12. Wei Luo, Zhiyong Wang, Zhihan LV. Method to Acquire a Complete Road Network in High-resolution Remote Sensing Image Based on Tensor Voting Algorithm. EXCLI JOURNAL, 2014,14,pp.123-128.
13. Song Zhang, and Huajiong Jing. Fast log-Gabor-based nonlocal means image denoising methods. 2014 IEEE International Conference on Image Processing (ICIP). Sydney,2014,pp. 2724-2728.
14. Alex Tek, et al.. Advances in Human-Protein Interaction-Interactive and Immersive Molecular Simulations." Biochemistry, Genetics and Molecular Biology. Protein-Protein Interactions-Computational and Experimental Tools.2012,12,pp.27-65.
15. Zhihan Lv, Alaa Halawani, Shengzhong Feng, Shafiq ur Rehman, Haibo Li. Touch-less Interactive Augmented Reality Game on Vision Based Wearable Device. Personal and Ubiquitous Computing. 2015,5,pp.563-569.
16. Tianyun Su, et al.. Rapid Delaunay Triangulation for Random Distributed Point Cloud Data Using Adaptive Hilbert Curve. Computers & Graphics. 2015,4,pp.123-126.
17. Xiaoming Li, et al.. WebVRGIS Based Traffic Analysis and Visualization System. Advances in Engineering Software. 2015,2,pp.452-458.
18. Jiachen Yang, et al.. A portable biomedical device for respiratory monitoring with a stable power source. Sensors. 2015,4,pp.125-130.
19. Wei Gu, et al.. Change detection method for remote sensing images based on an improved Markov random field. Multimedia Tools and Applications. 2013,12,pp.456-458..
20. Zhihan Lv, Alaa Halawani, Shengzhong Feng, Haibo Li, and Shafiq Ur Réhman. Multimodal Hand and Foot Gesture Interaction for Handheld Devices. ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM),2014,11, pp.102-105.
21. Zhanwei Chen, et al.. Uncorrelated Discriminant Sparse Preserving Projection Based Face Recognition Method. Multimedia Tools and Applications. 2014,12,pp.523-525.
22. Lijun Song, et al.. Joint Channel Estimation and Signal Detection for OFDM System without Cyclic Prefix over Doubly Selective Channels. International Journal of Bifurcation and Chaos. 2013,12,pp.414-418.

The Old and New Notes Recognition Algorithm Based on Image Edge Character

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Abstract
The classification accuracy of the existing notes feature recognition based on image processing technology is widespread poor, it's vulnerable to the restriction from external conditions. Aiming at the defect, the denomination recognition method about note image is improved. And the notes image pre-processing include two parts of

image enhancement and image segmentation is analyzed. Where, the histogram change enhancement and image edge detection are adopted in this paper, respectively. Secondly, an improved matching algorithm is put forward here, which is based on one-dimensional gray projection, and it's found that it is faster for notes image denomination recognition by adopting the new algorithm. Finally, through the difference of the histogram change of the old and new note image, to identify its old or new. In this paper, by experiment the notes feature recognition algorithm based on image processing can achieve the standard of distribution technology, and its identification accuracy can achieve over 99%. It has the characteristics which are accurate, reliable and real-time, which can play a positive role in promoting the development of paper clarification technology at present.
Key words: IMAGE PROCESSING, NOTES IMAGE, ONE-DIMENSIONAL GRAY PROJECTION

1. Introduction

As the speed of RMB internationalization to be more and more fast, it will put forward a higher standard for the circulation of RMB which is as the economic carrier. Since the 1990s, with the development of sensor technology and computer operation ability, because of its own intelligent automation, notes distribution equipment has gradually replace artificial, and it is basic equipment on notes automation processing for banking department[1].

Therefore, notes feature recognition technology become the key of notes distribution. Notes feature recognition not only includes the recognition of currency image denomination, image-oriented, defect detection of notes images, but also the degree identification of notes' old and new and its serial number etc.. Because of its quick circulation and big quantity on the market, notes is hard to avoid the artificially folding, alter, and abrasion. Therefore it need to continually distinguish true-false of notes and classify them for the bank system, and notes currency sorting is a kind of effective tool for enhance the efficiency of the banking business, it has the identification functions include currency denomination, image-oriented and old and new etc.[2].

In this paper, the research of notes feature recognition based on image processing can improve the notes distribution technology. Under the requirements of real-time, the ability of sorting of notes is improves, and ultimately high recognition speed and recognition rate is achieved.

2. Acquisition and Preprocessing of the Notes

Image Acquisition

In this paper, the required original notes image and the gray image which is processed are obtained by using a scanning method, they are as shown in figure 1(a) and 1(b), respectively. The resolution of the scanner determines the recognition speed of notes image. High resolution will lead to a larger image data, then the identification is slow,instead, it will be quicker. The resolution is divided into image resolution and the display resolution, and it only considers the former here.

(a)

(b)

Figure 1. The Original Image and Grayscale of the New Version 100 dollar

3. Enhancement of Notes Image

In the early period, the image enhancement is relative to the image recognition processing[3]. the effect of image can be better and its quality can be risen through image enhancement, and it can make the images be better for analysis. Because the image signal is always affected in the process of scanning and input to led the quality deterioration, we can apply image enhancement technology to make a series of changes to make the information we need more clear, at the same time, useless information has been removed or reduced. This paper mainly studies the histogram transform enhancement.

Histogram Transform Enhancement

As a result of the digital image pixels will change because of different grayscale values, in order to clearly show digital image gray level distribution, the digital image makes a histogram processing. The horizontal direction of the histogram represents the grey value and its vertical direction represents the probability of the grey value[4]. If the histogram distributions are concentrated in a small scale, it shows that the image contrast is very small and its characteristics is not obvious. And if its histogram is made an equalization processing, then all grayscale will ap-

pear the same probability, the contrast of the image at this time will reach the maximum. The purpose of image enhancement is reached then. As shown, figure 2 is the gray-level histogram of figure 1(b). After histogram equalization, images of the 64 gray level and the corresponding gray histogram are as shown in figure 3(a) and 4(a). The corresponding gray curve is as shown in figure 5, and after the homogenization of 32 grey level images are as shown in figure 3(b) and 4(b).

4. Segmentation of Notes Image

The technology that the digital image is divided into different areas and each area contains certain characteristics is called image segmentation technology [5-6]. Adopting digital image segmentation technology to process the desired part, it can reduce the

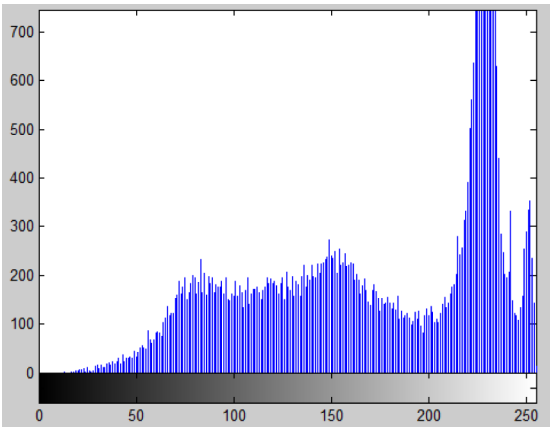
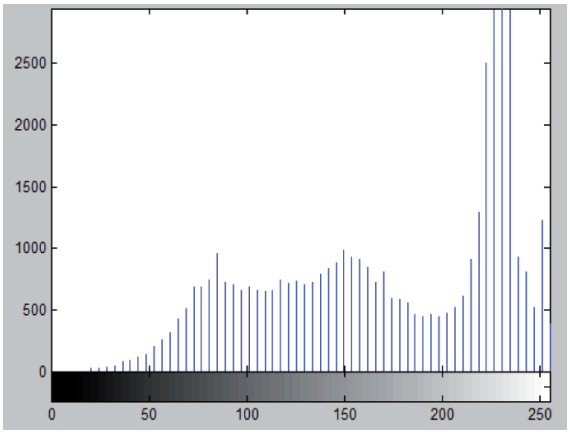


Figure 2. The Histogram of New Version 100 dollar Grayscale Image

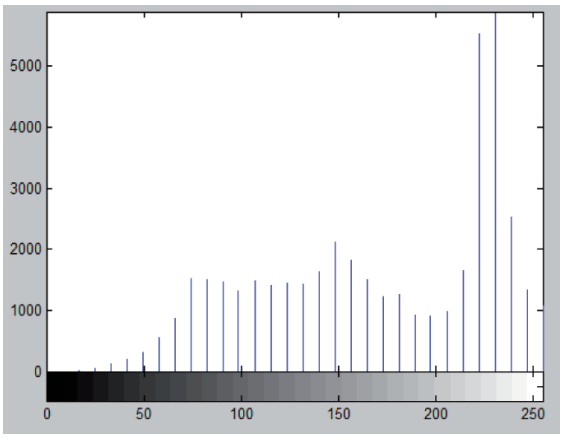
(a)

(b)

Figure 3. The Uniformity Grayscale of New Version 100 dollar



(a)



(b)

Figure 4. The Uniformity Histogram of New Version 100 dollar

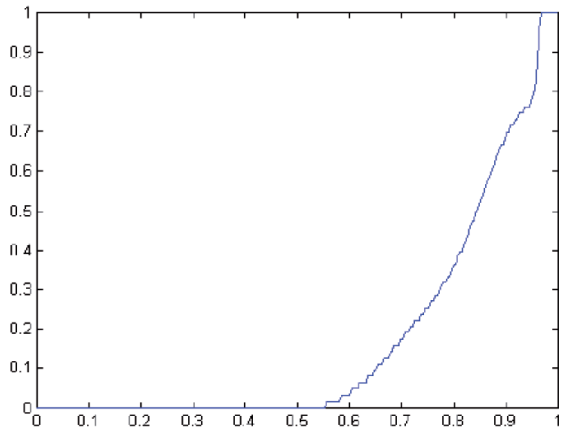


Figure 5. The Uniformity Curve of Histogram

amount of calculation and increase the speed of recognition. This paper mainly analyzes the edge detection method of notes image.

Image Edge Detection

To highlight the parts of images we take care of, while ignoring other, edge detection can achieve this effect. It can very well highlight those brightness changes are obvious in the image, which is the first step of digital image processing[7]. Take the new 20 dollar for example in this paper, we take its gray image and use Prewitt operator for testing. The grayscale image of new version 20 dollar is shown as follows in figure 6.

Figure 6. The Grayscale Image of New Version 20 dollar

Canny operator is widely used, which has a better anti-noise ability and accuracy. Therefore, it generally uses Canny operator for edge detection. Canny who summarizes the classical edge detection operator, and in 1986 he put forward three good criteria of edge detection operator and expressed them in the form of mathematical expression. Canny criterion and its mathematical expression is shown as follows.

(1) Excellent Ege Dtection Prformance

The expression of SNR is that in the following:

$$SNR = \frac{\left| \int_{-\omega}^{\omega} G(-x) f(x) dx \right|}{\left[\sigma \sqrt{\int_{-\omega}^{\omega} f^2(x) dx} \right]} \quad (1)$$

Where, f(x) is the impulse response of the filter In the boundary of $(-\omega, +\omega)$, G(x) is the edge function, δ is the Root mean square of Gaussian noise.

(2) Good Localization Accuracy

The equation of the localization accuracy is as follows.

$$Localization = \frac{\left| \int_{-\omega}^{\omega} G'(-x) f'(x) dx \right|}{\left[\sigma \sqrt{\int_{-\omega}^{\omega} f'^2(x) dx} \right]} \quad (2)$$

Among them, G'(-x) and f '(x) are the first derivative of G(x) and f(x).

(3) Edge Response Is Single Valued

To meet the condition that the edge response is single valued, fot the Impulse response derivative of the test operator, its average distance of zero crossing point neesd to meet , that's,

$$D(f) = \pi \left[\frac{\int_{-\infty}^{+\infty} f'^2(x) dx}{\int_{-\infty}^{+\infty} f''^2(x) dx} \right]^{\frac{1}{2}} \quad (3)$$

The image detected by Canny operator is shown in figure 7.

Figure 7. The Edge Detection Image by Canny Operator

5. Denomination Recognition of Notes Images

Feature Block of Notes

Denomination recognition of notes images has a lot of kinds, this paper mainly studies the notes feature block recognition and template matching method [8]. The feature block mainly refers to the parts which can represent the characteristics itself, that is, digital, etc.. Firstly, feature block identification mainly extracts the feature block which contains notes currency denomination from the notes image. Based on this, to make a template matching processing. Here some feature blocks of notes are as shown in figure 8, where they are respectively numbers in the middle of the front face of 20 and 100 dollar, numbers in the top right corner of the front face of 20 and 100 dollar.

Figure 8. The Feature Block

Template Matching Method

Template matching method uses a known feature image as the recognition template to contrast to the target image, and uses the similarity to determine whether the matching is successful or not. In this paper, the method of one-dimensional gray projection matching is studied. It is the gray-level projection of notes image in the horizontal direction and vertical direction, respectively, to form an one-dimensional image. And it's as a treatment target for quickly matching, whose main principle is to reduce the di-

mension and calculation data, then a higher matching speed can reach.

Assume that the function of the gray image is $f(i,j)$, the dimension is $M \times N$, the functions of the one-dimensional image formed by the projection in the horizontal direction and the vertical direction are as shown in equation (4) and (5), respectively, that's,

$$f_x(i) = \sum_{j=1}^{M} f(i,j) \tag{4}$$

$$f_y(i) = \sum_{i=1}^{N} f(i,j) \tag{5}$$

The similarity determination function of the normalized projection is similar to two-dimensional template matching is as shown in equation (6), that's,

$$R_x(i) = \frac{\sum_{i=1}^{N} S_x^{i,j}(i) \times T_x(i)}{\sqrt{\left(\sum_{i=1}^{N} (S_x^{i,j}(i))^2\right)}\sqrt{\left(\sum_{i=1}^{N} (T_x(i))^2\right)}} \tag{6}$$

Take the new 100 dollar for example, to make its projection in the vertical and horizontal direction as shown in figure 9.

The Simulation Experiment

In this paper, take the new 100 dollar and 20 dollar for example, and twenty of target identification samples are choosen for experiment respectively from each, the size of template is 30×59, the size of target identification samples is 45×75. And the enter direction is only considered to be positive here, the final results are as shown in table 1

6. The Recognition of the Old and New Notes

Based on the study of the recognition of the old and new notes, firstly, three new 100 dollar notes with different old and new degree are selected, which are as shown in figure 9. Where figure 10 (a) is entirely new, (b) is ninety percent new, (c) is eighty percent new. The gray-level histogram of these three notes were taken as comparison observation, it is concluded that the high part of the histogram changes obviously. This kind of circumstance is the result of the white part of the 100 dollar is more easy to be polluted than the other parts in the process of circulation. Then it can reflect the difference of the old and new notes.

Then the three 100 dollar images are made a threshold segmentation respectively in order to see their difference. After many times of experiments, it can be found that when the threshold is 179 samples of three old and new notes reflect very clearly. And the threshold segmentation images are as shown in figure 11, where the white part accounted for about 32.6% in the whole image (a), (b) and (c) are about 19.61% and 3.46%, respectively.

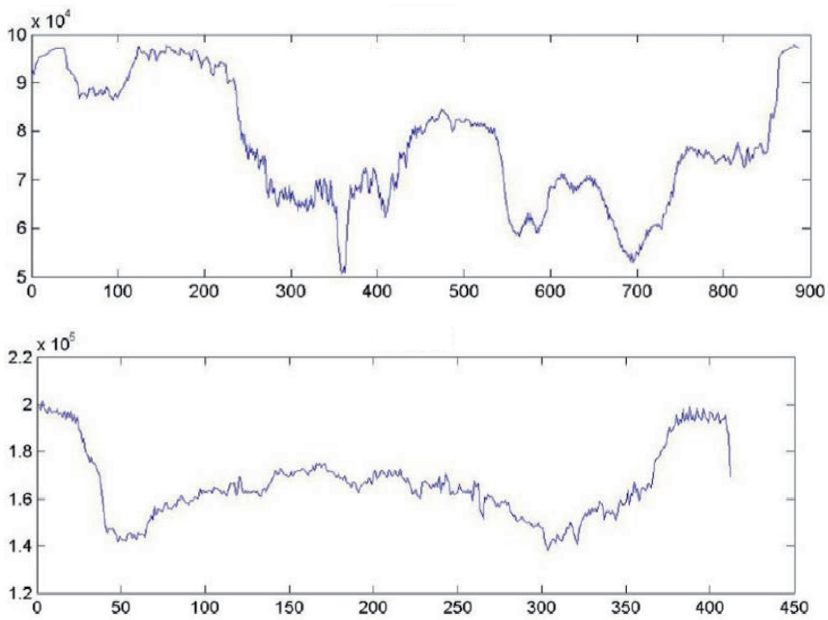
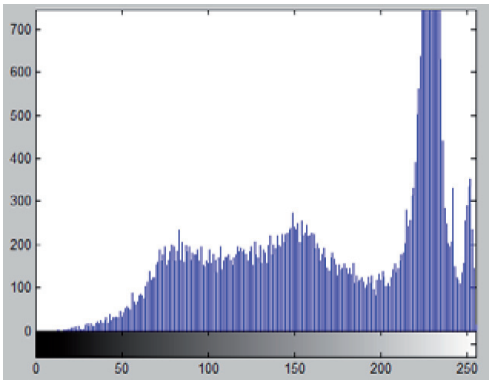


Figure 9. The Projection in the Vertical and Horizontal Direction

Tab. 1. Recognition Results

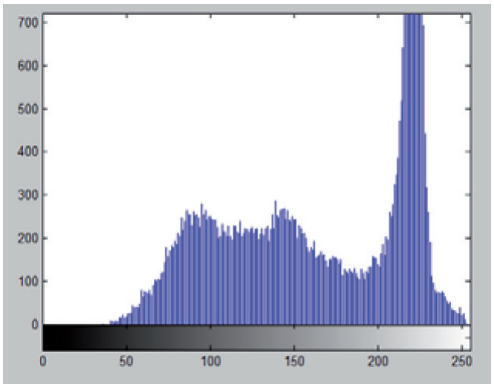
Denomination(dollar)	The Numbers of Notes	The Numbers of Notes Matched Successfully	Using Time	Matching Recognition Ratio
100	20	19	1.27×1.40	0.95
20	20	19	1.27×1.41	0.95

a(1) Entirely New Version 100 dollar



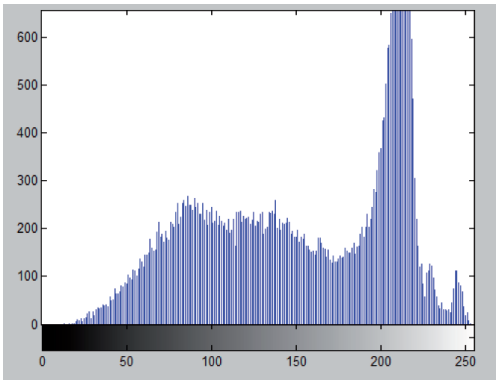
a(2) The Corresponding Histogram

b(1) Ninety Percent New Version 100 dollar



b(2) The Corresponding Histogram

c(1) Eighty Percent New Version 100 dollar



c(2) The Corresponding Histogram

Figure 10. The Image and Histogram of Different New and Old Banknotes

a(3) The Threshold Segmentation Image of a(1)

b(3) The Threshold Segmentation Image of b(1)

c(3) The Threshold Segmentation Image of c(1)

Figure 11. Banknotes After Divided by Threshold of 179

We analysis the three notes images from the experiment and find that different old and new notes have different gray level of the pixel points distribution. The white areas exist stain, then it is embodied in a little part of the curve surrounded by the high gray level area, and if the notes image becomes old and fades, the area of low gray level reduces. Corresponding to low gray level, the bright colour stain is mainly yellow, green.

Conclusion

Today, the rapid economic development drives the development of financial industry forward together. Then the distribution capacity of currency sorter is much higher now. Notes feature recognition technology based on image processing is the key of research about currency sorter, then the eyes about it is increasing, and its application areas are also increasingly wider. In this paper, aiming at the defects existed in currency sorter, the method of denomination recognition of notes is improved. And at the early stages of the image recognition, a lot of preparation work is made to make identification results more accurate and the recognition rate more faster.

References

1. Ding Rui-xin. Research and design of currency sorter image identification system[D]. Master degree theses of master of liaoning university of science and technology, Anshan, 2008, pp.47-48.
2. Jin Bing-tao. Research about currency sorter image recognition and the imperfect detection method[D]. Master's degree thesis of Harbin institute of technology, Harbin, 2007, pp.33-36.
3. Sajal-Raihan F. A Machine Vision Based Automatic System for Real Time, 2010, pp.83
4. Recognition and Sorting of Bangladeshi Bank Notes[C]. ICCIT Proceedings of 11th
5. International Conference on Computer and Information Technology, Khulna, Bangladesh, 2008, pp533-535.
6. Yin Gang, Jia Zhen-hong, Qin Xi Zhong, Yang jie. Research about license plate location and recognition based on digital image processing[J]. Journal of xinjiang university (natural science edition), 2010, 27 (3) , pp.258-263.
7. Wang Gang, Ji Xiaoping. Research about license plate recognition system based on MATLAB[J]. Journal of electronic design, 2009, 17 (11), pp.72-73.
8. Chen Yang. Research of the key technology of license plate recognition based on digital image processing[D]. Master degree theses of master of wuhan university of science and technology, wuhan, 2009, pp. 9-10.
9. Yang Shuying . Vc++ image processing program design (second edition) [M]. Beijing: tsinghua university press, 2005, pp.197-203.
10. Jin Ye. Note image analysis and understanding technology and application [D]. PhD thesis of Harbin institute of technology, Harbin, 2008, pp.2-7.