray-scale and color information in different steps. It is also very efficient and adaptive for various situations.

Our future work aims at constructing a whole system for recognizing courtesy amount with high performance. The method proposed in this paper will be used for constructing the binarization module. Work for detecting and removing column lines, segmenting and recognizing digit strings will be carried out in the near future.

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