PARTICLE SWARM OPTIMIZATION (PSO) APPROACH TO OPTIMIZE GPC CONTROLLER FOR PNEUMATIC ACTUATOR SYSTEM

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Specially dedicated to my beloved wife for her support and caring,

my family for their encouragement and blessings,

and my new born baby, aqeefmuaddib

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ABSTRACT

Particle Swarm Optimization (PSO) is a heuristic global optimization method and also an optimization algorithm, which is based on swarm intelligence. It comes from the research on the bird and fish flock movement behavior. The algorithm is widely used and rapidly developed because of its easy implementation and few particles required to be tuned. In this project, one of the most popular Model Predictive Control namely Generalized Predictive Controller will be optimized and tuned by using PSO. The performance of GPC controller is optimized and evaluated by using PSO and Binary Particle Swarm Optimization (BPSO) is compared. These two (2) techniques are used as controller parameter setting to monitor the position of Pneumatic Actuator System. Result will be presented in simulation and real-time approach. MATLAB Simulink is used as the platform to obtain the result and a DAQ (Data Acquisition) card is used as the interface for real time experiment.

ABSTRAK

*‘Particle Swarm Optimization (PSO)’*merupakansuatukaedahpengoptimuman global heuristik yang manaianyaberdasarkancariankelompokkawanankecerdikandalammendapatkanhasil yang terbaik.Kaedahiniterhasildariproses penyelidikanterhadapkelakuanpergerakankelompokkawananburungdanikan. Pelbagaikaedahtelahdigunakanolehparapenyeldikuntukmemudahkanpenggunaan proses pengoptimumaninitermasukpengubahsuaianbeberapa parameter tertentu.Melaluipelbagaikajiandanpengubahsuaianini, algorithm initelahdigunakansecarameluasdantelahberkembangdenganbegitupantasdanpesat. Melaluiprojekini, salahsatu*‘controller’*dari*‘Model Predictive Control’* yang sangat popular iaitu*‘Generalised Predictive Controller (GPC)’*akandioptimumkandenganmenggunakan PSO. Prestasidankeupayaanpengawal GPC yang dioptimumkandenganmenggunakan algorithm PSO akandibandingkandenganmenggunakan algorithm *‘Binary Particle Swarm Optimization (BPSO)’*. Kedua-duateknikpengoptimumaniniakandiujipadapengawal GPC dalammemantaupergerakanjarak ‘Pneumatic Actuator System’. Pendekatansecarasimulasidaneksperimenakandigunakanuntukmendapatkankeputusanujikaji. Perisian MATLAB Simulink dankad*‘DAQ (Data Acquisition)’*adalahsebagaiperantarauntukmendapatkankeputusanujikajiini.

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BPSO	-	Binary Particle Swarm Optimization
CARIMA	-	Controlled AutoregressiveIntegrated Moving Average
DAQ	-	Data Acquisition
DMC	-	Dynamic Matrix Control
FOPDT	-	First Order Model Plus Dead Time
GPC	-	Generalized Predictive Control
PAS	-	Pneumatic Actuator System
PASS	-	PneumaticActuatorSeating System
PID	-	Proportional-Integral-Derivative
PSO	-	Particle Swarm Optimization
PSoC	-	ProgrammableSystem on a Chip
SMC	-	Sliding Mode Control
SISO	-	Single In Single Out
TSVQ	-	Tree-Structured Vector Quantizes

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CHAPTER 1

INTRODUCTION

1.1 Overview

Over the past 40 years, digital control of industrial processes has changed from being the exception to the commonplace.Each succeeding year sees an increase in the range of applications and each advance in hardware design widens the potential application areas. Computers now form an integral part of most real-time control systems; such computers are generally referred to as embedded real-time computers and an understanding of how to design and build systems containing embedded computers is an essential requirement for a systems engineer.

The knowledge required covers both hardware and software design and construction, and of the two the software engineering is the most difficult and least understood. The difficulties of specifying, designing and building real-time software and also programming the algorithm needs significant effort from engineers and control practitioners to try and find simple way to solve the problems. Other issues in real-time such as rapid testing, nonlinearity and computational problem have led researchers in recent years to do intensive work on development methodologies to enhance control in real-time.

Therefore software such as MATLAB, LabVIEW, G2 and other simulation software would reduce the effort for implementation especially in algorithm to imply.

1.2 Problem Statement

Pneumatic actuator plays a major rule in today's world of driving element that extensively used in computerised robotics and automation. Due to their special attributes, pneumatic actuators have become alternate actuator in automated material handling task.

Pneumatic actuators are highly nonlinear characteristics and uncertainties make it difficult to achieve high performance.

Many modelling and control strategies that has been proposed by various researches such as Proportional-Integral-Derivative (PID) controller, Sliding Mode Control (SMC) Controller and Adaptive Controller.

Some of these controllers caused a slower performance at higher frequencies and chattering effect (SMC) and overshoot increased as time increased (PID).

Hence, this project will further improving the performance of existing pneumatic actuator system by applying Particle Swarm Optimization (PSO) technique in finding optimal controller parameters.

1.3 Objectives

The objectives of the project are as followings:-

- To optimize the Generalized Predictive Controller (GPC) using Particle Swarm Optimization (PSO)
- To conduct real time position control with the Pneumatic actuator System
- To validate the results obtained from simulation with the experimental data

1.4 Scope of the Project

In accomplishing this project, the scope of the work has been limited into a few parts which are:

i. Use the previously obtained transfer function for position control

ii. Simulation process using PSO to optimize parameters of the GPC controller

iii. Comparison and validation of simulation result will conducted with existing experimental setup

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