ABSTRACT

Designing a proficient fuzzy logic system is governed by a number of design parameters which include: controller architecture, fuzzification method, membership function formulation, rule base, inference engine, and defuzzification method. Proposed research work focuses on the design of optimized membership function by utilizing statistical attribute of the system. As the notion of fuzzy logic is based on uncertainty, an idea of having an empirical formula to determine membership function defies with the generalized applicability of fuzzy logic system.

Optimization of membership function has always been a field of research in fuzzy logic systems; however, majority of literature emphases on optimization of the "mathematical function" (shape) of the membership function and not the "support" of fuzzy sets in a membership function. In view of this proposed optimization algorithm is focused on obtaining the optimizing support for a fuzzy membership function and not on its shape (mathematical function). The proposed algorithm utilizes "entropy function" and "standard deviation" to obtain the optimization objective function for previously characterized membership functions. These predefined sets are distributed uniformly over the fuzzy variable's universe of discourse. The support of these predefined sets is modified by using the standard deviation, thus forming a variable membership function. Entropy for these displaced sets is optimized to obtain maximum combined entropy using genetic algorithms.

As PID controller outperforms practically every controller for linear systems; the applicability of the proposed algorithm is tested on a class of non-linear systems. Industry standard PID controller is chosen with which the performance of proposed fuzzy controller will be compared. Comparison is carried between: (a) transient parameters, (b) steady-state parameters, and (c) error indices.

Real-time control of inverted pendulum has always been a benchmark non-linear control problem. The proposed algorithm is deployed pendulum swing

up control and controller performance is evaluated. The results obtained are compared with the PID control and fuzzy control (without optimization).

Cross-coupling of MIMO systems introduces a new paradigm of challenge for controller design. The conventional PID approach is to design non-interacting loops and thus design individual controllers for each loop. Twin rotor MIMO system offers a significant cross coupling and therefore is an ideal system to test the robustness of the proposed controller. Pitch and yaw angle controllers for TRMS system is designed without design of a non-interaction loop and performance is compared with static PID controller.

With an increase in non-linearity of the system the efficacy of PID controller begins to degrade unless PID is equipped with adaptive control algorithm. Magnetic levitation is a non-linear control problem which offers a high degree of non-linearity and demands adaptive or advanced control strategies. To check the efficacy of the optimized controller the performance of proposed controller is compared with static PID control.

The theoretical developments have been validated by testing with application to real prototype model systems mentioned earlier, available in the lab as well as with their simulation models for verification and comparison under various conditions.