UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PARAMETER TUNING FOR PROPORTIONAL-INTEGRAL-DERIVATIVE CONTROLLER IN GANTRY CRANE SYSTEM USING SIMULATED KALMAN FILTER ALGORITHM

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

by

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This report is submitted to Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Industrial Electronic) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Kren adalah mesin yang mengangkat, menurunkan dan menggerakkan secara mendatar beban berat. Hampir setiap jenis industri yang digunakan untuk menyimpan beban berat atau industri import-eksport akan menggunakan kren untuk memindahkan beban berat dari tempat lain ke tempat lain. Kren gantri adalah salah satu daripada pelbagai jenis kren yang terdiri daripada mekanisme mengangkat, mekanisme tali mengangkat dan mekanisme perjalanan kren. Kren ini biasanya digunakan dalam galangan kapal dan meter simpanan besi. Pada masa kini, kerana semua perkara perlu dilakukan dengan lebih pantas, mekanisme kren gantri perlu ditingkatkan untuk menjadikan pergerakan troli kren gantri bergerak lebih cepat tetapi dengan kurang ayunan beban, jadi kerosakan atau terjatuh beban tidak berlaku. Kajian ini bertujuan untuk menaik taraf sistem kren gantry dengan melaksanakan kaedah PID kepada pengawal dan menetapkan parameter dengan menggunakan algoritma Penapis Simulasi Kalman. Dalam kajian ini, kecergasan terbaik dilakukan dengan memanipulasi nilai ejen dan algoritma lelaran. Kajian ini memberikan kelebihan kepada banyak industri lain untuk memperbaiki sistem mereka.

ABSTRACT

A crane is a machine that lifts, lowers and horizontally moves a heavy load. Almost every types of industries that used to storage heavy load or import-export industry used a crane to move a heavy load from other place to another place. A gantry crane is one of the various types of crane that consist lifting mechanism, hoist travelling mechanism and the crane travelling mechanism. This crane usually uses in shipyard and steel storage yards. Nowadays, because of all things need to be done faster, the mechanism of the gantry crane needs to upgrade to make the movement of the gantry cranes trolley move faster but less oscillation of the payload, so the load damage or drop did not occur. This study aims to upgrade the system of the gantry crane by implement PID method to the controller and tuning the parameter by using Simulated Kalman Filter algorithm. In this study, the best fitness was carried out by manipulated the value of agent and iteration of algorithm. This study give advantage to many others industrial to improve their system.

DEDICATIONS

To my beloved parents and friends.

ACKNOWLEDGMENT

In the name of Allah, the Compassionate, the Merciful, Praise be to Allah, Lord of the Universe, and Peace and Prayers be upon His Prophet and Messenger. With Grace and Blessing from Allah, I am Rafida Binti Bahari from Faculty of Electrical and Electronic Engineering Technology have succeeded in completing my final year project together with this thesis. First and foremost, I would like to thank to Allah S.W.T, because of His willing and Blessing, I have succeeded in complementing this project. High appreciate to my supportive project supervisor, Mr. Amar Faiz Bin Zainal Abidin for his guidance during performing this project.

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ACO	-	Ant Colony Optimization
GA	-	Genetic Algorithm
GCS	-	Gantry Crane System
K_P	-	Gain proportional
K_i	-	Gain Integral
K_d	-	Gain Derivative
OS	-	Overshoot
PID	-	Proportional Integral Derivative
SKF	-	Simulated Kalman Filter
SSE	-	Steady State Error
TLBO	-	Teaching Learning Based Optimization
Ts	-	Time settling

CHAPTER 1

INTRODUCTION

1.1 Overview

Gantry crane is one of heavy machinery transporter that commonly used in factory, port, warehouse where heavy load needs to be moved. A crane has been used for a long time to move a load from one location to another. In general, crane is a machine used for lifting and lowering a load vertically and moving it horizontally with-it hoisting mechanism. Crane has varieties of types like automatic crane, gantry crane, cantilever gantry crane and overhead crane (Bolger, Harrington, Hill, & Mango, 2016).

The interconnection of trolley movement and payload oscillation has an impact that needs to be considers. Once the trolley moved with desired position with high speed, this will bring undesirable's payload oscillation. This common unescapable load swing causes an efficiency drop, load damages, and even accidents. Therefore, in order to avoid it happen, a control mechanism is required for position of the trolley and the oscillation of the payload.

There are several types of controller to control the gantry crane was proposed. One of the most common used in the industry controller was Proportional-integral-Derivative (PID). In order to control the mechanism using PID, an optimal parameter was used to tuning the PID controller so the best parameter for the system can be used. In this system Simulated Kalman Filter (SKF) algorithm will be used.

1.2 Problem Statement

A crane has been used to move load from one location to another location. For this lifting performance, accurate and efficient equipment are required. In other word, when the load moves, the crane must be controlled so that the load reaches the location needed with less or without swinging.

The main problem in the nonlinear gantry crane is the fact that the interconnection of the trolley movement and payload oscillation that make the effect of the load. Where when the movement of the trolley was too fast to desired position the oscillation of the payload will increase and can make the load damage or drop (Jaafar et al. , 2017).

Therefore, PID controller was applied to the gantry crane system to control the movement of the trolley and the oscillation of the payload. In addition, in order to get high performance of the PID controller, the proper optimization tuning method used to get the best parameter for the controller.

1.3 Objective

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

i. To model PID controller of Gantry Crane System problem based on Hazriq et al. (2017) using Simulated Kalman Filter.

ii. To study the performance of number of iteration Ni versus number of agents, Nt in Gantry Crane System.

iii. To analyse the overall performance of the Gantry Crane system.

1.4 Project Scope

This project consists of a few scopes and guidelines to assure that this project able to conduct around the expected borderline and right direction for achieving those objectives. Hence, the project work scope is studying the behaviour of gantry crane by simulate the dynamic system of gantry crane that controlled by PID.

In this project analysis, the model of the gantry crane system from the existing project was used as to compare their performance result with the algorithm that has been used. Then, Simulated Kalman Filter been applied to the system to tune in the PID controller in the system. Number of iterations that has been in this analysis is 100 to 500 and the number of agents is 10 to 50. This range was applied because it is the maximum range to get the best solution of Kp, Ki, and Kd of the PID controller.

In this project, in the simulation sum absolute error was used to minimize the error of the system. The absolute error of the sum or difference of a number of quantities is less than or equal to the sum of their absolute errors (Weisstein et al, 2000).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter 2 is to review some fundamental ideas from the research. It is necessary to study on journal that related to the project because knowledge and skills needed to complete the project. In other word, this chapter is the brief or idea on published journal that similar as this project.

2.2 Nonlinear Gantry Crane System

A gantry crane system is a machinery that commonly used in industries that related to the process moved and carrying heavy load such as container or big size of concrete. The system of gantry crane consists of payload and trolley that attached each other by a cable vertically. The concept of system of the load that attached vertically with the trolley has same concept with the pendulum and free to oscillate in a 360 direction. The example model of the gantry crane system as shown in Figure 2.1.

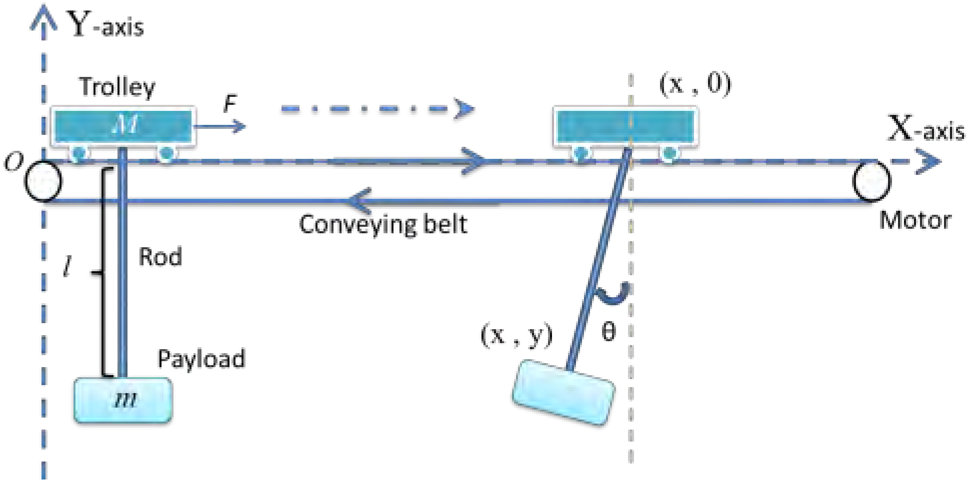

Figure 2. 1: Example of the Gantry Crane System

For effective and efficient crane system for the industry, a lot of people proposed development of the controller to upgrade the crane system. Therefore, linear and nonlinear dynamic model of a gantry crane system are proposed (Paper, Mohamed, & Teknologi, 2016). This project is proposed to investigate the linear and nonlinear dynamic models for a gantry crane system and to make it easy to do analysis to develop effective and efficient controller for the system. In this project, a mathematical concept is implemented to the system for understanding the actual process of the gantry crane to solving problem that ascend (Whitham, John Wiley, & Sons, 1974). Thus, Lagrange's equation was chosen to be used because competent to be derived for higher order system (Jaafar, Mohamed, Jamian, Ghani & Kassim, 2013). The equation of Lagrange's equation is written as:

$$\frac{d}{dt}\left[\frac{\partial L}{\partial q_i}\right] - \frac{\partial L}{\partial q_i} = Q_i \qquad (2.1)$$

Where L, Q_i, and q_i represent the Lagrangian function, nonconservative generalized forces and independent generalized coordinates respectively. From this equation 2.1 a complete nonlinear of the gantry crane system can be obtain by considering the dynamic of the motor. As the result, the model of the gantry crane that has payload oscillation phenomenal with the trolley is linear with the natural response of the actual gantry crane as proven in Figure 2.2 the system response of trolley and Figure 2.3 system response for payload oscillation and can be used to implement the controller to the gantry crane.

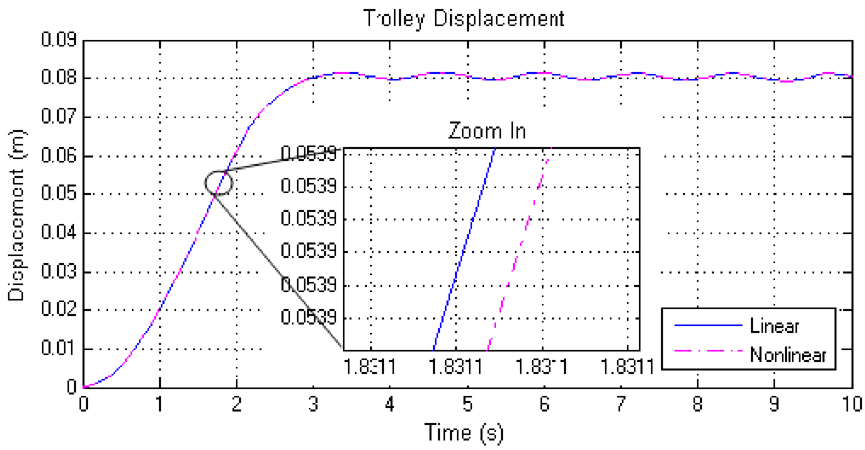

Figure 2. 2: System response of trolley

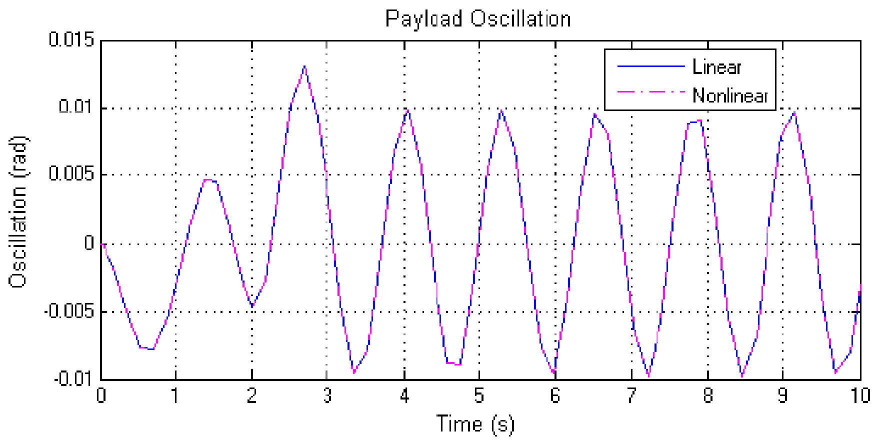

Figure 2. 3: System response of the payload oscillation

Furthermore, the investigation for the dynamic behaviour of a GCS was proposed (Jaafar et al., 2013) to find a parameter of the system with the actual system and to verify factor that effect the performance of the gantry crane system (GSC). In this project, Simulink of MatLab been used to represent the model of the nonlinear GCS. Bang-bang controller used in the simulation to give an input signal to the GCS so the trolley can be accelerate, decelerate and stop in the certain point. In order to find a parameter and to know factor that affected of the gantry crane system, value of voltage, load mass, cable length, and trolley mass was manipulated. As the result, as shown in Figure 2.4, distance that trolley can be reached affected by the mass of the payload and the mass of itself, the larger of the mass, the less distance the trolley can be reached. Then, the length of cable will affect the frequency of the oscillation of the payload, the larger of the length of cable, the highest frequency of the oscillation of the payload produced.

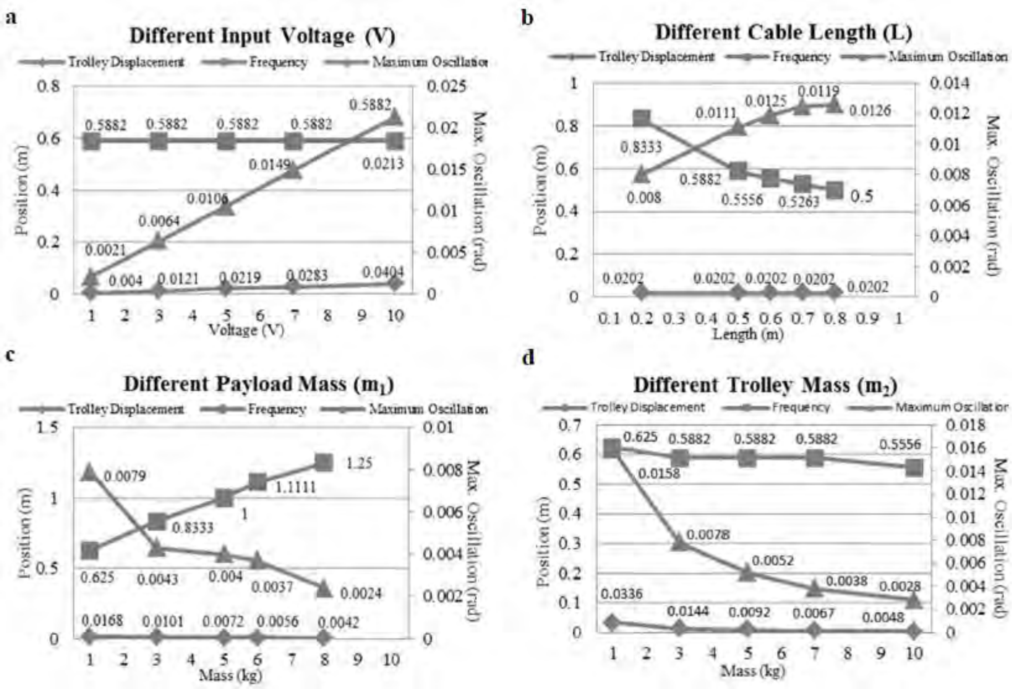

Figure 2. 4 : Result from the experiment