Position Control for Motorized Belt Driven Table

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ABSTRACT

A belt driven system is more cost attractive than a screw-driven system, but the problem with elasticity makes the positioning of a belt driven table inaccurate. An FL controller with frictional and elasticity compensator was proposed to be a better controller than a conventional PID. An existing conveyor system complete with the motor driver was used in this project. Using PRBS input, the input output data was gathered and the parametric model of the conveyor was identified by MATLAB SID Toolbox. The model was then used to develop the conventional PID controller, the proposed FL controller and also frictional and elasticity compensator, in Simulink environment by simulation. The developed controllers were then implemented physically to control the conveyor. Data was gathered and compared for the evaluation of positional tracking and end-point controlling performances. For positional tracking, a conventional PID controller shows the best performance in hardware implementation, but for end-point positioning, the FL controller with compensator showed the better performance in both simulation and hardware implementation than the conventional PID controller. The FL controller with compensator could improve the performance of equipment which requires only the end-point positioning control such as vision inspection machine, insertion machine and cutting machine significantly.

ABSTRAK

Sebuah sistem pacuan tali sawat adalah lebih menarik dari segi kos dibandingkan dengan sebuah sistem pacuan skru, tetapi masalah yang disebabkan oleh keanjalan dan geseran menyebabkan pengawalan kedudukan sistem pacuan tali sawat tidak tepat. Pengawal “FL” dilengkapi pemampas geseran dan keanjalan telah dicadangkan sebagai pengawal yang lebih baik daripada pengawal “PID” konvensional. Sistem penghantar yang telah tersedia lengkap dengan pemacu motor telah digunakan. “PRBS” signal telah digunakan sebagai input, data input output telah dikumpulkan dan model berparameter untuk sistem penghantar telah dikenalpasti. Model ini kemudiannya telah digunakan untuk membangunkan pengawal “PID” konvensional, pengawal “FL”, dan juga pemampas geseran dan keanjalan, dalam persekitaran “Simulink” secara simulasi. Perlaksanaan sebenar sistem-sistem pengawalan kemudiannya dijalankan dengan menggunakan kekotak “I/O” dari ”Real-Time Windows Target Toolbox”. Data telah dikumpulkan dan perbandingan telah dibuat untuk menilai pengawal kedudukan yang terbaik. Bagi perlaksanaan perkakasan sebenar, pengawal “PID” konvensional telah menunjukkan prestasi terbaik bagi pengawalan penjejakan berterusan, tetapi, bagi kawalan kedudukan titik akhir, pengawal “FL” dilengkapi pemampas geseran dan keanjalan telah menunjukkan mutu pengawalan yang terbaik. Pengawal “FL” dilengkapi pemampas geseran dan keanjalan ini boleh meningkatkan prestasi dari segi ketepatan bagi peralatan yang hanya memerlukan kawalan titik akhir kedudukan seperti mesin pemeriksaan secara visual, mesin penyisipan dan juga mesin pemotong dengan ketara.

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LIST OF ABBREVIATIONS

DAQ	-	Data Acquisition
FIS	-	Fuzzy Inference System
FL	-	Fuzzy Logic
LFSR	-	Linear feedback shift register
MaxAE	-	Maximum Absolute Error
MLS	-	Maximum Length Sequence
PC	-	Personal Computer
PID	-	Proportional – Integral – Derivative
PRBS	-	Pseudo random binary signal
QRB	-	Quadratic residue binary
QRT	-	Quadratic residue ternary
RMSE	-	Root Mean Squared Error
s	-	Standard Deviation
SID	-	System Identification
TPB	-	Twin prime binary

CHAPTER 1

INTRODUCTION

1.1 Project Background

Motorized tables are widely used in the industry today. The usage ranged from machine tools, electronic assembly and laboratory automation [1]. Examples of applications such as microscopy, CNC engraver/router, automatic testing/calibration, pick and place, automatic dispensing, semiconductor inspection, pc board drilling and plastic fabrication require high accuracy and good repeatability.

The drive system is one of the most critical components in a positioning system [2] . There are two most used systems, a screw driven system and a belt driven system. A screw driven system may consists of lead screws or ball screws. Screw driven systems have higher positioning accuracies but are very expensive to setup and maintain [2]. A belt driven system in the other hand is a much cheaper alternative. Besides offering a lower cost it also offers higher speed and much longer travel [2]. One of the problems with belt driven systems is the difficulties in controlling their position. These difficulties arise from nonlinearities within the system, such as belt flexibility, stretch, vibration, backlash, friction, loads change, delays and other nonlinearities [1], [2]. Since the cost advantage is very attractive, various controllers were developed by researchers to address these aforementioned problems.

1.2 Problem Statement

It was established that belted system for motorized table system is desirable due to its lower cost and higher linear speed achievable than ball screw system. The cost of the belting system could be as low as 30% of the cost of a ball screw system [3]. But the elasticity of the belt combined with Coulomb friction of the system caused inaccuracies in table position [4] . Therefore, a controller which can address the elasticity and Coulomb friction problem to improve positional accuracies is desired. It was proposed that a Fuzzy Logic Controller coupled with a friction and elasticity compensator can overcome the aforementioned problems.

1.3 Project Objectives

The objectives of the project are:

i. To design a positional controller using PID controller and FL controller.
ii. To overcome the issues of friction and elasticity by using compensator.
iii. To simulate the system and validate the result via experiment.

1.4 Project Scope

This project focused on a flat belt conveyor system with DC motor which equipped with an existing driver, in a laboratory scale experiment which was readily available in the PLC laboratory of the German-Malaysian Institute. A mathematical model derived from fundamental laws will be used as the basis for its system identification using MATLAB System Identification Toolbox. The design stage of the controllers utilized MATLAB Simulink environment. The hardware implementation of the controllers was by Advantech PCI-1716 data acquisition card with PC running Simulink Real-Time Windows Target executable acted as the controllers. Then the performance of the FL controller and frictional and elasticity compensator were compared against the developed PID controller.

1.5 Project Report Outline

Chapter one served as the introduction to the project, stating its objectives and also scope of work. Chapter two introduced the theory involved in this project and also literature that has been reviewed. Chapter three elaborates on the methodology including the equipment used in this project. Chapter four is where the results including the controllers developed and analysis on the positional accuracies are discussed. The conclusion and possible future work of the project are presented in chapter five.

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