Abstract

The first part of this thesis includes a brief comparison between electric motors and hydraulic actuators for high performance robotics applications. Hydraulic actuators with fast valves are shown to be superior because of their large torque to mass ratios and their extended bandwidth. One such hydraulic actuator is characterized and its highly nonlinear dynamics are modeled and identified. A simulator implementing this dynamic model is shown to predict the system's behavior satisfyingly. A lead-lag force controller that yields a large bandwidth and good accuracy is also designed.

The second part is devoted to the modeling and control of an in-parallel actuated, redundant, revolute joint mechanism. An autonomous kinematic calibration method is presented, and tested on a prototype of the joint. The actuator forces are optimized to reduce internal force, and to minimize their maximum magnitude. A method to generate a pre-load force in the joint to eliminate backlash is also presented. Finally, a PD controller, a robust PID controller, and a robust H^∞-optimal controller are designed to control the joint angle. Results are presented for position and impedance control experiments, and the PD and H^∞-optimal controllers are shown to be superior to the PID controller in terms of trajectory tracking and robustness to variations in the joint's inertia. A variable bandwidth, nonlinear position controller is also developed and tested experimentally.