INTELLIGENT CONTROL OF NONLINEAR SYSTEMS

by

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Non linear systems – Control

Certificate

This is to certify that the thesis entitled **"Intelligent Control of Nonlinear Systems"** being submitted by Shubhi Purwar to the Department of Electrical Engineering, Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy is the record of tne bona-fide research work carried out by her under our supervision. In our opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted either in part or in full to any other university or institute for the award of any degree or diploma.

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Abstract

In this thesis, we address the control of nonlinear, SISO and MIMO systems that can be represented in the strict feedback form where some of the nonlinear functions are not known. The paradigms of intelligent control used to solve the nonlinear control problem in this thesis are the neural networks and the fuzzy logic systems. The objective of both methods is to use function approximation methods to estimate unknown nonlinear functions. These estimated nonlinear functions are then used in the controller design. In the last few decades, intelligent control using fuzzy logic systems (FLS) and neural networks (NN) has undergone a rapid development to design feedback controller for complex systems. They have proven to be very powerful techniques in the discipline of systems control, especially when the controlled system is hard to be modeled mathematically, or when the controlled system has uncertainties and nonlinearities.

The problem is to design a (Chebyshev neural network) CNN/FLS controller that forces the output to track a specified smooth reference trajectory with bounded errors. The overall structure of the controller is based on

- Backstepping control
- Adaptive Sliding mode control
- Lyapunov stability based output feedback control

A control law is proposed for the backstepping control of strict feedback form of nonlinear systems using FLS. The proposed scheme is applied to induction motor to demonstrate its effectiveness. An adaptive sliding controller with single sliding surface for mismatched systems is developed. The performance of the proposed controller

structure is compared to the multiple sliding surface controller for a single link manipulator with actuator dynamics. A controller structure based on Lyapunov stability is developed for rigid link robot manipulator with only position measurements and constrained input. The system uncertainties, which may be due to payload variation, disturbance etc. are estimated using CNN/FLS. The control structure for the trajectory-tracking problem of a wheeled mobile robot, which is a nonholonomic system, is developed. In this case both position and velocity measurements are available. The uncertainties are present in both the kinematics and dynamics, which are estimated exploiting the approximation properties of CNN/FLS.

For all the approaches considered in the thesis an online tuning law of the neural network weights and parameters of FLS is presented. Stability proofs are given in the sense of Lyapunov where it is shown that all the signals in the closed loop system are uniformly ultimately bounded. The efficacy of the approaches presented in this thesis has been validated through simulation studies.

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