Implementation of Computer Vision Algorithms for Position Correction of Chip-Mounter Machine

Fernandez Elian[1], Farkhad Ihsan Hariadi[2], Muhammad Iqbal Arsyad[3]
School of Electrical Engineering and Informatics, Institut Teknologi Bandung
Microelectronic Center, Institut Teknologi Bandung
Jl. Ganesha 10, Bandung-40132, Indonesia
[1]elian.wijaya@yahoo.com, [2]hariadi@ic-proc.paume.itb.ac.id, [3]m.iqbal.arsyad@stei.itb.ac.id

***Abstract*— Chip mounter is a machine in SMT Line that has the task of picking and placing SMD components onto a PCB that has been coated with solder paste. To be able to place SMD components accurately and rapidly onto PCB, it is necessary to have a desciption on the location the chip to be placed on the PCB, the current position of the chip, and the current position of the chip footprint on the board. This paper describes the steps that have been designed and implemented to meet the 3 requirements mentioned by using a digital microscope camera as a downward vision and the use of image processing algorithms as the computer vision feature of the chip-mounter. In the image processing algorithms used here, color thresholding in HSV color model for object selection is incorporated. In order to sharpen the result of object selection, morphological opening and closing are invoked. Canny operator is used to get the edge of the object. Upon contouring the object, the centroid location of the selected object can subsequently be calculated. As shown during the test, the computer vision method implemented in this work is capable of producing data required by the chip-mounter to do position correction if there is non-uniformity errors of the pattern on the PCB panel.**

Keywords*— *Chip Mounter, SMT Line, SMD, PCB, Downward Vision, Computer Vision, Image Processing, Thresholding, HSV Color Model, Morphological Opening, Morphological Closing, Canny Edge Detection, Centroid.

I. Introduction

Currently, Indonesia already has enough local companies that produce electronic equipment. As the times progressed, the size of the circuit and the electronic components used were also getting smaller. The situation is accompanied by the increasing demand for electronic equipment production due to the needs of the population is increasing. In order to respond to these challenges, many local companies are turning to use SMD component assembly machines.

SMT is a method used to produce electronic circuits by placing components on the PCB surface. SMT machines are widely used by electronics companies because the use of this machine has a level of automation and better accuracy compared to manual installation of components. The SMT component assembly process takes place on machines that are divided into different parts with different tasks. The working order of this machine is known as SMT Line. The ideal SMT Line array consists of Loader, Screen Printer, SPI (Solder Paste Inspection), Chip Mounter, Multi Mounter, MAOI (Multi Auto Optical Inspection), Reflow Oven, SAOI (Soldering Auto Optical Inspection) and Unloader.

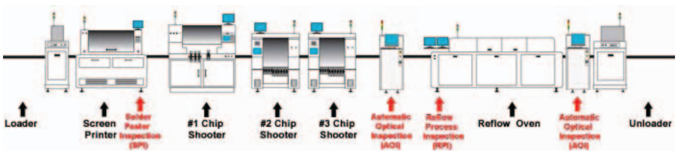

Figure 1 SMT Line

But there are other obstacles for local electronics companies in terms of the economy, that is, there are still few local companies capable of producing SMD component assembly machines so that local manufacturing companies buy the machines by importing from abroad. As a result, production costs are becoming higher, and local electronics manufacturing companies are becoming more difficult to grow and less competitive with international manufacturing companies in Indonesia.

Thus, the solution offered to overcome the problem is to develop a SMT machines. However, there are time and cost constraints faced by the developer. Therefore, the SMT machine that will be developed on this project is only limited to chip mounter machine. The developed chip mounter machine will have an easy-to-use GUI and a high degree of accuracy for the pick and place process of SMD components.

II. Software Design and Implementation

A. GUI Design

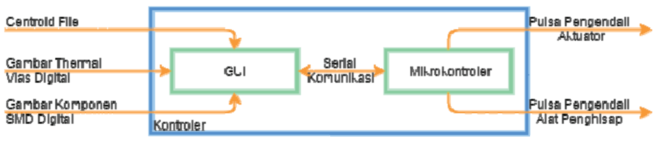

Figure 2 GUI Flowchart

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GUI (Graphical User Interface) is an interface between user and CNC machine hardware. Its function is to give commands to be run by the machine. The user's command was designed in the form of buttons that will send data to the microcontroller in the form of characters or strings via serial communication port. Here is the first version of GUI design.

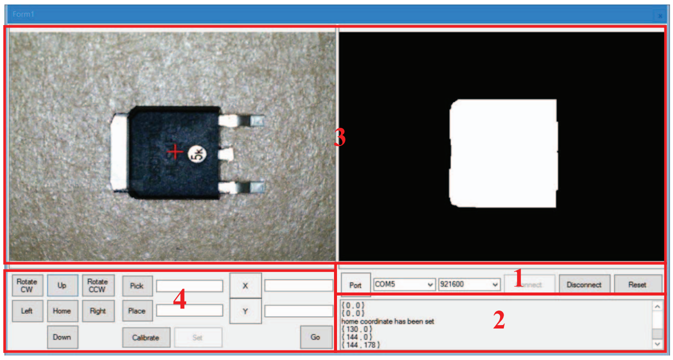


Figure 3 GUI Design

According to its function, the GUI design above can be divided into 5 sections as follows:

1) Communication Section. There are COM port box, baud rate box, and connect or disconnect button.
2) Machine Activity log Section. Displays the activity of the machine sent by the microcontroller.
3) Downward Vision Section. Displays the captured images and the results of component detection algorithms by computer vision.
4) Machine Control Section. There are buttons to navigate the arm of the machine, pick and place components, and calibrate the origin point of the machine arm.

B. Computer Vision Algorithm

The computer vision algorithm was performed in real-time on the downward vision of the GUI. The centroid of the component was searched by using image processing with OpenCV library within EmguCV wrapper.

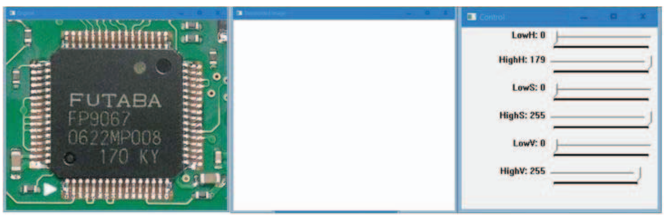


Figure 4 Before Color Detection

The first step is to get a rough selection of the desired object. This is done by color selection. Original images in RGB color model (Red, Green, Blue) were converted to the HSV color model (Hue, Saturation, Value). It then displays the original image, the color thresholding result in the HSV model, and the HSV control variable.

Color selection was done by changing the value of the HSV variable until the thresholded image shows the desired object. After color selection is done, morphological opening and closing is done to get the desired object intact. Next is the edge detection process to get the contour of the desired object. Canny operator is used to detect the edge of the desired object. Afterward, the contour is drawn from the edge detected and then a bounding rectangle is drawn from the contour. Bounding rectangle is used to detect the centroid of the selected object.

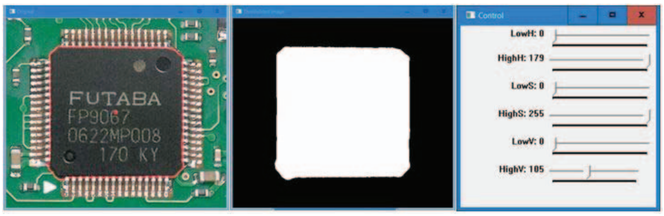


Figure 5 After Color Detection

C. Integrating Computer Vision to GUI

The previously designed computer vision algorithm is then integrated into the GUI and tested for moving images (using the camera). However, in the actual picture there is a problem when detecting small components type such as SOIC8 because of the distance between adjacent components on trays so that the downward vision will detect more than one component. Therefore, the image to be processed will be masked first at the top and bottom without changing the position of the original image. The size of the masking image will be adjusted to the size of the largest component to be processed, i.e. TQFP44. The purpose of masking the image is to narrow the viewpoint of the downward vision so that in one frame only 1 component is captured and to reduce the contour size of the components around. Next, the centroid is determined by selecting the largest contour size and then a bounding rectangle is drawn to determine the centroid of the component.

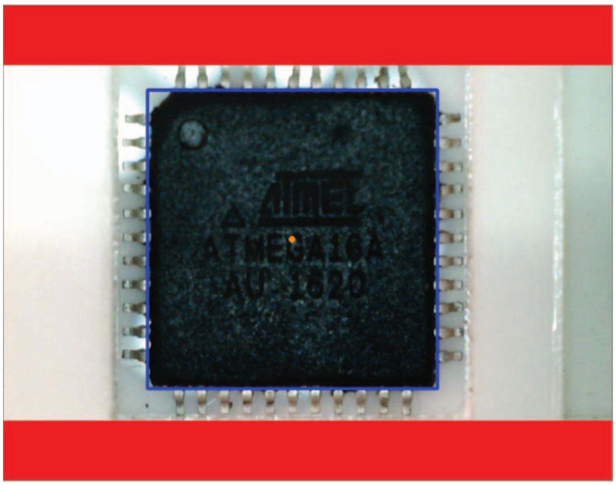


Figure 6 Component Centroid Test Result

In addition, downward vision is also used to detect thermal pad on PCB panels. The thermal pad image processing algorithm is similar to the component image processing algorithm, the difference between the two is only in the size of the masking and the threshold value to distinguish the thermal pad from the surrounding object.

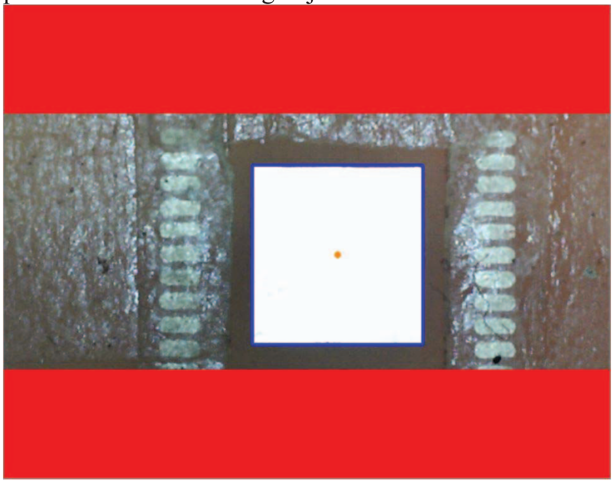


Figure 7 Thermal Pad Centroid Test Result

III. Testing and Analysis

A. Downward Vision Test Result

Here is a picture of the downward vision test results.

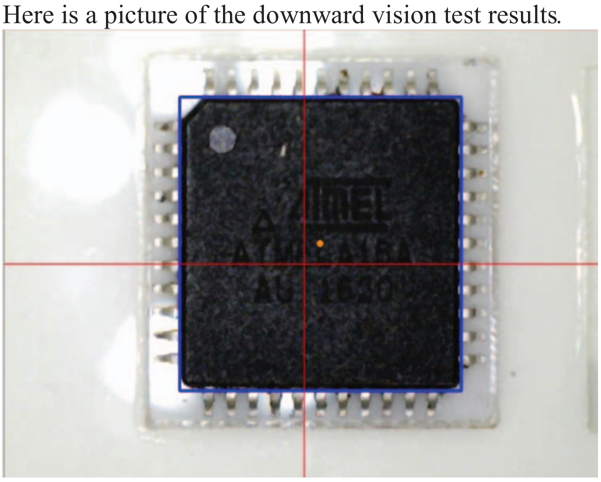


Figure 8 Downward Vision TQFP-44 Test Result

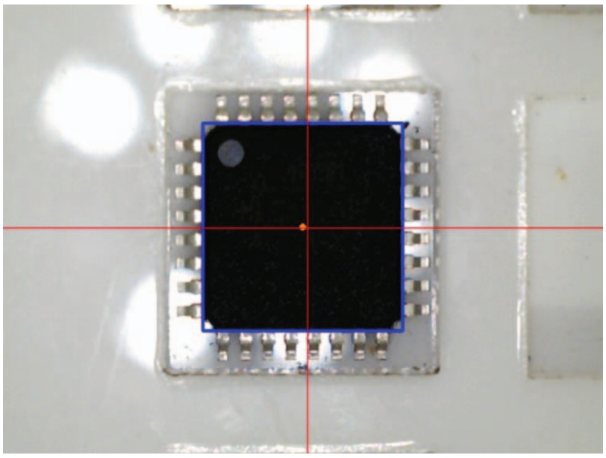


Figure 9 Downward Vision TQFP-32 Test Result

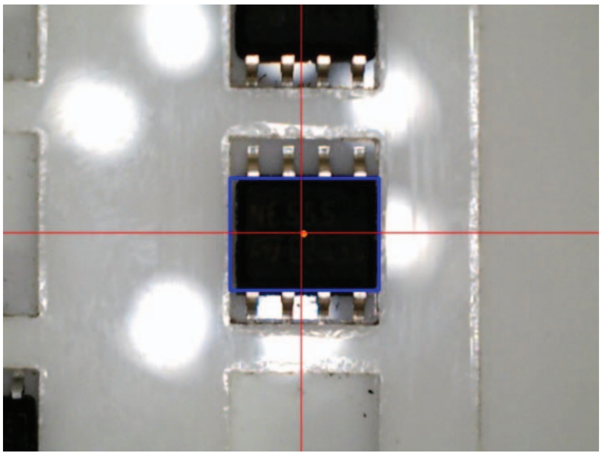


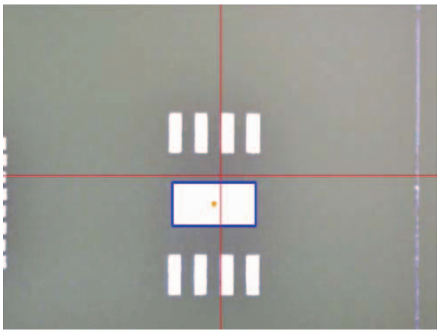
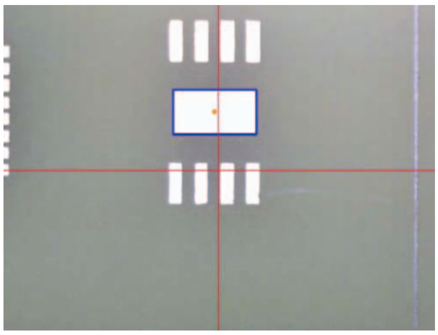
Figure 10 Downward Vision SOIC-8 Test Result

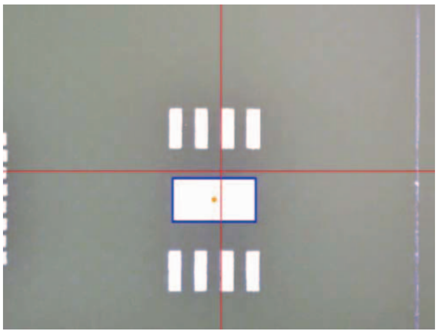
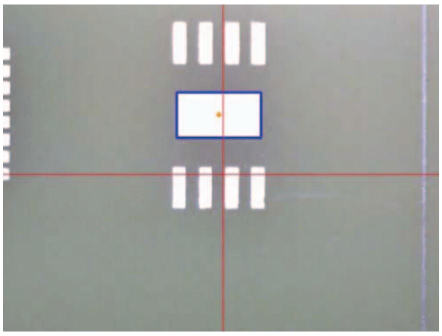
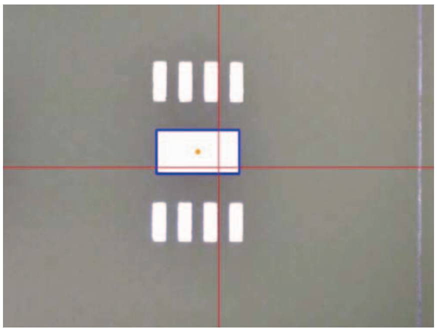
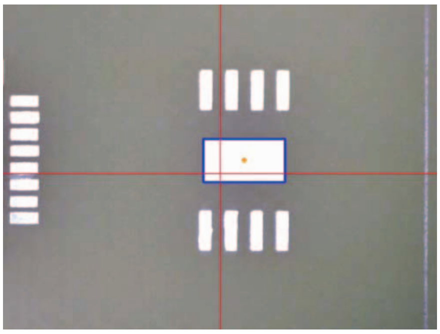
Based on the test results of the three images above, it can be concluded that downward vision is able to detect the centroid of each component type; TQFP-44, TQFP-32, and SOIC-8. The centroid of the component is obtained from the square that surrounds the outer portion of the component. The downward vision has not been able to detect the angle of the component. However, this is not a problem, given the specifications do not include the accuracy in rotational placement.

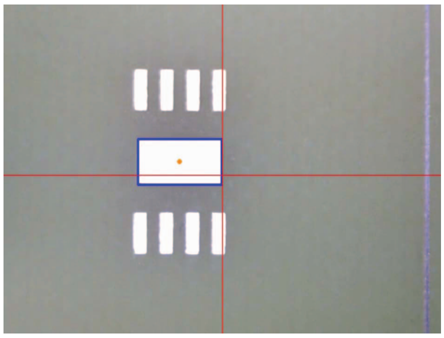
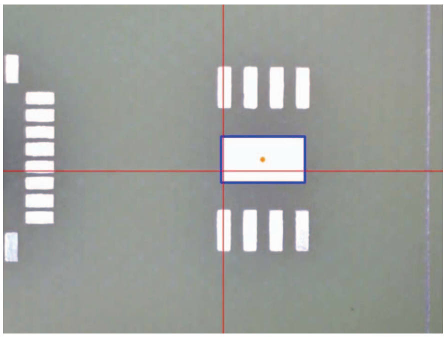
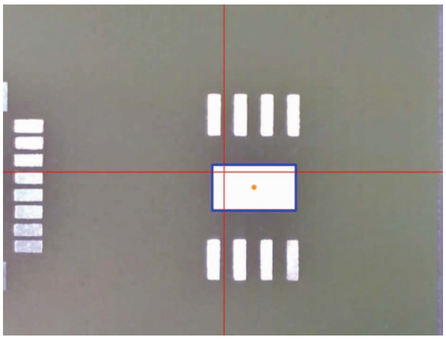
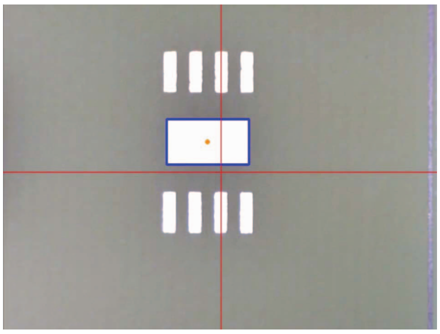
B. PCB Panel Error Tolerance Result

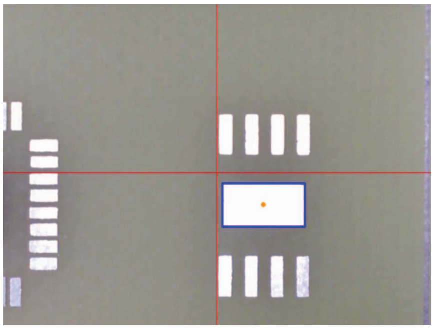
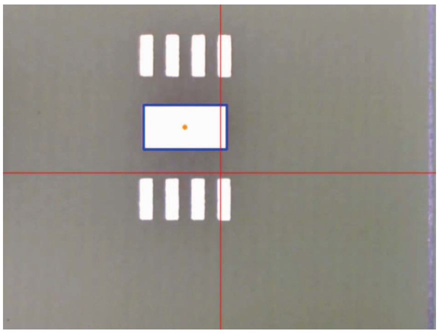
The following table shows the results of the PCB panel error tolerance test.

Table 1 PCB Panel error tolerance

Error Test	*Downward Vision*
1mm offwards Y axis	
1mm towards Y axis	

2mm offwards Y axis	
2mm towards Y axis	
1mm offwards X axis	
1mm towards X axis	

2mm offwards X axis	
2mm towards X axis	
1mm towards X axis and offwards Y axis	
1mm offwards X axis and towards Y axis	

2mm towards X axis and offwards Y axis	
2mm offwards X axis and towards Y axis	

Based on the above test result table, it can be concluded that downward vision is able to detect thermal pad on PCB with error tolerance up to 2mm. Since the tests with SOIC 8 were successful, it can be concluded that downward vision is able to detect PCB panel errors on TQFP-44 and TQFP-32 component type that have larger thermal pad sizes than SOIC-8. Thus, thermal pad detection becomes essential to improve the accuracy of component placement in the automation process.

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IV. CONCLUSION

Computer vision can be used to improve the accuracy of the pick and place process of the chip mounter machine. The algorithm used for computer vision is taken from the basic of image processing. Selection of objects in an image can be done through the color selection of the image. Basic morphological processes such as opening and closing in image processing can be used to sharpen the results of object selection.

From the whole process of computer vision algorithm implementation, it can be concluded that the downward vision of the chip mounter machine has answered the need of high accuracy of pick and place process.

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