Ballot character recognition based on image processing

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Ballot character recognition based on image processing

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Abstract. According to the relevant provisions of the "Election Law of the People's Republic of China", the engineering software required for the implementation of large-scale conference elections can set voting regulations for "differential elections", "equal elections", and "alternative elections". This paper proposes an automatic ballot recognition system based on image processing, which is suitable for all levels of people's congresses, party and government meetings or other meetings. It has complete functions and stable recognition. It can automatically count and summarize the voting results and display the voting results on the big screen. Show on the display system. Firstly, the paper ballot is scanned by a scanner to obtain the image of the ballot. Secondly, the system will preprocess the image of the ballot and segment the image into regions.Thirdly, according to the handwritten character recognition algorithm based on image processing and Shen filter proposed in this paper, the handwritten characters "√" and "×" in the subregion are recognized.The final experimental results show that the recognition accuracy of the system is as high as 99.82%, which has an absolute advantage over the traditional manual voting, and can meet the performance requirements of high efficiency, accuracy, objectivity and security of large-scale conference election.

1. Introduction

Democratic elections are an important way to realize civil rights and to feed back the wishes of citizens. The vote count of elections is a very critical and important link in the electoral process. The perfection of the electoral system is related to the completion of the electoral work. In the development of the electoral system, there are three ways of counting votes. One is based on manual vote counting, the second is based on electronic elections, and the third is based on machine recognition and smart ballot boxes. In the past democratic elections, manual votes were usually recorded and counted. This method has certain advantages in small-scale elections, but when the scale of elections increases, there are disadvantages such as time-consuming and large errors. And the influence caused by subjective factors is inevitable. Second, there have been many schemes in electronic elections [1, 2]. These schemes are more efficient than manual vote counting. However, they all have a problem that cannot be ignored. In order to protect privacy during elections, they usually treat votes. Encrypted relevant information to prevent leakage, and on the other hand, because the result of the vote count must have a voucher that can be used for verification, the ballot information needs to be disclosed. David Chaum [3, 4] designed a numerical ballot for remote electronic voting. The scheme consists of a series of fixed bits, with 0 and 1 representing agreement and disagreement respectively. However, in large-scale elections, the execution efficiency of such a

method will be affected. The content of the ballot is relatively abstract, and it is difficult to be trusted and accepted by the voters [5], and it may even face many network security issues [6]. In other words, although electronic elections have excellent performance and application prospects, their security and reliability are still problems to be solved. Regarding the computer vision ballot recognition method, generally use cursor mark OMR (Optical Mark Reader) [7] recognition and optical character recognition OCR (Optical Character Reader) [8] these two recognition technologies. Jiang Weiguang developed a smart ballot box in 1995 using the photoelectric principle of Optical MarkReader (OMR), and realized real-time statistics of election votes using a computer [9]. OMR ballots usually use optical mark recognition technology to identify the dots on the information card. The content is intuitive and the vote counts are fast and accurate. However, the paper requirements for ballots are very high, which leads to high printing requirements and costs. expensive. OCR ballot is the use of optical character recognition technology to complete the statistics of the ballots. The ballot face is composed of a form, which contains the candidate's information and the position of the fill-in, etc., and symbols such as tick √, cross × and circle ○ are usually used to represent willingness. For example, the tabular ballot used in China's grassroots elections [10], but There are still some problems in practical application.

It can be seen that the above three methods have their own advantages and disadvantages. Based on these shortcomings and related image processing technologies, the paper designs a conference ballot automatic recognition system. In terms of security, traditional paper ballots are retained to ensure the verifiability of voting results; in terms of application, the counting method is simple and reliable, and can be completed with only common office equipment, which is easy to implement; in terms of promotion, it has The advantage of lower cost is easy to promote.

2. Votes automatic identification system

The ballot paper designed in this paper is embodied in a table format in terms of geometric structure, including election information area, election opinion area, and explanation area; there are boundary positioning lines on the left and right sides, and the page number recognition point is added to the lower left corner of the ticket according to the principle of 8421 binary. It can be used to quickly identify the page number of the ballot. The overall face of the ticket is shown in Figure 1.

Director of the votes

Number	Provinces	candidate	Unit	Opinion
1	Provinces	Name	Unit	
2	Provinces	Name	Unit	
3	Provinces	Name	Unit	
4	Provinces	Name	Unit	
5	Provinces	Name	Unit	
6	Provinces	Name	Unit	
7	Provinces	Name	Unit	
8	Provinces	Name	Unit	
9	Provinces	Name	Unit	
10	Provinces	Name	Unit	

Instructions for filling in the ballot: agree to draw "√" in the space to the right of the name, do not agree to draw "×", and do not draw any symbol for abstaining.

Fig.1. Sample Sheet.

According to the characteristics of the geometric and logical structure of paper ballots, the automatic ballot counting system mainly includes three sections: image preprocessing, ballot positioning and identification, and ballot statistics. First scan the collected paper ballots, convert the ballot information into image information, and align them for trimming and tilt correction; then according to the geometric characteristics of the ballots, the ballots are positioned and the page numbers and symbols are identified; then, in accordance with the requirements of the election In the vote statistics part, the discriminant function of questionable votes and invalid votes is added; finally, the result of the vote count is transferred to the database, and the result of the vote is visualized on a large screen.

3. Preprocessing of ballot images

The ballots are scanned with a scanner and stored as pictures. During the scanning process, some force majeure factors may cause the scanned ballots to be skewed. Therefore, the ballot images need to be preprocessed. The main process of pretreatment is as follows:

3.1. The binarization of the image

The binarization of the image is to make the entire image appear black and white. The method is to change the gray value of all points in the image to 0 or 255, and select a suitable threshold to make a gray image with 256 brightness levels. Obviously reflects the overall and partial characteristics of the image. After the binarization process, the collection property of the image is only related to the position of the point with the pixel value of 0 or 255, the processing process is simple, and the amount of data processing and compression is small. In order to better distinguish between the background and the part of the election frame, we choose to set a global threshold. All pixels whose grayscale is greater than or equal to the threshold are judged to belong to the ballot page content, and their grayscale value is 255. Otherwise, the grayscale value is 0 indicates the background area. In the image and processing of this article, The pixel value of a point on the image is represented by $I(x, y)$, set the threshold to 100, and binarize it, expressed by the formula:

$$\begin{cases} I = 255, I \geq 100 \\ I = 0, I \leq 100 \end{cases} \tag{1}$$

3.2.Perform tilt correction on the picture

First calculate the size of the original image, record the row and column values separately, then calculate the tilt angle, and correct it if the tilt angle is larger. Determine the size of the new image after rotation and generate an empty matrix, and then use the transformation matrix to transform the rotated coordinates to the original image. After the coordinate space transformation, it is transformed to $(x - y)$ the coordinate space and passes through the point (x_i, y_i) straight line.

3.3.The edge position of the frame is extracted

First find the leftmost and rightmost border lines respectively. In order to ensure reliability, choose 3 points on each side, take the average of the three points and record them as the coordinate points of the border, so that you can find the horizontal and vertical coordinates of the edge of the frame. How many respectively. In the same way, find the upper and lower boundaries respectively, take out the area of the box and mark it.

4. Handwritten symbol recognition and statistics

4.1.Page number recognition

Considering that in large-scale conference elections, there will be many candidates and there will be more than one page of votes. Therefore, when designing the ballot, a page number positioning symbol is added to the lower left corner of the ballot to facilitate the page number distinction of the ballot.

4.2.Regional segmentation of information blocks

After scanning the horizontal and vertical directions of the ballot box respectively, the positioning frame of the two directions is found out and then it is segmented.The segmentation effect is shown in the following figure 4:

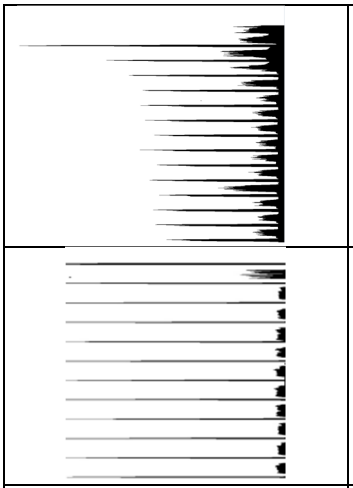

Fig.2. Horizontal orientation.

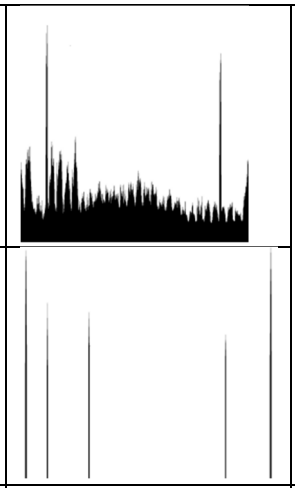

Fig.3. Vertical orientation.

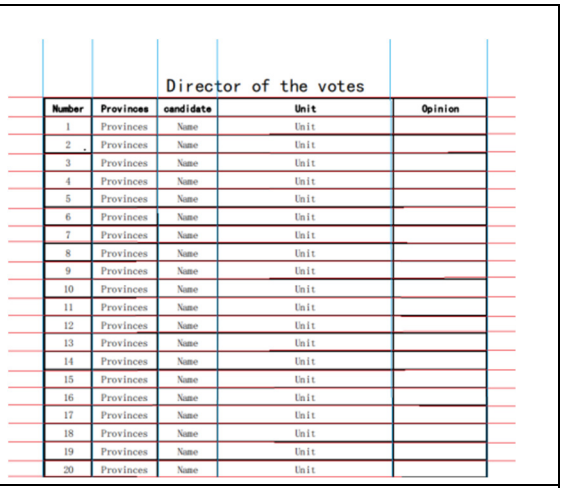

Fig.4. Segmentation results.

4.3.Character recognition

Recognition of handwritten characters is a core task in the system. In the preliminary work, each voting block can be segmented, and then the "√ "and "×"characters can be distinguished according to the principle of different distances between two points of different characters. Because the scanned ballot image may be affected by noise, the Shen operator is introduced to smooth the image. The Shen operator is a low-pass filter. The specific method is as follows:

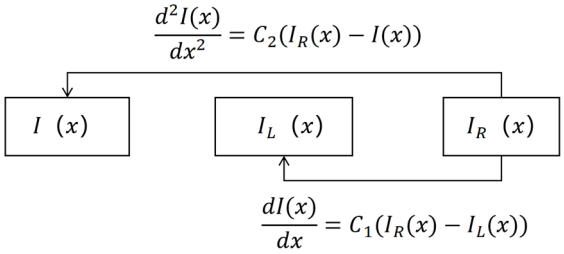

Fig.5. Shen's operator flow chart.

Shen used rigorous mathematical methods to prove that the operator can not only perform low-pass filtering, but also obtain the first and second derivatives through it. The flow of the operator is shown in Figure 5.

Assuming that the signal of the image is $(x)(x = 0,1,2,\ldots,N)$, first get the filter $I_L(x)$ from left to right:

$$\begin{cases} I_L(0) = I(0) \\ I_L(x) = aI(x) + (1-a)I_L(x-1) \quad x = 1,2,\ldots,N \end{cases} \tag{2}$$

And then you compute it from right to left I_R=(x)

$$\begin{cases} I_R(N) = I_L(N) \\ I_R(x) = aI_L(x) + (1-a)I_R(x+1) \quad x = N-1, N-2, \cdots, 1, 0 \end{cases} \tag{3}$$

In the above equation(1),(2), $0 < a < 1$, I_R=(x) is the value obtained after Shen filtering of the image signal. Taking a handwritten character as an example, the variation of the distance between two points of a character is shown in the figure 6 below:

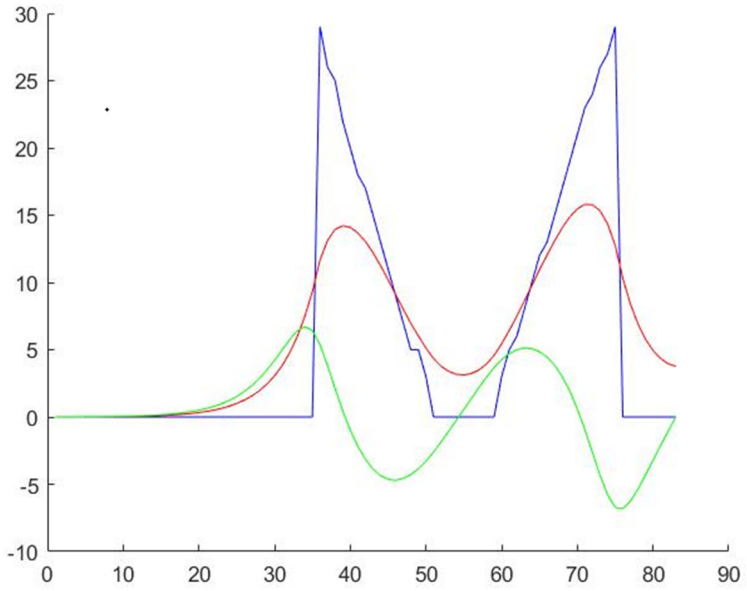

Fig.6. A graph of the distance between two characters.

In Figure 8, the purple line represents the curve of the distance change between the two points of the character, the red line is the smoothed curve, and then the green curve is obtained after the first-order difference. It can be seen from the figure that there are two maximum points and one minimum point in the purple line, and these three points are all zero-crossing points on the green curve, so it can be judged that the handwritten character is "×".The identification effect of votes is shown in Figure 7.

Director of the votes

Number	Provinces	candidate	Unit	Opinion
1	Provinces	Name	Unit	✓
2	Provinces	Name	Unit	✓
3	Provinces	Name	Unit	✗
4	Provinces	Name	Unit	✓
5	Provinces	Name	Unit	✓
6	Provinces	Name	Unit	✗
7	Provinces	Name	Unit	✓
8	Provinces	Name	Unit	✓
9	Provinces	Name	Unit	✓
10	Provinces	Name	Unit	✗
11	Provinces	Name	Unit	✗
12	Provinces	Name	Unit	✗
13	Provinces	Name	Unit	✓
14	Provinces	Name	Unit	✓
15	Provinces	Name	Unit	✗
16	Provinces	Name	Unit	✓
17	Provinces	Name	Unit	✓

Fig. 7.Part of the demonstration of the identification effect of the ballot.

5. Experimental results and analysis

In order to verify the effectiveness of the system in this paper, 100 votes were selected for the test.The experimental environment and results are shown in Table 1 below.

Table 1. Experimental environment Settings.

Hardware	Configuration
The operating system	Microsoft Windows 10
CPU	Intel(R) i7-3770 3.4GHz
Memory	4GB
Development-environment	Visual Studio 2017
Development tools	Visual Studio 2017
The scanner	Iridescent scannerAV222A+

Through several experiments on votes with a capacity of 100, it can be seen from the experimental results in Table 3 that the system designed in this paper has advantages over manual counting in both speed and accuracy.

According to the experimental results in Table 2, there are 100 test votes, which are divided into 5 groups on average. The manual counting group has two people in each group, and the other two people are responsible for the automatic counting of votes by the system. The automatic counting time of this system is 196 seconds, of which 180 seconds are used for scanning, and the automatic counting time is 16 seconds to complete the counting of 100 votes, the accuracy rate is 99.82%, compared with manual counting in the recognition speed, recognition accuracy has a great advantage.

Table 2. The experimental results.

Counting ways	Configuration					Automatic counting
	GROUP1	2	3	4	5	
Number of votes (sheet)	20	20	20	20	20	100
Time (s)	204	195	210	180	223	196
Average speed (s/sheet)	10.2	9.75	10.5	9	11.15	1.96
Wrong number of tickets	1	5	0	6	2	1
Mean accuracy	86.00%					99.82%
Number of votes counted	10					2

$$Note: Accuracy = \frac{Number\ of\ Correct\ Options}{Total\ Options} \times 100\%$$

$$= \frac{Number\ of\ Candidates \times Votes - Wrong\ Votes}{Number\ of\ Candidates \times Votes} \times 100\%$$

6. Conclusion

This paper designs a fast recognition system for paper ballot, which can be realized by using common office equipment, which is convenient and efficient. After the image of the ballot is obtained by the scanner, it can be imported into the system for identification. The software interface is clear and clear, and the discriminant function of the problem ticket and invalid ticket is added in the part of the vote statistics, which effectively ensures the accuracy of the statistics. The recognition speed of the system can reach 300-375 sheets/min, the recognition accuracy of 99.82%, compared with manual counting has an absolute advantage, to meet the election work requirements of high accuracy,objectivity,security,efficiency.

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