INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Design of a Few Backstepping Sliding Mode Based Robust Control Techniques for Robot Manipulators

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SHORT ABSTRACT

To design a structurally simple controller for robot manipulators is a challenging task because these are highly coupled multi input multi output nonlinear dynamic systems. Quite often there happens to be a compromise between the controller structure and its performance. This thesis focuses on designing a controller that yields satisfactory performance while maintaining its structural simplicity. The basic methodology used in the thesis is the backstepping based sliding mode controller. Since robustness against the mismatched uncertainty cannot be guaranteed by the conventional sliding mode controller (SMC), it is integrated with backstepping methodology. To find a solution to the problem of undesirable high frequency chattering in the control input due to SMC, an integral backstepping based SMC (IBSMC) is proposed. Although effective, this method leads to increased structural complexity of the controller due to the requirement of differentiation of manipulator dynamics. This complexity is minimized using a first order low pass filter instead of direct differentiation resulting in the integral adaptive dynamic surface control (IADSC). Chattering mitigation is also attempted by using an adaptively tuned controller gain which uses a lower input energy to produce similar tracking performance for the manipulator. Stability issues arising due to the presence of filters motivated to propose a proportional integral derivative (PID) type sliding surface for using in the adaptive backstepping SMC giving rise to the ABSMC-PID. This ABSMC-PID method is also used for impedance control of a robot manipulator. A model free controller is developed next using the time delay estimation and the PID sliding surface in the backstepping SMC is replaced by a fast terminal sliding surface that can provide finite time convergence of the tracking error. This adaptive backstepping based fast terminal SMC (ABFTSMC) can be used effectively for higher DoF manipulators or in the cases where determining the manipulator model is not easy. Detailed Lyapunov based stability analysis is conducted for all the proposed controllers. Simulation studies are carried out to validate the proposed control methodologies against some existing control methods. Implementation of dynamic control on a position commanded servomotor actuating the robot manipulator is next attempted in this thesis. Experiments are conducted on a robot arm to investigate about the possibility of realizing the proposed dynamic control methods in real time applications.