SIMULATION OF TWO HULLED UNMANNED SURFACE VESSEL CONTROL SYSTEM FOR SURGING AND HEADING MANEUVER FOR COASTAL SURVEILLANCE

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SIMULATION OF TWO HULLED UNMANNED SURFACE VESSEL CONTROL SYSTEM FOR SURGING AND HEADING MANEUVER FOR COASTAL SURVEILLANCE

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A report submitted
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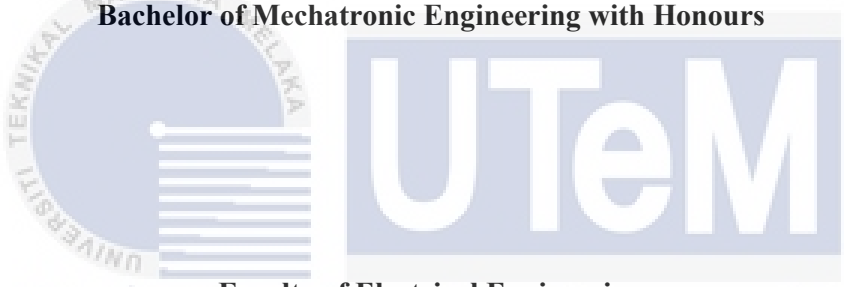

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this thesis entitled "SIMULATION OF TWO HULLED UNMANNED SURFACE VESSEL CONTROL SYSTEM FOR SURGING AND HEADING MANEUVER FOR COASTAL SURVEILLANCE is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 5th JULY 2021

APPROVAL

I hereby declare that I have checked this report entitled "SIMULATION OF TWO HULLED UNMANNED SURFACE VESSEL CONTROL SYSTEM FOR SURGING AND HEADING MANEUVER FOR COASTAL SURVEILLANCE" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : .....

Supervisor Name : DR. MOHD FAID BIN YAHYA

Date : 4-JULY-2021

DEDICATIONS

To my beloved parents and siblings

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ABSTRACT

In recent years, study on unmanned surface vessels (USV) has increased dramatically, leading to the implementation of USV in many fields through the production of new engineering and manufacturing equipment. For the implementation of the USV control system, an understanding of vehicle maneuverability and vehicle efficiency is necessary. The major goal is to design a USV closed loop controller that can change the nonlinearity of the USV because the USV has complicated hydrodynamic properties in the presence of varying. This research will therefore concentrate on the design of an effective controller for surging and heading of two hulled USV. In this study, the sliding mode control is selected as the controller for the USV as the controller using a dynamic 3 DOF model. The outcome of the controller will be evaluated on the basis of comparable simulation experiments under different parameters to figure out the best speed and heading for the USV.

ABSTRAK

Dalam era globalisasi ini, kajian tentang kapal permukaan tanpa pemandu (USV) meningkat secara dramatis, yang mengarah pada pelaksanaan USV di banyak bidang melalui pengeluaran peralatan kejuruteraan dan pembuatan baru. Untuk pelaksanaan sistem kawalan USV, pemahaman tentang kemampuan pergerakkan kenderaan dan kecekapan kenderaan diperlukan. Matlamat utama adalah untuk merancang pengawal gelung tertutup USV yang dapat mengubah ketidaklinieran USV kerana USV mempunyai sifat hidrodinamik yang rumit dengan adanya variasi. Oleh itu, penyelidikan ini akan tertumpu pada reka bentuk pengawal yang berkesan untuk melonjak dan menuju katamaran. Dalam kajian ini, "Sliding Mode Control" SMC dipilih sebagai pengawal untuk USV supaya padan dengan kelajuan yang berbeza dan untuk menentukan parameter model manuver pada kelajuan yang berbeza. Hasil pengawal akan dinilai berdasarkan eksperimen simulasi yang setara di bawah parameter laluan yang berbeza untuk mengetahui kelajuan dan kemudi terbaik untuk USV mengikuti jalan yang diberikan.

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LIST OF SYMBOLS AND ABBREVIATIONS

USV	-	Unmanned Surface Vessel
UUV	-	Unmanned Undersea Vehicle
ASC	-	Autonomous Surface Craft
UOV	-	Unmanned Ocean Vehicles
ASMC	-	Adaptive Sliding Mode Control
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CHAPTER 1

INTRODUCTION

1.1 Introduction

In modern year, unmanned surface vessel (USV) research has increase speedily, encouraging the application of USV in different fields with the production of new electrical and mechanical equipment. For the development of an automatic control system to control the USV motion and as a guide for the future design of similar vehicles it is important to understand the maneuverability and performance of a vehicle. The research background, research motivation, problem statement, objective and scope of study will be emphasized in this chapter. Background studies show the simulation of USV control system for surging and heading maneuver for costal surveillance. The issues and problems that are presented with respect to the simulation are mentioned. In addition, the shortcoming and limitation of the USV control system are discussed as problem statement. Objectives were suggested based on the problem statement. Finally, several scopes are listed to identify the limits and limits of the research in supervising the study upon completion

1.2 Research Background

For the last few decades, robotic technologies have emigrated from science fiction devices to commercialized products. Robots are programmable devices that can typically perform a series of actions independently or semi-autonomously. With the rapid growth of technology, the field of robotics has been indeed been applied to the coastal region known as the USV. USV is observed and produced by research laboratories, companies and government. Defense, robotics and bathymetric mapping are the tasks shown by the USV.

In early development of USVs, ASCs were introduced in 1993 and was built for different types of missions. This vessel is a replication of fishing boat as a framework of navigation testing and control systems required by the ASC. This ASC is mostly used to collect basic bathymetry data in the Charles River in Boston, MA [1]. Several of the major flaws of the ASC were its compact scale which restricted its strength and the maintenance. A new ASC has been established to continue the bathymetry studies. The requirements of the next ASC are to build a device that is as flexible and efficient as a small manned vessel while preserving its small size for fast deployment and survey operations [2].

The US Navy focused on UUV (Unmanned Undersea Vehicle) before USVs. The location of the USV at air and sea level enables them to transmit radio frequency transmissions. Any military applications can affect USV in communication systems and activities. Naval USVs were built for mine clearing or port protection, and these vehicles are based on conventional surface vessels that are strong, inflatable hulls.

Many types of ocean sources, such as wind, solar and wave energy, are counted as alternative energy sources under progresses that have been used to drive USV prototypes. UOV Inc. fabricated a few prototypes of unmanned sailing vessels fitted with durable sails and solar panels for aboard fuel [3]. A community of unified USV could guide an extensive analysis of the ocean's real-time state. In addition, many research and military missions would learn from these actions.

1.3 Motivation of Research

Malacca and Singapore Straits is the main route for vessels to operate between the Far East, Middle East and ports along the way. Nowadays, the Straits of Malacca through Singapore have more than 100,000 shipping flows each year. The high number of ships passing thru these straits means increasing probability of danger especially when the ships are concentrated at chokepoints.

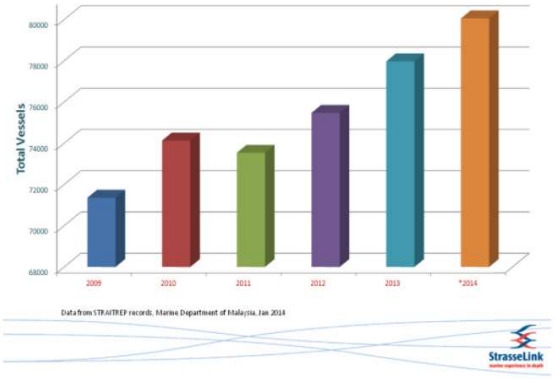

Figure 1.1: Data from STRAITREP records, Jan 2014

The straits have been the primary shipping channel for centuries between the Indian Ocean and the Pacific Ocean. Approximately forty percent of all the oil carried by water goes through Malacca and Singapore Straits from the Middle East toward China, Japan, South Korea and the Pacific Rims. The crowded shipping traffic associate with narrowness of the straits makes navigation difficult. The narrowness of the Strait is below 2 nautical miles, generating the most significant traffic choke points throughout the world. In fact, the haze created by open fire in the jungle and agricultural land burns in Sumatra may have a significant effect on marine visibility. Other than that, piracy and sea robbery also remain as threat for the marines where the pirate may hijack the ships.

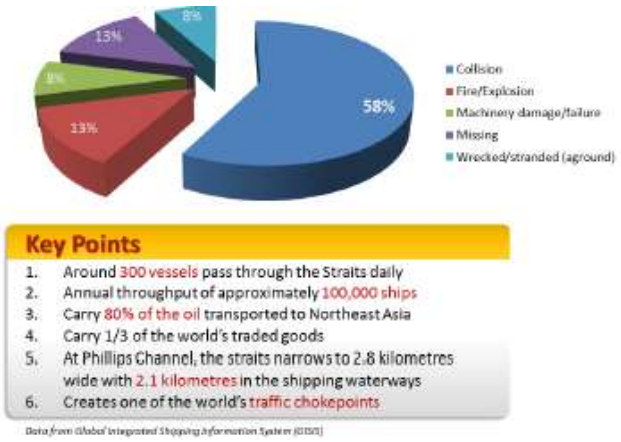

Figure 1.2: Statistic of accidents in Malacca/Singapore Straits

The accidents occur at the Straits involve contacts, collision, foundering, fires, engine troubles and leakages. The situation considers serious because it may cause loss of live and may extend of the casualties. Two large ships MV B Oceania and Xin Tai Hai collided 8 nautical miles southwest of Pulau Pinang when en route to China in 2011 which cause the loss of MV B Oceania. MV B Oceania announced that they had a malfunction in both generators, which left them unable to alter their course. Since they were unable to navigate, both boats collided. Luckily, all 23 crew members were rescued by a passing container ship. [4].

Figure 1.3: Accident between MV B Oceania and Xin Tai Hai

1.4 Problem Statement

Unmanned surface vessels (USVs) are applicable in many situations including environmental monitoring and surveillance. A closed loop controller for USV allows for the changes of displacement and angles of the USV. The research needs to be carried out by developing a controller parameter that minimize the nonlinearities in USV dynamics and kinematics that can be referred to as USV's surging and heading, because USV has complex hydrodynamic characteristics in the presence of uncertainties which is not suitable for PID controller due to PID controller is a linear system capability [5].

The appropriate development of the unmanned surface vessel (USV) depending on the type of controller must be examined in order to achieve the best performance in terms of surging and heading as ships do not have side-force propellers to balance and are inefficient at speeds above 2 to 3 knots. [6].

1.5 Research Objective

On the basis of the problem statement, two (2) objectives are defined as follows:

1. To design an ASMC controller for surging and heading of two hulled USV

2. To analyze the capabilities of the controller in term of surging and heading of USV

1.6 Scope of Study

In order to achieve the intended objectives of the project, certain limitation have been highlighted as follows:

1. The disturbance of wind, wave, current, and other marine environment is neglected.

2. The ASMC controller design is tested and validated in MATLAB software only.

3. The real time simulation is tested in Simulink software only

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

For this section, the study of two unmanned surface vessel literature, variety of controller is ASMC and the controller performance analysis is achieved by pointing to articles, thesis and journals from trusted websites such as IEEE, Sciencedirect and Google. Any of the study limitations, the data acquisition, the approach originally stated by other authors and the purpose of the research are also included in this chapter. Overview and research differences for this research study are discussed at the end of this section.

2.2 Theory and Basic Principle

This section describes the concept and fundamental principle relevant to the creation and implementation of unmanned surface vessel controllers. This section also provides an overview of historical and development process of unmanned surface vessel with some fundamental development. In addition, basic mathematical method of two hulled USV is mentioned in this section.

2.3 Development of USV

Today USVs have been built and displayed in experimental lab, government users and corporations. Global positioning systems have made USVs more lightweight, powerful and inexpensive. Higher and longer bandwidth wireless data have been the secret to the rapid evolution of USVs for a plethora of requests.

In early development of the USV, ASCs had been developed at the MIT Sea Grant College Program in 1993 and labeled ARTEMIS. This vessel is a replicate

scale of the fishing trawler as a prototype for evaluating the guidance and control systems demanded by the ASC. This ASC was used throughout the Charles River in Boston, MA to collect basic bathymetry data. [1]. The ARTEMIS's weakness was its compact scale, restricting its durability. ARTEMIS' field activities were restricted to the Charles River district, a region of minimal interest to researchers. Then, to develop more usable capabilities, a kayak platform was added. It was later mounted with audio detection systems and used to track tagged trout. [6].

A new ASC was created in order to continue the automatic bathymetry studies that began with ARTEMIS. The new ASC configuration is based on a desire to build a device as compact and efficient as a tiny manned vessel while retaining the scale for fast deployment and test procedures. During1996-1997, the latest ASC ACES (Autonomous Coastal Exploration System) was developed [2]. ASC ACES brought back to the lab in early January 1998 to improve the mechanical systems. In 2000, is when current ASC platform was renamed as AutoCat, model modifications and improvements were tested. [7].

Figure 2.1: MIT's *AutoCat*, 2000

The US Navy began testing its unmanned underwater vehicle (UUV) long before the navy concentrated on USVs. The location of the UPS at the air and sea interface enables the navy to transmit airborne radio frequency communications and

undersea audio signals. They are also the answer to the idea of combat area for the network. In past years, several UPSs have been shown to support long-term shifting baseline UUV navigation [8]. The next evolution of USVs works in naval programs as nodes in the network.

Figure 2.2: Three MIT 'kayak' USVs Operating in a Network.

Naval USVs were built as military purposes for port defense and mine clearing. Most USVs are based on conventional surface boats, such as inflatable durable hulls. In relation to navigation, some small USV can be installed with control and satellite tracking systems and most of them are controlled by staff on land or any other vessels.

Therefore, several USV style catamarans or known as two hulled USVs were built to serve academic knowledge [9][10]. The Italian catamaran USV, known as SESAMO, was used in Antarctic hydrographic studies. The catamaran is an ideal option where the catamaran has all the stability, potential for load and easy accessibility to the deck that is suitable for educational applications. The basic agreements that have assisted studies and interconnected processes with UUVs reflect a similar catamaran as SESAMO known as ROAZ from Portugal. [11].