

University of Macau

Abstract

**KINEMATICS, DYNAMICS AND CONTROL OF
PARALLEL ROBOTS**

by Xu Qing Song

Thesis Supervisor: Prof. Li Yangmin

In this thesis, the issues of kinematics, dynamics, and control of two types of parallel robots including a general 3-PRS parallel robot and a general 3-PUU parallel robot have been investigated in details.

First of all, the foundational kinematics problems have been proposed where the inverse kinematics solutions of the parallel robots were both derived in closed form, and the forward kinematics problems were solved numerically through three different approaches for a general 3-PRS parallel robot and in closed form for a general 3-PUU parallel robot, respectively. The singularity conditions under which the parallel robots become uncontrollable were presented. The kinematic features such as workspace, stiffness, and manipulability were investigated with the changing of architectural parameters, and the simulation results that indicated clearly the tendency of variations on kinematic characteristics with respect to different sets of architectural parameters are helpful in architecture design. In addition, the kinematic optimal design was performed for a general 3-PRS parallel robot with respect to maximum workspace volume, and for a general 3-PUU parallel robot based on maximum manipulability index, respectively. Secondly, the inverse dynamics modeling has been developed, where the inverse dynamics model of a general 3-PRS parallel robot was derived through two different approaches with their accuracy verified by the simulation results, and the inverse dynamics equation of a general 3-PUU parallel robot was formulated using the adopted simplifying hypothesis. In the control issues, although there is no known closed-form forward kinematics solution for a general 3-PRS

parallel robot due to the complexity, the kinematics control has been implemented successfully with the forward kinematics problem solved by the approach of artificial neural network, and both the kinematics control and dynamics control for a general 3-PUU parallel robot have been performed with well performances, in which the later also verified the accuracy of the inverse dynamics modeling.

The research work presented here provided a sound basis to develop either a general 3-PRS parallel robot or a general 3-PUU parallel robot for specific applications, and also provided the bases for further researches into both the robot design and advanced control strategy issues.