

IMPLEMENTATION OF MECHINE VISION IN CONTROLING A MODELLED GANTRY CRANE

(Implementasi Mesin Visi Dalam Pengontrollan Sebuah Model Mesin Derek)

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ABSTRAK

Mesin derek sangat bermanfaat dalam membantu pekerjaan manusia. Dalam pengoperasian mesin derek, dua faktor utama yang perlu diperhatikan adalah keselamatan kerja dan produktivitas. Untuk meningkatkan kedua faktor tersebut, dibutuhkan alat pengontrol yang baik untuk mengantisipasi fenomena ayunan yang timbul akibat pergerakan mesin. Vision system telah diaplikasikan dalam proyek ini sebagai detektor jarak untuk mendeteksi jarak sepanjang pergerakan troli mesin derek. Pengontrol fuzzy merupakan jenis pengontrol cerdas yang dipilih untuk memecahkan ketidaklinearan yang ditimbulkan oleh vision system dan sensor sudut. Pengimplementasian dilakukan menggunakan software Labview dengan Vision dan Fuzzy Control toolkit. Proyek ini berhasil menerapkan vision system dan pengontrol fuzzy dalam mengendalikan sebuah model mesin derek.

Keywords: *Mesin derek, vision system, pengontrol fuzzy, Labview*

INTRODUCTION

Cranes as one of the major equipments in industries, exists in most places – from domestic industries to naval yards to warehouses. In these places the productivity of the activities depends on how efficiently the cranes are managed. One of the challenging in the control of the cranes is to deal with swaying phenomenon introduced by the trolley motion. This swaying not only reduces the efficiency of the cranes, but also can cause safety problem in the complicated working environment.

A gantry crane can be modelled as a pendulum in laboratory level (Ziyad and Daqaq, 2007). Therefore a pendulum will be a modelled gantry crane as the object of this project. Trolley of the crane is powered by an electromotor, the length of the cable is fixed as the weight of the container and the angle of the cable is equipped with a sensor. The other sensor is needed to detect the trolley journey and it will be solved using a camera.

Many control strategies based on the classic or modern control techniques have been proposed and

tested in laboratory level for controlling crane systems, such as PID control, adaptive control, optimal control, and nonlinear control etc. However, from the practical point of view, real-time control requires some simplification of the experimental model, and human intervention is always necessary for this type of control. In general, a controller based on the experience of the human operator is desired for the practical purpose.

Within this project the fuzzy control will be used to be implemented simultaneously with vision feedback system in controlling a modelled gantry crane.

CONTROLLER DESIGN

The goals for designing the controller are stable, no steady state error (container exactly on truck), no overshoot (no bump in the cabin of the truck), and the settling time is as fast as possible.

A fuzzy control was chosen for controlling the crane and it was done with LabView Fuzzy

Control Toolkit. LabView is a graphical programming language that is produced by National Instrument. Its features are simple, user friendly and easy to be learned.

The aim of fuzzy control is normally to substitute a fuzzy rule-based system with a skilled human operator. A fuzzy controller is comprised of three basic components: the fuzzifier, the rule base, and the de-fuzzifier as seen in the figure below (Anonymous, 2009).

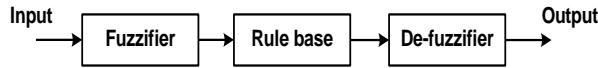


Figure 1. Basic of fuzzy components

The process of converting crisp values into membership functions is called fuzzification. The rule base, together with the formulation of the fuzzy sets, forms the knowledge base of the fuzzy system. By weighting, fine-tuning of the consequents of the rules is possible, without changing the reference fuzzy sets. This process is called defuzzification (Brian and Ben, 2006).

The membership functions of the controller are separated into one input and one output member and the input member is distance and the output is voltage as follows.

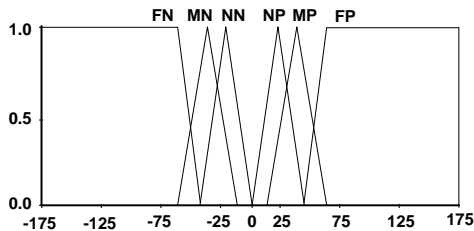


Figure 2. Input membership

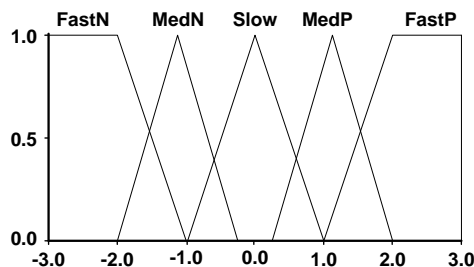


Figure 3. Output membership

Because the crane system is very simple with one input and one output, the input and output memberships are connected with simple IF..THEN

conditions. Therefore the rule base only consists of six rules as simplified in table 1.

Table 1. Rule base

UTILS RULE	IF DISTANCE	THEN VOLT
1	FN	FastN
2	MN	MedN
3	NN	Slow
4	NP	Slow
5	MP	MedP
6	FP	FastP

As the result of defuzzification, some amount of voltage will be applied to the gantry crane.

IMPLEMENTATION

1. Block Diagram

Block diagram of the overall system can be figured in following figure.

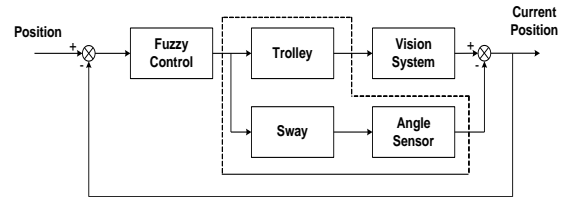


Figure 4. Block diagram of the system

Trolley, sway and angle sensor represent the real crane system. The system will be connected to a computer using an interface coded NI cDAQ-9172 produced by National Instrument.

The angle sensor and vision system will give the current position of the trolley and the pendulum. The difference between current position and desired position will be processed inside fuzzy controller. Finally the controller will apply voltages to the crane system.

2. Programming

LabView 8.2 is a new version of LabView that comes with Vision Toolkit. It gives possibility to programme software based on vision system in LabView 8.2.

Implementation of the controller was done in LabView 8.2 and these parts can be explained as follows:

- Vision part
This part includes unit for connecting a camera, finding edge coordinates, and also

setting and drawing line. To start the vision part, a camera should be detected. If the camera is not connected, software can not be run. The idea of vision part in this software is to find some edges by setting values of contrast, filter width and steepness. Contrast parameter specifies the threshold for the edge contrast. Only edges with a contrast greater than this value are used in the detection process. Contrast is defined as the difference between the average pixel intensity before the edge and the average pixel intensity after the edge. Filter width specifies the number of pixels and steepness specifies the slope of the edge. This value represents the number of pixels that correspond to the transition area of the edge (Anonymous, 2009).

- Conversion part

The edge coordinates will be found in a matrix and it is hard to take matrices calculation in LabView. Therefore the matrix value should be separated into vector values and this unit is built to handle it.

- IO part

This part will connect a computer with the crane system. Output of this interface is voltage which is read from fuzzy control and its input is data from angle sensor of the system.

- Fuzzy part

Fuzzy part in this software is just a simple part with a VI (virtual instrument) to open and read a file which is containing information about membership, rule base and surface of the fuzzy control.

- Soft start part

The soft start will give ramp voltage signal to the system until the voltage matches with voltage from fuzzy control. This unit can reduce the sway of starting but it will increase the consumption time.

Result of the implementation is software that can be run under LabView 8.2 or higher version.

3. Software Outline

After running the software, a dialog box will open to select a fuzzy control file and then a camera should be selected to run the software. A Logitech QuickCam Pro 5000 camera was used with this software.

In default, manual control is selected to give a chance for an operator to select the coordinate for vision system. For controlling the crane, at least 3 edges should be found by vision part. Two of them will be used for defining the length of block and the other for defining the position of the crane trolley.

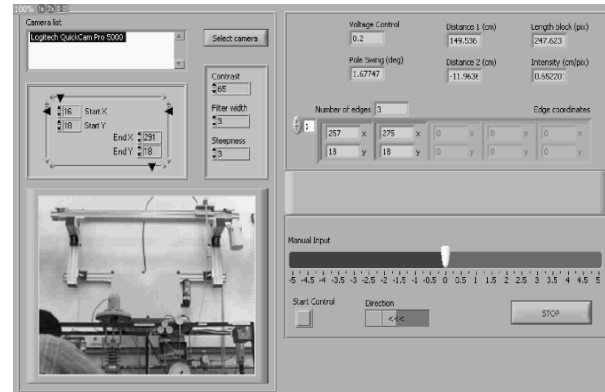


Figure 5. Front panel of software

Front panel of the software is shown in figure 5. In this figure, the program finds 3 edges and the controller was run with soft start. The camera can detect the length of the crane block about 247.6 pixels. The distance about 149.5 cm and so the intensity is about 0.652 cm/pixels. The voltage control box will show the voltage applied to the crane motor and the direction button is used to select direction of the crane (left or right).

RESULTS AND DISCUSSION

To test the software, some experiments were done. As the result, the software is success to control the crane with very small overshoot at the end of every test although some problems happen along the testing.

The problems introduced in the experiments are probably because of the lamp using for lighting inside the room. The lamp is near to the right side of the crane block and because the block is made from bright material, the light is easy to be reflected. Therefore the light distribution along the crane block is not same. The problem is not appeared when the trolley moves to the left because the controller can detect not more than 4 edges and the distance is calculated correctly.

When the trolley moves to the right side, any edges are found. The edges which are detected by the camera are more than 4 and it made errors in calculating the resolution. Finally it will introduce errors for calculating the distance. Data recorded from the experiment was used to produce both two graphs below. Time consumption is fixed to 1/10 second of the curves time.

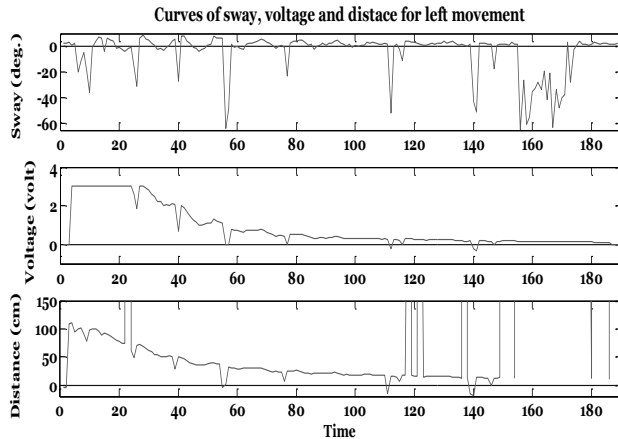


Figure 6. Curves of the left movement

From figure 6, when the controller is switched to work, voltage is going to maximum for a while. After the condition, voltage is going down proportionally by decreasing of the distance. Because the system is started without soft start, the sway is appeared along the process but finally there is no sway and the crane reaches its position faster.

Spikes of voltage are caused by errors which are introduced in edges detection of the camera and the voltage will be applied incorrectly. The other spikes in sway are caused by interference inside the angle sensor.

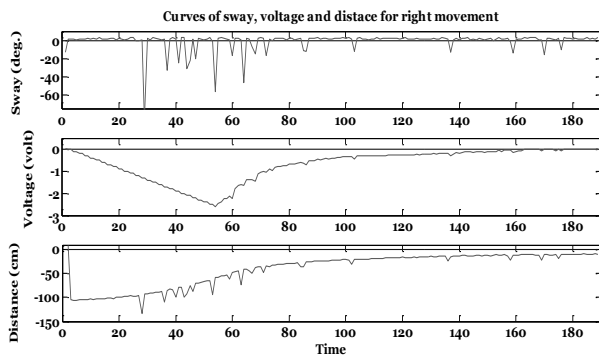


Figure 7. Graph of the right movement

On figure 8, the voltage input was increased by the soft start action and after it reaches the controller

voltage then the voltage was fully controlled by the controller. Controller will drive the voltage down proportionally with decreasing of the distance. Because of the errors after soft start released the voltage to controller, the voltage is directly going to zero and it makes more swaying. Actually before the voltage is given to the controller, the errors were introduced. It is not affecting the soft start because it can only give the voltage to the controller if it has voltage lower then or equal to the controller voltage. The experiments data of swaying at starting and ending of the trolley are given in the table 2.

Table 2. Sway data

Experiment	Right		Left	
	Start	End	Start	End
1 st	1.47098	1.97573	1.34479	0.89740
2 nd	1.11536	1.43656	0.65649	0.75974
3 rd	1.20713	2.07898	2.10192	2.73286
4 th	2.58373	2.36577	1.02358	2.72139
5 th	1.78071	0.84004	-13.2242	2.33135
Average	1.63158	1.73942	-1.61948	1.88855
pOS (%)	0.45322	0.48317	-0.44986	0.52460

The data on table 2 shows that the overshoot percentages (pOS) are very small about less than 1%. According to the data, it can be assumed that the crane exactly reaches its position and the controlling objectives are fulfilled.

CONCLUSIONS

A vision system was used in this project to solve the gantry crane needs of a distance sensor. Using a Logitech camera, the vision device detected the distance in pixel unit about 247.6 pixels.

For controlling the crane, a fuzzy controller was chosen with distance as input member and voltage as output member. A simple IF..THEN condition to connect both memberships is offering 6 rules for the controller.

Implementation is fully done in LabView 8.2. Both LabView toolkits, Vision and Fuzzy Control Toolkit, are additional toolkit using in this project. The computer vision was done with LabView Vision Toolkit and Fuzzy Control Toolkit is used to design software of the controller.

Effect of lighting and characteristic of the material which is measured can make some influence in vision measurement. Therefore it

will give errors in finding an object based on edge detection.

Result of the experiments show that the implemented software is success to drive the crane with fulfilling all of the controller requirements.

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