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A NEW APPROACH ON OBJECT SLIPPAGE CONTROL IN A COOPERATING MANIPULATORS SYSTEM

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ABSTRACT

Considering slippage in the end-effectors of a set of two cooperating manipulators grasping an object, this paper presents a new dynamic modeling and control synthesis of grasping phenomenon. This dynamic modeling is based on a new formulation for frictional contact where equality and inequality equations in the standard Coulomb Friction model are converted all to a single second order differential equation with switching coefficients. Accuracy of the friction model is verified by comparing its results with those of SimMech. Then equations of motion are reduced to conventional form for non-constrained system. Assuming the new reduced order system to be BIBO, internal stability of the whole system is analyzed. In the control synthesis of the system a multi phase controller is utilized to control the trajectory tracking of the object as well as slippage control of the end-effectors on the object surfaces. For the proposed controller, a proof is given for system stability and its performance and robustness are shown numerically. The results show superiority of the method and its desirable and excellent performance.

Keywords: sliding condition, cooperating systems, frictional point contact, grasping.

1 INTRODUCTION

During the past two decades, cooperating systems and multi-fingered hands was greatly studied. Grasp phenomena is an important issue in this field and many researches have paid attention to it.

Grasp analysis and synthesis are two essential themes in these researches. The closure properties are related to capability of grasp in holding an object in the presence of external load or disturbances. Form closure is a geometric property depending upon frictionless contacts whereas force closure is based on frictional point contacts. Most of researchers in the grasp phenomena have focused on answering two questions: 1- How to find appropriate conditions for form/force closure grasps? 2- How to determine optimality criteria for testing the closure property and how to derive methods and algorithms for computing contact locations?

Early, Reulaux introduced concept of force and form closure grasps [1]. Salisbury and Roth developed several different types of finger contacts and showed which finger configurations allow complete immobilization of the gripped object relative to the fingers, and also allow for the manipulation of the object by the fingers while maintaining the grasp, using screw theory [2]. Mishra et al. proposed necessary and sufficient condition for force-closure grasp with friction point contacts (FPCs) [3]. Xiong characterized form closure as a geometric condition which states that the origin of the wrench space lies within the interior of the convex hull of the contact wrenches [4].

Answering to second question led researchers to garsp synthesis. Tung and Kak presented a new theorem and an algorithm for fast synthesis of two-fingered force-closure

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