Advanced Science and Technology Letters
Vol.98 (CES-CUBE 2015), pp.14-17
http://dx.doi.org/10.14257/astl.2015.98.04

# Path Optimization with Minimal Time at Surface Mount

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**Abstract.** In general, the components stop in front of a vision camera for inspection before moving to their respective placement position. This study presents a method of identifying the fastest path for the gantry when inspecting components without stopping before a camera. The gantry moving trajectory took into account the speed and distance of passing by the vision camera. Through simulations, we found that the Fly1-Motion method improved productivity by 15%, and the Fly2-Motion method by 22%.

**Keywords:** SMT, Surface Mount Device, Optimal Path Search

## 1 Introduction

SMT is a method of placing surface mount devices via reflow soldering, a process in which a solder paste is used to attach electronic components onto PCBs [1][2].

This study proposes a method of identifying the fastest path for picked up components to pass by a camera without stopping before being placed onto PCBs.

This study, which is focused on "moving technology for passing by the camera", presents a method of moving picked up components to PCBs in the shortest possible time without stopping before a camera for visual inspection.

## 2 Related Work

Taking into account the distance traveled in the X and Y axes, there are a total of 16 paths when the pickup and placement sections are each divided into four. Among the 16 possible paths, this study examines and addresses existing problems for the commonly used path shown in Fig. 1.

ISSN: 2287-1233 ASTL

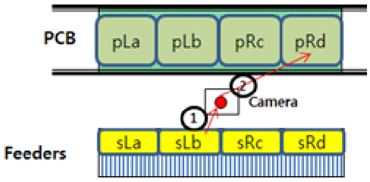


**Fig. 1.** Moving path

The conditions for maximum gantry speed, gantry acceleration, pickup position, camera position and placement position are outlined in Table 1.

**Table 1.** Input conditions

| Item | X axis | Y axis | Unit |
|---|---|---|---|
| Max Velocity | 2.0 | 2.0 | m/sec |
| G Acceleration | 2.0 | 2.0 | g |
| G [M/Sec^2] | 9.81 | 9.81 | m/sec^2 |
| Acceleration | 19.6 | 19.6 | m/sec^2 |
| Pickup Position | -2.0 | -150 | mm |
| Camera Position | 0 | 0 | mm |
| Place Position | 300 | 250 | mm |

### 2.1 Components stopped before camera for inspection (Stop-Motion)

Under this method, electronic components are stopped before the camera for inspection before moving to PCBs for placement[3][4]. The speed at the camera position is 0m/sec in both the X and Y axes.

This method involves deceleration before stopping in front of the camera, followed by acceleration after stopping. The total simulation time was 427m/sec because of the long time consumed in acceleration and deceleration.

### 2.2 Components passed by camera considering distance in X and Y axes (Fly1-Motion)

Under this method, electronic components are passed by the camera without stopping by taking into account the distance in the X and Y axes.

This method does not require deceleration in the longer Y axis, along which a speed of 2m/sec is maintained. The total simulation time was 363m/sec, an improvement over the Stop-Motion method by 64m/sec. However, this method does not reduce time significantly due to the slower speed in the X axis.

This study presents a method of rapidly passing by the camera position even for the shorter X axis, and verifies through a simulation that productivity is enhanced[5].

## 3 Fly2-Motion Method

This study proposes a method of optimizing speed in the X axis when picked up components are passed by the camera for inspection, thus shortening the overall moving time of the gantry. The faster the speed at which components pass by the camera, the shorter the time required to reach the PCBs.

Because the distance to be traveled in the X axis is 20mm under the Fly1-Motion method, the speed becomes 0.318m/sec. A greater distance is acquired by moving in the direction opposite to the X axis before accelerating, thus reaching a higher speed at the camera position.

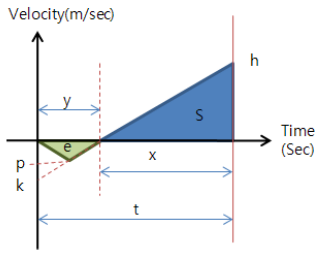


**Fig. 2.** h Velocity Graph

Input conditions in Fig. 2:
d: distance moved, t: moving time, j: acceleration
s: distance moved during x (+direction), e: distance moved during y (-direction)
h: maximum speed

$$t = x + y,\ j = h / x,\ d = s - e,\ s = xh / 2 \tag{1}$$
$$p = k / 2 = hy / 2x \qquad (k = hy / x) \tag{2}$$
$$e = py / 2 = hy^2 / 4x = h(t - x)^2 = (ht^2 - 2htx + hx^2) / 4x \tag{3}$$
$$\therefore\ d = xh / 2 - hy^2 / 4x \qquad (h = j\,x) \tag{4}$$
$$jx^2 + 2jtx - jt^2 - 4d = 0 \tag{5}$$
$$x = (-jt \pm \sqrt{(2j^2t^2 + 4jd)}) / j(\ 0 < x \le t) \tag{6}$$
$$\therefore\ h = -jt \pm \sqrt{(2j^2t^2 + 4jd)} \tag{7}$$

When the components are moved as shown in Fig. 2 under the conditions of Table 1, a speed of 1.241m/sec in the X axis (h) can be achieved at the camera position by moving a distance of e (-20mm) in the opposite direction for a time of y (62m/sec), and a distance of s (+40mm) for a time of x (64m/sec).

# 4 Comparison of Three Methods

Table 2 compares the moving time of the three methods: Stop-Motion, Fly1-Motion, and the proposed Fly2-Motion.

**Table 2.** Result of Fly2-Motion

| Mode | Total time (m/s) | Difference (m/s) | % | V. of Camera Pos. X | Y |
|---|---|---|---|---|---|
| Stop-M. | 427 | | | 0.0 | 0.0 |
| Fly1-M. | 363 | 64 | 15% | 0.3 | 2.0 |
| Fly2-M. | 334 | 93 | 22% | 1.2 | 2.0 |

# 5 Conclusion and Future Work

This study tested three methods of passing by a vision camera for a gantry style SMT machine. The Fly1-Motion method involved less time compared to the Stop-Motion method, which requires components to stop in front of the camera. Through simulations, we found that the Fly1-Motion method improved productivity by 15%, and the Fly2-Motion method by 22%.

As future work, the proposed method can be applied to surface mount devices to improve CPH. Vibration and heating of the motor are problems that must be addressed.

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