Cooperative Dual Arm with Vision Guidance

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***Abstract*—In this paper, the cooperative task of a dual arm robot with vision guidance is presented. The robot has two 6-DOF arms and implements the robot operating system (ROS) which provides software libraries to control the robot. The arm navigation package in the ROS is used to solve the inverse kinematics and trajectory generation. The robot's trajectories are guided by vision system which utilizes the Microsoft Kinect's camera for color tracking of target objects. Experiment results show that the dual arm robot can perform cooperative tracking task of various patterns such as straight line, circle, and rectangular shapes effectively.**

***Index Terms*—Dual robot arm, vision guidance, robot operating system (ROS).**

I. Introduction

Robot arms are widely used in the industrial for quite a long time. However, there are still many tasks such as multiple points handling task for complex assembly or moving in very large workspaces that cannot be handled by a single robot arm. Hence, a dual arm robot type would be a candidate to accomplish those tasks. There are several previous research works related to designs of two-arm robot which has two 6-DOF arms like human arms to move in many paths. Guo-Shing's work shows that the design of 6-DOF robot arm and method of solving robot's inverse kinematics for trajectory planning [1]. In addition, various control strategies defined for different tasks such as relative dual position control, relative Cartesian position control, relative distance control, and full dual position control are discussed for the dual arm robot [2]. To manipulate object by robot, the vision system is also used to locate the position of object. The vision system can involve many algorithms such as visual servoing [3], stereo-based 3D localization [4], active stereo [5], edge visual detection [6], and etc. The performance of cooperative tracking task of dual arms is still a challenge case to be investigated. Hence, this paper proposes the design and operation of cooperative tracking task of a dual arm robot built at the institute of field robotics.

This paper includes three important sections. First, the system overview along with the design of dual arm robot hardware and software components is explained. Next, the experiments and results are shown. Finally, the conclusions and future works are also discussed.

II. System Overview

In this proposed system, the robot named "snowface one" has two 6-DOF arms to perform cooperative tasks. The performance test of tracking accuracy with handling two bottles is investigated. There is also a vision system used for tracking color markers on the table. The system overview is illustrated in Fig. 1.

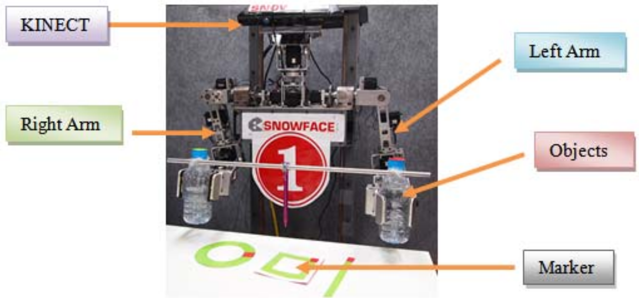

Fig. 1. System overview

A. Hardware Components

The main hardware components consist of the robot with two 6-DOF arms and the vision system. The proposed robot uses 16 servo motors which are Robotis's RX64 and EX-106+ motors for its actuators. Twelve motors are installed for two arms' joints along with 2 motors for two grippers, and 2 motors for pan-tilt camera head. The Robotics' motors are shown in Fig. 2.

Fig. 2. RX64 and EX-106+ servo motors [7]

Two bottles are used in grasping task. Bottle's caps contain the color marker to be tracked by the vision system. Furthermore, there is color markers consists of red color for path initial and green color for path marker. There are 3 path markers which are straight line, rectangular, and circular shapes. A pen is attached between two bottles. It is used to measure the accuracy of tracking when the robot arm moves.

For the vision system, it utilizes the Microsoft Kinect's camera which has also an IR sensor to detect the position of the target object. It can provide the depth information of the target object. The vision is applied for tracking the path shown on the marker. The robot will be moved to track the detected path. The Microsoft Kinect's camera is shown in Fig. 3.

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Fig. 3. Microsoft Kinect's camera [8]

B. Software Components

The robot operating system (ROS) [9] is implemented in this proposed system. The ROS has several software packages to create auto generated inverse kinematics solution, 3D visualization environment for robots, motion planning, and etc. The arm navigation package is applied for path planning and controlling the servo motors. The robot's model is represented in the form of the unified robot description format (URDF) which is an XML format for representing a robot model. The URDF file is created by using several robot parameters such as transformation, orientation matrix, joint limit, kind of material's link, and etc. for describing a robot's model into XML file. Moreover, the RVIZ package is used to simulate the robot motion from trajectory planning and test the inverse kinematics before controlling the actual robot. Fig. 4 shows the 3D simulation of the proposed robot.

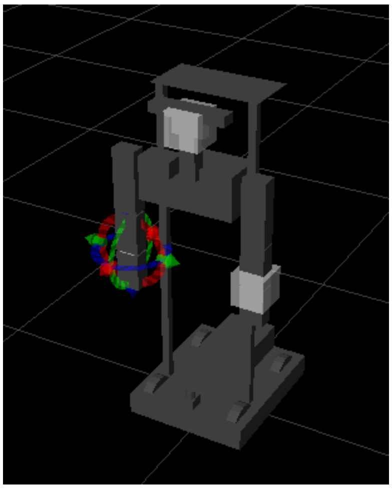


Fig. 4. Simulation in ROS

III. Experimental Results

In the experiment set, the robot acquires the position of bottle cap with color marker from the vision system. The robot is then controlled to grasp those bottles which have a pen attached on a rod connecting two bottles. Next, the vision system is applied for color tracking using HSV color model to track the path on the marker. There are three paths which are straight line, rectangular, and circular paths. Fig. 5 shows that the red points are the initial positions of markers. The robot will be controlled to coordinate both arms to bring the pen to track those paths. The experiment results show that the robot arm can move the pen to track the path effectively. Fig. 6(a), Fig. 7(a), and Fig. 8(a) show the graphs of three path shapes.

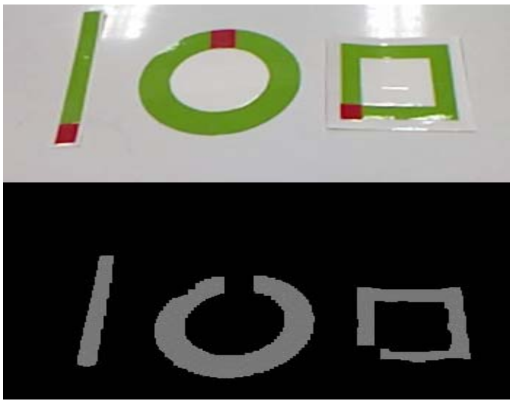
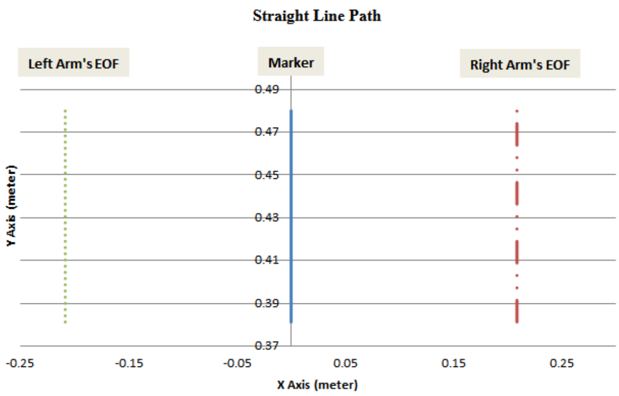
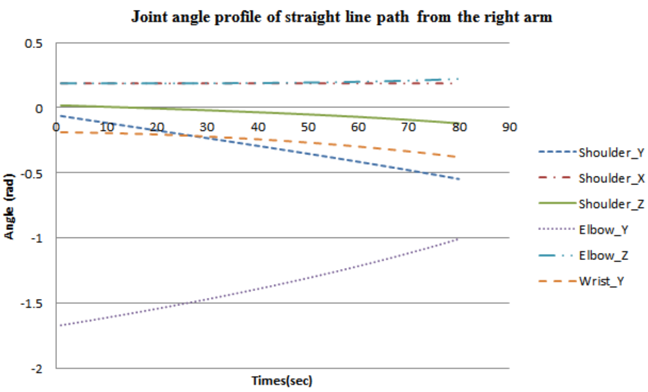


Fig. 5. Shapes of markers

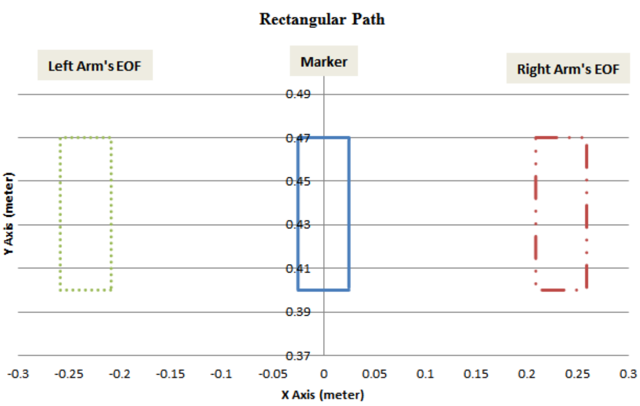


(a)



(b)

Fig. 6. The tracking result of the straight line path and joint angle profile of the right arm



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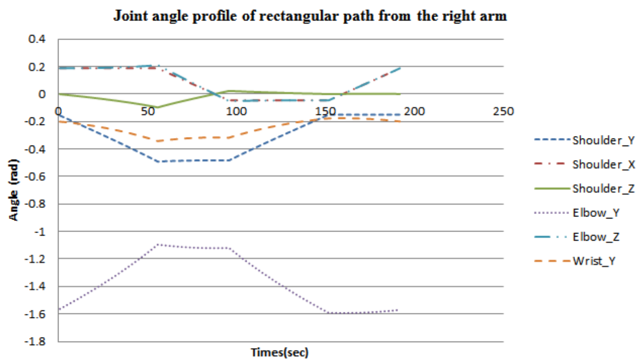
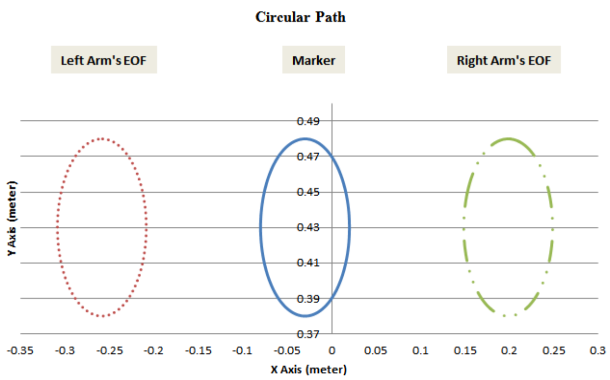


(b)

Fig. 7. The tracking result of the rectangular path and joint angle profile of the right arm



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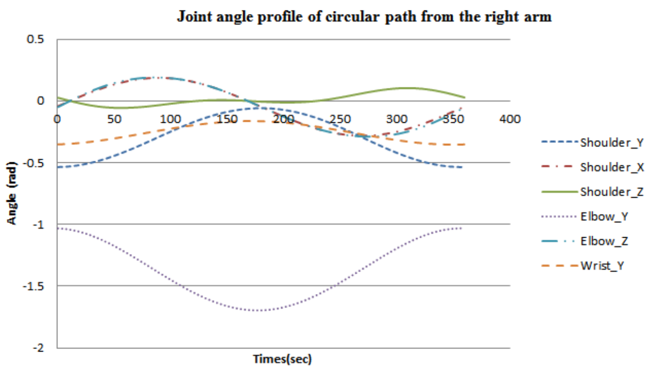

(b)

Fig. 8. The tracking result of the circular path and joint angle profile of the right arm

Each graph consists of the green plot showing the path of the left arm's end-effector, the blue plot showing the path of the marker, and the red plot showing the path of the right arm's end-effector. The right arm's joint angle profile of each tracked shape is shown in Fig. 6(b), Fig. 7(b), and Fig. 8(b). In Fig. 6(b), the joint angle profile has a straight line form. Some joint angles in the straight line path have a small variation because the path is changed in only one axis. The joint angle profile in the rectangular path consists of four straight lines as shown in Fig. 7(b).

The joint angle profile in the circular path has changes in both X and Y axes look like a sine wave. In addition, the robot can be controlled to move back to the initial position at the end of tracking. The tracking results of rectangular and circular paths do not provide the exact shapes as the detected marker's shapes because of limitation of dual arm robot's workspace and vision's tracking error.

IV. Conclusions and Future Works

This research proposed the cooperative tracking task of the dual arm robot with vision guidance. The robot consists of two 6-DOF arms and it can track in three cooperative paths of both arms, which are straight line, rectangular, and circular paths, effectively. The vision system utilizes the MS Kinect's camera to acquire the paths of detected markers.

This proposed dual arm robot's abilities can be improved for 3D shape tracking, a path with the obstacles, and etc. In addition, the robot gripper needs to be enhanced to reduce the vibration during moving in each path.

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