

Literature Review of PID Controller based on Various Soft Computing Techniques

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Abstract: This paper profound the various soft computing techniques like fuzzy logic, genetic algorithm, ant colony optimization, particle swarm optimization used in controlling the parameters of PID Controller. Its widespread use and universal acceptability is allocated to its elementary operating algorithm, the relative ease with the controller effects can be adjusted, the broad range of applications where it has truly developed excellent control performances, and the familiarity with which it is deduced among researchers. In spite of its wide spread use, one of its short-comings is that there is no efficient tuning method for PID controller. Given this background, the main objective of this is to develop a tuning methodology that would be universally applicable to a range of well-liked process that occurs in the process control industry.

Keywords: Fuzzy Logic, Genetic Algorithm, Ant Colony Optimization, Particle Swarm Optimization.

I. Introduction:

PID (Proportional-Integral-derivative) tuners have been used for several decades in industries for process control applications. PID controller has been extensively applied in practical industry due to its engaging attributes such as simple architecture, facile design and parameter tuning without complicated computation. However, the PID controller usually requires some a priori manual retuning to make a Successful industrial application. To bypass this obstacle, an adaptive PID (APID) controller is proposed in this paper which is composed of a PID controller and a fuzzy compensator. Without needing introductory offline learning, the PID controller can automatically online tune the control gains located on the gradient descent method and the fuzzy compensator is designed to eliminate the effect of the approximation errors introduced by the PID controller upon the system stability in the Lyapunov sense. PID controllers are widely used as the preferred controller approach due to their design simplicity and its reliable operation. A simple PID structure consists of three terms which are K_p , K_i and K_d referring to Proportional, integration and derivative gains respectively. The parallel design of PID controller (after this refers as PID controller) sums the all the error signal, $e(t)$ after being multiplied by PID gains, K_p , K_i and K_d to produce the input signal, $u(t)$. The adjustment process of the values K_p , K_i and K_d is called 'tuning' or 'design' of PID controller. The tuning approaches can be detached into two groups which are the conventional and the alternative approaches. The conventional outlooks include the observed methods and the methodical methods which widely used by control designers. The possible approaches are restricted to methods that employ the stochastic process in the tuning rules.

Stochastic process mentions to one whose behaviour is non-deterministic, where any of its sub-system resolute by the process of deterministic action and a random behaviour. The PID control strategy is named after its three modifying terms, whose sum integrates the manipulated variable (MV). The proportional, integral, and derivative terms are computed to calculate the output of the PID controller. Representing $u(t)$ as the controller output, the final form of the PID algorithm is:

$$u(t) = MV(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d}{dt} e(t)$$

Where

K_p : Proportional gain, a tuning parameter

K_i : Integral gain, a tuning parameter

K_d : Derivative gain, a tuning parameter

e : Error = $SP - PV$

t : Time or instantaneous time (the present)

τ = Variable of integration; takes on values from time 0 to the present time t .

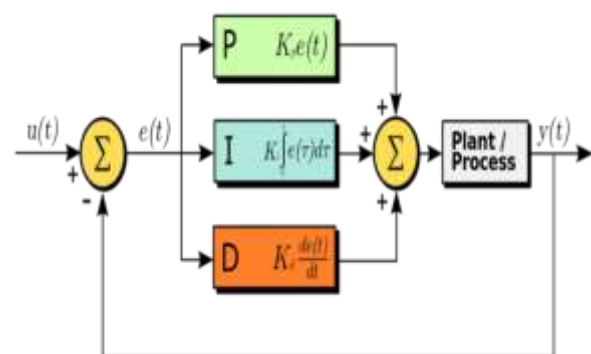


Fig. 1.1 Parallel architecture of PID controller

Table 1.1 Various Control Actions

Control Actions	Estimates	When to use
P	Present	Slow response systems, offset tolerant systems
I	Past	Too slow to be used often
D	Future	Not used alone because of high sensitivity and no set point
PI	Present & Future	Most widely used
PID	All	Most robust, can be noise sensitive, often used

Various combinations of P, I, & D can be used according to the requirements as shown in Table 1.1. There is various tuning strategies based on an open-loop step response. While they all follow the same basic idea, they differ in slightly in how they extract the model parameters from the recorded response, and also fluctuate marginally as to relate appropriate tuning constants to the model parameters. There are four different methods, the classic Ziegler-Nichols open loop test, the Cohen-Coon test, Internal Model Control (IMC) and Approximate M-constrained Integral Gain Optimization (AMIGO). Naturally if the response is not sigmoidal or 'S' shaped and exhibits overshoot, or an integrator, then this tuning method is not applicable.

II. Literature Review:

The paper [2] discussed the concept and design procedure of genetic algorithm as an optimization tool. Further, the paper reconnoiters the deep-rooted methodologies of the literature to realize the workability and applicability of GA for process control applications. The simulation result showed better optimization of hybrid genetic algorithm controllers than fuzzy standalone and conventional controllers.

The paper [3], aims at manually carrying through the optimization of the experimental way adopted for traditional PID controller parameters, an optimization method based on improved ant colony optimization for PID parameters of BP neural network presented. The results shown by numerical simulation that the optimization strategy on PID parameters has stronger pliability and adaptability and are further verified practicability and validity of proposed method.

The paper [4] described an efficient and fast tuning method based on modified genetic algorithm (MGA) structure to find

the optimal parameters of the proportional-integral-derivative (PID) controller so that the desired system specifications are contended. To demonstrate the effectiveness of presented method, the step responses of closed loop system were compared with that of GA. Simulation results indicate that the performance of the PID controlled system can be significantly improved by the MGA- based method.

The paper [5] offered the development of a fuzzy-neural-network (FNN) proportional-integral (PI)/proportional-derivative (PD)-like controller with online learning for speed trajectory tracking of a brushless drive system. The design implemented the innovative use of the extended Kalman filter (EKF) to train FNN structures as part of the PI-/PD-like fuzzy design. The FNN structure had two parallel FNN PI-/PD-like controllers, each with four internal layers. EKF trained each FNN by adjusting the weights and the membership function parameters. Thus, the recommended EKF-based architecture presented an alternative to control schemes appointed so far. The objective was to exchange the conventional PID controller with the proposed FNN PI-/PD-like controller with EKF learning mechanism. Assessments of the algorithm performances provided confirmation of improvement of the FNN PI-/PD-like controller over PID control. Experimental testing results disclosed that the proposed controller assimilates and robustly responds to a wide range of operating conditions in real time.

The paper [9] described an efficient and fast tuning method based on modified genetic algorithm (MGA) structure to catch the optimal parameters of the proportional-integral-derivative (PID) controller so that the anticipated system specifications were satisfied. To exhibit the effectiveness of presented method, the step responses of closed loop system were compared with that of GA. Simulation results indicated that the performance of the PID controlled system can be significantly improved by the MGA- based method.

A hybrid model [12] was designed by combining the genetic algorithm (GA), radial basis function neural network (RBF-NN) and Sugeno fuzzy logic to regulate the optimal parameters of a proportional-integral-derivative (PID) controller. The approach used the rule base of the Sugeno fuzzy system and fuzzy PID controller of the automatic voltage regulator (AVR) to progress the system sensitive response. The rule base was developed by proposing a feature mining for genetic neural fuzzy PID controller through integrating the GA with radial basis function neural network. The GNFPID controller was found to possess excellent features of easy implementation, stable convergence characteristic, good computational efficiency and high-quality solution. It was asserted that GNFPID was highly efficient and robust in refining the sensitive response of an AVR system.

K. Prem Kumar [13] described two different speed controllers i.e., fuzzy online gain tuned anti wind up Proportional Integral and Derivative (PID) controller and fuzzy PID oversees online ANFIS controller for the speed control of brushless dc motor had been proposed. In order to approve the effectiveness of the proposed controllers, the brushless dc motor was operated under constant load condition, varying load conditions and varying set speed conditions. The simulation results under MATLAB environment have pictured better performance with fuzzy PID managed online ANFIS controller under all running conditions of the drive.

In 2015, Lalit Chandra et al. [37] presented the controller gains were optimized using a more recent powerful evolutionary optimization technique called "Cuckoo Search". Investigations revealed that dynamic responses of the system with BES were better than without BES. The sensitivity analysis revealed that the optimum controller gains in presence of BES obtained at nominal conditions and at nominal parameter was robust and needed not be reset to uncertain change in system loading, inertia constant and location and magnitude of step load perturbation.

III. Conclusion:

This paper gives the literature analysis about soft computing techniques which are familiarized by different researchers. This review article is also offering the current status of tuning of PID controller system using soft computing techniques.

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