THE DEVELOPMENT OF EMBEDDED POSITIVE INPUT SHAPING FOR VIBRATION CONTROL OF FLEXIBLE MANIPULATE USING PIC

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"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Control and Instrumentation)"

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DEDICATION

Specially dedicated to

My beloved parents, brother,

and all of my best friends.

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ABSTRACT

This thesis presents investigation into the applications and performance of positive input shaping in command shaping techniques for the vibration control of a flexible robot manipulator. A constrained planar single-link flexible manipulator is considered and the dynamic model of the system is derived using the assume mode method and is explained. An unshaped bang-bang torque input is used to determine the characteristic parameters of the system for design and evaluation of the input shaping control techniques. The positive shaping technique is designed based on the properties of the system. Simulation result of the response of the manipulator to the shaped inputs form matlab simulation tools are presented in the time and frequency domains. Performances of the shapers are examined in terms of level of vibration reduction, time response specifications. The effects of derivations orders of the input shaper on the performance of the system are investigated. Next, the positive input shaping algorithm is embedded into PIC. Comparative of the PIC and simulation in matlab is presented. Finally, an analysis assessment of the impact amplitude polarities of the input shapers on the system performance is presented and discussed.

ABSTRAK

Tesis ini membincangkan penyelidikan dalam aplikasi and prestasi teknik pembentukan positif input dalam kawalan getaran terhadap pengolah lentur robot. Sebuah kendalan satu-link planar pengolah lentur robot ditimbangkan dan model dinamik diperolehi dengan menggunakan kaedah misalkan dan dijelaskan. Teknik kawalan bang-bang yang belum dibentuk digunakan untuk menentukan ciri-ciri daripada parameter system untuk merekabentuk dan penilaian teknik pembentuk positif input. Teknik pembentuk positif direka berdasarkan sistem ini. Keputusan similasi daripada pengolah lentur robot kepada bentuk input daripada aplikasi matlab akan ditunjukan dalam bentuk waktu dan frekuensi domain. Prestasi daripada pembentukan itu diuji dari segi kekurangan tahap getaran and masa tindak balas spesifikasi. Kesan daripada darjah derivatif pembentukan input dalam sistem prestasi akan diselidikan. Teknik pembentukan positif input akan ditanam dalam PIC. Berbandingan antara PIC dan simulasi dengan mengguna matlab akan dibentangkan. Akhirnya, laporan analisis dalam sistem prestasi dalam bentuk amplitud akan dibincang and dibentang.

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LIST OF SYMBOLS

E	-	Young Modulus
I	-	Area moment of inertia
ρ	-	Mass density per unit
τ	-	Torque
A	-	Cross sectional area
I_H	-	Hub inertia
r	-	Radius
M_p	-	Payload mass
T	-	Kinetic energy
U	-	Potential energy
D	-	Damping
K_n	-	Stiffness matrix
F	-	Vector of external force
Q	-	Nodal displacement vector
ω	-	Natural frequency
ζ	-	Damping ratio
θ	-	Angular displacement
x	-	Distance from hub
N_i	-	Number of impulse
A_i	-	Amplitude of impulse
t_i	-	Time of impulse
*	-	Convolution
s	-	Second

t	-	Time
ZV	-	Zero vibration
ZVD	-	Zero vibration derivative
ZVDD	-	Zero vibration derivative-derivative
PSD	-	Power spectral density

CHAPTER 1

INTRODUCTION

1.1 Introduction

Flexible manipulator is finding an increasing number of applications especially in automation and manufacturing industries. Robots that were once used to pock and place work pieces are now being used in more complex tasks such as assembling and working at unmanned places.

Flexible robot manipulators exhibit many advantages over rigid robots; they required less material, are lighter in weight, consume less power, require smaller actuators, are more maneuverable and transportable, have less overall cost and higher payload to robot weight ratio. However, the control of flexible manipulator to achieve and maintain accurate positioning is challenging. Due to the flexible nature of the system, the dynamic are significantly more complex. Problem arises due to precise positioning requirements, system flexibility which leads to vibration, the difficulty in obtaining an accurate model of the system and non-minimum phase characteristics of the system. In this respect, a control mechanism that accounts for both rigid body and elastic motion of the system is required. If the advantages associated with lightness are not to be sacrificed, accurate models and efficient controllers have to be developed.

Control of machines that exhibit flexibility becomes important when designers attempt to push the state of the art with faster and lighter machines. Many researchers have examined different controller configurations in order to control machines without exciting resonances. However, after designing a good controller, the input commands to the closed-loop system are "desired" trajectories that the controller treats as disturbances. Often these "desired" trajectories are step inputs or trajectories that the machine cannot rigidly follow. The considered vibration control schemes can be divided into two main categories: feed forward and feedback control technique.

Active vibration controls of slewing flexible structures, such as the flexible robotic manipulator system, have experienced rapid growth in recent years. Most of the attention has been focused on eliminating vibrations that result in the structure when control applied. The vibration of flexible manipulator or system often limits speed and accuracy. The vibration of such manipulator or system is usually caused by changes in the reference command or from external disturbance. If the system dynamics are known, Commands can be generated that will cancel the vibration form the system's flexible modes. Accurate control of flexible structures is an important and difficult problem and has been an active are of research book.

This paper presents investigations into the application and performance of input shaping control schemes with positive input shapers for vibration control of a single-link flexible manipulator. Moreover this paper provides a comparative assessment of the performances of these schemes. The results of this work will be helpful in designing efficient algorithms for vibration control of various systems. The Zero Vibration (ZV) shaper is the basic shaper, and constraint the vibration to zero at the modeling frequency. To increase robustness to parameter variations, the order of derivative or higher, of residual vibration constraints of ZV shaper is also constrained to zero to yield what are known as Zero Vibration Derivative (ZVD) shaper. In this work, input shaping with positive input shaping (ZV to ZVDD) is considered.. The dynamic model describing the motion of the flexible manipulator is derived using the assume mode method. Simulation exercises are performed within the flexible manipulator simulation environment. First, to obtain the characteristic parameter of the system, the flexible manipulator is excited with a single-switch bang-bang torque input. Then the input shapers are designed based on the properties of the manipulator and used for preprocessing the input, so that no energy is fed into the system at the natural frequencies. Performances of the developed controller are assessed in term of level of vibration reduction, time response specifications and robustness to errors in vibration frequency. Simulation results in time and frequency domains of the response of the flexible manipulator to the unshaped input and shaped inputs with positive are presented and discussed.

1.1 Objective

The objective of this study:

i. To develop the research on positive input shaping for vibration control of a flexible robot manipulator.
ii. To study the dynamic characteristic of the flexible manipulator in order to construct the controlling method to reduce the vibration.

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