CERTAIN INVESTIGATIONS ON MODEL BASED CONTROLLER DESIGN TO IMPROVE THE CLOSED LOOP PERFORMANCE OF INDUSTRIAL CONTROL SYSTEMS USING INTELLIGENT TECHNIQUES

Abstract

Control engineering is one of the cornerstones of industrial automation that has contributed more to the development of modern industrial society. Real world industrial processes are inherently nonlinear in nature over a wide range of operating conditions and most of them are multivariable in nature with complex interactions. Hence it demands sophisticated control strategies to meet the rigorous design specifications of nonlinear and multivariable control systems.

Majority of applications in industrial automation are still dominated by PID controllers and there have been a number of advances in conventional PID controllers in recent years. But there are some limits beyond which PID controllers can no longer guarantee the required control quality or bring about stable behaviour especially while controlling the processes with very high time constants, highly non-linear behaviour or significant interactions. Model based controllers provide the competitive edge needed to meet such challenges and ensure efficient operation and reliability of industrial control systems.

Model based controller incorporates knowledge of how the system dynamics change with the operating conditions. The main aim of this research is to design and analyse model-based controllers to improve the closed loop performance of industrial control systems using intelligent techniques. An essential prerequisite for designing model-based controllers is an accurate mathematical model. There are several nonlinear system identification techniques built on input-output representation, popularly known among them is artificial neural networks. Various applications were practically and successfully implemented in control design using classical fully connected neural networks. The structure of the neural model plays a significant role mainly to control complex systems.

This study focuses on neural networks-based system identification and model-based control design of multivariable system and nonlinear system. Nonlinear AutoRegressive eXogenous (NARX) is considered as the sensible choice for control aimed modelling. NARX is used as the approximation tool for the identification of

complex multivariable system and nonlinear system. NARX architecture significantly improved the quality of identification because of its dynamic feedback using past inputs and past outputs within a finite time interval.

One of the prevalent model based control scheme is Robustness setpoint Tracking Disturbance rejection Aggressiveness (RTDA) controller known for its elegant features. The controller has four expedient tuning parameters where the aggressiveness, robustness, setpoint tracking and disturbance rejection of the closed loop system can be easily improved. All the tuning parameters act independently without affecting each other and hence capable of solving tuning associated problems compared to conventional PID controller and Model Predictive Controller (MPC).

The main focus of this thesis is to propose the design of NARX predictive neural model based RTDA control and its implementation for nonlinear conical tank system and multivariable quadruple tank system. The complicated interactions, multivariable zeros, nonlinear dynamics, tuning associated problems, modelling errors, process uncertainties, load disturbances, chaos, and bifurcation are few of the control challenges on which the designed controller has to perform spectacularly well. The effectiveness of the proposed controller for conical tank system and quadruple tank system is verified using simulation. The simulation study on this controller proves its effectiveness as a justified elegant controller as same as the popular MPC.

An intelligent technique known as Particle Swarm Optimization (PSO) algorithm is also used in the controller design for optimizing the values of RTDA controller parameters to improve the closed loop performance.