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Full paper

Dynamic Analysis and Control Synthesis of Grasping and Slippage of an Object Manipulated by a Robot

Shahram Hadian Jazi, Mehdi Keshmiri * and Farid Sheikholeslam

Isfahan University of Technology, Isfahan 8415683111, Iran

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Abstract

Grasping an object by a cooperating system such as multi-fingered hands and multi-manipulator robotic system has received much attention. Research has focused on analysis of force-closure grasps and the synthesis of optimal grasping, when there is no slipping condition. Although the control system is designed to keep the contact force in the friction cone and avoid the slipping condition, slippage can occur for many reasons. In this research, dynamics analysis and control synthesis of a manipulator moving an object on a horizontal surface using the contact force of an end-effector are performed considering the slipping condition. Equality and inequality equations of frictional contact conditions are replaced by a single second-order differential equation with switching coefficients in order to facilitate the dynamic modeling. Accuracy of this modeling is verified by comparing the results of the model with those of SimMech. Using this modeling of friction, a set of reduced order form is obtained for equations of motion of the system. A new method is proposed to control the object motion and the end-effector undesired slippage based on the reduced form. Finally, performance of the method is evaluated both numerically and experimentally.

Keywords

Grasping, contact modeling, slippage control, frictional contact, undesired slipping, cooperating system

1. Introduction

Grasping an object in a cooperating system such as multi-fingered hands and multiple robots is an important issue for researchers. During a full multi-fingered manipulation cycle, grasp planning arises on several occasions, such as when an object is first picked up. Grasp analysis and synthesis are fundamental problems in the study of grasp planning. Many papers can be found on testing and planning force-closure grasps. In grasp analysis, most of the research has been focused on finding appropriate conditions for force-closure grasps. Previously, Salisbury and Roth developed

* To whom correspondence should be addressed. E-mail: mehdik@cc.iut.ac.ir

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