UNIVERSITI PUTRA MALAYSIA

PROPORTIONAL-INTEGRAL CONTROL OPTIMIZATION USING IMPERIALIST COMPETITIVE ALGORITHM

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PROPORTIONAL-INTEGRAL CONTROL OPTIMIZATION USING IMPERIALIST COMPETITIVE ALGORITHM

By

MOHAMMADSOROUSH SOHEILIRAD

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Master of Science

June 2012

Dedicated

To

My dearest parents

For their extensive love

and

Their endless care

Abstract of thesis presented to the senate of University Putra Malaysia in fulfilment of the requirement of the degree of Master of Science

PROPORTIONAL - INTEGRAL CONTROL OPTIMIZATION USING IMPERIALIST COMPETITIVE ALGORTHM

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June 2012

Chairman: Maryam Binti Mohd. Isa, PhD

Faculty: Engineering

PID controller is well-known for its employment in industrial automation. The applications of PID controller span from small industry to high technology industry. PID controller can be tuned using classical tuning techniques such as Iterative Methods, Direct Synthesis and Tuning Rules. However, empirical studies have found that these conventional tuning methods result in an unsatisfactory control performance for the nonlinear systems and most of control practitioners prefer to tune most nonlinear systems using trial and error tuning because of this reason. A suitable tuning technique is needed for a wide range of control loops that can tune the PID controller with minimum cost, the highest of reliability and with optimum solution.

In this dissertation, an attempt has been made to design and implement the PID Controllers by employing the Imperialist Competitive Algorithm (ICA) technique as well as the Genetic Algorithm (GA) and the Particle Swarm Optimization (PSO) algorithm, for a selected plant. ICA is one of the newest computational algorithms that emulate the process of imperialistic competition. The system selected for modeling and simulation is a laboratory size continuous stirred tank heater (CSTH) in series with a Connecting Tank and a circulation pump.

The results from these three methods have been compared to each other based on the performance information. This comparison shows that the ICA characteristic can facilitate faster convergence to the optimal solution after 25 iterations, whereas, the GA and PSO can converge after 92 and 43 iterations respectively for the level system. Furthermore, the ICA shows the minimum cost (performance index) which is measured by the Integral of Absolute Error (IAE), in both systems compared to the GA and the PSO. The IAE from the ICA in the level system is 7.9, from the GA is 8.2 and from the PSO is 8. Moreover, the IAE values for the temperature system are 323432, 324762 and 396253 which are from ICA, PSO and GA respectively. These values show an acceptable reduction especially in the temperature system. This implies that the ICA can be used to tune the PI control loops for a continuous stirred tank heater with a minimum cost and better response in compare with the GA and the PSO.

Sari tesis dipersembahkan kepada senat bagi University Putra Malaysia dalam perlaksanaan syarat-syarat darjah bagi Master Sains

BERKADAR- KAMIRAN PENGOPTIMUMAN KAWALAN MENGGUNAKAN ALGORITMA PERSAINGAN IMPERIALIS

Oleh

MOHAMMADSOROUSH SOHEILIRAD

Jun 2012

Pengerusi: Maryam Binti Mohd. Isa, PhD

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Pengawal PID terkenal untuk aplikasi dalam industri automasi. Aplikasi pengawal PID adalah dari industri kecil kepada industri berteknologi tinggi. PID pengawal boleh ditala menggunakan teknik penalaan klasik seperti lelaran Kaedah, Sintesis Langsung dan Peraturan Tuning. Walau bagaimanapun, kajian empirikal telah mendapati bahawa kaedah penalaan konvensional mengakibatkan prestasi kawalan yang tidak memuaskan bagi sistem tak lelurus dan kebanyakan pengamal kawalan lebih semar untuk menala sistem yang paling tak linear menggunakan percubaan dan penalaan ralat. Satu teknik penalaan yang sesuai diperlukan untuk pelbagai gelung kawalan yang boleh menala pengawal PID dengan kos minimum, tertinggi kebolehpercayaan dan dengan penyelesaian yang optimum.

Dalam disertasi ini, suatu percubaan telah dibuat untuk membentuk dan melaksanakan Pengawal PID dengan menggunakan Algoritma Imperialis Bersaing (ICA) teknik serta Algoritma Genetik (GA), dan yang Particle Swarm Optimization (PSO) algoritma, bagi tumbuhan dipilih. ICA merupakan salah satu algoritma pengiraan terbaru yang mencontohi proses persaingan imperialis. Sistem yang dipilih untuk pemodelan dan simulasi adalah saiz makmal berterusan dikacau tangki pemanas (CSTH) dalam siri dengan Tank 1 Menyambung dan pam peredaran.

Hasil daripada ketiga-tiga kaedah telah berbanding antara satu sama lain berdasarkan maklumat prestasi. Perbandingan ini menunjukkan bahawa ciri-ciri ICA boleh memudahkan lebih cepat penumpuan kepada penyelesaian optimum selepas 25 lelaran, manakala, GA dan PSO boleh berkumpul selepas 92 dan 43 lelaran masing-masing untuk sistem peringkat.Tambahan pula, ICA menunjukkan kos minimum (indeks prestasi) yang diukur oleh Integral Ralat mutlak (IAE), dalam kedua-dua sistem berbanding GA dan PSO. IAE dari ICA dalam sistem tahap ialah 7.9, dari GA adalah 8.2 dan dari PSO ialah 8.Tambahan pula, nilai IAE untuk sistem suhu adalah 323432, 324762 dan 396253 yang dari ICA, PSO dan GA masing-masing. Nilai-nilai ini menunjukkan pengurangan boleh diterima terutama dalam sistem suhu. Ini membayangkan bahawa ICA boleh digunakan untuk menala gelung kawalan PI untuk pemanas tangki terus dikacau dengan kos yang minimum dan tindak balas yang lebih baik berbanding dengan GA dan PSO.

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I certify that an Examination Committee has met on **15 June 2012** to conduct the final examination of Mohammadsoroush Soheilirad on his Master of Science thesis entitled "Proportional-Integral Control Optimization Using Imperialist Competitive Algorithm "in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently submitted for any other degree at University Putra Malaysia or other institutions.

MOHAMMADSOROUSH SOHEILIRAD

Date: 15/June/ 2012

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