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Study on Adaptive Threshold Segmentation Method Based on Brightness

Abstract. *Image segmentation is one of the most important steps before the image data analysis, which divided the image into several areas that have strong similarity. With the more and more widely application of the mesh fabric, the quality requirements are more stringent. As the impact of uneven illumination, the image brightness is inconsistent, which bring a great difficulty to the image segmentation of the mesh fabric. In order to eliminate the effect of uneven illumination in the image acquisition of linear CCD camera, the adaptive threshold segmentation method based on brightness is proposed. Compared with the Otsu method, it is better to eliminate the influence of the uneven illumination and provide a good foundation for subsequent data analysis.*

Streszczenie. *Analizowano system segmentacji obrazu polegający na podziale obrazu na obszary o dużym podobieństwie. Przy nierównym naświetleniu powstaje problem segmentacji. Zaproponowano adaptacyjny system progowej segmentacji bazujący na analizie jasności. (**Adaptacyjna progowa segmentacja obrazu bazująca na analizie jasności**)*

Keywords: image segmentation, uneven illumination, mesh fabric, linear CCD
Słowo: przetwarzanie obrazu, segmentacja.

1. Introduction

Image segmentation is a method that the image is divided into several areas with specific properties, in which the interested targets can be acquired [1]. It is the key step to realize the automatic defect detection of mesh fabric. The segmentation quality will affect the defect extraction directly. The common methods of image segmentation include the segmentation method based on the threshold, the segmentation method based on region, the segmentation method based on edge and so on [2-7]. The segmentation method based on the threshold, which includes the overall threshold segmentation and local threshold segmentation, is widely studied due to the simple realization and high efficiency. Currently, segmentation quality which has not uniform standards is assessed depending on the application effect.

Fig.1. Image captured by linear CCD camera (2816*512 pixels)

Mesh fabric is a fabric which has certain rules in the fabric structure. It is more and more widely applied in automobile, medical, sports and leisure, filtering and cleaning, security and other areas. Linear CCD camera is widely used in fast motion detection for high-precision requirements. In order to achieve the automatic on-line detection of mesh fabric, the linear CCD camera is chosen as the image acquisition device. Fig.1 is the mesh fabric image acquired by the linear CCD camera. According to the working principle of linear CCD camera, the image has the same brightness from top to down, but the brightness varies from left to right. If using the global threshold segmentation or local threshold segmentation, the segmentation effects are both unsatisfactory because of the uneven illumination. In view of this, the adaptive threshold segmentation method based on brightness is proposed. First, the image is divided into several regions according to the brightness. Then the image is segmented by the selected threshold of each region. This method can eliminate the influence of the uneven illumination and provide a good foundation for subsequent data analysis.

2. Adaptive Image Partition based on Brightness

2.1. Image Denoising

The noises of the image have a great influence of the image segmentation, so it should be deal with firstly. Median filter and mean filter are the typical methods of Image denoising [8-10], which are widely used for the denoising ability and simple realization and so on. The main noise of the image is Gaussian noise. As the Mean filter has a good real-time and better handling of Gaussian noise, it is chosen to eliminate the noise [11-12]. Mean filter templates are commonly used 3 * 3, 5 * 5, 7 * 7, etc. With the increase of the template size, processing time and the degree of image blur will deteriorate, a 3 * 3 template is selected. The effect of mean filter with 3 * 3 template is shown in Fig.2.

Fig.2. The effect of 3 * 3 mean filter

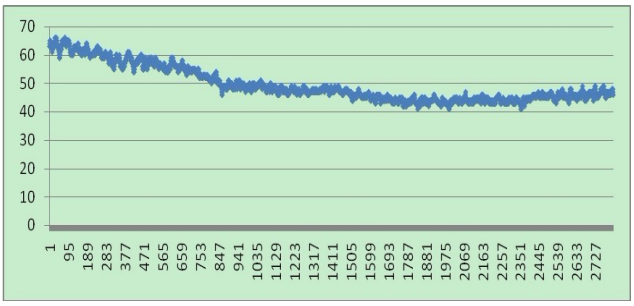

Fig.3. The brightness curve

2.2. Image Brightness Analysis

As mentioned previously, the images that are acquired by the linear CCD camera have the same brightness from top to down. Through the analysis of the mesh fabric images,

the mean of the rank of the image is taken to represent the brightness information. The brightness curve is shown in Fig.3.

As shown in Fig.3, the image brightness declines from left to right, the maximum gray value is 66, and the minimum gray value is 41. The overall brightness has a large difference, and the local brightness is small, which is consistent with Fig.2.

2.3. Image Partition based on Brightness

By the analysis of the brightness curve and the summary of the change rule, the adaptive image partition method based on brightness is proposed. At first, brightness average *Ave*, maximum *Max* and minimum *Min* are obtained according to the curve. Secondly, the image is divided into several regions by the interval [*Ave*, *Max*] and [*Min*, *Ave*]. Finally, in order to overcome the wave phenomenon of the image brightness which results in only a few or dozens of pixels into a region, the pixel threshold *P* is used. Figure 2 processed by the algorithm is divided into two regions: *A*[0,859], *B*[860, 2816]. Regions after image partition are shown in fig.4.

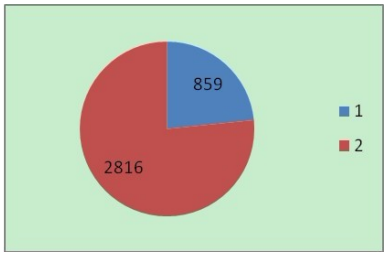

Fig.4. Image partition regions

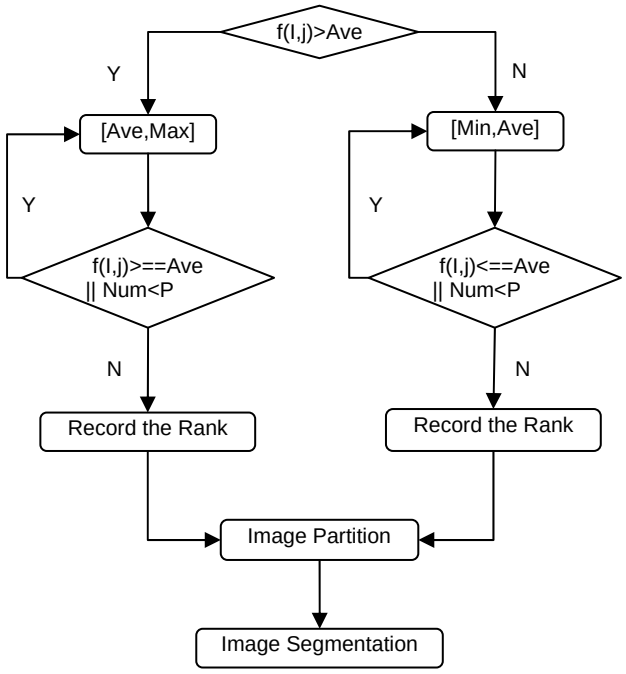

Fig.5. The process image segmentation algorithm

3. Adaptive Image Segmentation based on Brightness

After the image partition, the appropriate threshold *T* needs to be selected for the adaptive image segmentation. Through the analysis of the gray histogram of the segmented region, the region average is chosen to segment the image to save the process time.

$$g(i,j)=\begin{cases}1 & f(i,j)\geq T\\ 0 & f(i,j)<T\end{cases} \tag{1}$$

Where: *i, j* – the number of ranks, *f (i, j)* – the gray value of *(i, j)*; *T* – the region average, *g (i, j)* – the gray value of *(i, j)* after divided.

The process of image segmentation algorithm is shown in fig.5:

4. Analysis of Experimental Results

This paper compared the proposed segmentation method with Otsu segmentation method. Otsu threshold method is a segmentation method that threshold is been chosen automatically, which is derived on the least squares method. The basic idea of Otsu threshold method is to divide the gray histogram of image into two groups in a certain threshold. When the variance of the two groups is the maximum one, choose the threshold as the best.

On the one hand, viewed from the segmentation results, the segmentation results of the Otsu segmentation and the proposed method in this paper are shown in Fig.6 and Fig.7 respectively. From the Fig.6 and Fig.7, it can be concluded that the method proposed in the paper is better obviously. Broken hole is the main defect of mesh fabric, and the hole size is the main feature to identify it. In Fig.6, the hole of region *A* is broken almost, while the hole size of region *B* is too small. Both of the two would be identified as the defect in the subsequent defect recognition, which may cause great difficulties for the detection. In Fig.7, the hole size of the region *A* and *B* is consistent basically, which provide a good foundation for the feature extraction and the subsequent defect identification.

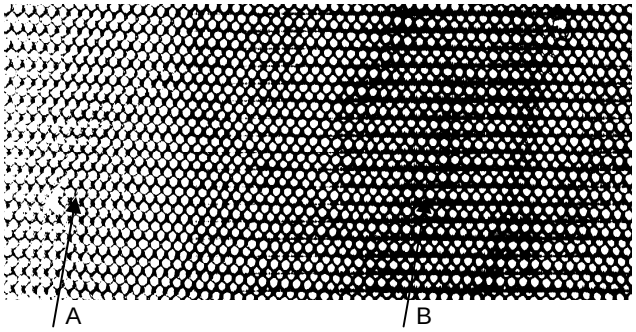

Fig.6. Segmentation result by Otsu method

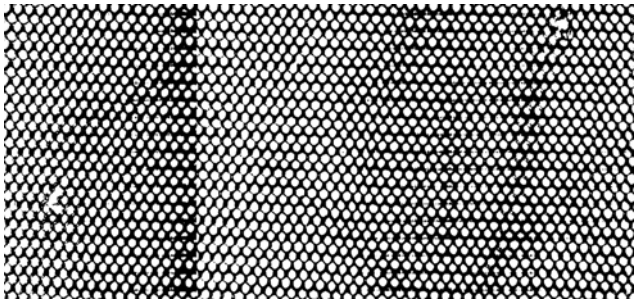

Fig.7. Segmentation results by proposed algorithms

On the other hand, as shown in Table 1, the segmentation method in this paper has a good superiority on the real-time. Otsu segmentation method took 47 milliseconds, and the segmentation method in this paper took 31 milliseconds. Also, experiments show that the processing time increases with the increase of the blocks.

Table 1. Processing time comparison

Segmentation Methods	Time-consuming（unit：milliseconds）
Otsu Segmentation Method	47
Segmentation Method based on Brightness	31

The experimental results demonstrate that the adaptive threshold segmentation method based on brightness can

effectively eliminate the effect of uneven illumination and meet the real-time performance.

5. Conclusions

Due to the impact of uneven illumination, the image brightness is inconsistent, which brings a great difficulty to the image segmentation of the mesh fabric. For the automatic detection of mesh fabric, the adaptive threshold segmentation method based on brightness is proposed to solve the difficulty of image segmentation caused by uneven illumination. Firstly, the brightness curve is obtained; then the image is divided into several regions by the analysis of the brightness curve; finally, regions are segmented separately. The experimental results demonstrate that the adaptive threshold segmentation method based on brightness can effectively eliminate the effect of uneven illumination and meet the real-time well.

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