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# Sensorless Force estimation of SCARA robot system with Friction Compensation

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**Abstract**

In this paper, the friction compensation method of SCARA robot is proposed. During the operation, the friction force in the system causes the heat to the robot and system. Since heat which occurred in the system is accumulated for a long time, the robot and system have been damaged. Moreover, performance and stability of the system have been reduced. Therefore, compensation of friction force is an important method for increase performance and stability of the system. In this paper, the disturbance observer is used with mathematic modelling of friction compensation for compensate the friction force in the system. From the simulation results, the system which has a friction force compensation can show the increasing of performance and stability.


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Keyword : SCARA Robot; PID controller; Friction Force Compensation; Disturbance Observer

## 1. Introduction

Recently, industrial robots are widely used in many applications especially in industrial work. They are used to help the human operator during the operation for improve the performance, accuracy including robustness of the robot control system in medical, transportation, industrial scenes and so on. Moreover, they can use instead of human in the dangerous situation such as a place which has radioactivity. Therefore, robot is used to support the human operator for improve the accuracy and precision of the operation [1, 2].

For design the control system, force response is a key for using to design the controller of the robot. Recently, force sensor is widely used in industrial application for measure the external force. However, force sensor has a limitation which reduce the robustness and performance of the system such as force sensor gives a low bandwidth of measuring and a measured force signal comes with high noise. Therefore, Disturbance Observer (DOB) is used instead of force sensor for estimate the external force. Moreover, it can improve the accuracy of force estimation and robustness of the whole system [3, 4].


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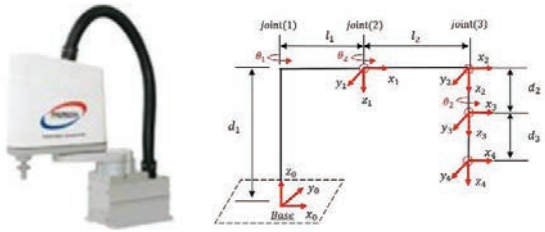


Fig 1. Link coordinate systems for the SCARA robot

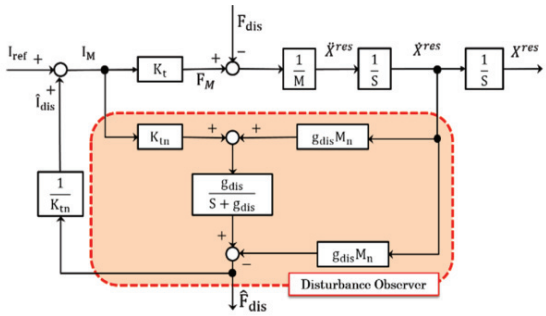


Fig 2. Force Control based on Disturbance Observer

Some industrial motion control system has non-smooth nonlinear characteristic, such as friction, dead-zone and backlash. The most familiar problem is friction force which is discontinues with respect to velocity of the two body surface in contact. Friction force which occur in the system has degrading effect in the stability and performance of force control system. Moreover, heat which occur by friction force in the system causes the damage to the robot manipulator [5].

In this paper, we propose a new friction compensation method in order to solve the problem of friction in robot manipulator. Disturbance Observe (DOB) is applied to the SCARA robot system for estimate the friction force. After compensation friction force back to the system, the friction force is reduced while the performance and robustness of the system are improve. This paper is consists of 4 sections. The section 2 shows the structure of SCARA robot, Disturbance Observer (DOB) and friction force and friction compensation method. are described. The experimental results are represented in section Finally , the last section summarized the paper.

## 2. SCARA Robot and Disturbance Observer and Friction Force

### 2.1 SCARA Robot

In this paper, the force estimation techniques is used on SCARA robot experiment. SCARA robot is use in assembly and relocated a large device. The structure of SCARA robot which shown in Fig. 1 are consists of 4 axes. The movement of joint 1, 2 and 3 move in X-Y plane while joint 4 moves in Z axis. Joint 1 which hold with based of robot is called shoulder because its operation like a human shoulder. This joint can move from 115 degree left to 115 degree right. Second, joint 2 is called an elbow because its operation like a human elbow. The movement of this joint is 140 degree which same as joint 1. Third, joint 3 which move in Z axis can move up and down with 120 centimeters. Finally, joint 4 is called wrist because its operation like a human wrist. The movement of this joint is 360 degree.

### 2.2 Disturbance Observer.

Recently, robot has used in many industrial applications with human operator. During the operation, robot control system must be safe for saving the human operator. Therefore, the force sensor has used to measure the external force. Since the force sensor has a limitation which degrade performance of the control system such as low bandwidth and high noise level, DOB is applied to the control system. Disturbance Observer (DOB) is a method for estimate the external force instead of force sensor. Current of motor and angular velocity of motor are used to be inputs for DOB. Output signals from DOB has a less noise level because of the low pass filter. Moreover, the bandwidth of the force estimation is increasing. Afterward, the force estimation from DOB is compensated to the system for improve the performance and robustness of the whole system. The structure of DOB is shown in Fig. 2.