PERFORMANCE ASSESSMENT OF A DECENTRALIZED CONTROLLER FOR COOPERATIVE MANIPULATORS; NUMERICAL AND EXPERIMENTAL STUDY

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ABSTRACT

There are two possible methods for controlling the manipulators that cooperate in carrying an object: using a single central controller for the whole set and using decentralized controllers for each manipulator. Using the first method requires a perfect knowledge of the whole system's dynamics and the carried object. Due to implementation problems, among them the uncertainty about the manipulated object's mass, using this method is impractical. This makes using the second method inevitable. In this method, manipulators are controlled separately and they are unaware of each other's condition. The effect of each manipulator on the other one is like a disturbance. In this paper, the performance of second method is analyzed by numerical methods. For confirming the results experimentally, this method has been implemented on an experimental setup. The results indicate the desirable performance of this method.

1. INTRODUCTION

In recent years, the use of cooperative manipulators has been increased. Mechanical manipulators that cooperate in carrying an object, make kinematic closed loops.

The formation of these closed loops imposes constraints on the motion of the system that makes the control of these systems more difficult in comparison with the closed loop ones.

Studies undertaken in this field can be categorized to inverse kinematics, dynamics, path planning, control and optimization of cooperative manipulators system. Following studies are among the important works done in this field: Yun, Tam and Bejczy derived the equations of motion of two cooperative manipulators by considering the whole system as a kinematic closed loop [1]. Cooperation of manipulators for carrying an object with indeterminate dynamics was studied by Kato, Ito, Uematsu and Luo [2]. Tsai-Yen studied the online manipulation planning for two cooperative manipulators in a dynamic environment [3]. Hu and Goldenberg studied an adaptive approach to motion and force control of multiple coordinated robot arms [4]. Uzmay, Burkan and Sarkaya examined the performance of adaptive and robust control techniques in planar cooperative manipulators [5]. Al-Yahmadi, Abdo and Hsia studied the modeling and control of two cooperative manipulators carrying a flexible body [6]. Bolic, Al-sharhan and Gueaieb examined a robust controller for cooperative manipulators with uncertain dynamics [7]. Umetani, Kurazume and Yoshida studied the problem of two cooperative manipulators installed on a hanging spatial platform [8]. Zheng and Luh studied the optimal load distribution applied on the grippers of cooperative manipulators in order to apply the least possible force on the carried object [9]. Kwak, Kim Yi and Lee examined the use of additional actuators for reducing the shock effects on the robotic systems [10] and Keshmiri and Naghshine studied real time control and optimization of dynamic systems by using additional actuators [11].

Obviously, regardless of control method used, coordinated control of manipulators is inevitable. A system of cooperative manipulators can be controlled by two general methods:

First, controlling of each manipulator separately such that it can track the predefined desired path with the coordination of other manipulator. In this case, each manipulator is unaware of the other's condition and the effect of each manipulator on the other one is like a disturbance. This method is called *decentralized* or distributed control.

In the second method, the system of cooperative manipulators is regarded as a single system and a single controller is designed for it. This method is called *centralized* control. Using the second method requires a complete knowledge of the entire system's dynamics, specially the dynamics of the carried object. Since in industrial applications the manipulators may carry objects with different sizes, using this method is not practical. For this reason and the simplicity of implementation, decentralized controllers are widely used. In this paper, the performance of decentralized control method in controlling two planar cooperative manipulators is analyzed numerically and then examined experimentally by manufacturing two planar two-link manipulators.

1.1. Problem Definition

Figure 1 shows the schematic and constructed setup in cooperation for carrying an object. The aim is numerical analysis and experimental study of decentralized control of this system.

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