PREFACE

This thesis focuses on the regulation and stabilization of nonlinear system. Every physical system when modeled in detail, exhibits nonlinearity to some extent. Nonlinearity in physical system is due to uncertainty of parameters variation, disturbance due to noise or due to undesired location of pole/zeros. Regulation and tracking control of nonlinear systems is a key-point research among various control experts.

The performance limitation associated with regulation and tracking control of linear time-invariant systems are well understood in the classical and modern control theories. Many physical applications need to satisfy performance requirement and robust stability simultaneously. This multi-objective problem has been formulated under the optimization framework. The multi-objective optimization is achieved via evolutionary algorithm which is helpful in refining the parameters of the controller.

Teaching learning based optimization is a well known evolutionary algorithm is designed in a way so that controller will be able to balance the metal ball in the air space through magnetic levitation system. The magnetic levitation system is inherently nonlinear. The main issues that are coupled with the magnetic levitation system are inner coupling, misalignments between the sensors and actuators, and self-excited vibration. These issues were resolved by designing a suitable controller. There exist many linear methodologies to analyze, design and synthesize feedback controllers, but they cannot be applied directly to nonlinear systems. Feedback linearization is used to derive linear control systems from nonlinear dynamic systems. Linear control is a very well developed subject with many relevant and successful applications for systems whose behavior in the desired operating ranges can be accurately described by these linear approximations.

Regulation and tracking control of nonminimum phase systems are then investigated by various conventional control schemes like PID controller, Smith Predictive control and evolutionary algorithm like Grey Wolf Optimizer.

Next, the controller is designed to regulate and stabilize the nonlinear system. The controller is designed for SIMO (single-input multi-output) nonlinear system. It is quite challenging to control such system due to the fact that they have fewer actuators than degrees of freedom to control. They are under-actuated systems. The SIMO system considered here is the inverted pendulum system on cart which is a perfect benchmark problem for control engineering applications. The conventional controllers can be utilized for certain classes of cascaded under-actuated systems, more advanced methods are required to develop controllers for parallel systems, which are not in a cascade structure. The conventional control techniques like PID control, LQR control and intelligent control techniques like Fuzzy logic control are designed for controlling such a system. The SIMO system considered here is the inverted pendulum system on cart which is a benchmark problem in control system society.

The paradigms of intelligent control used to solve the nonlinear control problem in this thesis are the conventional methods, fuzzy logic systems and the evolutionary algorithms. The objective of every method is to enhance the system properties and to obtain the desired system requirements. The nonlinear systems are linearized when they are controlled via conventional methods and for other methods function approximation is used to estimate unknown nonlinear functions. The estimated nonlinear functions are then used in the controller design.

In the last few decades, intelligent control using fuzzy logic systems (FLS) and evolutionary algorithms 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.

Sensitivity and Robustness is the primary issue while designing the controller for non-linear systems. One of the performance objectives for controller design is to keep the error between the controlled output and the set-point as small as possible. The control of many non-linear, inherently unstable systems using conventional methods is both difficult to design and marginally satisfactory in implementation. The introduction of optimization techniques in control engineering that makes use of evolutionary computation and an implicit imprecision has incorporated to such systems with an objective to achieve higher optimality and satisfactory performance. Biologically inspired optimization technique like Grey Wolf Optimizer (GWO), and meta-heuristics techniques like Teaching Learning Based Optimization (TLBO) plays vital role for enhancing the performance of the controller parameters.

The contributions of this thesis are to design various control algorithms for three different classes of nonlinear systems: systems with actuator saturation, nonminimum phase systems with time delay and for unstable nonminimum phase systems.