# Progress Report of WP2

Automation Technology Center

Hong Kong University of Science and Technology

## Review

Products of computer, communication and consumer electronics are called 3C products. Nowadays, with higher requirements of the manufacturing process, rapidly rising labor cost and shaper and shaper shortage of labor supplies, there is an urgent need and huge potential market to adapt robotized automation solution for 3C assembly.

The ultimate goal of this project is to comprehensively classify and evaluate robot configuration for a given type or class of assembly operations, and to develop an efficient algorithm for robot configuration selection. Simulation or experiment shall be conducted for verification of effectiveness as well.

In WP1, our group conducted a few surveys by site visiting factories including: Rapoo, DJI, Flextronics, Yaskawa to learn about typical 3C assembly operations. After these surveys, we conclude and establish a mathematical model for these typical operations on  and . According to the discussion with ABB and suggestion from ABB, in WP2, we will firstly make a little change and review these typical operations: Snap Fit, Screw Driving and Gluing. Secondly, we will establish a database of 4 typical robot configuration which can perform such operations.

Below is the review of these typical operations with more details:

### Snap Fit

The definition of Snap Fit: A Snap Fit is a mechanical joint system where part-to-part attachment is accomplished with locating and locking feature (constraint features) that are homogenous with one or the other of the components being joined.

As same as we discussed before about pressing, to snap fit two parts together, a proper amount of force should be exerted along the normal direction. As we can see, snap fit emphasize more on force side. Without loss of generality, we assume that the local normal direction is along the z-axis and the required force is . In x and y direction, usually there is no motion, . To demonstrate the snap fit operation, we choose the FPC connector of the iphone as an example (Figure 1). The type of the FPC connector is 0.4mm ‘Receptacle Housing Assembly J-Bend Tail With Nail’ with 22 pin. According to the FPC connector datasheet, the insertion force is 25.9N (Max). Practically, in our experiment, the measured insertion force is just around 6N due to the wear and tear during the experiment process. Without considering too many other requirements, the basic robot configuration that can perform such snap fit operation has to be able to provide at least 25.9N force with accuracy less than 0.4mm.

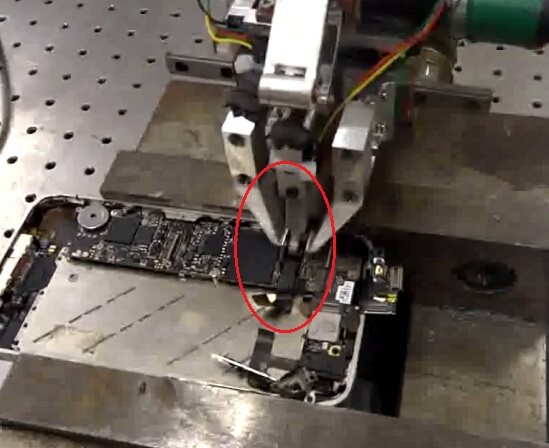
 

Figure 1. the snap fit process of the iphone FPC connector

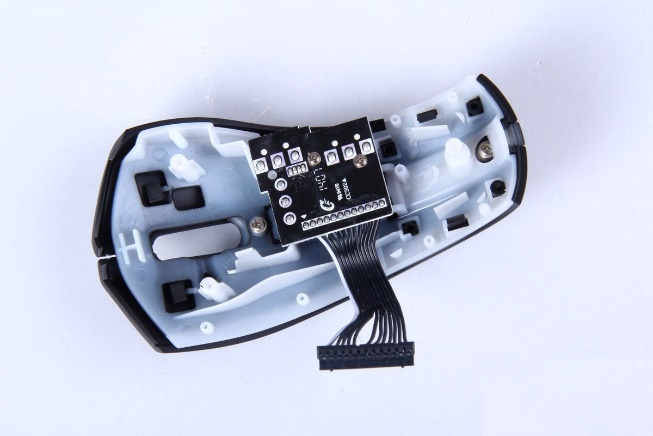
### Screw Driving

From our conclusion in the previous report, the screw driving process requires position control in x and y direction and force and torque control in z. To demonstrate, we choose the Rapoo V90 mouse, Fig 1 is the top and bottom view of V90.

Fig 1. Top view and bottom view of Rapoo V90 mouse



Fig 2. Inside the Rapoo V90 mouse



In Fig 1 and Fig 2, inside the red circle are the screws used. There are a total of 9 screws. As we have concluded in the previous report, screw driving requires control of and, where the latter should be specified by application. Here the precision according to our experiment:

* for x and y, 0.25mm in each direction;
* for roll and pitch, in each axis is acceptable;
* for , it should fall into 5N(so as not to slip) to 10N(so as not to damage the screw);
* for , it should not exceeds certain limit so as not to break the screw.

Note that if we choose some flexible mechanism as discussed in report 1, force control in z-axis is redundant.

### Gluing

We didn’t mention gluing in the previous report, here we shall follow the same analysis pattern for gluing operation.

As mentioned in working report 1, we didn’t encounter much gluing operations in our field visit. But

## Database

After the review of these typical operations, four various robot configurations will be chosen to perform these operations in this part. Repeatability, cycle time, payload, working range would be the first four determinants. ABB is the global leader in automation technologies with widely used robot all around the world, especially ABB IRB120 which has been put into use in Rapoo’s mouse and keyboard assembly factory. Surely, the 6-axis robot IRB120 would be our first choice to perform such 3C operations. In addition, we choose another ABB 6-axis robot IRB140 which is small and exquisite enough to perform these tasks. Since ABB does not produce the 4-axis SCARA robot which is also appropriate for these operations, we decided to choose the typical SCARA G1-225 from Epson and AR-F500H from Hirita. See Table 1 for the detail robot specifications.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Type** | **Specifications** | | | | |
| **Repeatability** | **Cycle Time** | **Payload** | **Working Range** | **DOF** |
| **(+/- mm)** | **(s)** | **Rated(kg)** | **(mm)** |  |
| Epson G1-225 | 0.01 | 0.3 | 0.5 | 125+100+100 | 4 |
| Hirata AR-F500H | 0.02 | 0.3 | 2 | 250+250+200 | 4 |
| ABB IRB-120 | 0.01 | 0.58 | 3 | Figure X | 6 |
| ABB IRB-140 | 0.03 | 0.85 | 6 | Figure X | 6 |

Table 1. the selected robot specifications

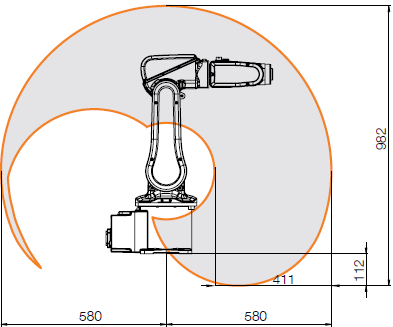
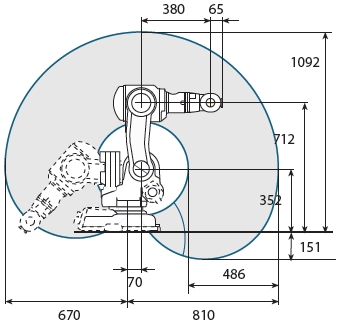
 

Figure x. The working range of IRB120 (Left) and IRB140 (Right)

## Qualitative Analysis

According to Table 1, the repeatability of the robot we choose is in millimeter range. And the degree of freedom of the robot is 4 or 6. There is no doubt that the repeatability and the DOF are the dominant two specifications to determine whether the robot is able to perform the operations or not. On the DOF aspect, 6 DOF robot is sufficient to implement all the tasks no matter the requirements on  or . 4 DOF robot is able to perform most of these operations. Obviously, the cycle time of 4-axis SCARA robot is just about half of that of 6-axis robot. In contrast, the payload of 6-axis robot is larger than 4-axis SCARA robot. But practically, the component of 3C products is usually quite small and light, so the 0.5~6kg range payload robot suffice to handle the 3C components.

Specifically, taking the Snap Fit operation as an example, on DOF aspect, IRB120 and IRB140 can provide the force  (25.9N) on all directions in . Surely, IRB120 and IRB140 is sufficient on DOF aspect. But the rest two SCARA robots can only provide force on axis. Whether the SCARA robot is able to perform the operation depends on the Snap Fit direction requirement. In terms of repeatability, the FPC Snap Fit operation stated in the review part requires the accuracy less than 0.4mm. Obviously, all of the four type of robot can satisfy the accuracy requirement. When comes to payload, the FPC connector is just a few gram which is far less than the rated payload of the four robots. Cycle time is not the factor to determine whether the robot can implement the operations. It will be used to evaluate the efficiency of the robot configuration in the future.

As to screw driving, the control requirements is

## Future work

In previous part, we make a qualitative analysis whether the four selected robot configuration is able to perform the typical 3C assembly operations. Among these specifications, repeatibility, payload, DOF are the factors to decide if the robot configuration is able to implement the operation or not. Cycle time and working range are the additional factors to evaluate the efficiency of the robot. In next step, we will move to the robot efficiency evaluation part. Specifically, the current repeatability model is not enough for us to evaluate the robot configuration for the 3C purpose, so we will also get involved in the repeatability modeling work appropriately.