PID OFFLINE TUNING USING GRAVITATIONAL SEARCH ALGORITHM

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Thanks to ALLAH S.W.T and his Prophet Muhammad S.A.W.

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ABSTRACT

PID controller is a common controller which is applied for many applications around the world. The simple structure and less effort of tuning make this controller being chosen in industrial and many research areas. The PID controller parameters usually tune heuristically to obtain the required output performance. This method has no systematic way of tuning procedure thus make the controller parameters tuning consuming a lot of time and effort. This problem will be more complicated when the system is dynamic and the performance of output response is the priority. With motivation of this problem, the Gravitational Search Algorithm (GSA) can be developed to make the process of PID controller tuning can be more easily and has systematic procedure of tuning method.

ABSTRAK

Pengawal PID banyak digunakan untuk aplikasi di seluruh dunia. Strukturnya yang mudah dan kurang usaha penalaan membuatkan pengawal ini banyak dipilih dalam bidang penyelidikan dan perindustrian. Parameter pengawal PID biasanya ditala secara heuristic untuk mendapatkan prestasi keluaran yang dikehendaki. Kaedah ini tidak mempunyai cara prosedur penalaan yang sistematik, membuatkan penalaan parameter pengawal mengambil banyak masa dan usaha. Masalah ini akan menjadi lebih rumit apabila sistem dinamik dan prestasi sambutan output menjadi keutamaan. Sehubungan dengan masalah ini, Algoritma Pencarian Graviti (GSA) boleh dibangunkan untuk membuatkan proses penalaan pengawal PID menjadi lebih mudah dan mempunyai prosedur kaedah penalaan yang lebih sistematik.

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LIST OF ABBREVIATIONS

PID	-	Proportional Integral Derivative
PD	-	Proportional Derivative
GSA	-	Gravitational Search Algorithm
PSO	-	Particle Swarm Optimization
MOPSO	-	Multi Objective Particle Swarm Optimization
LWS	-	Linear Weight Summation

LIST OF SYMBOLS

SSE	-	Steady State Error
OS	-	Overshoot
Ts	-	Settling Time
θ_{max}	-	Maximum Angle of Payload Oscillation
T	-	Period of 1 Cycle Oscillation
P	-	Proportional
I	-	Integral
D	-	Derivative
K_P	-	Parameter of Proportional
K_I	-	Parameter of Integral
K_D	-	Parameter of Derivative
$\boldsymbol{\omega}$	-	Initial Weight
$\boldsymbol{w_{SSE}}$	-	Weight for Steady State Error
$\boldsymbol{w_{OS}}$	-	Weight for Overshoot
$\boldsymbol{w_{Ts}}$	-	Weight for Settling Time
V	-	Input Voltage
m_1	-	Payload Mass
m_2	-	Trolley Mass
l	-	Cable Length
x	-	Horizontal Position of Trolley
θ	-	Payload Oscillation
T	-	Torque
F	-	Force

g	-	Gravitational
B	-	Damping Coefficient
R	-	Resistance
K_T	-	Torque Constant
K_E	-	Electric Constant
r_P	-	Radius of Pulley
z	-	Gear Ratio

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, there has been lot of efforts in developing algorithms based on the behaviors of natural phenomena. Various heuristic optimizations for example Harmony Search Algorithm (HSA), Artificial Bee Colony Algorithm (ABC), Firefly Algorithm (FA), Genetic Algorithm (GA), Particle Swarm Optimization (PSO) etc. methods have been proposed to solve variety of complex computational problems. These algorithms are very useful especially in terms of solving such as optimization problem in control engineering. Many researcher in many different areas are progressively analyzed these algorithms to solve different optimization problems. Some algorithms give a better solution for some particular problems than others because there is no specific algorithm to achieve the best solution for all optimization problems [1]. Hence, a new optimization algorithm called Gravitational Search Algorithm (GSA) have been proposed and applied to PID offline controller. The results show that performance of the proposed approach will be analyzed and compared with other optimization algorithms.

1.2 Overview of Project

Gravitational Search Algorithm (GSA) is a new optimization algorithm based on the law of gravity. This algorithm is based on the Newtonian gravity: ‘‘Every particle in the universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them” [2].

In this project, gantry crane system is being selected as a test bed model and GSA is implemented in find best optimal parameter for the controller. Gantry crane is a transporter system that widely used to transfer very heavy loads from one to another location. It supported by two or more legs and trolley. Crane operator will seat inside the trolley and responsibility to control and move the trolley with the payload hanged via cable hook which is directly connected to the trolley. The trolley will move along the horizontal rail until reach to the desired location [3].

There are two important roles to be considered in this test bed model which are position of trolley and payload swing angle. Trolley should move as fast as possible while payload should not give huge impact on the swing angle that can cause accident and harm people surroundings [4]. In order to control both of it, PID for position control and PD for anti-sway control are needed [5].

1.3 Problem Statement

i. PID controller parameter tuning is a constraint for optimum condition value. Finding the optimal value for PID controller parameter is significantly contributed to the advancement of control system knowledge and fulfills with industrial needs.

ii. A variety of efforts have been made in order to tune PID controller parameters for the best systems performance but still there is no optimal solution. In this work a tuning method for PID controller parameters will be presented to improve the performance for the gantry system. The GSA method which design based on computational artificial intelligence is believed can provide a better solution for this optimization problem.

1.4 Significant of Project

i. This project focuses on using the PID controller to improve the stability and performances of a control system.

ii. There are some difficulties in finding the optimal value of PID parameters. Recently, meta-heuristic global optimization algorithms become a popular choice for solving complex and intricate problems that contribute difficulties to solve by traditional methods. Therefore, Gravitational Search Algorithm (GSA) is chosen and implemented to tune PID parameter controller.

1.5 Objectives of Project

There are three objectives need to be achieved for this project.

- To obtain optimal PID controller gains for a gantry crane system using GSA.
- To verify the performance of the gantry crane in terms of position displacement and payload oscillation.
- To compare the result with other optimization method.

1.6 Scopes of Project

There are three scopes of work focused in this study area:

- Use MATLAB and Simulink in writing GSA code and for simulation analysis.
- Gantry crane control system is used as the test bed for the algorithm.
- Apply GSA method in finding the optimal PID gains of gantry crane system.

1.7 Methodology of Project

In term of methodology, it can be summarized as in Figure 1.1

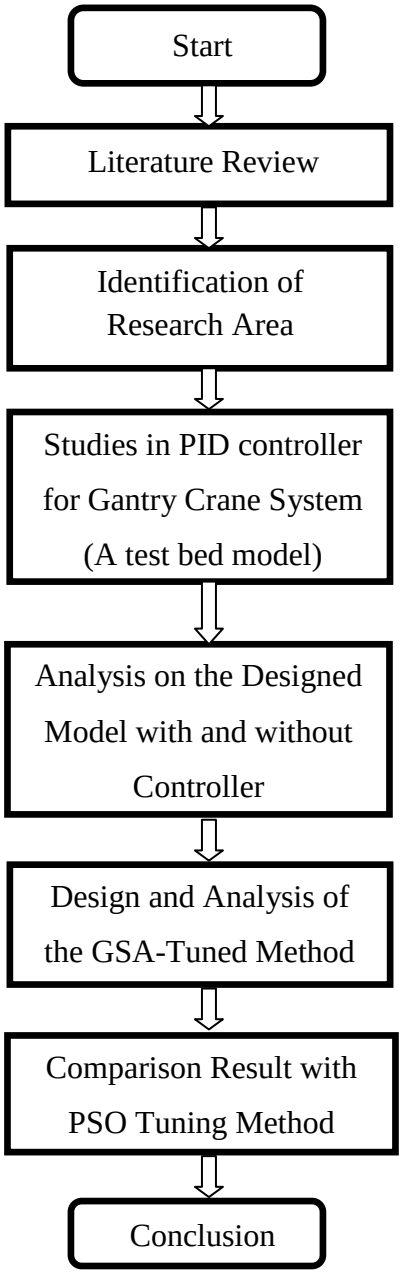

Figure 1.1: Methodology

1.8 Outline of Project Report

This section presents the outlines of the project report. This report is organized into five chapters and each of these chapters is generally explained.

Chapter 1 gives a brief introduction regarding on implementation of Gravitational Search Algorithm (GSA) to tune PID parameter controller. Problem statement, objectives, and significant of the project work will be stated and listed clearly.

Chapter 2 discusses literature review on Gravitational Search Algorithm (GSA). The development of optimization approach for the gantry crane system is reviewed based on previous researcher's findings.

Chapter 3 discusses characteristic of PID controller and gantry crane system model and mathematical expression used in this project.

Chapter 4 consists of two phases of work. The first phase involves analysis of gantry crane model without PID controller. The second phase involves analysis with PID controller and it will be tuned by using GSA methods. At the end of this chapter, results will be compared with PSO in order to identify the best technique tuning method.

Chapter 5 contains conclusion regarding on the whole work and recommendation for the future works.

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