SWAY REDUCTION ON GANTRY CRANE SYSTEM USING DELAYED FEEDBACK SIGNAL (DFS)

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Special dedicated to my beloved mom, dad and my family

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ABSTRACT

Gantry crane system is widely use in the industry application for transporting the payload. The crane system is design to be able to move the loads to the required positions. However, moving the payloads using the gantry crane is not an easy task especially when strict specifications on the swing angle and on the transfer time need to be satisfied. So, to overcome this problem, a solution is needed so that the crane can move the loads quickly, accurately and safely without vibration and swing of the loads from the starting to the finishing point. The Delayed Feedback Signal is the one of the method in order to reduce the vibration and also sway angle of loads. This closed-loop system is the technique used in this investigation to actively control the rope of the gantry crane for not to sway too far in the system. Response of the position of the trolley and the sway angle of the payloads are presented using the SIMULINK in the MATLAB software.

ABSTRAK

Sistem kren *'gantry'* telah digunakan meluas dalam aplikasi industri terutamanya untuk mengangkut muatan. Sistem kren direka untuk membolehkan muatan dipindahkan ke tempat yang sepatutnya. Walaubagaimanapun, kerja-kerja pemindahan muatan menggunakan kren *'gantry'* bukanlah tugas yang mudah terutama apabila ketepatan ukuran pada sudut ayunan dan masa pemindahan perlu dititikberatkan. Oleh yang demikian, untuk mengatasi masalah ini, satu penyelesaian diperlukan supaya kren dapat memindahkan muatan-muatan dengan lebih cepat, tepat dan selamat tanpa getaran dan ayunan daripada permulaan sehingga ke hujung kren. *'Delayed Feedback Signal'* ialah satu kaedah untuk mengurangkan getaran dan juga sudut ayunan. Sistem ini ialah teknik yang digunakan untuk mengawal tali kren *'gantry'* untuk tidak berayun jauh dalam sistem itu. Tindakbalas bagi kedudukan troli dan sudut ayunan beban akan ditunjukkan dengan menggunakan SIMULINK yang terdapat dalam perisian MATLAB.

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CHAPTER I

INTRODUCTION

This chapter will discuss about the gantry crane system with the use of the Delayed Feedback Signal (DFS). The project introduction, objective, problem statement, scopes of work, methodology and the project activity will also be presented.

1.1 Introduction

The used of the gantry crane system for transporting payloads is very common in industrial application. However moving the payload using the gantry crane is not an easy task especially when strict specifications on the swing angle and on the transfer time need to be satisfied. To overcomes this problem, an intelligent gantry crane system needed to introduce.

This project is about to design the actual gantry crane system that use the anti-sway control with the effect of disturbances in the dynamic system. Propose of the project is to reduce the sway angle of the payload and act as disturbances cancellation when the crane transfer the load from one point to other point. The „Sway Reduction on Gantry Crane System Using Delayed Feedback Signal" project is about to build the model of the gantry crane with small sway angle or if possible to

reduce the sway angle approximately to zero. It is involve the study of the anti-sway controller which used to control the sway angle, the Eurel-Lagrange equation and Delayed Feedback Signal.

Delayed Feedback Signal (DFS) is the technique used in this investigation to actively control the rope of the gantry crane for not to sway too far in the system. This system is a closed-loop system. These projects consist of hardware and software used. Most of the project is used the MATLAB to simulate the program and send data to the crane system so that it can control the rope. A complete analysis of the simulation results for the technique is presented in time domain and the frequency domain respectively. Performances of controllers are examined in term of sway angle suppression and disturbances cancellation.

1.2 Objective

The objective of this project is to reduce the sway angle of the gantry crane rope by using the Delayed Feedback Signal (DFS) and in the same time it can cancel the disturbances by the side effect. The DFS technique is used as a controller to control the sway angle of the payload when it transfers the load so that it can move quickly, accurately and safely without vibration from the starting to the finishing point.

1.3 Problem statement

Gantry crane is widely used in our live for factory, industries, transportation and also construction to load and unload the goods. But there are also several things needed to give attention. The crane has to move the goods faster without any problem. This is to minimize the time so that they can move many loads. Besides, a skillful and well experience operator is needed to handle the gantry crane manually for stopping it at the right position. The crane can cause dangerous to the worker if there any careless mistake that is made by the worker during their work. So, the worker should be serious when doing their work.

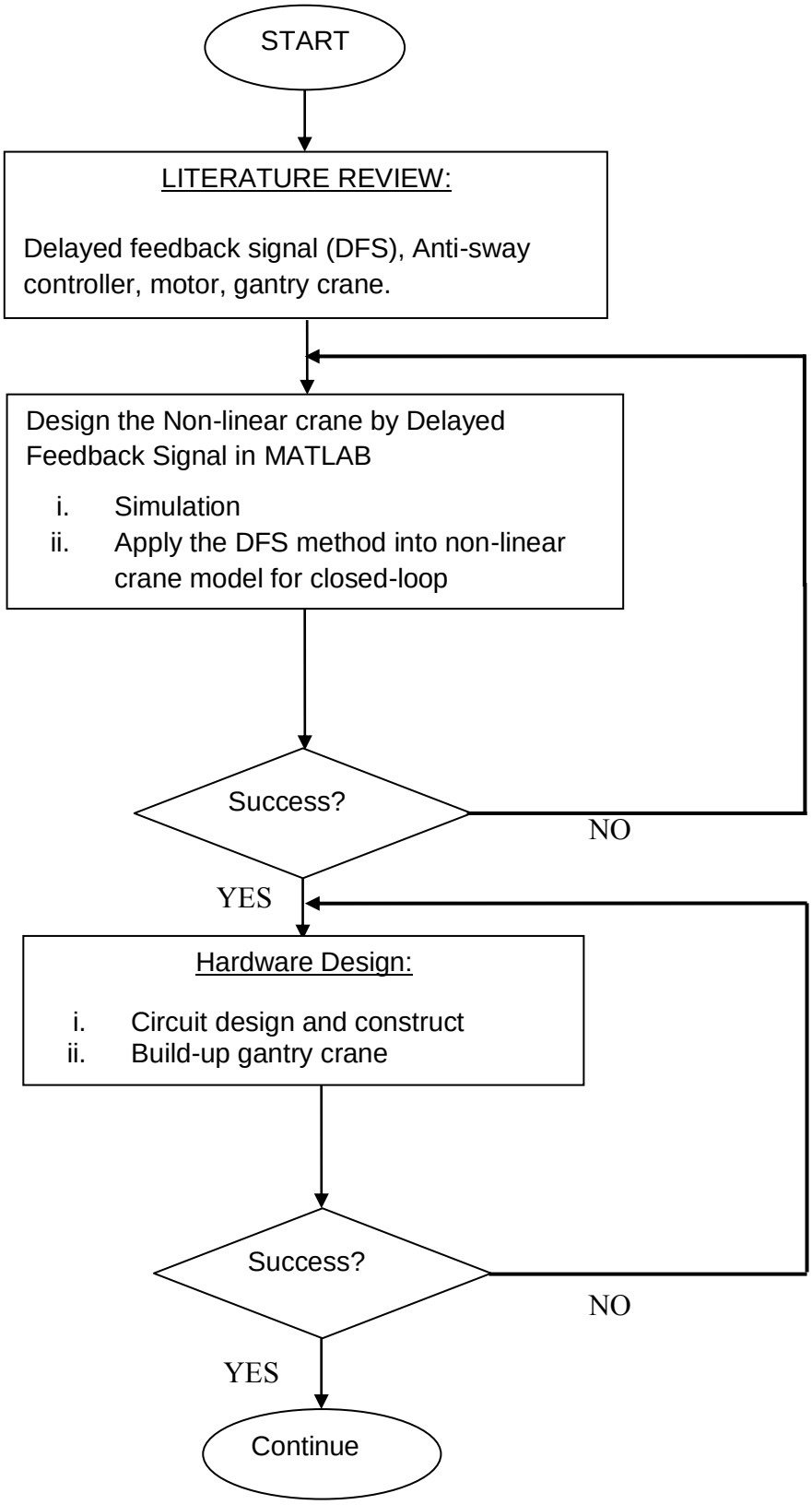
When transfer the load, operator needs time to wait for the string to stop the vibration after some movement. The vibration is the serious problem in the system. So, if the gantry crane can be completed with the Delayed Feedback Signal and anti-sway controller, the crane can go smoothly without vibrations and can reduce the swing angle of the payloads. The work environment will become a safe place to work for the worker while all jobs can be done quick and accurate.

1.4 Scope of Work

This is the guidelines of the project and it should cover all these things:

1. Study the gantry crane system, sensors, and motor that will be used in the project.
2. Study the Eurel-Lagrange equation and the application in the gantry crane system.
3. Get the parameter for position of the trolley, sway angle, the height and length of the gantry crane.
4. Compare the estimated and the real value of the sway angle.
5. Design the controller that will be used in the system to control the sway angle which is Delayed Feedback Signal (DFS).

1.5 Methodology



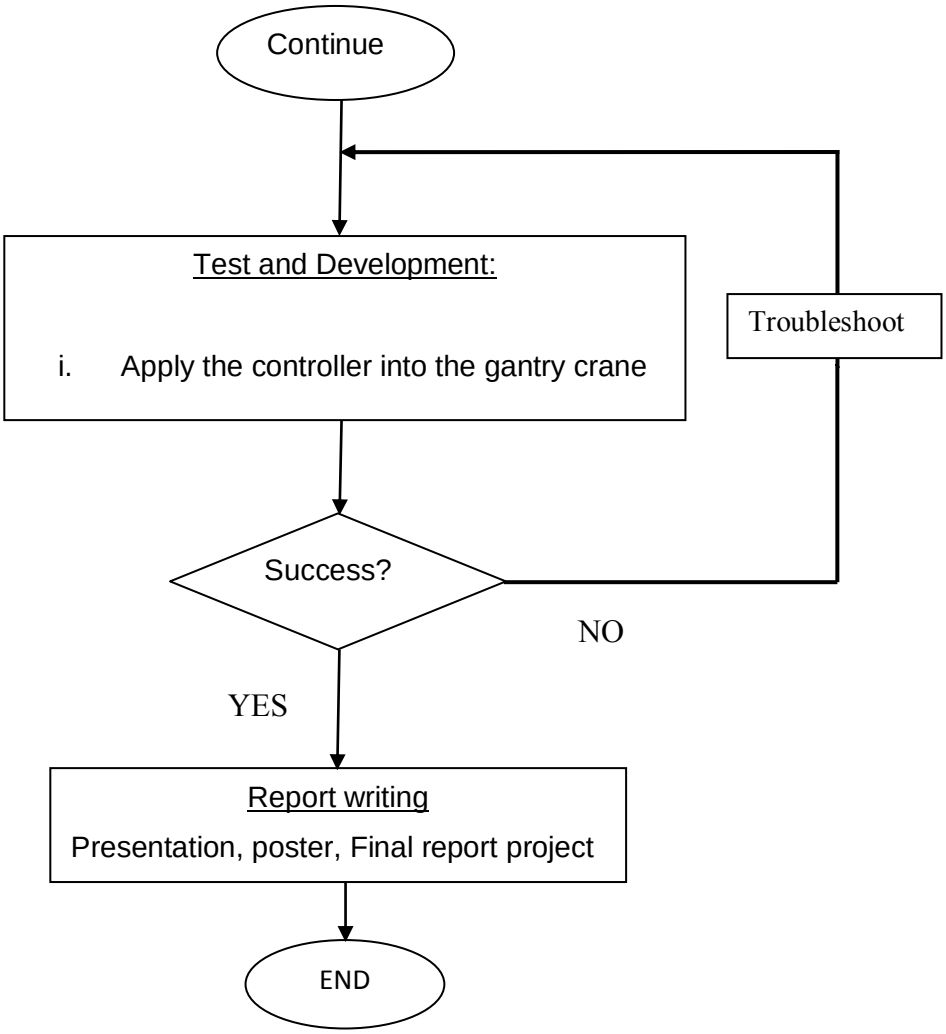


Figure 1.1: Project Flow Chart

Figure 1.1 shows the flow chart of this project. The first step is to understand the project and do researches about gantry crane, DFS controller, vibrate sensor, sway angle sensor and the motor controller. The research is to identify the function of the gantry crane, the specification needed and the parameter that will be used to design the hardware. The DFS controller contain the mathematical method that require the deeply understand of the calculation.

Next step is to run the simulation of the gantry crane system in the MATLAB and try to add the DFS controller. The result of the simulation, with and without the DFS controller is then compared. If the result is not same as the expectation, the simulation is done again by redoing the calculation. After the result is obtained, this project is proceed to the hardware design. In this section, the focus is in the circuit design and construction, built of the gantry crane model and the motor controller circuit.

After the hardware is done, then it will be tested by applying the controller to the gantry crane. This section is to determine whether the project is succeeded or not. If there have any problem, the troubleshooting process has to be run to configure the problem so it can be fixed. And lastly, after the project is succeeded, the focus is on report writing and presentation.

1.6 Thesis Outlines

This thesis consists of six chapters. The following chapters are the outline of the implementation of Delayed Feedback Signal to the gantry crane system.

Chapter I Will discuss briefly the overview of this project such as introduction, objectives, problem statement, scope of the project, methodology and thesis outlines.

Chapter II Contains the research and information about the project on several important concepts of the gantry cranes, the swing control, technology and tools used in the study. Every facts and information, which found through journals or other references, will be compared and the better methods have been chose for the project. This chapter will also include several types of crane.

Chapter III Includes the detail about designing and modeling the gantry crane system.

Chapter IV Includes the detail about simulation results, analysis, observation and discussion of the performance of the Delayed Feedback Signal technique that presented in. This includes the simulation part and the real part.

Chapter V Includes the detail about the hardware design involved schematic diagram, PCB layout, components required and working principle for each circuit. In this chapter also discuss about the components that required completing the gantry crane model, and the sensor circuit used.

Chapter V Describes more about result. This chapter also discusses about the conclusion of the project and the future works recommendations.

CHAPTER II

LITERATURE REVIEW

Literature review in this chapter is to make a research on the several techniques and learn from the past to make the gantry crane project more successful. The whole effort of studying the gantry crane, the mathematical method and the DFS controller will leads to the result as expected.

2.1 Study of Gantry crane

Gantry cranes are designed for lifting and positioning loads. The various types of gantry cranes, including the aluminum gantry crane, the steel gantry crane and the portable gantry crane, are essential for the efficient operation of many industrial facilities, factories, shipyard, and high building constructions. These cranes are similar to overhead cranes except that they have a bridge for carrying the unit's trolley and are usually supported by two or more rigid legs. Additional related equipment that many industrial companies find indispensable include the lifting jib, the hoist trolley, the festoon system, the chain hoist and the portable lift. Study of the control system for the gantry crane is complicated since the different type of crane and it various applications on the industry. Some applications require traversal time, no swing motion of goods when loads moved, and optimization motion of trolley.

The crane should move the loads as fast as possible without causing any excessive movement at final position. However the gantry crane, mostly result in a swing motion when payloads suddenly stop after fast motion. The swing motion can be reduce but need the time consuming. Research on the control methods that will eliminate the sway angle of the gantry crane has found the great deal of interest for many years. Active sway angle control of gantry crane indirectly produces sources that absorb the energy caused by unnecessarily sway angle of string consequently to reduce the effect on the crane system.

Research on the control methods that will eliminate the vibration of the system found a great deal of interest for many years. To solve the problem arising due to the unwanted structural vibrations there are 2 methods used which passive and active control. The passive control methods consist of mounting passive material on the structure in order to change dynamic characteristics. The method is expensive and work at high frequencies. The active vibration control relate to generating unnaturally sources that absorb the energy caused by the unwanted vibrations to reduce the effect to the crane system. Leug in 1930 is among the first researcher who used the active vibration control to cancel the noise vibration[1].

Many ideas in controlling the gantry crane system based on the open-loop system have been suggested. These include the development on the computed torque based on a dynamic model of the system, utilization of single and multiple-switch bang-bang control function, and also combining the crane system with the command shaping technique have been investigated in reducing the vibration of the system[7]. These input shaping techniques include filtering techniques based on low-pass, band-stop and notch filters, and input shaping. The input shaping proved the effective for controlling the oscillation of gantry crane when the loads not undergo hoisting[3]. The open-loop time optimal strategies were applied by many researchers but end with poor outcomes because open-loop strategies is sensitive to the system parameters and could not counter back the disturbances[2].