Abstract

Overwhelming controllers have been successfully used in the past for trajectory tracking and impedance control of serial manipulators. However, application of overwhelming control to parallel manipulators is not a straight-forward task because of the closed loop kinematic architecture of the manipulator. An overwhelming controller-based implicit system inversion scheme is proposed in this work to control a hydraulically driven parallel manipulator. The electro-hydraulic actuator in the leg is modelled by including the dynamics of the servo-valve and the servo-cylinder. A leg-space force-feedback controller is proposed for controlling the hydraulic pressures acting on the pistons of the actuators. It is shown that an approximate inverse model, which is computationally efficient, is sufficient for the controller design. The developed overwhelming controller is used for impedance control with appropriate modifications so that the interaction forces can be accommodated by modulating the impedance at the interface of the manipulator and the environment.

The performance and robustness of the developed overwhelming controller have been validated with two test-case applications with different objectives. The first concerns a human-in-the-loop vehicle simulator system where real-time performance and positioning accuracy are important. A machining operation is considered in the second case, which is a slow process, *i.e.*, the real-time performance is not so important. However, the machining process requires very high precision in tool positioning and limits are placed on the interaction forces between the tool and the job which requires impedance control.

In order to develop proper dynamic models of complex mechatronic multibody systems like the parallel manipulator and the vehicle of the vehicle simulator, modular modelling approach is preferred. Bond graph modelling, which is a multi-disciplinary and modular modelling approach, is used in this thesis for model representation and controller development.

Detailed bond graph models of quarter car, bicycle vehicle and four-wheel vehicle are developed for the vehicle simulator. These vehicle models allow change of vehicle configuration, *e.g.*, choice between standard, anti-lock and regenerative braking systems. Moreover, a simple graphics interface showing the terrain and skyline is developed for the vehicle simulator.

***Keywords*:** Parallel manipulator, Multibody system, Bond graph, Overwhelming control, Vehicle dynamics, Trajectory tracking, Impedance control, Vehicle Simulator.