Study on Edge Detection Method of Aluminum Foil Image

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***Abstract*—The machine vision method is used to detect the surface defects of aluminum foil image, as the problem of location deviation is inevitable in image sequence imaging, and an image edge detection algorithm is used to extract aluminum foil image sequences efficiently. Firstly, the SUSAN operator is used to detect the edge of the foil image, and threshold aluminum foil images are obtained to determine the effective region of the foil in the image. Then, the nearest neighbor pixel filling method is used to carry out the nonlinear correction of the extracted aluminum foil image boundary. The experimental results show that the proposed method can extract the aluminum foil region quickly and accurately, and it lays a good foundation for the detection and recognition of aluminum foil surface defects.**

Keywords- Aluminum Foil Image; SUSAN Operator; Nearest Neighbor Filling; Edge Detection

I. INTRODUCTION

Aluminum foil surface quality is an important index that has an influence on use value of aluminum foil materials. During the production of them, how to effectively detect their surface defects becomes especially critical. Now, the fundamental principle of automatic visual inspection for aluminum surface defects[1-4] is to utilize imaging devices to acquire aluminum foil images that are further input into the computer to perform surface defect detections for these images obtained by means of machine vision[5]. In order to accurately detect the defects on the aluminum surface, extracting the aluminum foil area in the image is an important pretreatment operation.

Now, the common edge detection algorithms including First-Order Differentiator, edge detection operators of second derivative model, the phase congruency method and the method based on corner detection, etc. [6-8]. The precondition of adopting First-Order Differentiator is that the differential operation can enhance the change, and at the same time, the image brightness changes at the feature boundary. Typical first-order edge detection operators including Prewitt operator, Sobel operator and Canny operator etc., Besides the first order differential method, two order differential can also be applied, and zero points can be found in the two order information, the commonly used two order edge detection operator including Laplacian operator and Marr-Hildreth operator etc.. The phase congruency method is a method based on frequency domain, it able to detect image features in large range, and it is invariant for the local illumination. The method based on corner edge detection mainly including Harris operator and SUSAN operator, etc., the computational complexity of the Harris operator is high, as it is necessary to do Differential processing and Gauss filtering. SUSAN operator detects corner points by comparing gray image pixel values, and it has such advantages as simplicity, at the same time, the image noise can be reduced under the condition of preserving the structure. Firstly, the SUSAN operator is used to detect the edges of aluminum foil images quickly. Then, the nearest neighbor method is used to carry out nonlinear correction of the image boundaries, and then to extract the full aluminum foil image. Experimental results show that the proposed method has such advantages as quick and accurate, and it has a preferable practical reference value.

II. ANALYSIS OF EDGE DETECTION METHOD OF ALUMINUM FOIL IMAGE BASED ON SUSAN OPERATOR

A. Principle analysis of SUSAN operator

SUSAN operator deals with minimum kernel similarity regions, and it primary accumulates difference between the components of the template which is Nuclear centered, its advantages lay in that it has fast calculation speed. Firstly, using the prototype template and the center point of the circle, compare the pixel values at the center of the circle with the other pixel values in the template circle. Then, counting the number of pixels that are similar to the pixel value of the center of the circle, and comparing with the pre-set threshold, in order to determine whether it is the edge of the image. For discrete images, take a discrete circle consisting of 37 pixels, and the center of the circle is called the nucleus of the template. The area of the thick line is the discrete circle, as shown in Figure 1 following.

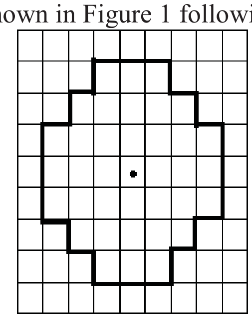


Fig.1 Discrete circle and kernel of SUAN template

Within the template circle, the number of pixels of a circular template that has the same brightness value as the kernel is called USAN (Univalve Segment Assimilating Nucleus). When the circular template is all in the image area, USAN area is the largest, when the template is biased toward the edge of the image, the USAN region is getting smaller, and when the center of the template is in the corner position, USAN area is the minimum. Generally, The USAN value at the edge point is less than or equal to half its maximum value, so, by setting the USAN threshold, Compare the USAN of each pixel in the image with the set threshold, and the pixels that are smaller than the threshold are determined as the edge point of the image.

The circular template is moved pixel by pixel on the detected image, and Compare the pixel values of the nuclear pixel values and the circular template, the comparison process can be described as:

$$\sigma(s,s_0)=\begin{cases}1 & if\,|I(s)-I(s_0)|\le T\\ 0 & if\,|I(s)-I(s_0)|>T\end{cases} \tag{1}$$

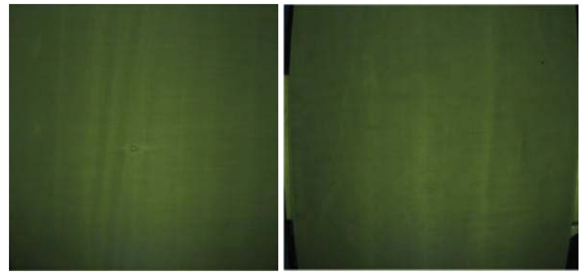
Where, s_0 Represents the position of the template in an image, s Represents other locations within the template, $I(s_0)$ Represents the pixel value at the position s_0 in the image, $I(s)$ Represents the pixel value at the position s in the image, T is the threshold of a pixel similarity. Compare all pixel values in the template circle, and accumulate the results ($\sigma(s,s_0)$), that is,

$$N(s_0)=\sum_s \sigma(s,s_0) \tag{2}$$

$N(s_0)$ is the sum of the pixels of the image USAN at the position s_0 at the template kernel. After getting the USAN value $N(s_0)$ of each pixel in the image, then compare with the set threshold g. If $N(s_0)<g$, the pixel location s_0 in the image is detected as an edge point in the image, the maximum value of the USAN region of the edge point depends on the threshold g, if the value of g is too large the edge mistaken detection may occur, on the contrary, the edge omit detection may occur, in this paper, the threshold g is equal $0.75*M$ (M is the maximum USAN value for a template). At the same time, the prototype template cannot be too large, the larger the template, the larger the calculation, in this paper, the size of the template is 37 pixels.

B. Analysis of edge detection of aluminum foil image by using SUSAN operator

An industrial camera that collects aluminum foil images is mounted on top of each aluminum foil production line, in the process of aluminum foil moving, it is inevitable that the deviation will occur. The effective area of the aluminum foil image presented in Fig. 2(a), an offset image of aluminum foil during operation presented in Fig. 2(b).



(a) (b)

Fig.2 The collected aluminum foil images

From the image shown in figure 2(b) above, when the aluminum foil band is migrated in the running process, the collected images contain background interference information, at the same time, the left and right boundaries of aluminum foil images are nonlinear, in order to retain complete aluminum foil image information, in this paper, the nonlinear edge is calibrated by the nearest pixel filling method on the basis of extracting the foreground information of aluminum foil image, and finally we can get the complete aluminum foil image.

The method flow of this article is shown in Fig.3:

Aluminum foil images collected by industrial camera

↓

SUSAN operator is used to detect the edge of aluminum foil images

↓

The edges of aluminum foil Threshold Image

↓

Extract the image that contains the complete aluminum foil regions

↓

The nonlinear edge is calibrated by the nearest pixel filling method

↓

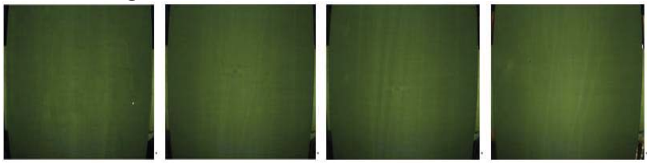
Get the complete aluminum foil image

Fig.3 Flowchart of the proposed method

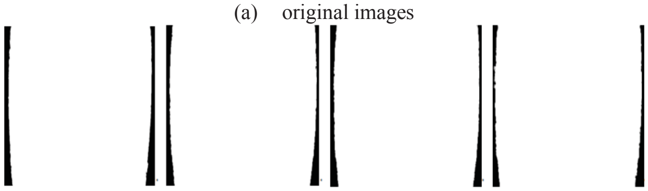
III. NUMERICAL EXPERIMENT

Experimental running equipment: CPU is Intel Core i7 2.60GHz, internal memory is 4G, Windows 7 operating system, software Development Environment MATLAB 2012b.

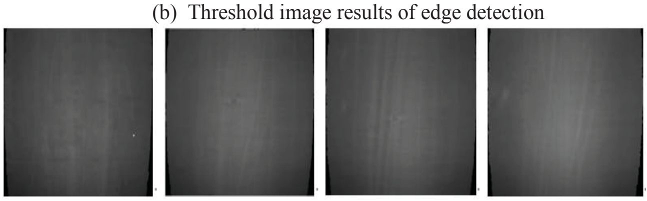
Aluminum foil images collected by industrial camera, the experiment was carried out by randomly extracting 100 aluminum foil images with position offset. Each aluminum foil image of the 100 images is successfully extracted the foreground information, take four images in the experiment were analyzed and explained, the experimental results are shown in Fig.4.



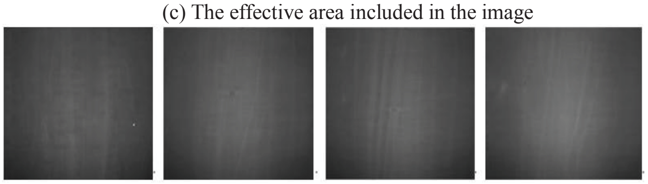
(a) original images



(b) Threshold image results of edge detection



(c) The effective area included in the image



(d) The results of nonlinear correction of the effective area

Fig.4 Results of extraction of aluminum foil full area

As shown in Fig.4(a), aluminum foil images with position offset which collected by industrial camera, in Fig.4(b), SUSAN operator is used to detect the edge of aluminum foil images, in Fig.4(c), the extracted images containing the effective regions of the aluminum foil based on threshold Images of Fig.4(b), in Fig.4(d), the complete aluminum foil images is obtained after nonlinear edge is calibrated by the nearest pixel filling method. The results shown in Fig. 4(d) include the complete information in the original aluminum foil images in fig. 4(a), and it lays a foundation for the detection and recognition of the surface defects of aluminum foil. At the same time, it takes no more than 0.3s to process an image of size 640 * 480, it has the advantage of low time complexity.

IV. CONCLUSIONS

In this paper, the aluminum foil image collected by industrial camera contains background noise process on aluminum foil production, how to effectively extract the image information of aluminum foil is studied. Firstly, the boundary information of aluminum foil image is obtained by using the SUSAN operator. Then, the nearest neighbor pixel interpolation method is adopted to correct the boundary of the aluminum foil image. Finally, the aluminum foil image information was extracted from the aluminum foil image containing background noise. The experimental results show that the proposed method is effective for the Pretreatment of surface defects of aluminum foil image.

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