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Position and Force Control of the SCARA Robot based on Disturbance Observer

Niphun Surapong[1, a *], Chowarit Mitsantisuk[2,b]

[1,2]Department of Electrical Engineering, Faculty of Engineering, Kasetsart University, Bangkok, Thailand

[a]g5514501230@ku.ac.th, [b]*fengcrm@ku.ac.th,*

Abstract

Mostly force sensor, used to measure external force, is equipped at the end effector. However force sensor is expensive and capable to measure only external force around the area that force sensor is attached. Therefore, the action could not be found outside the end effector. As a result, to improve the performance, disturbance observer (DOB), designed to control the position and force, is used to estimate external force instead of force sensor. In this paper, SCARA robot is used to draw the parabola on the board with a pen at end effector. From the results show effective position control of the SCARA robot and force control without using of force sensor as the robot is drawing.

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Keywords: Disturbance Observer, Force sensor, SCARA robot ;

1. Introduction

For several decades, there are numerous papers with the objectives to the development of industrial robots to use, for example, welding robot and assembly robot. Also, recently, much research about industrial robot, especially industrial robot that works with human, would have the safety as the most concerned point. Therefore force control would be necessary to improve the performance of the robot and allow for safety to work with human.

A force sensor is often attached at the end-effector of a robot arm to measure the force when touches the objects. Therefore the robot arm could not be monitored when there is no sensor equipped. For this problem we would apply the disturbance observer [1]-[2] to the system for estimate the external force for improve the performance of position control. Moreover, it can detect the external force which act on the robot manipulator without using force sensor.

In this paper, we use the position control to control the position of the SCARA robot to move in a desire direction. Moreover, the disturbance observer is used to detect the external force for design the force control system. After the external force is compensated to the system, the robustness of the control system is improved. This paper is

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organized as follows. In section II, SCARA robot structure and system are explained. Section III proposes the disturbance observer. Section IV and V describes the SCARA robot control system. Experimental results is shown in section VI. Finally, this paper summarized are shown in section VI.

2. SCARA robot system

2.1. Structure of the SCARA robot

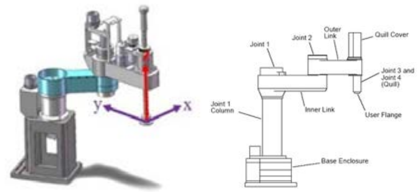

Fig.1. Structure and Joint of the SCARA robot

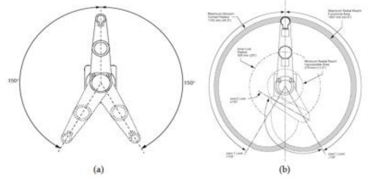

Fig.2. Areas of work of the SCARA robot

The structure of SCARA robot which shown in Fig. 1 is consists of 4 joint connected with each other. Joint 1,2 and 3 have moved in x-y plane while joint 4 has moved in z axis.

From Fig. 1, joint 1 which connected with base is called shoulder because of its movement. It can move 150 degree of each left and right side. The movement of joint 1 is shown in Fig. 2. Joint 2 which connect with joint 1 is called elbow. It can move with 300 degree same as joint 1. Joint 3 and 4 which called wrist are connected with the end effector.

2.2. Kinematic of the SCARA robot

Kinematic is a mathematics modelling which use to describe the structure of robot and relationship between position of each joint and movement of the robot. Kinematic is consist of 2 parts, Forward Kinematic and Inverse Kinematic.

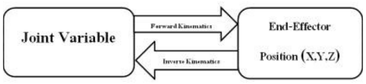

Fig.3. Kinematic of the SCARA robot

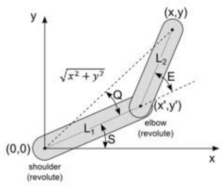

Fig.4. Equation of the SCARA robot

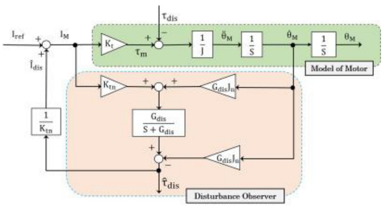

Fig.5. Disturbance Observer

From Fig. 3, forward kinematic is use to calculate the position of robot by using position information of each joint. On the other hand, inverse kinematic is use to calculate the position of each joint by using position information robot.

From Fig. 4, forward kinematics of SCARA robot are shown in eq.1 and 2 while inverse kinematics of SCARA robot are shown in eq.3, 4 and 5.

$$x = L_1\cos(S) + L_2\cos(S+E) \quad (1) \qquad y = L_1\sin(S) + L_2\sin(S+E) \quad (2) \qquad E = +\cos^{-1}\left(\frac{x^2+y^2-L_1^2-L_2^2}{2L_1L_2}\right) \quad (3)$$

$$S + Q = \arctan 2\left(\frac{y}{x}\right) \quad (4) \qquad Q = +\cos^{-1}\left(\frac{x^2+y^2+L_1^2-L_2^2}{2L_1\sqrt{x^2+y^2}}\right) \quad (5)$$

Where L1 and L2 are length of robot arm. Position of x and y axis are x and y respectively, S, E and Q are angle of L1 with x axis, angle of L1 with L2 and L1 with plane from origin to end effector.