Image-assisted Assembly and Disassembly Process Using TM Six-Axis Collaborative Robotic Arm

Kuo-Hsien Hsia
Bachelor's Program in Intelligent Robotics, National Yunlin University of Science and Technology
123, University Road, Sec. 3, Douliu, Yunlin, Taiwan

Yi-Yan Liao
AMPOC Far-East Co., Ltd.
17F., No.171, Sung-Teh Road, Taipei, Taiwan

Ching-Yuan Pan
MTmation Engineering of Automation Systems
28F-12, No. 99, Sec. 1, Xintai 5th Rd., Xizhi Dist., New Taipei City 221, Taiwan
Email: khhsia@yuntech.edu.tw, eane135759@gmail.com, yuan2295@gmail.com

Abstract

This paper explores the development of the TM collaborative robot arm in industrial applications. With its in-house developed TMflow software, TM robot streamlines the intricate human-machine interface of industrial robots and modularizes various tool functions, allowing operators to quickly familiarize themselves. The focus of this paper is on programming the TM collaborative robot arm using TMflow to achieve automatic image-assisted localization for assembly and disassembly. Collaborative arms improve the accuracy and efficiency of assembly and disassembly, reducing manual errors and wasted time. In terms of safety, compared with general robotic arms, collaborative arms are safer, allowing them to cooperate safely with human workers and reducing the incidence of workplace accidents.

Keywords: Collaborative robot, COBOT, TMflow, assembly and disassembly process

1. Introduction

Collaborative robot (Cobot) arms are an advanced form of robotic technology designed to work alongside human workers to complete a variety of tasks and jobs. These robotic arms have highly flexible movement capabilities and advanced sensing systems that can identify and adapt to different working environments. Traditional industrial robot arms are usually set up in fixed work areas, with operators controlling the robot arms, and strict safety protection measures are required to avoid collisions with people. However, as manufacturing continues to grow and advance, so does the need for more flexible, safer and more efficient ways of working.

There are many applications of robotic arms. Fu-Chun Liang proposed a new way of making Takoyaki with a robot arm on the premise that humans prepared the materials [1]. Yu-Ting Chen used a robotic arm to grind the surface of workpieces [2]. The grinding moving path of the robot arm was planned using the surface joining method and the hierarchical algorithm based on the information about the surface of the workpiece by a structured light scanner.

Robot arms are often combined with machine vision in applications. Bing-Ting Tsai used machine vision to identify the position of objects in [3], so that the robotic arm can grip the object from different directions. In [4], Cheng-Long Lee used machine vision to know the position and distance of the object to intelligently generate the moving path of the robotic arm, so that the robotic arm can move to the corresponding position and then use eye-in-hand photography to find defects on the object. In [5], Yi-Ru Wu used machine vision combined with a robotic arm to pick up items, and designed an adaptive clamp that can transform items of different shapes into parallel or open-angle clamps for elastic clamping, through deep learning training. The results estimate that the center and shape of the model can effectively complete clamping.

This paper is organized as follows: In section 1, there is a brief introduction of this paper and relative works in the past. In section 2, there is a brief introduction of the collaborative robot TM5-900 used in this paper. In section 3, there is a brief description of the experiment environment. In section 4, some discussions about the assembly and disassembly processes are shown. In section 5, there will be a short discussions and conclusions.

2. TM5-900 collaborative robot

Techman collaborative robot (TM Cobot) arm TM5-900 [6], as shown in Fig. 1, is used in this research. It is a 6-axis robotic arm that covers a reach of 946 mm and carries a load capacity of up to 4 kg. It is suitable for 3C industry, automobile industry, food industry and other fields. TM Cobot is the only robot arm equipped with an eye in hand, e.g. a camera at the end of the robot arm. Its hand-eye camera uses a global shutter. The positioning accuracy measured by TM laboratory with a working distance of 100mm is 0.1mm for 2D condition. The positioning accuracy of TM Landmark 3D is 0.24mm. In reality, accuracy will vary due to factors such as ambient light sources, object characteristics, and vision programming. In addition to the built-in hand-eye camera, the TM5-900 can also be equipped with an external camera to expand its functionality. TM5-900 uses TMflow as its programming environment.

TMflow is a fully graphical design that can significantly reduce the learning threshold. The programming process is based on a step-oriented approach, making the operation more intuitive and easily understood. There is a FREE button and a POINT button at the end of the arm, allowing users to easily carry out hand movement and positioning operations. This design allows users to quickly and easily program the TM5-900 robot arm and flexibly respond to different application requirements.

Fig.1. Techman TM5-900 Cobot [6].

3. Experiment Environment

The experiment uses a TM Cobot to assemble and disassemble a solid-state drive (SSD). The components of the SSD are shown in Fig. 2. They are assembled from three parts, namely the upper cover, the printed circuit board (PCB) and the lower cover. The Cobot arm uses the vacuum suction cup in Fig. 3(a) and the electric screwdriver in Fig. 3(b) for assembly and disassembly. We use the suction cup to assemble and disassemble the three parts of the SSD, and use the electric screwdriver to tighten or remove the M2 flat head screws to loosen the SSD components. Two trays are designed for the task, as shown in Fig. 4. The left one is for accommodating 24 M2 flat head screws, and the right one, the assembly tray, provides a fixed assembly position. TM Landmark is used for positioning for both trays. The removed screws will be placed in the business card box as shown in Fig. 5. The business card box is designed with grooves to allow the screws to escape the magnetic force of the electric screwdriver. After the business card box is full of screws, pour the screws in the box into the screw organizer so that the removed screws can be used again.

In addition, in order to enable the Cobot to install two end effectors at the same time, we designed an adapter block made by 3D printing so that the two end effectors

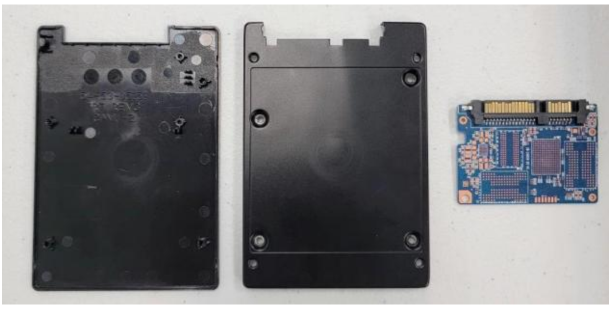


Fig. 2. Components of the SSD for this paper.

(a) vacuum suction cup (b) AE-SDL-1800 electrical screwdriver

Fig. 3. End-effector used in this paper.

Fig. 4. Trays for the task.

can be fixed on the end flange surface of the Cobot at the same time. As shown in Fig. 6(a), the vacuum suction cup and the electric screwdriver can be fixed on the black jig at the same time, and then installed on the end flange surface of the Cobot, as shown in Fig. 6(b). The layout of the overall environment is shown in Fig. 7. The PCB is transported from the previous process to this station of the assembly process via a conveyor belt. In Fig. 7, the square with red TM inside is the TM Landmark for positioning.

4. SSD Assembly and Disassembly

4.1. *Assembly and Disassembly Processes*

The assembly process can be divided into two parts: SSD assembly and screw locking. The Cobot pick up the lower cover by the suction cup and then places it on the assembly tray. Then pick up the PCB by the suction cup and put the board into the slot of the lower cover in an oblique manner. Finally, pick up the upper cover by the suction cup and move it at an oblique angle so that the tenon of the upper cover engages the slot of the lower cover. Then enter the process of screw tightening. First, move the electric screwdriver to a position above any

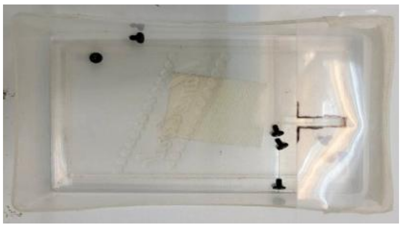
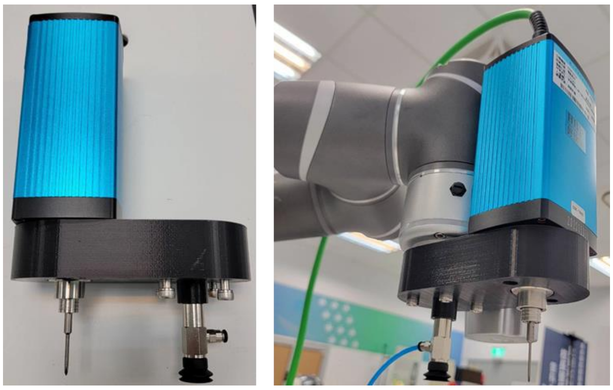


Fig. 5. Screw-recycling box.



(a) Adapter block with 2 end-effectors. (b) TM Cobot with dual end-effectors.

Fig. 6. Adapter block for dual end-effectors.

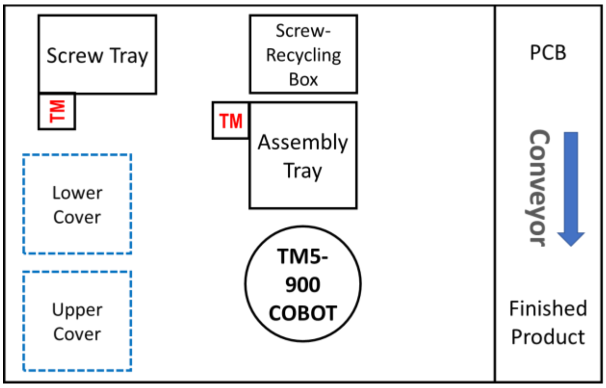


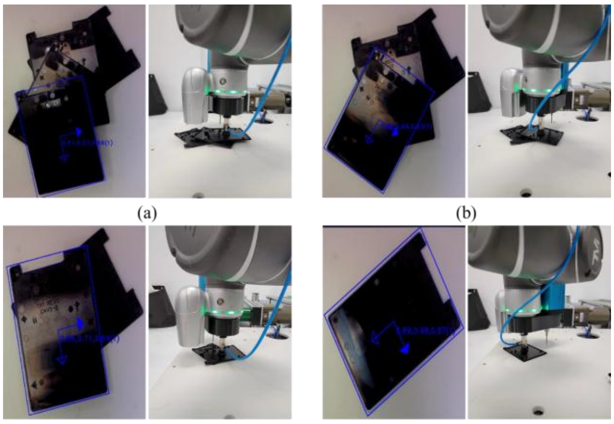
Fig. 7. Layout of the whole system.

screw in the Screw Tray, close to the screw with a low rotation speed to pick up the screw. Then move to the top of one screw hole. Similarly, first in a low rotation speed to make the screw engage the screw hole, and then rotate at a high speed to lock the screw. Repeat until all 4 screws are locked.

The disassembly process is also divided into two parts: screw removal and SSD disassembly. First, use the electric screwdriver on the Cobot to remove the four screws. When removing the screws, the screwdriver should first gradually approach the screws at a low speed to engage the screws, then loosen the screws at a high speed, and use the grooves on the screw recovery box to disengage the screws. Then use the suction cup to pick up the upper cover, PCB, and lower cover in sequence and place them in position.

4.2. *Troubles in Assembly Process*

There might be some troubles in assembly process. Three cases are considered in this paper. The first case is the problem of insufficient ambient light. This problem can be solved using the ring light around the hand-eye camera on the TM Cobot. The second case is the problem of poor image processing. At this time, one can adjust the shooting light source and shooting position to achieve the best image capture and simplify the image processing process. The third case is object stacking. This may lead to object detection errors and confusion in the order in which objects are retrieved. The object detection problem can be solved with the previously mentioned solutions to the light source and image processing problems, while the picking sequence problem can be solved with the parameters of the object detection function. In the object detection function, when multiple objects are detected, they can be sorted according to the detection score, left/right, top/bottom, or center of the image. As shown in Fig. 8, the lower covers or upper covers are randomly stacked, and through the sorting method of object detection, the Cobot can pick up the top object.



(a) (b) (c) (d)

Fig. 8. Sequence of object-picking.

5. Conclusion

In this paper, we use TMflow to develop programs to control TM Cobot with vacuum suction cup and electric screwdriver to complete automated image positioning, SSD assembly and disassembly. By simulating the conditions of the real production line, the experimental environment is arranged to solve similar problems in the real case. These include acquisition and image processing issues, assembly and disassembly issues, and screw-related issues. This scenario will occur in many factories. It is very worthy of reference for manufacturers who want to automate production lines but have not yet done so.

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Authors Introduction

Prof. Kuo-Hsien Hsia

He received the Ph.D. degree in electrical engineering from the National Sun Yat-Sen University, Taiwan, in 1994. He is currently an Associate Professor of National Yunlin University of Science and Technology in Taiwan. His research interests are in the area of mobile robotics, fuzzy control and image processing.

Mr. Yi-Yan Liao

He received his master's degree in Electrical Engineering from National Yunlin University of Science and Technology in 2024. His research interests are collaborative robotic arms and image processing. He currently works as an engineer in automation.

Mr. Ching-Yuan Pan

He received his master's degree in Electrical Engineering from National Yunlin University of Science and Technology in 2024. His research interests are collaborative robotic arms and image processing. He currently works as an automatic control engineer in automotive automation production.