NONLINEAR CONTROLLER FOR GANTRY CRANE BASED ON PARTIAL FEEDBACK LINEARIZATION

MOHD RIZAL AMRIE BIN SAFI'IN

This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Industrial Electronic) With Honours

Faculty of Electronic and Computer Engineering

Universiti Teknikal Malaysia Melaka

May 2009

UNIVERSTI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : NONLINEAR CONTROLLER FOR A GANTRY CRANE BASED ON PARTIAL FEEDBACK LINEARIZATION

Sesi Pengajian : 2008/2009

Saya .....MOHD RIZAL AMRIE BIN SAFI'IN.....
(HURUF BESAR)
mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (∨) :

☐	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

Alamat Tetap:929 KG SERDANG, KUBANG SEPAT,

17030 PASIR MAS KELANTAN

AZDIANA BT MOHD YUSOP
Pensyarah
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Karung Berkunci No 1752
Pejabat Pos Durian Tunggal
76109 Durian Tunggal, Melaka

"I hereby declared that this report entitled Nonlinear Controller FOR Gantry Crane Based on Partial Feedback Linearization is a result of my own work except for the works that have been cited clearly in the references."

Signature : .....

Student : MOHD RIZAL AMRIE BIN SAFI'IN

Date : 30 APRIL 2009

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award the Bachelor of Electronic Engineering (Industrial Electronic) With Honours"

Signature : .....

Name : PN AZDIANA BINTI MD. YUSOP

Date : 30 APRIL 2009

Special dedicated to my beloved parents, family and fellow friends, who had strongly encouraged and supported me in my entire journey of learning…

ACKNOWLEDGEMENT

Firstly, I would like to be grateful Allah S.W.T with His divinity and blessing, I am managed to complete this thesis. I also would like to thank to my supervisor Mrs, Azdiana Binti Md. Yusop who has shares her time and attention as well as her knowledge in modeling the controller for gantry crane. Then, thank to my family especially to my mother who supported me, my friends and also to our lab technician, Mr Saifullah Bin Salam. Lastly, thanks to all people who has to help me to complete this project. Thank for everything.

ABSTRACT

Gantry crane systems are widely used in harbours and factories for loading and unloading of goods. The crane systems are desired to be able to move to the required positions as fast as possible while placing the payload at the appropriate position. To get that condition, the payload swing angle should be kept as small as possible. Based on partial feedback linearization, the portion of the dynamics corresponding to the active degrees of freedom is linearized by nonlinear feedback controller. The trajectory tracking control of the linearized system is studied by choosing the active degrees as the systems outputs. The portion of the dynamics corresponding to the passive degrees of freedom is taken as the internal dynamic of the crane system, and the analysis of the resulting zero dynamics shows the control system. Finally, experimental results on the scale crane shows feasibility of the developed controller design scheme.

ABSTRAK

Sistem kren gantry biasanya digunakan secara meluas di pelabuhan dan kilang-kilang untuk kemudahan mangangkat dan meletakkan beban dalam keadaan yang baik. Sistem kren yang biasa diperlukan di tempat tersebut adalah satu sistem yang berkebolehan bergerak ke sesuatu posisi dengan cepat dan tepat semasa mengangkat beban ke posisi yang dikehendaki. Bagi merealisasikan keadaan yang dikehendaki, sudut ayunan pada beban mestilah bersudut kecil kerana sudut yang kecil dapat menghindar beban daripada berayun ketika suatu pergerakan dilakukan. Berdasarkan pada suapbalik tak linear sudut yang aktif pada bahagian dinamik di selaraskan dengan menggunakan kawalan suapbalik linear. Di samping itu, kawalan trajektori dalam sistem ini dipelajari dengan memilih sudut yang aktif sebagai sistem output manakala sudut yang pasif pula diambil kira sebagai tenaga dalaman pada sistem kren tersebut dan analisis dibuat terhadap keputusan yang menunjukkan tenaga tersebut bersamaan dengan kosong pada sistem kawalan tersebut. Akhirnya, dengan keputusan ujikaji terhadap scalar kren, satu alat kawalan dapat dihasilkan.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Project Introduction

Gantry crane systems are widely used in harbours and factories for loading and unloading of goods. The crane systems are designed to be able to move to the required positions as fast and as possible while placing the payload at the appropriate position. In addition to these two requirements, the payload swing angle should be kept as small as possible; otherwise, large payload swings during transport may cause damage to the payload itself and surrounding equipment or personnel. It is essential that pendulum oscillation are constrained both safety reasons and for higher task execution speed. To overcome this problem, this project will design the controller based on Partial Feedback Linearization. A practical nonlinear controller design scheme for the gantry crane having various pendulum lengths. Based on Partial Feedback Linearization, the portion of the dynamics corresponding to the active degrees of freedom is linearized by Nonlinear Feedback Control. The trajectory tracking control of the linearized systems is studied by choosing the active degrees as the system outputs. The portion of the dynamics corresponding to the passive degrees of freedom is taken as the internal dynamics of the cranes system, and the analysis of the resulting zero dynamics shows that the stability of the zero dynamics guarantees the stability of the control system.

1.2 Objective of the Project

The objective of this project is to apply the technique of the Partial Feedback Linearization onto gantry crane to move to the required positions as fast as possible while placing the payload at the appropriate position.

1.3 Problem Statements

The purpose of this project is to certify that the crane should move the load as fast as possible without coursing any excessive movement at the final position. The disproportionate movement can cause industrial accident and it is very dangerous for workers in transporting heavy loads and hazardous materials in shipyards, factories, nuclear installations and high building construction.

To control of gantry crane system has been a heavily investigated problem due to both the theoretical challenges and the practical importance specifically precise payload positioning by gantry crane is difficult because the payload can exhibit a pendulum like swinging motion.

To control gantry crane, it needs a skillful operator to control manually to stop the swing immediately at the right position. It is also makes crane work very dangerous when workers or other obstacle exist in the crane workspace. The failure of controlling crane might cause accident and may harm people and surrounding. The large internal force also that can result in reduced payload carrying capacity or premature failure of stressed parts.

The proposed of nonlinear controller based on partial feedback linearization is to have good positioning performance as well as good capability to suppress the swing angle.

1.4 Scopes of the Project

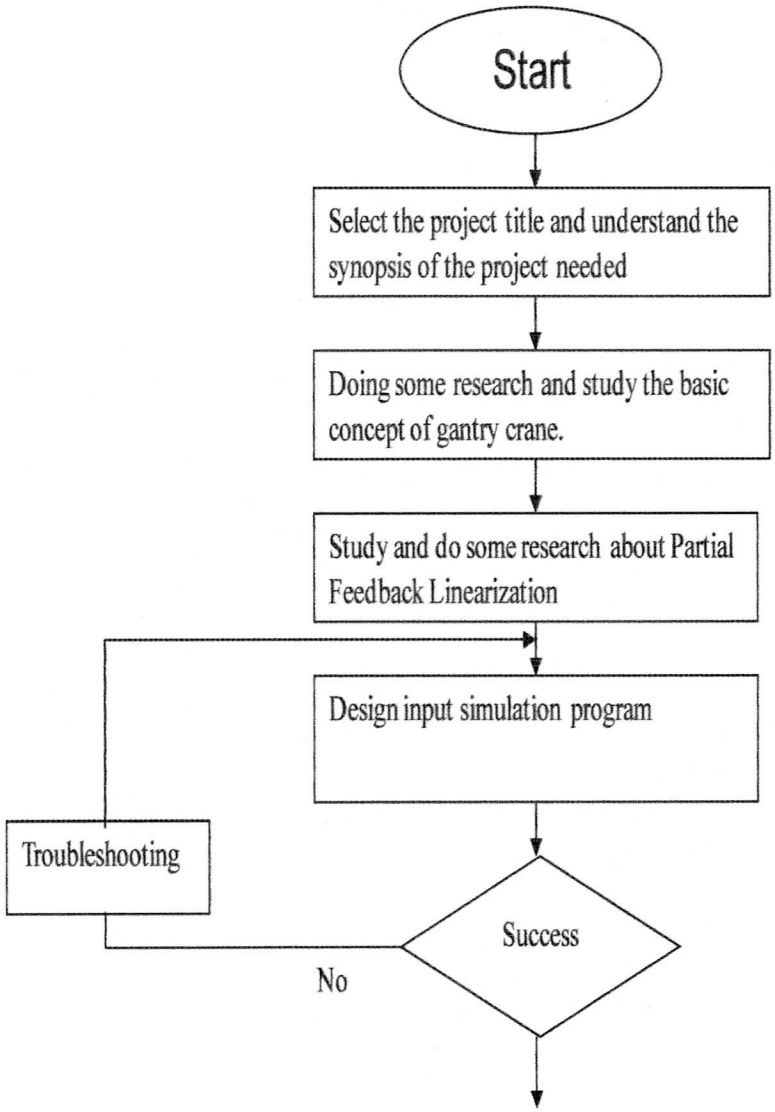
All projects have their own scope or limitation as a guideline throughout the completion of the project. The project scope for implementation this project is:

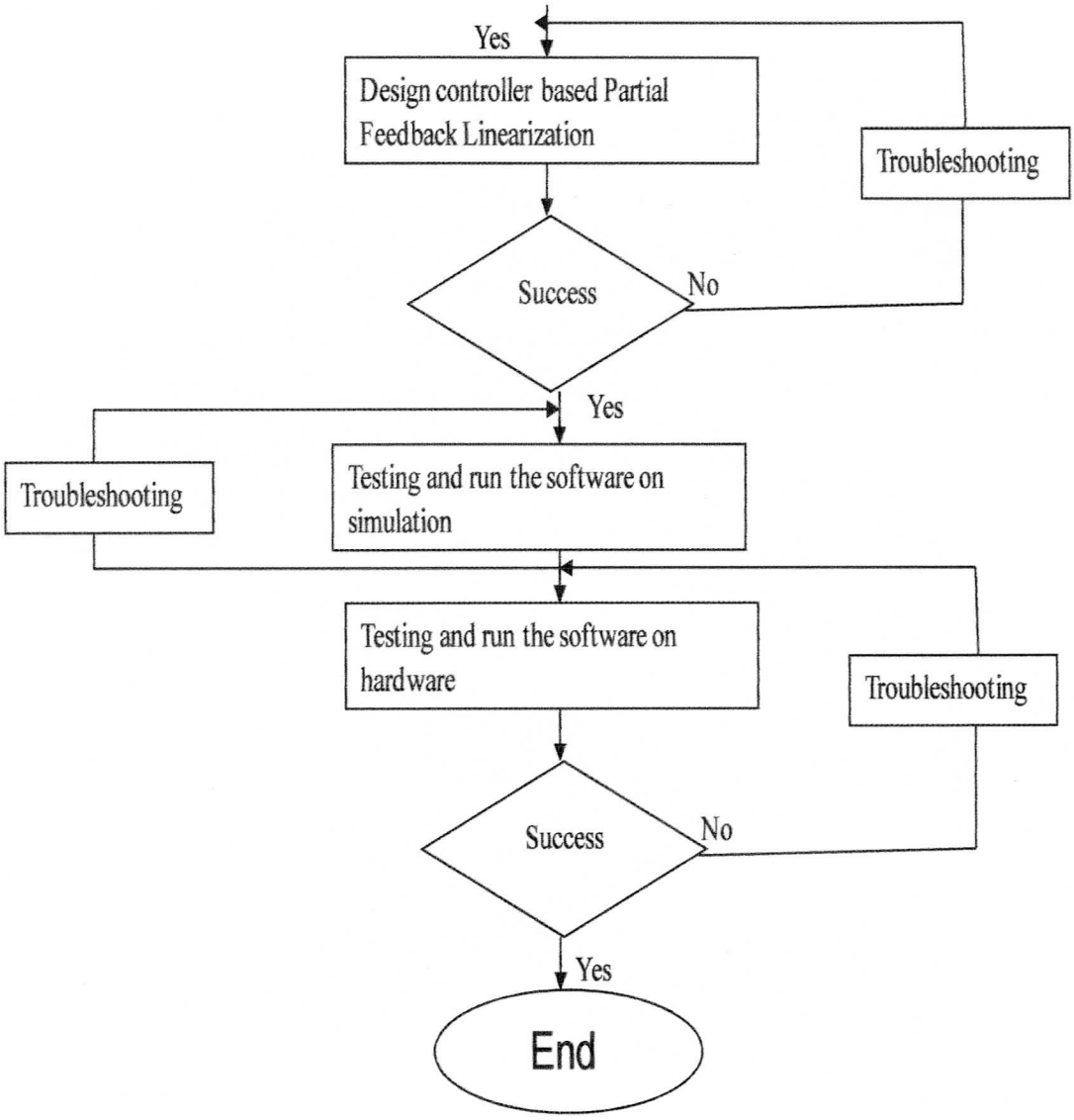
i) Do some researches about gantry crane system using Partial Feedback Linearization. Read up and study related technical knowledge.
ii) Study and learn about mathematical equation that involve in this project.
iii) Study and learn about Simulink in the Matlab Software.
iv) Apply Partial Feedback Linearization technique onto controller in the Matlab.
v) Apply the technique to the gantry crane, testing and troubleshooting.

1.5 Methodology of the Project

There are several phases or methods to be used to achieve the objectives of the proposed project. The first method is understood of the title and synopsis. It is important to gain more information of the idea and concept of this project. The information that related to the project is found from journals, articles, books, internet, lecture's note, etc. Then, the second method is doing some research about basic gantry crane and study and do some research about partial feedback linearization. The third stage is to construct the input simulation and the controller based partial feedback linearization. Finally, the last method is applying the controller onto the gantry crane.

1.5.1 Methodology Flowchart





1.6 Report Overview

This report consists 5 chapters where each chapter filled with detail of scope and description.

Chapter 1

Review about nonlinear controller for a gantry crane based on partial feedback linearization such as introduction, objectives, problem statement, scope of project and methodology of project.

Chapter 2

This chapter discuss about the literature review

Chapter 3

Describe about project methodology used in this project and project process flow.

Chapter 4

This chapter describes about result and analysis. On this chapter also write discussion about this project.

Chapter 5

This chapter describes about hardware interfacing.

Chapter 6

This chapter will clarify the recommendation and conclusion about this project.

CHAPTER II

LITERATURE REVIEW

This chapter will explain and discuss about research of gantry crane and the controller. This chapter also includes the theoretical part of partial feedback linearization.

2.1 Crane: overview

In our environment, there is a necessity to transfer the things like equipment, things etc. from one place to another, whether there are far or not. In the workplace, for example, at construction or industrial sites, ports, railway yards and other similar locations, special equipment is needed to transport the materials. These materials are usually heavy, large and hazardous, which cannot be handling by workers. In order to make the work easier, cranes have been used to lift, move, position or place machinery, equipment and other large objects. There are many types of crane that been used for these purposes, such as tower crane, overhead crane, boom crane, gantry crane and others. Figures 2.1 and 2.2 shows examples of overhead crane and gantry crane, respectively.

Figure 2.1 Overhead Crane

Figure 2.2 Gantry Crane