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The Shape Edge Measure of Automobile Airbag based on Image Processing

Mujun Xie, Peng Gao, Zhiqian Wang and Yuanchun Li

***Abstract*—At present, micrometer is used for measure the shape edge of automobile airbag. There are some shortcomings in this method. The number of test points is limited. Test data is not comprehensive. Detection speed is slow and a fixture can only test a kind of airbag. The method of airbag shape edge detection based on image processing is researched in this paper. The image of airbag is collected by CCD, and then it is sent to the computer to be processed and segmented. The edge of image is extracted through Canny edge detection algorithm in order to acquire shape edge of airbag in this paper, and the image similarity degree are calculated to provide the information of matching in the template matching process. Finally the comprehensive test shape edge of airbag is realized. The experimental results show that the detection method is effective feasible, intuitive and clear.**

I. INTRODUCTION

AIRBAG is installed into the plastic material box in the assembly process. Some situations will happen such as extrusion, rap and so on. These will make the appearance of automobile airbag bend deformation. The automobile airbag cannot be guaranteed closely to match with the car interior reserve installation holes position. This will lead to automobile airbag cannot popup normally when car collision happen. It will not ensure safety protection function. Therefore, the shape edge of automobile airbag is a very important technical index. The automobile airbag shape edge needs high precision detection in the assembly process.

Micrometer is used for existing detection method of the shape edge of automobile airbag, it is shown in Fig1.

The automobile airbag and the micrometer are fixed in the fixture in the detection process, and then each micrometer is aimed at the corresponding feature point position, after it is read one by one. There are some disadvantages in this method, detection time is long, and detection process is more troublesome. The appearance of the automobile airbag is irregular shape, it is detected only a few feature points that cannot represent the whole of automobile airbag shape edge, but several position of the automobile airbag can not make sure whether all the size meets design requirement or not. Detection data is not comprehensive. A kind of automobile airbag must correspond to each fixture. So, the different fixtures need to be designed according to different type of automobile airbags, the cost is raised. At the same time, micrometer is a contact-type measurement tool, so it will be worn. And it needs to be corrected and changed.

Therefore, the new measure method is researched necessarily. With the development of computer and photoelectric technology, non-contact measurement has been developed fast. This affords theoretical and technical support to the main theoretical basis of Optical principle, digital image processing and computer vision.

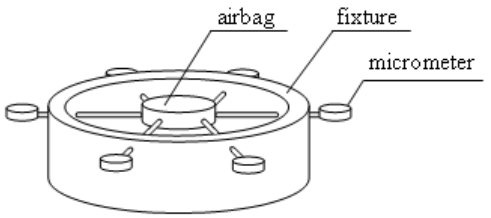

Fig. 1. Micrometer detection Principle diagram

II. IMAGE PROCESSING TEST PRINCIPLE

The diagram of airbag shape edge detection based on image processing is shown as in Fig 2.

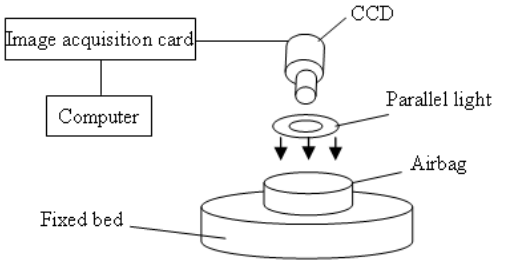

Fig. 2. Automobile airbag shape edge detection diagram

The image of airbag is collected by CCD camera. The parallel light is used in order to remove the outside uneven distribution of light source. The airbag image is sent to the computer to be processed [1]. The median filter is used to remove disturbance in the process of measurement. The method of template matching is used to finish the shape edge measurement of automobile airbag in this paper.

The following are the main steps in the automobile airbag

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M Xie is with the School of Electrical & Electronic Engineering, Changchun University of Technology, Changchun 130012, Jilin, PRC(phone: 0431-85716441; e-mail: xmj666@163.com).

P Gao is with the School of Electrical & Electronic Engineering, Changchun University of Technology, Changchun 130012, Jilin, PRC(e-mail: 13596405652@126.com).

Z Wang is with the Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, Changchun 130033, Jilin, PRC (e-mail: zhiqian_wang@sina.com).

Y Li is with the School of Electrical & Electronic Engineering, Changchun University of Technology, Changchun 130012, Jilin, PRC(e-mail: liyc@mail.ccut.edu.cn).

image detection:

Step 1: The image of airbag is collected by CCD, and then it is sent to the computer through the image acquisition card.

Step 2: The image of automobile airbag is processed. The median filter [2] is used to eliminate image random noise.

Step 3: The shape edge of airbag is extracted through Canny edge detection algorithm.

Step 4: The measure results are acquired by template matching algorithm between the ideal images and practical image of airbag.

III. Experiment Process of the Shape Edge of Airbag Measure

A. Measure Device

The measure device of airbag is made up of CCD (ANPVC1210), spherical lamp, image processing device PV200 and airbag fixed platform. The real diagram is shown as in Fig 3. 1-CCD, 2- spherical lamp, 3- airbag, 4-PV200, and 5- airbag fixed platform.

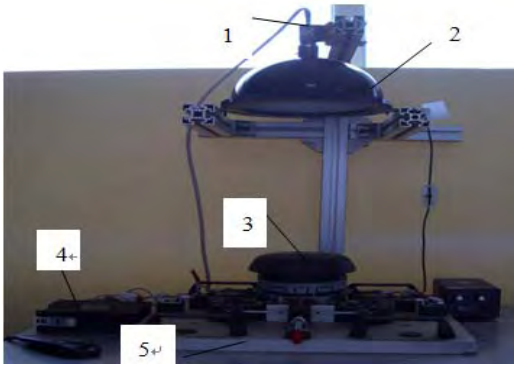


Fig. 3. Automobile airbag shape edge measure device

B. Image Collection And Filter

Relative changes of two images of the shape edge of automobile airbag are collected by CCD under the parallel light. The airbag of Steering wheel of Audi car is set as an example in this paper. The shape edge of automobile airbag normal and bump states are selected in the experiment process [3]. The original image of air bag is shown as in Fig 4.

The process of automobile airbag image pretreatment

Fig. 4. The airbag original image

process includes graying of color images and the noise removing [4]. The correlation function is used to turn the collection of the color images into the gray image. The digital matrix is obtained according to the gray image. The numbers in the matrix 0 is represented black. The 255 is represented white and in the middle of the numerical segments is represented the gray. The main purpose of the median filter is to eliminate the irrelevant information of automobile airbag image, and the useful true information is restored. The detestability of useful information is strengthened and maximize data is simplified. It is prepared for the subsequent further processing.

The 2D median filter is used in this paper for the effectual image de-noising method according to the automobile airbag image collection process, so the following definition can be for 2D median filter:

If $\{x_{ij},(i,j)\in I^2\}$ are shown digital image of the each point grey value, and A for filtering window, it is at the point of x_{ij} median for y_{ij}.

$$y_{ij}=MED\{x_{ij}\}=MED\{x_{(i+r),(j+s)},(r,s)\in A,i,j\in I^2\} \quad (1)$$

Formula (1) is shown the window A for x_{ij} median expression, and the window of 2D median filter can taken square, approximate circle or cross.

The 2D median filtering method used to eliminate the automobile airbag image noise is very effective. It has made a good foundation to achieve better automobile airbag image edge extraction detection.

C. Edge Extraction

The shape edge of airbag is extracted through Canny edge detection algorithm [5]. The image segmentation of airbag is finished in order to edge extraction to preparing for further image measure. And the Canny edge detection algorithm is the best measure method accord to the shape edge of automobile airbag.

The basic principle of Canny edge detection algorithm is that any direction of one order derivative of 2d Gaussian function is as noise filter [6], and through the image $f(x,y)$ convolution is filter. And then local gradient maximum value of image is used to determine the image edge according to the filter. Canny edge detection algorithm is used for the shape edge of airbag image in this paper; the following are the main steps in the automobile airbag image edge detection:

1) The image of airbag is smoothed through Gaussian filter.

Gaussian smoothing function is:

$$G(x)=\frac{1}{\sqrt{2\pi\sigma}}e\frac{-x^2}{2\sigma^2} \quad (2)$$

The σ is standard deviation of Gauss curve in the formula (2), it controls the smoothing degree.

2) The image of airbag of gradient amplitude and direction filter are calculated after the filter.

Canny edge detection algorithm is that amplitude and direction of Gradient of smoothed data matrix $I(x,y)$ are calculated through finite difference of one order partial derivative in the 2×2 field, among two arrays $P_x(i,j)$ and $P_y(i,j)$ of direction partial derivative of x and y respectively:

$$P_x[i,j]=(I[i,j+1]-I[i,j]+I[I+1,j+1]-I[i+1,j])/2 \quad (3)$$

$$P_y[i,j]=(I[i,j]-I[i+1,j]+I[I,j+1]-I[i+1,j+1])/2 \quad (4)$$

If the amplitude and direction of Gradient of pixel are calculated though rectangular to polar.

Gradient amplitude for:

$$M[i,j]=\sqrt{(P_X[i,j])^2+(P_y[i,j])^2} \quad (5)$$

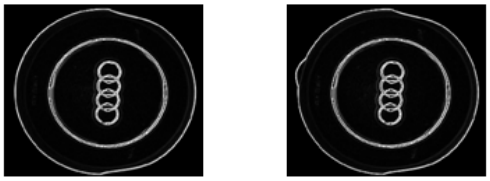
Gradient direction for:

$$\theta[i,j]=\arctan(P_y[i,j]/P_x[i,j]) \quad (6)$$

3) The Gradient amplitude is restrained through the maximum in order to find out the image gradient local maximum value point. And the other local maximum value is set to zeros to get the air refined image edge [7].

4) The image edge of airbag are detected and connected through double threshold algorithm.

Canny edge detection algorithm is used in airbag edge extraction. It is shown in Fig 5.

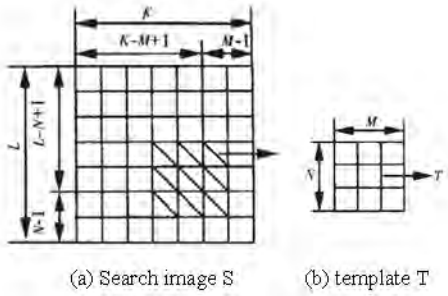


(a) normal (b) bump state

Fig. 5. Airbag Canny edge detection images

D. Image Matching And Analysis

The template matching method [8] is used for image matching of airbag. It is searching known template in one of the image, and then specific steps are researched through image template, it is shown in Fig 6, the T as image template in the picture (b), and image S is searched through image template T, sub-image $S_{i,j}$ is called by finding a similar part template. Among the top left corner of sub-image in the image S of coordinates are represented i, j .



(a) Search image S (b) template T

Fig. 6. Template matching schematic diagram

The values range of i, j such as (7) formula shows:

$$1 \le i \le K-M+1, \quad 1 \le j \le L-N+1 \quad (7)$$

The template matching can complete through the comparison the degree of similarity T and $S_{i,j}$.

T and $S_{i,j}$ similarity degree is calculated to use the following formula:

$$\begin{aligned} D(i,j) &= \sum_{m=1}^{M}\sum_{n=1}^{N}\left(S_{ij}(m,n)-T(m,n)\right)^2 \\ &= \sum_{m=1}^{M}\sum_{n=1}^{N}[S_{ij}(m,n)]^2 - 2\sum_{m=1}^{M}\sum_{n=1}^{N}S_{ij}(m,n)\times T(m,n) \\ &\quad + \sum_{m=1}^{M}\sum_{n=1}^{N}[T(m,n)]^2 \end{aligned} \quad (8)$$

The sub-image energy is represented the first part in the formula (8), it will also change with the change of (i, j) position. And the Cross-correlation function of sub-image and template image is represented in the second part of the formula (8), it will also change with the change of (i, j) . The template image and sub-image will be finished image matching when the maximum value appeared in this part. And the total energy of template image is represented the third part in the formula (8). It is a constant and has nothing to do with the (i, j) position. Then the template matching similarity degree is obtained through the second part normalized in the formula:

$$R(i,j)=\frac{\sum_{m=1}^{M}\sum_{n=1}^{N}S_{ij}(m,n)\times T(m,n)}{\sqrt{\sum_{m=1}^{M}\sum_{n=1}^{N}[S_{ij}(m,n)]^2}\sqrt{\sum_{m=1}^{M}\sum_{n=1}^{N}[T(m,n)]^2}} \quad (9)$$

If the template image and sub-image is completely consistent, the similarity is $R(i, j)=1$.

The image similarity degree is calculated according to the principle of template match, if template matching similarity degree more than 0.95, then it is qualified products. In the paper the normal image position of edge normal of airbag meet the error range and template matching similarity is 0.974. Thus, it is qualified product. While the bump shape of the part of the air edge beyond the upper limit value of detection area of reference image and template matching similarity for 0.832.So, it is unqualified product.

The reference image of edge shape of airbag is established according to standard machine size of the production of automobile airbag, it is shown in Fig7.

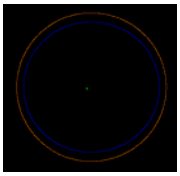
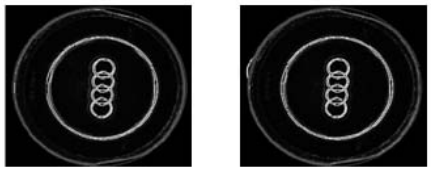


Fig. 7. Automobile airbag shape edge reference

Detection area (the Circular arc between great circle and Small round) of reference image is set to meet the airbag test tolerance ($\pm 5\%$) range. If the edge of image is in the area of Circular arc (between great circle and Small round), then the airbag is regard as qualified product. The shape edge information of airbag acquired through two images respectively is compared with the reference model template. It is shown in Fig 8. Therefore, the experimental results show that the based on image processing detection method is used for the shape edge measure of automobile airbag is effective feasible.

IV. CONCLUSIONS

In order to overcome the shortcoming of conventional



(a) normal (b) bump state

Fig. 8. Automobile airbag template match images

micrometer method of shape edge measure of automobile airbag, the image processing is used to carry out measure in this paper. Firstly, the automobile airbag image is collected by CCD camera, and then the color image is grayed. The median filter is used to eliminate the false light interference in order to achieve better automobile airbag image edge. Secondly, Canny edge detection algorithm is used to finish the shape edge extraction of automobile airbag image. Finally, the similarity degree is calculated through the principle of template match, and then the calculated result will express the information of products There are some advantages in this non-contact measurement method, the test process is simple, test data is comprehensive, and detection speed is high. The experimental analysis shows that the measure method based on image processing technology is a feasible and effective.

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