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Visual Inspection System for the Defect of Collet

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Abstract. Manual, semi-automatic or full automatic assembly processes always require a specific tooling set. Pick up and placement tools (collet) should have acceptable precision and reliability. So, defect detection of pick up tools plays an important role in semiconductor assembly process. In this study, we propose a defect detection algorithm and a user friendly motion and vision application, implemented in visual C++ environment for motion control and vision of collet inspection machine.

Keywords: Collet, Visual inspection, Auto focus, Defect inspection

1 Introduction

Machine Vision inspection plays an important role in achieving the quality control in manufacturing, reducing costs and ensuring a high level of customer satisfaction. In order of quality control for semiconductor manufacturing, tiny and precise tools such as pick up tools are used for pick and place for assembly process. These tools are produced from various materials, such as: plastics, ceramics and metal based, depending on the requirements. Most important quality of the collet such as shape and size and hole are very important to achieve high reliability to pick and place of sawed wafer in semiconductor packaging process. And, we propose the defect detection system based on machine vision and its image processing algorithm[1].

2 Visual Inspection system

Proposed automatic visual inspection system consists of 3 axis. X and Y axis are driving by servo motors with the resolution of 10um. Camera is mounted on Z axis which is driving by stepper motor with 1 um resolution. Two 2M cameras are used to acquire the image of collet. Depending on the size of collet, 4X and 10X magnification lens to be chosen to capture tiny collet image Fig.1 shows our inspection system.

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2.1 Auto focus

Focus is one of the important factors to get clear images stably and continuously. In order to focus automatically, we define the quality of focus to be measured in a pre-defined image area, the operator must produce maximum response when image area is perfectly focused. One way is to determine its second derivative. For two-dimensional images, the Laplacian is very often used [2]: Finally, the focus measure at a point (i, j) is computed as the average of the Laplacian, in a the predefined window around (i, j),that are greater than a threshold value:

$$F(i,j) = \sum_{x=i-N}^{i+N} \sum_{y=i-N}^{j+N} L(x,y) \text{ for } L(x,y) \geq T_i \tag{1}$$

Where, the parameter N determines the window size is used to compute the focus measure value. In contest to focus automatically and with high seed, we typically use a small window of size 3x3 or 5x5. The best focus image has maximum focus measure value among other 60 unfocused images.

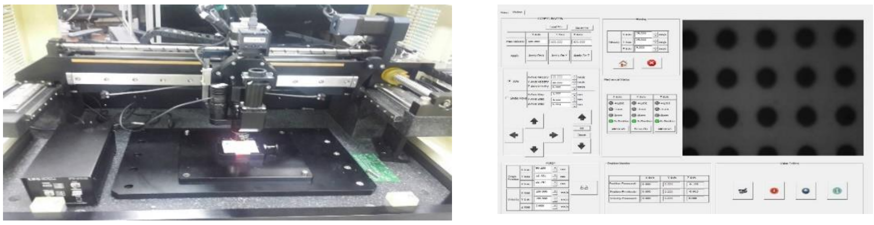


Fig. 1. Inspection system for Collet Defect

2.2 Calibration

Distortion is caused by either a characteristic of the lens or the position of the camera in relation to the subject. And it make an error on an image. Geometric correction is undertaken to avoid geometric distortion from a distorted image, and is achieved by establishing the relationship between the image coordinate system and geometric coordinate system using calibration data of the sensor [3]. A dotted calibration target is used. This calibration dot space is 0.125 mm and the relation between image coordinate (u, v) and world coordinate (x y), is expressed as equation (2).

$$x = a_1u^3 + b_1u^2v + c_1uv^2 + d_1v^3 + e_1u^2 + f_1v^2 + g_1uv + h_1u + i_1v + j_1 \tag{2}$$

$$y = a_2u^3 + b_2u^2v + c_2uv^2 + d_2v^3 + e_2u^2 + f_2v^2 + g_2uv + h_2u + i_2v + j_2$$

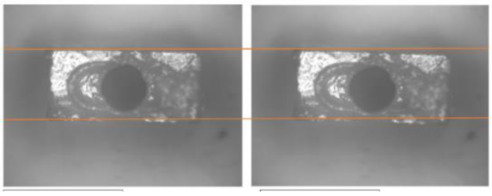
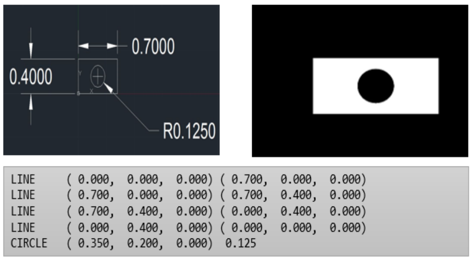


Fig. 2. Image correction result

2.3 Reference image from CAD data

The reference image is generated by CAD file (dxf format) and converted to image coordinates to detect the difference of image and CAD. The Fig 3. shows extracted reference image.



```
LINE    ( 0.000,  0.000,  0.000) ( 0.700,  0.000,  0.000)
LINE    ( 0.700,  0.000,  0.000) ( 0.700,  0.400,  0.000)
LINE    ( 0.700,  0.400,  0.000) ( 0.000,  0.400,  0.000)
LINE    ( 0.000,  0.400,  0.000) ( 0.000,  0.000,  0.000)
CIRCLE  ( 0.350,  0.200,  0.000)  0.125
```

Fig. 3. Reference image from CAD data

2.4 Detect detection algorithm

The defect of collect can be easily detected by the difference between reference images by CAD data and captured image. Proposed algorithm for defect detection is shown in Fig 4. Captured image is aligned after the calculation of rotation angle, and then compared the reference image.

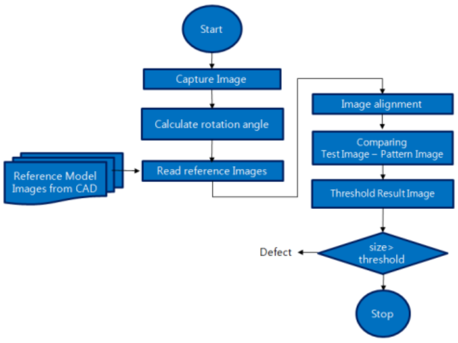


Fig. 4. Algorithm for defect detection and Matching result

3 Experimental Result

Finally, defect is detected by subtraction of calibrated image and reference image. The result of our proposed algorithm is shown in Fig. 5. The size difference of rectangle and hole are detected by comparing CAD data.

4 Conclusion

In this study, we developed an automatic visual inspection system to detect the defect of collect size and apply defect detection to the different semiconductor pick up tools. The vision resolution in x direction is 0.280 um and in y direction is 0.285 um and we can achieve 0.5 um accuracy. We will upgrade the speed of inspection till 2sec/ea.

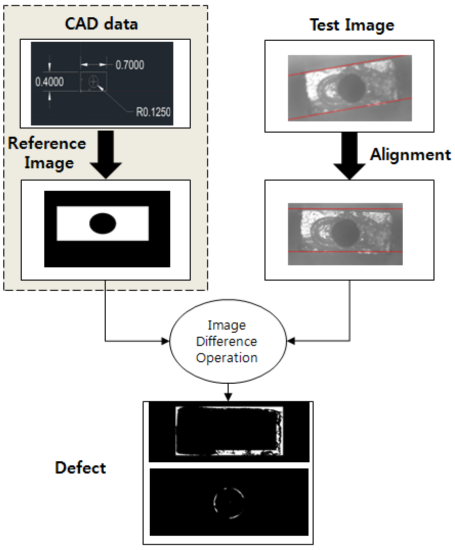


Fig. 5. Result of detection

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