A Novel Template Weighted Match Degree Algorithm for Optical Character Recognition

Mo Wenying and Ding Zuchun

Guangdong Zhongya Wireless Technology Co. Ltd.
mowenying@126.com, zuccding@gmail.com

Abstract

This paper introduces template matching algorithm, and put forward an improved template matching algorithm which based on the weighted matching degree. After the completion of the pre-processing of input characters, the algorithm uses the moving match of the standard character template with respect to image character template. What's more, in terms of calculating matching rate, a method of weighted matching degree has been used. Experimental results show that this algorithm can provide a more comprehensive matching rate between target character and stander character, and overcome the fallacious recognition produced by traditional calculation method of matching rate. It not only guarantees the accurate recognition rate of general character, but also effectively avoids the influence of adherent noise and partial distortion, which greatly improved the recognition rate of the character.

Keywords: character recognition, matching rate, weighted match

1. Introduction

With the rapid development of national economy, a variety of industry or civil instrumentation has been increasingly widely used. The traditional way of manual meter reading not only wastes a lot of manpower and material resources, but also inevitable errors made by manual meter reading and calculation. Obviously, traditional manual meter reading can no longer meet the requirements of modern management. We urgently need a new management method which has highly automatic efficiency to replace the traditional one. The new one can achieve unified management, remote meter reading, real-time monitoring, automatic charging and so on. These are the problems which are urgent to be solved in the process of building a smart city. So we can see that the automatic meter reading techniques play an important role in our intelligence city construction [1-7].

The automatic meter reading system can take advantage of the camera to obtain the image information of the meters, and carry out a series of processing of the images. The processing contains several modules: character positioning, character segmentation, character normalization, and character recognition. During these modules, character recognition (OCR) plays a very important role in it and should be received our great attention. In order to improve the recognition rate, currently, we have some common methods including template matching method, feature recognition method, peripheral contour method and so on. Methods used by most of the recognition system are based on template matching algorithm, and combined with feature recognition algorithm or other auxiliary algorithm, which have reached a high recognition level so far. However, we know that the quality of the images also depends on the external environment which is more or less different, so we can't guarantee the images received form the camera always keep in high quality. Because of uneven illumination, the phenomenon of partial

image in different brightness is common. In this situation, in addition to Gaussian noise, the images contain irregular noise into a piece. After image pre-processing, most of them will appear adherent noise or characters of missing partial strokes. For this image, the recognition rate is still not very satisfactory, generally only reach 98%. This paper aims at this problem and uses the method of template matching algorithm combined with algorithm of weighted matching rate to reduce the influence of adherent noise and characters of missing partial strokes. This method can strengthen the anti-interference ability of the system, and significantly improve the recognition rate of the template matching algorithm.

Section 2 introduces the basic knowledge of our algorithm. Section 3 will put forward the algorithm of digital character recognition based on the weighted matching degree of template matching method. In Section 4, we will provide the actual experimental results which confirm the effectiveness and improvement of the algorithm.

2. The basic process of template match algorithm

The template matching method is one of the effective ways to achieve the classification of discrete input mode. It's essence is to measure a certain similarity between the input mode and the sample, then take maximum similarity as the category of the input mode, which is different form SVM and BP neural network classifier. It extracts features according to the intuitive form of the character and uses related matching principle to discern, that means the input character and standard character matching in a classifier. It is often very fast.

As an example, take account of the process of two-dimensional image as, the correlation matching algorithm is as following.

Let the input character to be presented by function f(x,y) and the standard character to be presented by function F(x,y). After contrast in the correlator, the output is T(x,y). We use correlated variable quantity represent random variable quantity, and the correlated output will be

$$T(x1-x2,y1-y2)=\int \int f(x, y)F[x+(x1-x2),y+(y1-y2)]d x d y \qquad (2.1)$$

$$\text{When } x1=x2, y1=y2, \quad T(0,0)=\int \int f(x, y)F(x, y)d x d y \qquad (2.2)$$

$$\text{When } f(x, y)=F(x ,y)\text{时}, \quad T(0,0)=\int \int f(x, y)f(x, y)d x d y \qquad (2.3)$$

(2.3) is the autocorrelation function of input character, and $T(0,0) \geq T(x, y)$. $T(0,0)$ is the main peak, and the secondary peak will be show in other standard character. As long as the secondary peak is not equal to the main peak, we can use the appropriate threshold to identify them.

Template matching method depends on different features obtained from the time of modeling, it can be divided into methods of image matching method, stroke analysis, geometric feature extraction method and so on. While modeling and matching comparison, image matching method getting matched based on graphic block itself, and the result of recognition is based on the degree of similarity. It is the method used in this paper.

In order to make data processing more rapid and accurate, we should do image preprocessing. The image preprocessing is a series of conversion processing on the input image, so the image meet the requirement of character module of recognition. The first step of the image preprocessing is that isolating the character from the input

grayscale image. The most common methods is that binarization, denoising, positioning, segmentation. Image binarization means that to convert the grayscale into the image that containing only two type of gray value, which needs an appropriate threshold to distinguish between background and character. The mathematical expression is as follows:

$$f(x,y) = \begin{cases} 0, & f(x,y) < T \\ 1, & f(x,y) \geq T \end{cases}$$

(2.4)

T is the threshold value of binarization.

Then the next step is character positioning. Finding out the location where the character located in the picture, removing the background area, and extracting character area. The third step is character segmentation. Divide the characters into single ones. The final step is character normalization. Normalize each character into the same size of template characters.

3. Moving template matching method

Because of the different shooting environment and the illumination brightness changed over time, even the same characters show differences more or less after the processing of binarization. Moving template matching algorithm mainly aims at the characters effected by the noise and the missing strokes which existed normalized positioning error. It can capture the best position where the character is by moving standard template, thereby carry out the exact match. Moving template matching method is based on the template of target character, using the template of standard character to match the target character from eight directions of up, down, left, right, upper left, lower left, upper right, lower right. Its mathematical expressions are as follows:

Let the target character template to be presented by function f(x,y), and the standard character template to be presented by function F(x,y). Then:

Template upward moving match:

$$T(x, y) = f(x, y) \&\& F(x, y + \Delta y) \tag{3.1}$$

Template downward moving match:
$$T(x, y) = f(x, y + \Delta y) \&\& F(x, y) \tag{3.2}$$

Template leftward moving match:
$$T(x, y) = f(x, y) \&\& F(x + \Delta x, y) \tag{3.3}$$

Template rightward moving match:
$$T(x, y) = f(x + \Delta x, y) \&\& F(x, y) \tag{3.4}$$

Template upper leftward moving match:
$$T(x, y) = f(x, y) \&\& F(x + \Delta x, y + \Delta y) \tag{3.5}$$

Template lower leftward moving match:
$$T(x, y) = f(x, y + \Delta y) \&\& F(x + \Delta x, y) \tag{3.6}$$

Template upper rightward moving match:

$$T(x, y)=f(x+\Delta x, y)\&\&F(x, y+\Delta y) \tag{3.7}$$

Template lower rightward moving match:

$$T(x, y)=f(x+\Delta x, y+\Delta y)\&\&F(x, y) \tag{3.8}$$

As picture 1 showing below, graph (a) is target character and subgraph (b) is standard character. The number 1 presents foreground pixels, and the number 0 presents background pixels. The area enclosed by red lines is the correlated matching part between target character template and standard character template. Here, the standard character template rightward moving four pixels to match the target character template.
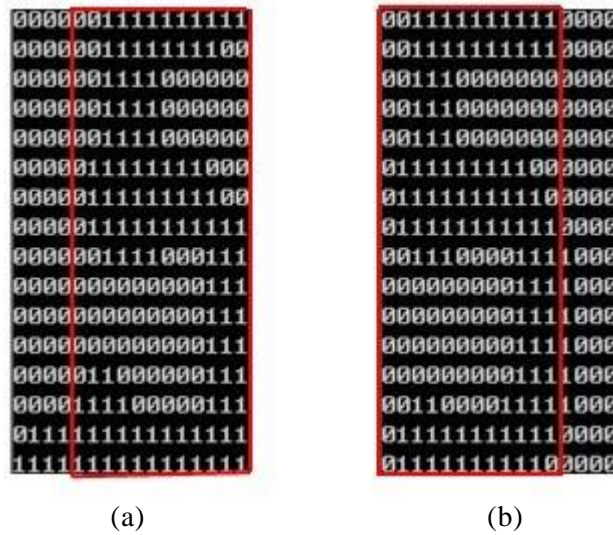

(a)   (b)

Figure 1. (a)target character; (b)standard character

From the figure above, we can see that the influence of adherent noise have been avoided by using moving template matching method, and the right area where the target character is have been captured accurately. Standard character template moved one pix column each time, and recalculated the C value, M value and N value of the overlapping area (that means the area enclosed by red lines). C value, M value and N value are used to calculate the matching rate of combinational value. The meaning and the mathematical expressions of C value, M value and N value are as follows:

C value means: the number of the overlapping foreground pixels in the overlapping area.

$$C = \sum f(x, y)\&\& F(x', y') \tag{3.9}$$

M value means: the number of the foreground pixels of the standard character in the overlapping area.

$$M = \sum F(x, y) \tag{3.10}$$

N value means: the number of the foreground pixels of the target character in the overlapping area.

$$N = \sum f(x, y) \tag{3.11}$$

Moving template matching method can greatly avoid the influence of adherent noise and missing partial strokes. Flexible move of the template made standard character and target character achieved a high degree of overlap, which has improved the matching degree of the character.

4. Weighted matching degree algorithm

Traditionally, the common methods related with template match of calculating matching rate are follows:

(1) Matching rate:

$$P1=c/m \qquad\qquad\qquad (4.1)$$

(2) Matching rate:

$$P2=c/n \qquad\qquad\qquad (4.2)$$

It is one-sided and inaccurate to use method (1) or (2) to calculate the matching rate between standard character and target character. As method (1), P1 is equal to the result of the number of the foreground pixels of the standard character in the overlapping area divided by the number of the foreground pixels of the target character in the overlapping area, which is not conducive to the characters of complicated structure. For example, the character 4, as the area enclosed by the red lines of the following picture 2(a) shown that the right vertical stroke of the character 4 is very similar to the standard character 1. When the standard character 1 matches with it, the matching rate could be 100%. On the contrary, when the standard character 4 matches with it, the matching rate could be 95%. Actually, the matching rate of 95% has been very high, and because of the final result is determined by the standard characters, so that, the final result is just unilaterally reflect the matching degree. That is easy to cause the wrong judgment. In addition, the disadvantage of method (2) is in contrast with the disadvantage of method (1). Using method (2) is not conducive to the characters of simple structure. As it is shown it the picture 2(b), when the standard character 4 matching with the target character 1, the matching rate could be 100%. However, when the standard character 1 matches with it, the matching rate is 98%. That's why it is one-sided and inaccurate to use method (1) or (2) to calculate the matching rate between standard character and target character.

Actually, the matching rate between standard character and target character means the similar degree of them. Only by making an combination of similar degree between standard character and graphic character can we obtain an result that can totally and accurately reflect the similar degree. All in all, the weighted matching degree algorithm that put forward by this paper is to make an combination of P1 and P2 with the weight of 0.6:0.4 to calculate the matching rate between standard character and target character. Only by making an combination of them with an suitable weight, can we overcome the disadvantage of each other and retain the advantage of each other. The mathematical expression of weighted matching degree algorithm is follow:

W= $0.6 \times P1 + 0.4 \times P2$ (4.3)

W is the matching rate of weighted matching degree algorithm.

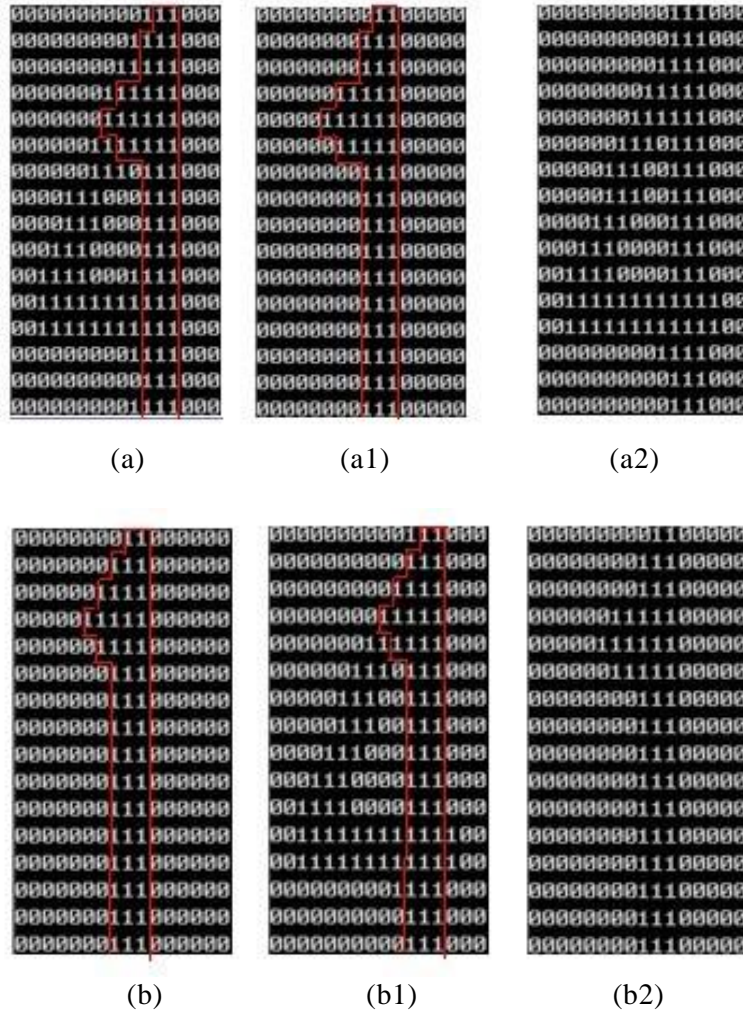(a)   (a1)   (a2)

(b)   (b1)   (b2)

Figure 2. (a) target character 4; (a1) standard character 1; (a2) standard character 4; (b) target character 1; (b1) standard character 4; (b2) standard character 1

The rate of combination is getting from a large number of experience. I have used five rate of combination to take the experiment on more than 600 samples. Finally, the 0.6:0.4 is the rate which can reach a recognition rate of 100% on all the samples.
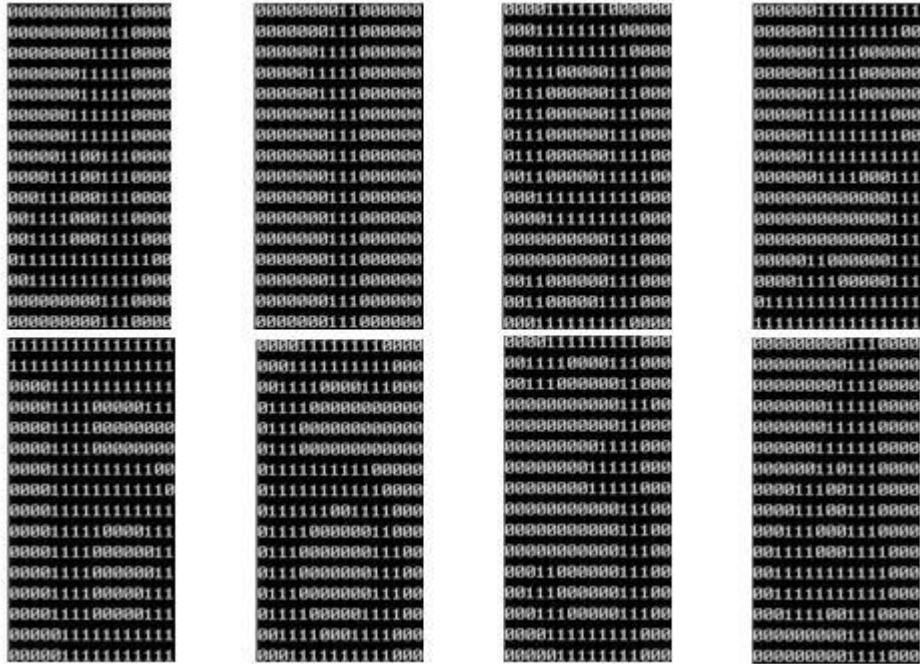
5. Analysis of Experimental Results

Figure 3. Results. From left to right and up and down are sub-graph a, b, c, d, e, f, g, h. They are target characters

Table 1. The experimental results

Target Characters	Matching Rate						
	P_1	P_2	$0.2P_1+0.8P_2$	$0.4P_1+0.6P_2$	$0.5P_1+0.5P_2$	$0.6P_1+0.4P_2$	$0.8P_1+0.2P_2$
a	0	1	1	1	1	1	1
b	1	0	1	1	1	1	1
c	0	1	1	1	1	1	1
d	1	1	1	1	1	1	1
e	1	0	0	0	1	1	1
f	1	0	0	0	0	1	1
g	1	0	0	1	1	1	1
h	0	1	1	1	1	1	0

Note: "0" represents the wrong recognition, "1" represents the right recognition.

We can see the results form table1 above, while used the first or the second method to calculate the matching rate between template character and target character, the

program made many errors. Using other weight to combine the results from the methods of P1and P2, more or less, it made errors. Only using the rate of combination of 0.6: 0.4, the program obtained the recognition rate of 100%. Therefore, we know that the values for reference of stander character and target character are important. We can't obtain the accurate matching rate by taking advantage of the single one. The result from the method of P1 shows a one-sided similar degree between stander character and target character, and the result from the method of P2 shows another. So, combining the tow results properly which can show the total similar degree between stander character and target character. Of course, we can't combine the arithmetic results from the methods of P1 and P2 simply. We should find a favorable weight. Only by taking advantage of the favorable weight to combine the arithmetic results from the methods of P1 and P2 can we get the accurate matching rate between stander character and target character. Finally, we have obtained the favorable weight from a larger number of experiments and the analysis of significantly enormous experimental data. It is 0.6: 0.4. But this weight may not be the most favorable one. It is just a most favorable weight from those that I had tried so far.

6. Conclusion

In the algorithm based on the weighted matching degree of template matching method, the template's moving matching can reduce the influence of the noise and the missing partial strokes, and make an accurate matching between standard character and target character; on the other hand, algorithm based on the weighted matching degree of template matching method takes advantage of a favorable weight of 0.6 : 0.4 to combine the arithmetic result of matching rate between overlapping part and stander character and the arithmetic result of matching rate between overlapping part and target character, which has made the program to obtain an exhaustive and accurate matching rate between standard character and target character. This algorithm has avoided the errors by the method of one-sided. The ability of recognition of the program has been greatly improved. Support by a lot of experience, the recognition rate of this program can reach 99.2%, which is a comparatively high level. In the further research, I want to supplement the characteristic recognition algorithm of similar characters. We know a lot of similar characters will be met in the research of license plate recognition, example 8&B, 0$Q, 2&Z and so on. I plant to use the algorithm of this paper combine with an effective feature recognition algorithm to do a further research of license plate recognition. Try my best use a variety of methods from others or myself to ensure the recognition rate of similar characters to improve the ability of recognition of the program. That's my favorite thing to do.

References

[1] D. Li, C. Sui and Y. Tang, "Research on Recognition of Dynamic Characters in Multi Digital Instruments", **(2007)**.
[2] N. Zhou, M. Wang, X. Huang, X. Lv and G. Wan, "Pretreatment Algorithm of Auto Plate Characters' Recognition", Computer Engineering and Applications, **(2003)**.
[3] C. Gu and W. Ge, "Character Recognition Based on Template Matching Method", **(2009)**.
[4] R. Kumar, R. C. Tripathi and M. D. Tiwari, "Morphological Pattern Based Approach for Retrieval of Similar Trademarks", **(2011)**.
[5] D. Shin, C. Im, H. Jeong, S. Kim and D. Won, "The New Signature Generation Method Based on an Unpacking Algorithm and Procedure for a Packer Detection", **(2011)**.
[6] G. Praveen, Vijayrajan, "Analysis of Performance in the Virtual Machines Environment", **(2011)**.
[7] Information on http://www.ccs.neu.edu.

Authors

Mo Wenying graduated from Guangdong AIB Polytechnic College in June, 2010. Now, she is working at Guandong Zhongya Wireless Technology Co. Ltd as a software engineer. Her main job is image processing and object recognition. She loves her job, because the job is very challenging and gives her a great sense of accomplishment.

Ding Zuchun is currently doing his exertions to research on computer vision, human pose discrimination and communication network also. He is always hardworking at his research work, which is proved to be useful for him to study for BSc, MSc and PhD from Zhejiang University, National University of Defense Technology and South China University of Technology respectively. He has been in charge of several national research projects and taken part in some application research work on relative domain, including signal processing and communication network successfully.