

*Full paper*

# Dynamic Analysis and Control Synthesis of Undesired Slippage of End-Effectors in a Cooperative Grasping

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## Abstract

This paper addresses dynamic analysis and control synthesis of object grasping in a cooperative multirobot system with  $n$ -serial manipulators from an undesired slippage point of view. Two control approaches are presented in this article; a modified version of a conventional method in grasp synthesis and a new method based on a new modeling of system dynamics. A new formulation for frictional contact is used in dynamical modeling, where equality and inequality equations of the standard Coulomb friction model are all converted to a single second-order differential equation. A multiphase controller is utilized to control the object trajectory tracking as well as object slippage in the new control approach. Performance and robustness of both approaches are studied numerically. The results show superiority of the new method and its desirable and excellent performance.

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## Keywords

cooperating system, object grasping analysis, slippage control

## 1. Introduction

Grasping is one of the interesting and important issues in cooperating manipulator systems. Picking an object, coordinated grasping, dexterity during grasping and unknown object grasping are some of the things researchers deal within grasp planning. Many related publications can be found on grasp planning, most of which focused on two fundamental problems of grasp analysis and grasp synthesis. In grasp analysis, researchers have tried to answer the question that how one can find

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