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RESEARCH ON CHIPS' DEFECT EXTRACTION BASED ON IMAGE-MATCHING

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Abstract- Image-matching is a basic task in image procession used to (geometrically) match two or more images such as different times, different sensors and different view points. Improved image-matching technology has been widely applied in medical image, remote sensing image, computer vision military and so on. What put forward at the present can be most divided into matching method based on gray and features. The article presents a scheme that is based on subtraction images matching with dynamic selection of templates, which overcomes these more sensitive disadvantages like gray, rotate, deformation and occlusion to achieve accurate calibration for different images.

Index terms: image matching; subtraction; dynamic selection of templates

I. INTRODUCTION

Image-matching is mainly used in two or more images' matching and fusion in different times, different perspectives, different sensors different angle of view and different photography condition, and it also will be a basic problem in image-processing [1].

Usually, the two or more images will be different by using the same or different sensors (imaging devices) for the same scene under the dissimilar condition (weather, photographs position and so on). The difference of a plurality of images in the same scene can be expressed: different resolution, different gradation attribute, different position (translation and revolving), different scale, different nonlinear transformation and so on. In order to analyze the different scenarios, it requires integrating data from those images, and the image-matching criterion is the critical step for the fusion data [2].

The image-matching has the practical significance such as remote sensing image-processing, computer vision, medical applications, target identification, environmental monitoring, weather forecasting and geographical information processing and so on.

In industrial production, a variety of detection, identification and other requirements will be encountered [3]. For instance, in PCB production line, the wiring connection needs to be detected. In the production of electronic components, the pin and circuit of chips must be checked. Then the image-matching technological advances in today's society helped cultivate the path for the development of chips' defect detection, thus, increasing the roles they play that vary from industrial applications to complex educational and entertaining projects [4].

II. THE BASIC THEORY OF CHIPS' IMAGE-MATCHING

a. The principle of chip image-matching

Image-matching is mainly used to solve the strict alignment of several images, chips image-matching refers to seek for a kind of correlation in space that make it consistent with the corresponding point in the other standard image [5].

Because of the different photography condition, one of the two images, which is photographed in different angle, different position from one chip can only reflect certain aspects of the characteristics.

To make analysis with two images, one chip will be moved and rotated to align with another. This alignment is the matching process. The motionless is named reference image while the other one is called as testing images. After the two images' subtraction, the defective portion of the chip is obtained.

b. Chips' image-matching algorithm

In this passage, it is used invariant moments to seek for the correlation in space relations of two images in matching, then making the maximum similarity (or minimum difference) between two images after correlation in space.

Generally, each point in the image A and B has a unique corresponding, and then obtained defect information by two images' subtraction of the test image, and then it is useful for the feature extraction and classification later.

c. The contents of chips' defect detection

The function of chips' defect detection mainly includes three facts:

(1) Through carrying on the real-time primary examination to chips, whether the image contains defects will be determined. If the defects don't exist on the image, following processing can be stopped and the next image will be judged in this system;

(2) The defects in chips' images can be located by rapid image-matching algorithm, and then using segmentation for these images. Because the proportion of images which contain defects is smaller in the chips products, and the main function of system is to analyze and statistics the defect information, only defects images are saved so as to save storage space and improve system efficiency.

(3) The defects region examination and the results of segmentation will provide important data basis for defect identification and classification. Therefore, the flaw examination precision will affect the accuracy of the classification, and then influence recognition performance of system [6]. At the same time, the real time defects detection is completed under the normal assembly line, the operation speed of algorithm has a crucial effect on the system.

III. THE REALIZATION OF CHIPS' DEFECT EXTRACTION ALGORITHM

While image-matching achieved in this chapter, the relative spatial locations of the two images will be used in similarity measuring, Optimizing location parameter, making errors minimal, and eliminate the errors in registration so as to achieve registration. It is shown in Figure 1.

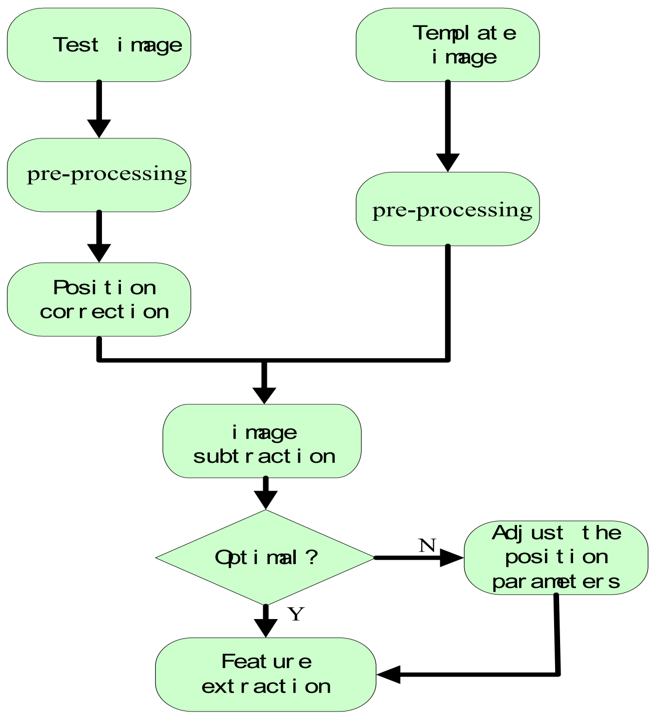

Figure 1. The flowchart of chips' image-matching

a. Image pre-processing

When the two-dimensional chips' images are captured by CMOS cameras, some noises are added to the image to cause the image distortion, and then the two-dimensional images of chips are unable fully to manifest the complete information as a result of the influence of tool or method in obtaining images. Therefore, it is extremely necessary for pre-processing before the implementation of the various types of image processing method. The image of quality can't be taken into account after pre-processing, but it only selects and highlights the interest features.

Pre-processing methods in this article are divided into the following four steps:

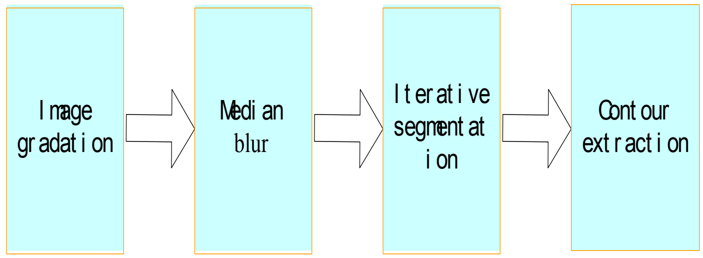

Figure 2. Pre-processing

a.i Image gradation

The original images have lots of unnecessary information after capturing, and carrying on these operations including image division, template matching, characteristic extraction for these original images often has large information to be processed. In this respect, gradation will be finished first. The main work contain: transfer original image to grey image, and then the bit of image will be turned to be 8. The result of gradation is as follows:

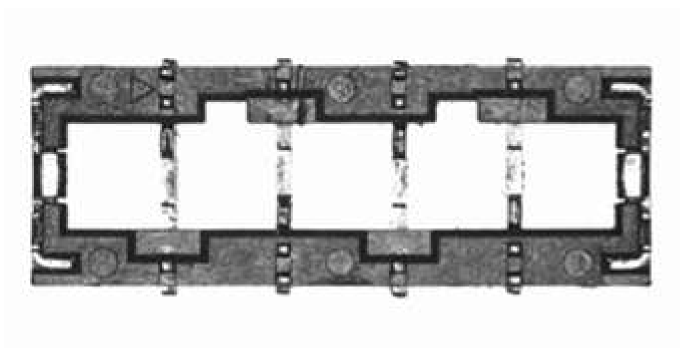

Figure 3. Image after gradation

a.ii Median blur

Median blur is a nonlinear signal processing technology in order to suppress the noise to be extremely effective in the image. Compared with the linear filter, it has two advantages: median blur can protect the image edges, but linear blur will bring image details fuzzy. Median filter is very effective in smoothing the sharp noise especially filtering pulse interference and image scanning noise [7].

The statistics of the image attribute is not required in the actual operation. The solitary points' form of noise can be inevitably produced in CMOS imaging procedures. These points correspond to the rarely pixels, and median filter is a powerful tool to remove these noise. The result of median blur is as shown:

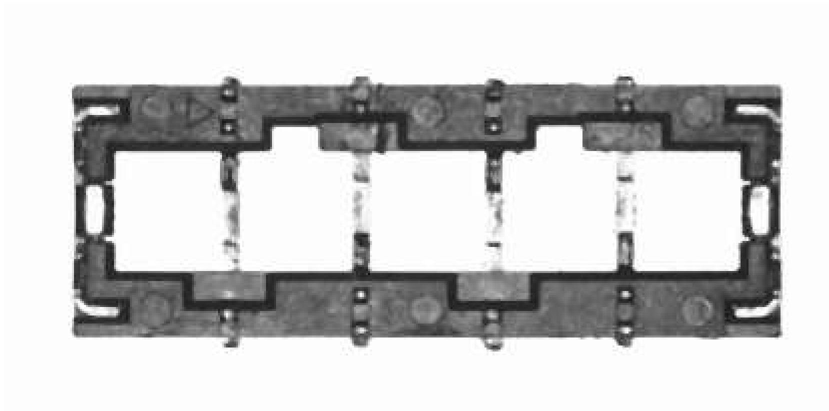

Figure 4. Image after median blur

a.iii Iterative segmentation

Image segmentation algorithm can be divided into two categories: image segmentation based on threshold and image segmentation based on edge. The gray value will be selected to distinguish whether it is target or not by using image segmentation based on threshold, which is equivalent to image binaryzation. Generally, threshold is calculated by histogram [8].

However, the image edge is applied to divide target into image by using image segmentation based on edge. The boundary in different image has generally an obvious edge which is used to segment image. In the context of this paper, image segmentation based on threshold is applicable.

The basic idea of iterative segmentation is: at first, an estimate threshold is set and a certain algorithm is used repeatedly to amend the estimated value in order to guarantee the revised results are superior to the previous. After a certain number of amendments, the results tend to converge, that is, the difference between the neighboring two results is small [9]. When the difference is small as an acceptable range, it indicates that an ideal threshold is found.

The result of iterative segmentation is as shown:

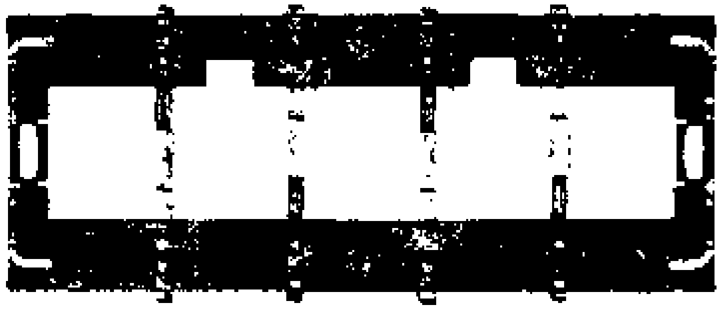

Figure 5. Image after iterative segmentation

Above all, the effects of pre-procession are as shown:

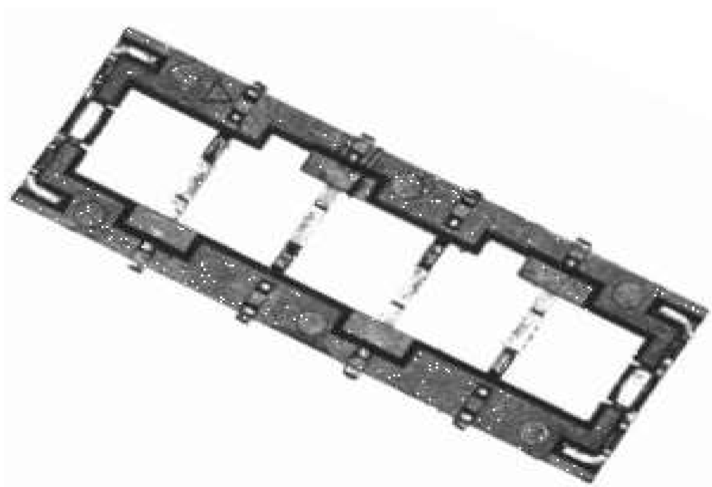

Figure 6. Template image

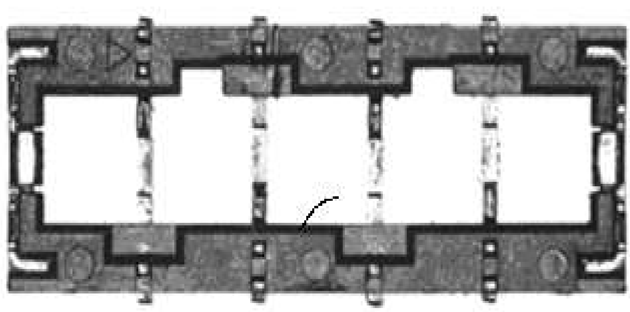

Figure 7. Test image

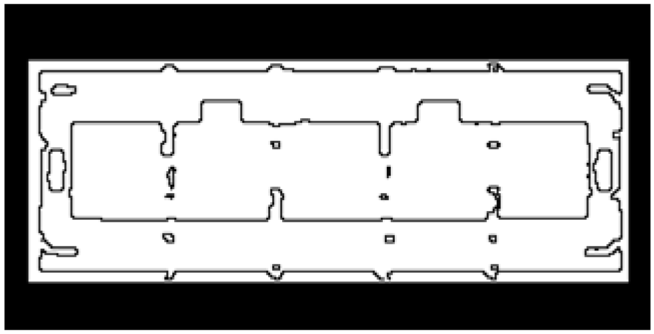

Figure 8. Temple image after pre-processing

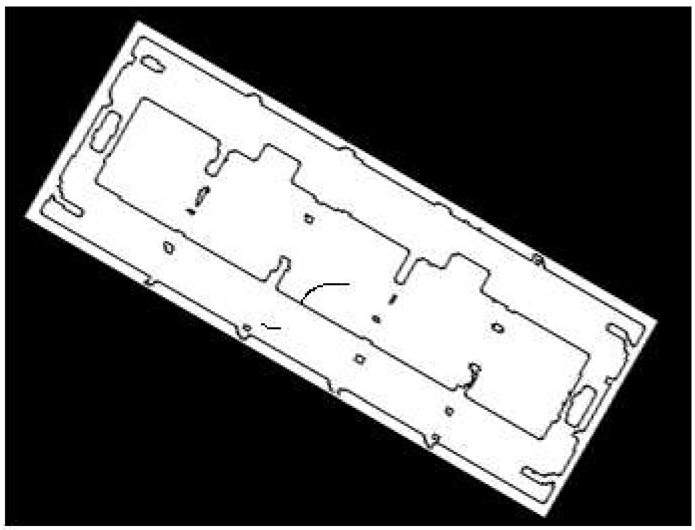

Figure 9. Test image after pre-processing

b. The adjustment of invariant moments

b.i Geometry moment of image

It needs to operate the pattern and the search space according to the image invariant in image-matching and image recognition. Consequently, Seeking for the invariant of image become a key and difficulty point in image-matching algorithm [10].Since the images' gradation has the displacement invariability, the pixel points are always selected as the invariant of image in the points' pattern matching. However, when changes in the scale or angle are large, the grayscale of the image is incompetent for invariants.

Other features of the image will be as the invariant of image in this case. Upon this, image of geometric moment invariants in this passage as the invariant features for image correction is adopted.

b.ii The physical meaning of images' geometric moments

1) Geometric moment of the part

According to $m_{pq} = \iint_{\xi} x^p y^q f(x,y)dxdy$ (p, q=0,1,2,3,4……),the zeroth order geometry moment means the sum of the values of the gray, that is a total brightness of image, also it can be regarded as the quality of objects. For binary images, m_{00} expresses sum of all grey levels which are one pixel, it can be seen as the area of objects as well.

2) First-order geometric moments and central moment

An image has two first-order geometric moments including m_{10} and m_{01}, which respectively are the image about x axis and y axis gradation moment, Its gradation is:

$$\bar{x} = \frac{m_{10}}{m_{00}} \qquad \bar{y} = \frac{m_{01}}{m_{00}} \qquad \text{(1a, b)}$$

The center of moment above has given the center of image region geometry. Generally, the geometry moment which can conveniently calculate the moves from the reference system zero point to gradation center of gradation moment is called the central moment. The formula of central moment is:

$$\mu_{pq} = \iint_{\xi} (x-\bar{x})^p (y-\bar{y})^q f(x,y)dxdy \quad \text{(p, q=0,1,2,3,4……)} \qquad (2)$$

The benefits of transforming geometric moments to the central moments are that the calculation of moment is independent of the image frame.

3) Second-order geometric moment and central moment

An image has three geometry moments: m_{20}、m_{02}、m_{11}.All these above are the images' brightness about measuring the point distribution changes in the image coordinate system. Second-order central moments including μ_{20} and μ_{02} which can determine some important properties of the image. In this article, the angle between the image spindle and the x axis is called azimuth of the spindle. Then the azimuth will be derived in mechanical perspective.

With the knowledge of mechanics, m_{20} and m_{02} is respectively inertia around the x and y axis. Assuming that a line passes through points (a, b) and has the angle named θ with the x-axis could satisfy:

$$(x-a)\sin\theta-(y-b)\cos\theta=0 \tag{3}$$

Then f (x, y) around the inertia of line is

$$\iint_{\xi}[(x-a)\sin\theta-(y-b)\cos\theta]^2 f(x,y)dxdy=0 \qquad (x,y)\in\xi \tag{4}$$

A line which causes its inertia to be smallest would be found. The derivation of the formula (4) on a or b, and make it equal to zero, then the next formula will be obtained:

$$\iint_{\xi}[(x-a)\sin\theta-(y-b)\cos\theta]\ f(x,y)dxdy=0 \tag{5}$$

According to geometric moments, the above formula can be written as

$$m_{10}\sin\theta-am_{00}\sin\theta-m_{01}\cos\theta+bm_{00}\cos\theta=0 \tag{6}$$

Simplify the above equation:

$$(\bar{x}-a)\sin\theta-(\bar{y}-b)\cos\theta=0 \tag{7}$$

As can be seen, minimum value is

$$a=\bar{x},\ b=\bar{\ } \tag{8a, b}$$

Accordingly, the inertia of the smallest inertia line is:

$$\iint_{\xi}[(x-\bar{x})\sin\theta-(y-b)\cos\theta]^2 f(x,y)dxdy \tag{9}$$

Thus it can be seen that the minimum inertia line passes through the center $(\bar{x},\bar{y})$ and also has an angle with the x-axis:

$$\theta=\frac{1}{2}\tan^{-1}\left(\frac{2\mu_{11}}{\mu_{20}-\mu_{02}}\right) \tag{10}$$

4) The invariant moment of image

From above formula, the differences characteristics between two images' shape are attributed by different bands of geometric moments and center moments. The so-called invariant moments' characteristics are mainly to maintain the invariable characteristics after translation, revolving and the transformation of scale.

In this article, the center coordinates $\bar{x}$ and $\bar{y}$ of moment and relative coordinates Δx and Δy will be figured out, as a result, the spindle angle could be calculated by invariant moment. So the parameters of relative position which can be used for revolving and transferring between two images are obtained for adjustment. The results of invariant moment are as follows：

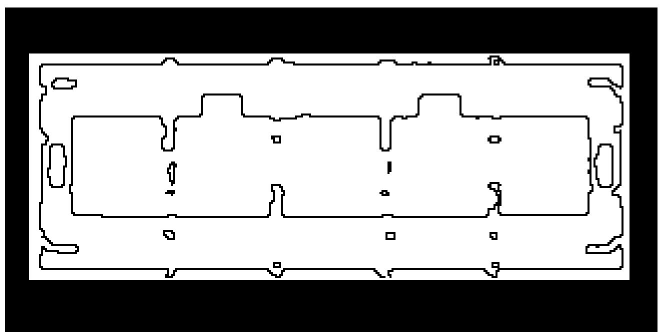

Figure 10. Template image after adjustment

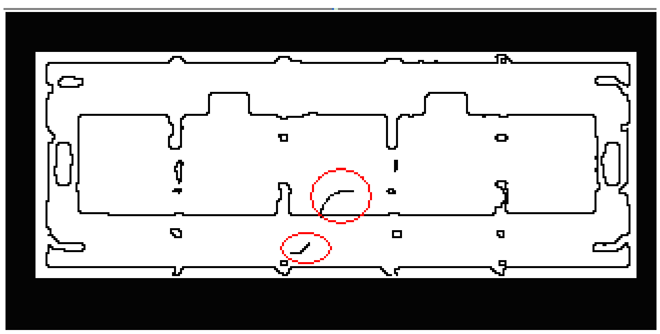

Figure 11. Test image after adjustment

c. Subtraction method

c.i The principle of the subtraction method

Image subtraction is an algebraic operation. It is usually applied in these images which don't have the big distortions [11]. The template image and test image are captured on the same chip production line, so the distortions in two images are not big. The manufacture flaw is the main difference between two images. The high speed examination can be achieved by subtraction method because of its simple and high efficiency. $f(x,y)$ and $g(x,y)$ respectively represents the template and test image, meanwhile, $s(x,y)$ is the result of subtraction:

$$s(x,y) = f(x,y) - g(x,y) \tag{11}$$

c.ii Realization of subtraction

In the process of subtraction, dynamic datum image is selected: the subtraction between test image and template image. A template image in front will be selected as the datum image for subtraction, so the speed is slow. Upon this, the differences between two images can be minimized. Moreover, with its good reliability and accuracy, accumulated errors which are caused by poor performance will be avoided [12].

In the process of subtraction, negative gray value named negative subtraction will appear. Of course, the negative subtraction needs to be negated. Similarly, positive gray value named positive subtraction will appear. The positive and negative subtraction may appear at the same time. Therefore, the combination of positive and negative subtraction is used to reduce the registration error. The result of subtraction is as shown:

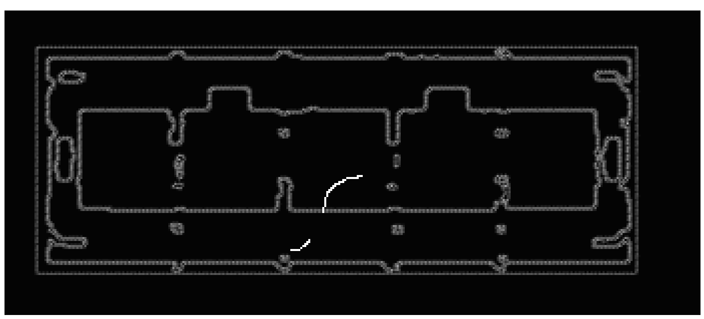

Figure 12. Test image after subtraction

From Figure 3-9, the defect parts have already appeared. However, the problem is that the unnecessary parts are not completely removed, and then the error must be eliminated. The experience shows that the gray level difference exists in defective parts and the residual parts. Upon this, the threshold is set to split them. Generally, the grayscale value of residual parts is 180~220, the grayscale value of defective parts is 230~250, therefore, suitable threshold is selected as 225.

Result after splitting is as follows:

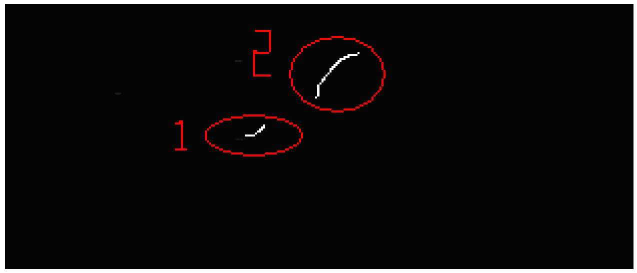

Figure 13. Test image after splitting

IV. ANALYSIS OF THE RESULTS

All in all, the two scratch defects have been found out. In this article, the simple several geometry parameters including area, length and pixels will be calculated for the purposes of classification. Upon this, these geometry parameters could be figured out. The result of marked 1 is: area A1=1.000000, length L1=18.142136, pixels M1=7,and the other is: area A2=6.000000, length L2=35.342346，pixels M2=21. The unit of area and length is pixel.

In a word, five defects including glitch, broken filament, floccosoids, scratch, neglected loading could be found out. Other defects in this article may not be proposed, but in my experiment, these geometry parameters must be figured out in the following table.

Table 1: The parameters of defects

Kinds of defects	Glitch	Broken filament	Floccosoids	Scratch	Neglected loading
Area	1.000000	6.000000	15.000000	4.000000	76.000000
Length	18.142136	35.342346	57.689435	24.564331	276.985420
Pixels	7	21	47	16	105

These characteristics are measured based on the principles of image pixel. Some initial work is finished for classification. Moreover, what the most important is that how the kinds of defects are to be classified.

The results of experiment show that the method is not only simple and efficient, but also more accurate, and it has widely prospects in defects detection.

V. CONCLUSIONS

This project is from an enterprise, unlike artificial vision; a relatively new method named automatic detection is put forward to solve the actual problems in chips' defect examination. These works have been mainly completed in the article:

(1) Pre-procession for images. First of all, gradation processing is used, and then the image will be smoothed after gradation, and so iterative threshold will be carried on. At last, detection is appeared for the next process by contour extraction.

(2) Invariant moment correction for images. The offset angle and location of the image will be calculated to correct by using invariant moments, and it is one of the highlights in this article.

(3) Image-matching. Registration must be carried on when image correction is completed. In this article, subtraction is put forward to reflect on template selection and combination of positive and negative differences. Dynamic template is selected to eliminate outside interferences. After matching, the error is continued to eliminate. The experience shows the defect information is obtained to prepare for the classification by using threshold [13].

Weaknesses and shortcomings of the algorithm in this article:

(1) Because of all kinds of defects on chip, the partial flaw extraction is finished in this article. Other types of defects will be added to examine so as to achieve the integrity of the system and the needs of actual production.

(2) At present, the experimental condition is idealization. Registration algorithm is not used to the actual production in the system. The off-line research is also lack of the depth. In addition, the timeliness of algorithm also needs to be improved.

In conclusion, the defects can be identified by the algorithms. However, any computer method can't determine exactly as the eyes. Therefore, the strict template image must be adopted to ensure qualified products after detection. There are qualified products in scraps, the 10% qualified products can be chosen by artificial [14].

Furthermore, in the algorithm, instead of using the form of general detection methods, simulations and experiments have verified the system to be efficient [15-17].

ACKNOWLEDGMENTS

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