International Journal of Innovative
Computing, Information and Control
Volume 8, Number 1(A), January 2012
 ISSN 1349-4198
pp. 269–284

MULTI-OBJECTIVE OPTIMIZATION FOR PID CONTROLLER TUNING USING THE GLOBAL RANKING GENETIC ALGORITHM

Mohd Rahairi Rani, Hazlina Selamat, Hairi Zamzuri and Zuwairie Ibrahim

Centre for Artificial Intelligence and Robotics
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
81310 UTM Skudai, Johor, Malaysia
rahairi@yahoo.com; hazlina@fke.utm.my

Received August 2010; revised December 2010

Abstract. *Tuning of PID controller parameters for an optimized control performance is a multi-objective optimization problem. The problem becomes particularly difficult if the plant to be controlled is an unstable, nonlinear and under actuated plant. This paper proposes a modified genetic algorithm for the multi-objective optimization of PID controller parameters, called the Global Ranking Genetic Algorithm (GRGA). It combines two types of fitness assignment methods in the algorithm – the 'global ranking fitness assignment' method proposed in this paper and the dominance rank from the classical pareto fitness assignment method. The former is employed in the selection of parents and the latter is used in the elitism mechanism. In order to investigate the performance of the proposed algorithm, it is compared with the state of the art, Non-dominated Sorting Genetic Algorithm 2 (NSGA-II) using five ZDT series test functions. From the test problems analysis, the GRGA is observed to have better convergence property than the NSGA-II although it tends to lose its diversity of solutions in the earlier part of generation before recovering back when approaching the true pareto front. Then, the GRGA is applied to a highly difficult PID controller tuning problem, balancing a rotary inverted pendulum system. Results show that the GRGA has the capability to optimally tune the PID controllers based on the nonlinear model of the pendulum.*

Keywords: PID controllers, Controller auto-tuning, Genetic algorithm, Evolutionary algorithm, Multi-objective optimization, Inverted pendulum

1. Introduction.

Proportional-Integral-Derivative (PID) controller is one of the most popular controllers applied in industries. Simple in structure, reliable in operation and robust in performance, result in its popularity among control engineers [1]. However, a research reported that 80% of the PID-type controllers in industries are poorer or less optimally tuned, that 30% of the PID loops operate in manual mode and that 25% of the PID loops actually under default factory setting [2]. Over the years, many methods have been proposed for the tuning of the PID controllers, both in the deterministic or stochastic frameworks [2,3]. Tuning of the PID controllers is not a straightforward problem especially when the plants to be controlled are nonlinear and unstable. A rotary inverted pendulum, for example, has an unstable, nonlinear and chaotic motion of its arm and pendulum, and a PID controller can be very difficult to tune using the conventional deterministic PID tuning methods.

Tuning the PID controller coefficients can be considered as a parameter optimization process to achieve a good system response. In time domain specification, a good system response is a response that has a minimum rise time, settling time, overshoot and steady state error. Therefore, the tuning process of the controller has multiple objectives to be