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MSER and connected domain analysis based algorithm for container code locating process

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***Abstract*—Effective and efficient automatic container code recognition is an essential component of intelligent port management. Higher sensitivity and intelligence are required in container code locating process. Based on the edge of container code area and the color of the container surface, a container code locating algorithm based on Maximally Stable Extremal Region (MSER) and connected domain analysis is proposed in this paper. This algorithm is an efficient algorithm of container code characters location in complex scenes. Then, this paper further proposed a strategy to combine multiple algorithms. The correct rate under the algorithm combination strategy reached 97.19%, and the time is within 0.6s, effectively adapt to the diversity and code permutation of container code permutation, significantly improve the positioning ability of the container, which can meet the requirement of real time in practical application.**

Keywords-container code locating; MSER; connected domain analysis; algorithm combination strategy;

I. INTRODUCTION

With the requirement of port automation management, optical character recognition(OCR) [1] begins to be used in container code recognition system widely. Container code locating is the foundation of the identification number. Different from license plate recognition [2-3], higher sensitivity and intelligence are required in container code locating, due to the severity of nonuniform illumination, invalidation of color information and rust on the container surface.

The common and classical methods for container code locating contains container locating algorithm based on mathematical morphology and container locating algorithm based on multiple features. The use of edge detection and mathematical morphology algorithm proposed in the literature [4], the actual image edge extraction is easy to appear the character missing or impurity adhesion. Image edge extraction is sometimes hard to get the desired effect, directly affect the locating accuracy of the container code region. Algorithms in document [5] to achieve locating by row column scanning method, this algorithm is very hard to avoid interference by impurities. In view of the complex environment, this paper proposes an algorithm for container code locating based on maximally stable extremal region and connected domain analysis ,and put forward a combination strategy of this algorithm and the traditional algorithm.

II. LOCATION ALGORITHM

Before the localization algorithm, it is necessary to preprocess [6] the image samples, including gray level transformation, histogram equalization and homomorphic filtering. Gray level transformation is to change the collected RGB image into gray image, which is the preparation of feature extraction in the process of localization; histogram equalization is a useful technique for improving image contrast; homomorphic filtering is used to deal with uneven illumination images in frequency domain.

In this paper, we present an algorithm for the container code locating based on MSER and connected domain analysis. Combining this algorithm with the traditional algorithm based on edge and mathematical morphology, a combination strategy of this algorithm and the traditional algorithm in different backgrounds is proposed, to effectively improve the positioning performance of the algorithm in complex background by the plurality of rows or columns of characters, and improve the accuracy of locating.

A. Container Code Location Algorithm Based on Edge and Mathematical Morphology

The algorithm based on edge and mathematical morphology firstly extracts the edges of the image after preprocessing using the Sobel operator. Then, the edge image is processed by mathematical morphology, so that the same line or the same column character area is connected as a whole. Finally, through multiple connected domain analysis, the impurity region which does not meet the rule is excluded, and the region satisfying the filter condition is selected as the candidate region. Edge-based localization algorithm has a strong resistance to edge image extraction. When the rust, oil, fences and other disturbances near the container number, the character edge is easy to be linked together with impurities near the container code area. This causes the edge image of the code region to become deformed, the area may be removed when connected domain analysis is performed. Still possible, when the code region appeared to fade, image edge extraction may be incomplete. Based on this traditional algorithm, in order to adapt to the complex surface of the container, we propose to extract candidate code region by MSER, and then through the connected

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domain analysis for further screening, to improve the accuracy of the locating algorithm.

B. Container Code Location Algorithm Based on MSER and Connected Domain Analysis

MSER based on the concept of watershed algorithm, according to the different threshold for binary image [7], the threshold for the entire range of gray level range, and the binary image will undergo a gradual process from black to white. The area of some connected areas varies little with the threshold, and this region is called the maximally stable extremal region. The specific discriminant formula is as follows:

$$v(i)=\frac{|Q_{i+\Delta}-Q_{i-\Delta}|}{|Q_i|} \tag{1}$$

Where Q represents the area of the i connected region, Δ represents a slight threshold variation, and when the v(i) is less than a given threshold, the region is considered as the maximum stable extremal region. MSER algorithm is often used in natural text detection, and can be adapted to different sizes of characters by adjusting the parameters.

In this paper, we propose a container location algorithm based on MSER. Firstly, we extract the maximum stable region in a certain area from the gray scale of preprocessing. The area chosen in this paper is between 100 pixels and 500 pixels. In order to adapt to the different arrangement of the container code, the MSER images are respectively located in the row or column direction. The proposed algorithm for row or column direction is as follows.

1) Column orientation

First of all, MSER images are processed by mathematical morphology opening or closing operations several times, which are used to fill the gaps between the characters, the gaps between the characters, and to remove small areas of impurities, as shown in Fig. 1(d). After that, the area of the processed image is selected as the candidate character area according to the condition of the circumference, length and width, aspect ratio and so on. Finally, the size of the remaining connected domain and the positional relationship between the respective connected domains are analyzed, and the region with higher possibility is chosen as the candidate region, as shown in Fig. 1(e);

2) Row orientation

Similar to column positioning, MSER images are processed by mathematical morphology opening or closing operations several times, which are used to fill the gaps between the characters, the gaps between the characters, and remove small areas of impurities. However, the size of kernel in mathematical morphology is different from that of column orientation,as shown in Fig. 2(d). After that, the area of the processed image is selected as the candidate character area according to the condition of the circumference, length and width, aspect ratio and so on. The arrangement of the characters can be divided into one line without gaps, one line with gaps, two lines without gaps, three or four lines without gaps and so on, different permutations will have different preset parameters, the results are shown in Fig. 2(e).

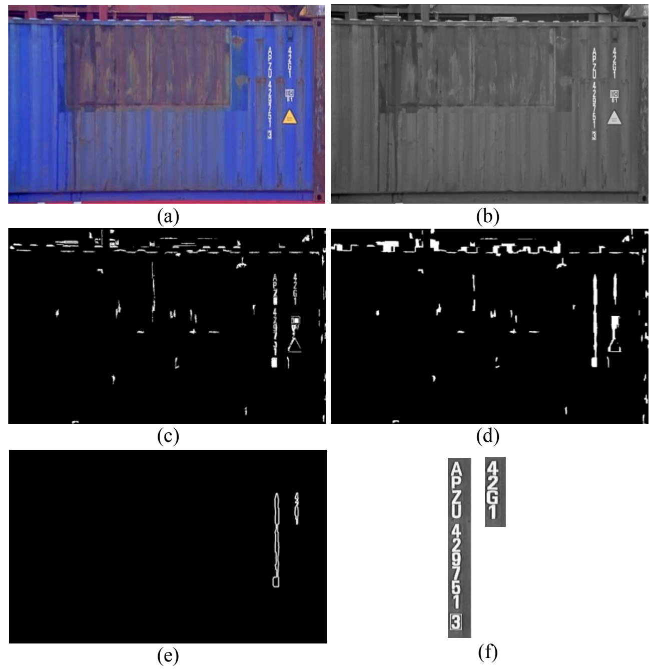

Figure 1. Column locating algorithm renderings: (a) original image, (b) Preprocessed image, (c) MSER image, (d) Mathematical Morphological Processing, (e) Remaining region, (f) locating result.

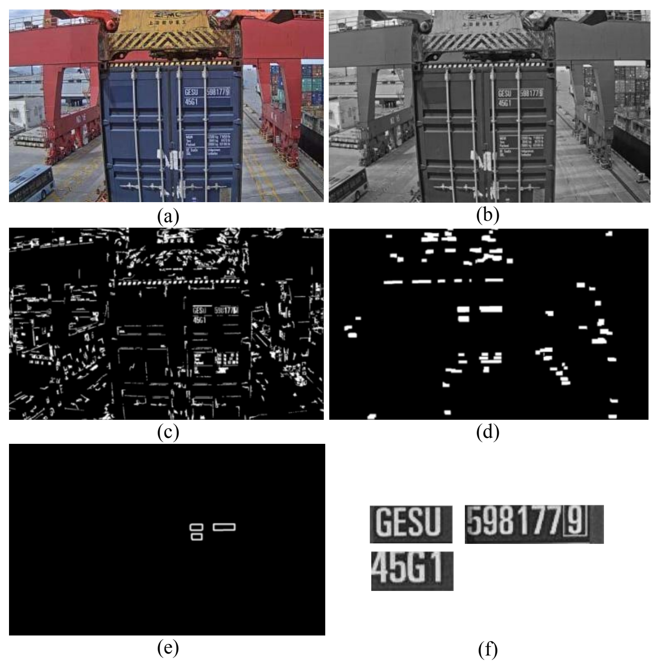

Figure 2. Row locating algorithm renderings: (a) original image, (b) Preprocessed image, (c) MSER image, (d) Mathematical Morphological Processing, (e) Remaining region, (f) locating result.

C. Single Character Locating Algorithm Based on MSER and Connected Domain Analysis

As the data analysis suggests, horizontal arrangement of the container code may appear adjacent characters too wide. Single independent area can be calculated by the MSER algorithm. But the interval between individual characters is too large to be connected by mathematical morphology, so that the characters in a row break into multiple parts, independent character areas can not meet the screening conditions, the code area will be removed. If the size of the kernel in the mathematical morphology processing increases, the broken characters can be connected, other impurities and the box area will be connected as a whole. So, further proposes an algorithm based on MSER and connected domain analysis for single character location. The basic flow of the algorithm is as follows:

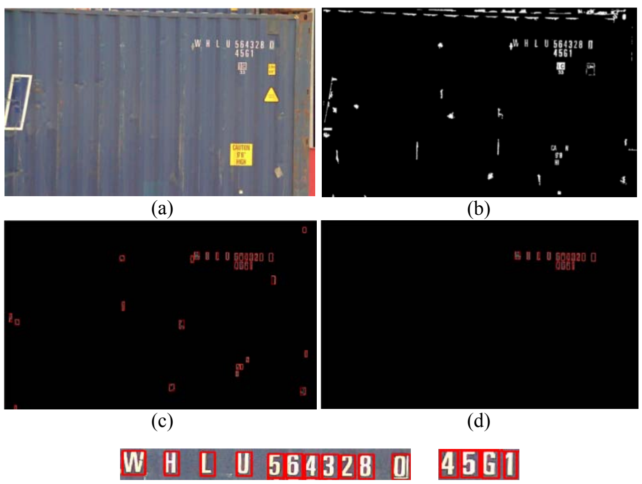

Figure 3. Row locating algorithm renderings: (a) original image, (b) Preprocessed image, (c) MSER image, (d) Mathematical Morphological Processing, (e) Remaining region, (f) locating result.

1) Candidate regions in MSER images are processed small scale mathematical morphology to connect gaps between individual characters, as shown in Fig. 3(b);

2) Through the domain analysis, the proper areas is selected with the length, the width and the aspect ratio of the minimum circumscribed rectangle of a single connected domain in a certain ranges.As shown in Fig. 3(c);

3) The remaining candidate regions are analyzed one by one. The position of the connected domain is represented by the upper left corner of the smallest circumscribed rectangle of the connected domain, shown in Fig. 3(d);

4) If the remaining area is more than the total number of characters in the container code area after one filter, return to step 3) to re-analyze the positional relationship of the remaining connected area. If the number of remaining connected domains is equal to the number of container code characters, it is detected whether the remaining rectangle is located near the same horizontal line or two horizontal lines. If it is satisfied, the locating process ends, as shown in Fig. 3(e). If the above conditions are not satisfied, then adjust the preset character information, re-step 1). This paper sets up five different sets of character information.

D. Algorithm Combination Strategy

Due to the uncertainty of the condition of the container surface, it is difficult to achieve high positioning accuracy by relying on a single positioning algorithm. If you only use a variety of localization algorithms in a fixed order, it cannot meet the requirements of real-time applications. Therefore, this paper proposes a combination strategy for container code locating algorithm. The flow chart of the localization algorithm is shown in Fig. 4.

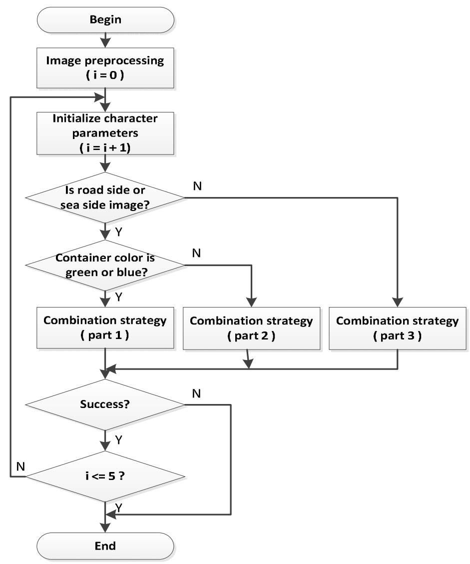

Figure 4. Chart algorithm flow

After preprocessing the image, the preset parameters of the single character are initialized, including the maximum or minimum character width, the maximum or minimum character height, the maximum or minimum character space, the size of the kernel in the mathematical morphology. This paper sets up five different sets of character parameters to suit the differences between the samples.

According to the relevant prior knowledge, we put the container into three categories. Each category develop an algorithm combination strategy to improve the accuracy of the algorithm. The samples are sorted by color detection algorithms. Container surface color is divided into red, green, blue, and others. Image samples contain images taken from the front side, the rear side, the sea side, the land side. The proportion of rows arranged in the front or rear image samples is higher, and the extra samples is more average. The category of the collected samples can be obtained from the number of the acquisition device. This paper use three different strategies to locate the code respectively:

1) Part 1 is mainly applied to the image taken from the sea side or the land side, and the color of the container surface is blue or green. Using MSER image to do row locating and column locating, if the locating fails, the next step we will use MSER image to do single character locating. If the locating still fails, edge image will be got, we use edge image to do row locating and column locating;

2) Part 2 is mainly applied to the image taken from the sea side or the land side, the color of the container surface is not blue and green. We will use the MSER image to do column or row locating respectively. If the locating fails, the next step we will use edge image to locate code; and then, single character positioning will be used;

3) Part 3 is mainly applied to the extra samples. We use MSER image and edge image to do line location in turn, and then use the image to locate the individual characters. If the locating fails, partial algorithm for column locating are added to handle samples in special cases.

Three combination strategies are taking to combine the various positioning methods. When one of the positioning methods in the combination strategy takes effect, the subsequent locating operation will no longer be carried out.

III. EXPERIMENT

In this section, several experiments are conducted to evaluate the performance of the proposed algorithm and the combination strategy. Samples were used in the experiment, including various environments such as Container type, illumination, camera angle, etc. The number of samples in each category is shown in Table I.

TABLE I. COMPOSITION OF CONTAINER SAMPLES

Algorithm	**Container number**	**Image sample number**
daytime	1622	5132
night	902	9396
allover	2524	14528

The algorithm based on Edge Image and Mathematical Morphology (EMM) is used to compare with the algorithm based on MSER and connected domain analysis (MSERDA) and the multiple algorithms under the combination strategy(MACS). The test results in the Table Ⅱinclude daytime accuracy(DA), night accuracy(NA), overall accuracy(OA).

TABLE II. THE ACCURACY OF EACH ALGORITHM

Algorithm	**DA**	**NA**	**OA**
EMM	0.9581	0.8958	0.9358
MSERDA	0.9593	0.9124	0.9425
MACS	0.9871	0.9446	0.9719

Table Ⅱ shows, compared with the EMM algorithm, the MSERDA algorithm performs better, especially at night. Specifically, the accuracy under our combination strategy is far higher than two other algorithms, whether day or night. The daytime accuracy under our combination strategy can reach 98.7%, and overall accuracy can reach 97.1%. The experimental results verify the effectiveness of the proposed algorithm and the combination strategy.

TABLE III. AVERAGE TIME TO LOCATE A SAMPLE

Algorithm	**EMM**	**MSERDA**	**MACS**
average time (s)	0.4435	0.4332	0.5683

The proposed algorithm ran on Intel Core i5 at 2.3 GHz using Visual Studio 2013. Table Ⅲ shows the time to process characters by three algorithms. It shows that the time of the proposed algorithm and algorithms under our combination strategy is equivalent to the traditional algorithm, and is less than 0.6s, which can meet the requirement of real time in practical application.

IV. CONCLUSION

In this paper, an effective and efficient container code locating algorithm based on MSER and connected domain analysis is proposed. The problems that changes in luminous condition, colour fading, rusts and is damaged can be effectively solved by our algorithm. Meanwhile, an algorit-hm combination strategy is proposed to optimize the existing algorithms. The result is obviously improved, and the time consuming can meet the requirement of real time in practical application. Experimental results demonstrate the superior performance of the proposed algorithm and show significant improvement over the tradition.

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