AN IMPROVED FUZZY LOGIC CONTROLLER FOR DEPTH CONTROL OF THE VIDEORAY PRO III UNDERWATER VEHICLE

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Mechatronic Engineering

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“I hereby declare read through this report entitle “An Improved Fuzzy Logic Controller for Depth Control of the VideoRay Pro III Underwater Vehicle” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronic Engineering”

Signature	:	………………………………………
Supervisor’s Name	:	………………………………………
Date	:	………………………………………

“I declare that this report entitle “An Improved Fuzzy Logic Controller for Depth Control of the VideoRay Pro III Underwater Vehicle” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidate of any other degree.

Signature : ……………………………………

Name : ……………………………………

Date : ……………………………………

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ABSTRACT

Nowadays, human ability is limited in deep water or seabed. There some places in underwater that human unable to reach due to dangerous and high pressure. However, the underwater vehicle is created to overcome the problem. Underwater vehicle function to help scientist make an underwater research and commonly used in deep water industries. The main point is the ability of underwater vehicle able to be controlled. However, the conventional like PD also has a problem to control nonlinear operation. The PID controller also hardly to achieved zero overshoot. Thus fuzzy logic controller is introduced to overcome the problem. In this project, the objectives are to design and improved fuzzy logic controller (FLC) for depth control of underwater vehicle (based on VideoRay Pro III), to analyze performance of system response of depth control in terms of zero overshoot, faster rise time and small steady state error using FLC and to verify the system response of the depth control using hardware implementation between Matlab/Simulink and Microbox 2000/2000C. For the methodology, the pressure sensor MX5700ap, step down voltage, microbox 2000/2000C, air compressor, thruster and multimeter are used during an experiment. The experiment was setup to analyze performance of PID and FLC in terms of zero overshoot, faster rise time and small steady state error. The final experiment carried out to study the effect of membership function of real-time fuzzy logic controller using open loop simulation data. The result shows fuzzy logic controller display a best performance in term of faster rise time, zero overshoot and small steady state error than mathematical modelling PID and real time PID.

ABSTRAK

Pada masa kini, kemampuan manusia adalah terhad di dalam air yang dalam atau dasar laut. Terdapat beberapa tempat di dalam air yang manusia tidak dapat mencapai disebabkan tekanan berbahaya dan tinggi. Walau bagaimanapun, kenderaan bawah air dibuat untuk mengatasi masalah tersebut. Fungsi kenderaan dalam air untuk membantu ahli sains membuat penyelidikan di bawah air dan biasanya digunakan dalam industri dalam air. Apa yang penting ialah keupayaan kenderaan bawah air dapat dikawal. Walau bagaimanapun, konvensional seperti PD juga mempunyai masalah untuk mengawal operasi tidak linear. Pengawal PID juga hampir tidak dicapai terlajak sifar. Oleh itu pengawal logik kabur diperkenalkan untuk mengatasi masalah ini. Dalam projek ini, objektif adalah untuk mereka bentuk dan bertambah baik pengawal logik kabur dan untuk mengawal kedalaman kenderaan bawah air (berdasarkan VideoRay Pro III), untuk menganalisis prestasi tindak balas sistem kawalan kedalaman dari segi terlajak sifar, lebih cepat meningkat masa dan kecil ralat, dan untuk mengesahkan tindak balas sistem kawalan kedalaman menggunakan pelaksanaan perkakasan antara Matlab / Simulink dan Microbox 2000 / 2000C. Untuk kaedah ini, sensor tekanan MX5700ap, penurun voltan, microbox 2000 / 2000C, pemampat udara, pendorong dan multimeter digunakan semasa eksperimen. Eksperimen adalah persediaan untuk menganalisis prestasi PID dan kawalan logik kabur dari segi terlajak sifar, lebih cepat meningkat masa dan kecil ralat. Percubaan terakhir dijalankan untuk mengkaji kesan fungsi keanggotaan masa nyata pengawal logik fuzzy menggunakan simulasi gelung terbuka. Hasil kajian menunjukkan pengawal logik fuzzy memaparkan prestasi yang terbaik dalam tempoh lebih cepat meningkat masa, terlajak sifar dan kecil ralat daripada pemodelan matematik PID dan masa sebenar PID.

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CHAPTER 1

INTRODUCTION

1.1 Project background

The ROV is a tethered underwater vehicle which is in unmanned categories. ROV commonly used in deep water industries which is involved in oil and gas activities. ROVs widely uses in offshore construction, military and scientific community. ROV used to as replace manned rescue system in military and helps scientist to make a research about underwater knowledge, deep sea animal and plants. The final year project is focused in designing the fuzzy logic controller to improve system response in terms of minimum overshoot, faster rise time, small, steady state error for depth control of the ROV (based on VideoRay Pro ROV III)

1.2 Motivation

The main encouragement to choose this title 'An improved Fuzzy Logic Controller for depth control of the VideoRay Pro III underwater vehicle' rather than other project because ROV is an interesting knowledge. ROV are widely use in several of application. ROV also can be used to explore science or natural environment at seabed. In paper [8] mentioned about impacts using ROV which is the two hundred ninety individuals completed the questionnaire in summer 2005. The respondent in the study raged from 12 to 84 years old. The question was designed to examine the impacts using an ROV had on individual's interactions with and connection to the natural environment. Table 1.1 shows that positive perceptions regarding ability of the ROV to be fun, safe and interesting to use as well as safe, low impact and conservation oriented. Furthermore, respondents suggests it was good science and research tool. However, negative perceptions were noted only among adults and included the possibility of becoming disconnected from nature. From the case study shows that the ROV offers an alternative to who's loved to explore natural environment but may fear the water, have physical limitations or want to explore depths not physically possible.

Table 1.1: ROV Perceptions [8]

Perceptions of ROV	Mean	Stand. Dev.
The ROV could be useful.	4.76	.67
The ROV was creative.	4.50	.98
The ROV was exciting.	4.39	.97
The ROV helped me understand the natural resource.	4.19	1.12
The ROV was easy to use.	3.80	.25
The ROV was difficult to use.	2.02	1.27
The ROV was stressful to use.	1.77	1.24
The ROV was boring to use.	1.38	.90

Note: Responses were measured on a 5-point scale with 1=strongly disagree and 5=strongly agree.

Other than that, ROV had function to solve underwater tragedy like deep water horizon oil spill in the Gulf of Mexico. The broken oil pipe in the Gulf of Mexico dumped 300 million gallons of water a day into Charles River (figure 1.1) and affected the water supply to for two million people The problem was determine by enlisted ROV to investigate the immediate wellhead area. The ROV discover two leaks which one from a kink in the riser and a primary link from the end of the riser, where it broken off from the rig. It a risk for human to dive in 5000' down in the Gulf of Mexico and ROV is a solution for critical situation [7].

Mysterious tragedy MH370 also used ROV in search black box in a seabed of Hindi Ocean. ROV can firm, scan and crucially pick up things from the seabed (figure 1.2).Other example is Remora which can function 6000metres which is used in salvage AF447 and other crashed planes [6]. Another important thing in ROV is the system response for depth control. In order to develop a better response in depth control for future, an analysis from fuzzy logic controller is introduced.

Figure 1.1: Broken 21” oil pipe 5000’ down in the Gulf of Mexico taken by ROV [7]

Figure 1.2: ROV helps missing MH370 [6]

1.3 Problem Statement

There are many problems happen in a remotely underwater vehicle that related with control system. The conventional controller like PD also has a problem with depth control of the ROV. The PD controller is not suitable in a nonlinear operation of depth control. The conventional PID controller also hardly to achieve zero overshoot in system response of depth control. This problem is crucial because it might cause damage to the remotely underwater vehicle if it contact directly with the seabed. Thus, intelligent control system such as fuzzy logic controller is needed in order to solve PD and PID problems.

The fuzzy logic controller is considered as new controller method to improve depth control of the ROV. Therefore, a shifting membership function will be used to analyze the effect of system response of depth control. The results is one simple contribution to this field of study.

1.4 Objectives

The objectives of final year project are:-

1. To design and improve the fuzzy logic controller for depth control of underwater remotely operated vehicle (based on VideoRay PRO ROV III)
2. To analyze performance of system response of depth control in terms of zero overshoot, faster rise time and small steady state error using FLC
3. To verify the system response of the depth control using hardware implementation between MATLAB/Simulink and Micro-box 2000/2000C.

1.5 Scope and Limitation

This project is mainly about the control system. The prototype based on VideoRay Pro III was used in this project. The prototype of the ROV is built by following parameters of thruster construction VideoRay Pro III (2 horizontal thruster and 1 vertical thruster). The dimension of prototype built up by refer to VideoRay Pro 3s (30.5 x 22.5 x 21cm). Since this project related with depth control, the movement of ROV covered a vertical up and down. The depth of ROV while doing an experiment is set less than 5m only. This project were carried out in a condition disturbance will be assumed to zero. This project were implement the intelligent control system which is Microbox 2000/2000C. The experiment related with Microbox 2000/2000C was setup in CIA Lab, FKE since a Microbox 2000/2000C is prohibited to use out of CIA lab, FKE.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will focus on ROV depth control. The topic cover about controllers that use in ROV. The main point in this chapter are to know an advantages and disadvantages each of controllers that effect the performance of depth control. Related journal of implementation controller for underwater robot also will be review and study to gain a knowledge and able to improve an existing method.

2.1.1 Conventional controller

The conventional controller includes PID, PD and PI controller. Conventional controller widely used in industrial control system. In term of stability and overshoot, intelligent system is more effective than conventional system. However, both system have their own advantages and disadvantaged by depending on applications.

- PID controller is a combination proportional, integral and derivative controller. The sum of three elements to calculate the output of PID controller.

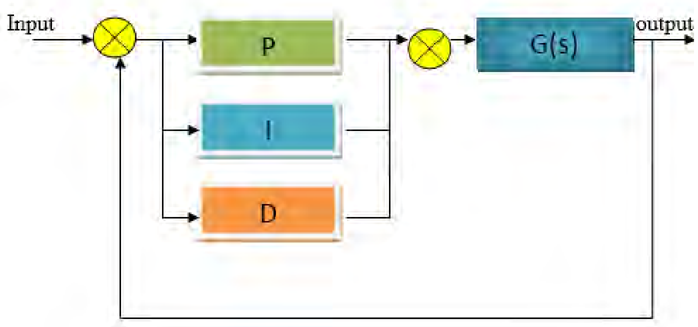

Figure 2.1: Block diagram of PID controller

Where,

K_p: Proportional gain, a tuning parameter

K_i : Integral gain, a tuning parameter

K_d: Derivative gain, a tuning parameter

e : Error = SP-SV

t : Time or instantaneous time (the present)

T : Variable of integration; takes on values from time 0 to the present t.

2.1.2 Intelligent controller

Nowadays, an intelligent control shown some success in a control method. For example neural network, fuzzy logic controller and genetic algorithm. Intelligent controller like fuzzy logic show a highly time consuming but it is suitable for nonlinear motion and need some tuning process in order to increase a performance. Fuzzy logic widely used in washing machine, rice cooker, and others. Block diagram of fuzzy logic controller as shown in Figure 2.2.

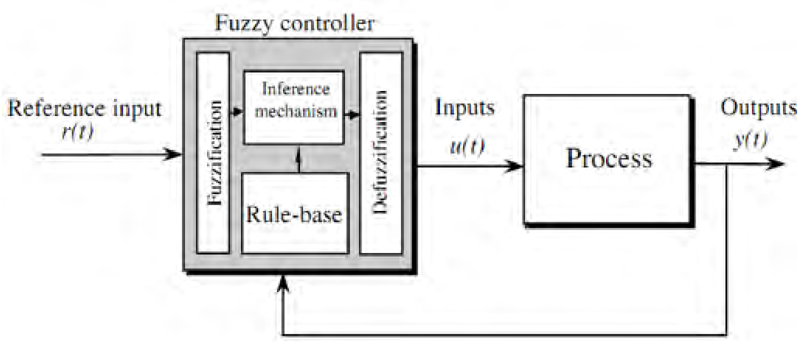

Figure 2.2: Block diagram of fuzzy logic controller [9]

Component:

- Rule-base – set of rules regarding on how to control
- Fuzzification – transforming process of numeric input into any form that can be used and detected by inference

- Inference mechanism – this mechanism use information that is formed from fuzzification and decide which rules will be applied in that of situation
- Defuzzification – convert the conclusion into numeric input for the plant that is reached by inference mechanism.

2.2 Related Previous Work

According to S. M. Zanoli [1] the PID controller with an input smoothing pre filter is introduced as a tuning of the pre filter parameters shown to reduce an overshoot. The Newtonian or a Lagrangian formalism is used as a system equation to derive a general non-linear model that described the dynamic of an underwater vehicle. The depth control divide in two different method which is continuous input smoother (CIS) as shown in Figure 2.3 and discrete fuzzy smoother DFS as shown in figure 2.4 [1].

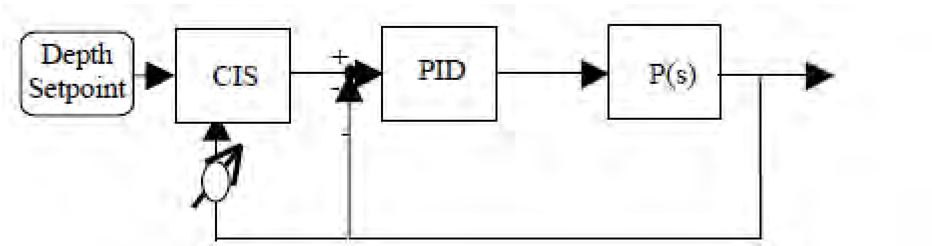

Figure 2.3: CIS Control scheme [1]

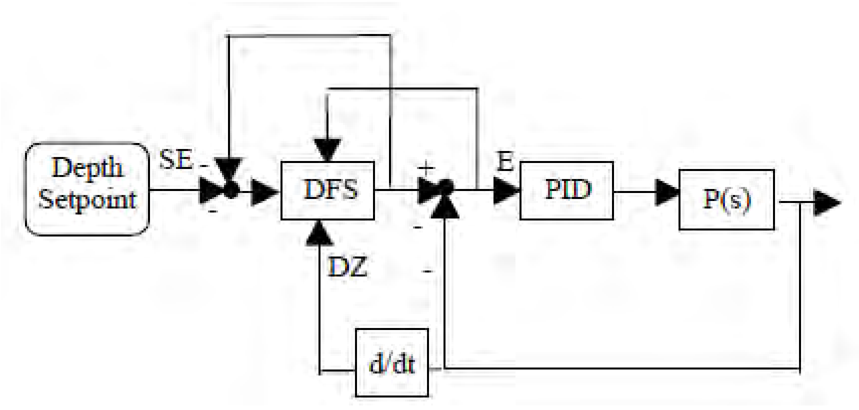

Figure 2.4: DFS Control Scheme [1]