UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZED PID CONTROLLER PARAMETERS TUNING USING TEACHING LEARNING BASED OPTIMIZATION ALGORITHM FOR CONTROLLING ACTUATOR POSITION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

By

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Penggerak adalah salah satu sistem yang paling sering digunakan dalam industri dan peralatan rumah. Banyak industri menggunakannya kerana ia membantu mereka membuat kerja mereka lebih mudah. Sistem penggerak digunakan dalam robot dan juga digunakan untuk mengangkat tan beban. Oleh itu, pengendalian dan pengendalian penggerak memerlukan pengetahuan khusus dan pengawal yang sesuai. Projek ini membentangkan kajian penalaan pengawal Derivatif Integral *Proportional dalam mensimulasikan parameter Derivatif Integral Proportional untuk simulasi. Pengawal Derivatif Integral Proportional yang direka dengan pengoptimuman dengan algoritma Pengoptimuman Berdasarkan Pengajaran Pembelajaran dicadangkan. Projek ini digunakan oleh perisian MATLAB Simulink dalam menunjukkan output projek ini. Parameter Derivatif Integral yang seimbang dan kecergasan kecergasan dan nilai kecergasan guru dicatatkan. Ralat persegi panjang telah digunakan untuk simulasi ini. Difahamkan bahawa pengawal Derivative Integral yang disesuaikan dengan Pengajaran Pengoptimuman Berdasarkan Pengajaran pada kertas ini memberikan hasil memuaskan kerana keluarannya agak stabil.*

ABSTRACT

An actuator is one of the most commonly used system in industries and home appliances. Many industries used them because it helps them to make their work easier. The actuator system is used in robot and also used to lift a tan of a load. Therefore, handling and controlling the actuator need a specific knowledge and a suitable controller. This project presents the study of tuning a Proportional Integral Derivative controller in tuning Proportional Integral Derivative parameters for simulation. A Proportional Integral Derivative controller designed by optimization with the Teaching Learning Based Optimization algorithm is proposed. This project utilized by MATLAB Simulink software in showing the outputs of this project. Proportional Integral Derivative parameters and best fitness and teacher fitness value are recorded. Sum Square Error was used for this simulation. It was observed that the tuned Proportional Integral Derivative controller by Teaching Learning Based Optimization on this paper give a satisfying result as the output is quite stable.

DEDICATION

To my beloved parents Abdullah Bin Awang and Jamilah Binti Abdullah thanks for your supportive moral support throughout this project. I also would like to thank my supervisor, Amar Faiz Bin Zainal Abidin for his guidance and help. Besides that, I want to thanks to all my lecturers and friends that help me in completing this project from the beginning to the end.

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LIST OF ABBREVIATIONS AND NOMENCLATURE

DNN	-	Dynamic Neural Network
EHA	-	Electro-hydraulic Actuator
GD	-	Gradient Descent
HSA	-	Harmonic Search Algorithm
IAE	-	Integral of the absolute value of the error
ITAE	-	An absolute value of the error
ITASE	-	An absolute value of the squared of the error
Kd	-	Derivative gain
Ki	-	Integral gain
Kp	-	Proportional gain
Ni	-	Number of Iteration
Ns	-	Number of Students
PEA	-	Pneumatic Electro Actuator
PID	-	Proportional Integral Derivative
PSO	-	Particle Swarm Optimization
PWM	-	Pulse Width Modulation
SSE	-	Sum Square Error
tf	-	Teacher fitness
TLBO	-	Teaching Learning Based Optimization
ZN	-	Ziegler-Nichols

CHAPTER 1

INTRODUCTION

1.0 Background Study

According to Hanbay (2018), actuators made the life of society became easier. Actuators are used in many different industries around the world and also are used at home for most peoples. They come in the form of different sizes, types, and uses. Without the assistance from them, most of difficult will become impossible to do. Without realizing most people used actuator in their daily life. For example, people used a car to travel from one place to another is the most basic application that uses actuator in its system. Another example of actuator used in daily life is most of the electrical appliances at the kitchen uses actuator.

An actuator is one of the main components in moving and controlling a system, as for example piezoelectric actuator, hydraulic cylinder, a pneumatic actuator, screw jack etc. according to Physik (2018), actuators can be defined as a mechanical or electro-mechanical device which its movements can be controlled and sometimes its movements are limited. It can be manipulated with many ways such as electrically, manually or by using fluids. Actuators commonly move in bidirectional which is rotation and linear. In today era, many companies used actuator in their system to move a robot for example. They used this system because it makes their work easier for example in lifting a 100-tan load.

Basically, an actuator is hard to control without a controller. A few controllers who can be easily found in industries nowadays used proportional integral derivative (PID)

controller, fuzzy logic controller and so on. To support those controllers, some companies used optimization method to support controller to get a better result and product for their company to evolve and gain more profit. Teaching-Learning-Based Optimization (TLBO) Algorithm is chosen as an optimization algorithm method. TLBO will determine the value for Sum Square Error (SSE).

1.1 Problem Statement

There are a few problems happen during this project. Firstly, it is difficult to tune PID parameters by using traditional way. The traditional way which is classical PID controller uses the classic method to tune PID parameters. It took a long time to tune those parameters than another method. So, the optimization method was used to tune PID parameters. Optimization method was used because it had various type of optimization to tune PID parameters and it is fast to tune the parameters.

Then, according to Khairuddin Osman (2013), optimization method that he used which is Harmony Search Algorithm (HSA) needs to be improved to get a more reliable and adaptive for more case study implementation. From his paper which is Harmony Search Algorithm (HSA) Optimization in Tuning Proportional-Integral-Derivative (PID) Controller for Pneumatic Cylinder, it can be seen that the actual and desired output value is almost the same. Hence to try imitates and improve in controlling actuator position, another optimization method to tune PID parameters is introduced in this paper.

1.2 Objective

The objectives of this project are listed as follows:

i. To simulate actuator model based on Khairuddin Osman (2013) using PID controller

ii. To tune PID controller using teaching-based-learning-optimization (TLBO) algorithm some square error

iii. To study the relationship between the number of iteration (Ni) and the number of students (Ns)

iv. To compare the result of this project with Khairuddin Osman (2013)

1.3 Scope of Work

The model actuator used by Khairuddin Osman (2013) used both hardware and simulation actuator. He used those two as he wants to compare the result for both simulation and hardware. In this paper, the only simulation result is presented without hardware. This is because the output for Khairuddin's paper is out of value for real time. its value is too big when uses in real time. So, to avoid from getting unrealistic and unreliable value, only simulation result is presented.

PID controller in Khairuddin Osman (2013) paper, he compared to PID controller which is a classic PID controller and cascade PID controller. On his paper, it's obvious that cascade PID controller is more efficient than classic PID control. So, this paper only uses a classic PID controller is used. This controller is chosen because to prove that classical PID can also eliminate overshoot as cascade PID controller.

Harmony Search Algorithm (HSA) was used in his paper. There are a few improvements can be made the system he implemented in his journal. Although most of the output obtained is good, but there is still room for improvement in tuning PID parameters. To compare the result from previous research, teaching-learning-based optimization (TLBO) algorithm is presented in this paper. The reason for choosing this algorithm because this

algorithm is parameter free. This method works on the effect of the influence of a teacher on learners.

Sum squared error (SSE) is one of the examples of error that are mostly used in analyzing the optimization method. This error is chosen to compare the value of SSE error in this paper with the previous paper. SSE also is chosen as it produces more accurate error's value than another type of error like Absolute Mean Error (AME).

This project has its own iteration, best fitness, and best solution. This project utilizes 500 iterations. Iteration is a repeating process of a system. From iterations value, it can be said that this project will have 500 cycles to get 100 data of TLBO. 500 iterations will have the accurate value in comparison with 100 iterations. Best fitness and best solution are data which have the best value among 100 data. The best value is determined by the lowest value of best fitness or teacher fitness, tf.

1.4 Significant of Project

According to previous work that has been conducted by researchers, a lot of controllers has been designed to find the best performance of actuators. Most of the controllers are designed to control the pneumatic and hydraulic actuator. These actuators are designed because of both of them capable of supporting more load, force, control, ruggedness, speed and duty cycle. However, it has not been solved as expected results.

Since most of the industries used PID controller in their company, it leads to the main reason why this project used this kind of controller. This project uses a simple PID controller for an actuator system to see the effectiveness of this system. Typically, due to the basic structure and vigorous exhibitions in a wide range of working conditions.

Nevertheless, some difficulties are present during obtaining optimal value for PID parameters. Hence, many researchers started to use an optimization method as this method able to find accurate and acceptable values. Consequently, Teaching Learning Based Optimization (TLBO) is chosen as the optimization method. This optimization method is chosen as it is a simple but effective tuning method for PID controller. By applying a simple tuning method, it can give a huge benefit to industry thus improve control system knowledge significantly and suitable for industrial needs.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

A literature review is a shape of text that intent to check the critical points of current awareness for any related information so as to enhance the understanding of the concept and certain terminology which is used in the project.

2.1 Body of Knowledge

2.1.1 PID controller

This project which is to tune PID parameters by using optimization method. An Actuator is chosen as an object to be controlled by a PID controller. An actuator can be described as a mover for moving or actuating an object. An actuator can also be as a motion which means it can do various kind of function such as open, close, upward, downward, push, pull, block and ejecting an object. Those types of works are mostly done by an actuator in most of daily used application and also in industries such as a robot to make work faster. There are two types of an actuator which is the linear and rotary actuator. A linear actuator is an actuator that can move forward and backward on a set linear rotary backward while rotary actuator moves in a circular direction for a non-limited period in the same direction.

There are four types of the actuator which are the hydraulic, pneumatic, electrical and mechanical actuator. The hydraulic actuator used hydraulic power to facilitate mechanical operations, a pneumatic actuator moves by applying compressed and high-pressure air into linear or rotary movement, electrical actuator used electrical power to actuate equipment and