DESIGN THE SENSOR FOR OBSTACLE AVOIDANCE FOR UNDERWATER APPLICATION USING A LASER DISTANCE FINDERS

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SUPERVISOR ENDORSEMENT

"I hereby declare that I have read through this report entitle "Design the Sensor for Obstacle Avoidance for Underwater Application Using A Laser Distance Finders" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Mechatronic)."

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STUDENT DECLARATION

I declare that this report entitled "Design the Sensor for Obstacle Avoidance for Underwater Application Using A Laser Distance Finders" 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 candidature of any other degree.

Signature : ……

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ABSTRACT

This report is about Design of sensory system for obstacle avoidance for underwater application using a laser distance finder. Unmanned Underwater Vehicle (UUV) equipped with a variety of sensors and components depending upon the mission of the application of UUV or application of the vehicle. One of the biggest challenges in developing the UUV with complicated systems is the cost. UUV must be able to interpret its environment by gathering information from its sensors with higher accuracy. This is due to unpredicted condition in a deep sea where serious collision might occur if this kind of sensory system is not implemented to the UUV. The purpose of this Final year Project is to develop a sensory system that able obstacles avoidance for underwater application using laser distance finder as a tool to measure and detect obstacles at a required range. Next, to investigate the performance of laser distance finders in terms of range (distance between obstacles), accuracy and material detected. Lastly the objective is also to analyze the performance of underwater sensors on obstacle detection and distance measurement in underwater. The components used which is inexpensive Arduino Nano as microcontrollers, 5 mm blue LED and sensor using laser distance finder result in an autonomous vehicle that will able to avoid any obstacles while moving to a location. The laser distance finder is characterized by a wide-angle spatial transmission pattern, high range resolution, short minimum detection range and fast response time. The result will be that laser distance finder will be able to detect obstacles and also cause the UUV to avoid the obstacles in depth control.

ABSTRAK

Laporan ini adalah tentang menggunakan sebuah sensor untuk mengelak halangan bagi aplikasi bawah air menggunakan jarak laser pencari. Kenderaan dalam air tanpa pemandu (UUV) yang dilengkapi dengan pelbagai sensor dan komponen bergantung kepada misi applikasi UUV. Salah satu cabaran yang paling besar dalam membangunkan UUV dengan sistem yang rumit adalah kos. UUV mesti berupaya untuk mentafsirkan alam sekitar dengan mengumpul maklumat daripada sensor dengan ketepatan yang lebih tinggi. Ini adalah disebabkan oleh keadaan tidak dijangka di lautan dalam di mana perlanggaran yang serius mungkin berlaku jika jenis sistem sensor ini tidak dilaksanakan untuk UUV itu. Tujuan Projek Sarjana Muda adalah untuk membangunkan sistem sensor yang dapat mengelakkan halangan-halangan untuk aplikasi di bawah air menggunakan jarak laser pencari sebagai alat untuk mengukur dan mengesan halangan pada jarak yang dikehendaki. Seterusnya, untuk menyiasat prestasi jarak laser pencari dari segi rangkaian (jarak antara halangan), ketepatan dan bahan dikesan. Akhir sekali objektif ini juga untuk menganalisis prestasi sensor air pada mengesan halangan dan pengukuran jarak di bawah air. Komponen yang digunakan iaitu arduino nano murah sebagai pengawal mikro, 5 mm LED biru dan sensor menggunakan jarak laser pencari menghasilkan kenderaan bawah air yang dapat mengelakkan sebarang halangan sambil bergerak ke lokasi. Pencari jarak laser mempunyai ciri-ciri corak sudut lebar penghantaran spatial, resolusi pelbagai tinggi, jarak pengesanan minimum pendek dan masa tindak balas yang cepat. Keputusannya adalah pencari jarak laser akan dapat mengesan halangan-halangan dan juga menyebabkan UUV untuk mengelakkan halangan-halangan dalam kawalan mendalam.

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

This section covers four parts of this Final Year Project which are motivation, problem statement, objectives and also scopes.

1.1 Motivation

There have been many researches in underwater application field. As the need and applications of Unmanned Underwater Vehicles (UUVs) increase day by day, the research on UUVs become a popular and important topic nowadays. This field of research has been really wide and important in order to fulfill their explorations in ocean underwater. Unmanned Underwater Vehicles (UUV) have been develop in this underwater application research and are vital in marine researches and military purpose because there are various kind of missions that can be performed in extreme environment such as deep sea without risking the human's life. On top of that, UUVs play a very important role in intervention and monitoring in oil and gas industry and also have contributed greatly in a field of search and rescue mission [1][2][3].

Unmanned Underwater Vehicles (UUVs), are defined as all types of underwater robots which are operated with minimum or without intervention of human operator. The (UUV) covers both Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles

(AUVs). AUVs can be used for underwater survey missions such as detecting and mapping submerged wrecks, rocks, and obstructions that can be a hazard to navigation for commercial and recreational vessels. The AUV conducts its survey mission without operator intervention.

When a mission is complete, the AUV will return to a pre-programmed location where the data can be downloaded and processed. AUVs are usually untethered which make them capable of long range cruising provided with sufficient power supply. One example of AUV is the utilization of Bluefin-21 from the Australian Navy to perform missions for searching the black box's signals in the Southern Indian Ocean regarding the tragic incident of the missing MH370 which occurred on 8th march 2014 [4]. However, because of all the components that are embedded inside the hull, the AUVs are rather larger in size, heavier and also quite expensive.

Meanwhile, Remotely Operated Vehicles (ROVs) are an unoccupied underwater robot that is connected to a ship by a series of cables. These cables transmit command and control signals between the operator and the ROV, allowing remote navigation of the vehicle. An ROV may include a video camera, lights, sonar systems, and an articulating arm. The articulating arm is used for retrieving small objects, cutting lines, or attaching lifting hooks to larger objects. There are many uses for ROVs, but basically, they are tele-operated robots that are deployed primarily for underwater installation, inspection and repair tasks.

Recently study about the underwater robot goes actively and above all, the navigation in the underwater environment have occurred a challenging problem for the underwater robots [5]. UUVs can be in high at risk in underwater as obstacles could be anywhere. UUVs are expensive assets which can be breakdown and vanish if collision with obstacle happens. Thus a lot of cost is needed in order to fix the damages to the UUV. On top of that, obstacle avoidance for UUV is an extensively studied in this project. Many different approaches exist in order to solve the problems. Therefore, the idea of this project is created which is to design a sensor for obstacle avoidance for underwater application by using laser distance finder. Laser distance finders have advantages of being convenient for use, high accuracy, and short

measuring time. Laser distance finders are widely used in a variety of applications, such as architecture, exploration, construction and more. Therefore, implementation of obstacle avoidance mechanism can be a good measure to enhance the safety of the UUVs [15].

1.2 Problem Statement

An underwater vehicle must be able to interpret its environment by gathering information from its sensors. In the science of autonomous navigation, the primary objective is to describe objects located in the vehicle's environment so that computations can be made to navigate around obstacles that will impede its progress. Therefore, tremendous mechatronics knowledge is needed to design a control algorithm in order to perform obstacle avoidance mechanism. A suitable sensor needs to be design and implement to the UUV for obstacle detection within 1 meter in underwater. Besides, competency in programming is necessary to produce less error in the coding. A type of laser distance finder selected must be able to perform the required task in obstacle avoidance with consideration of various aspects of the environment such as color of the surface of the obstacles, types of material of the obstacles, and also distance of the obstacle from the laser to be detected. All these are important parameters that need to be considered in order to make the UUVs to be able to avoid any obstacles presence in its surrounding environment.

1.3 Objectives

The objectives of this project are:

1. To develop a sensory system that able obstacles avoidance for underwater application using laser distance finders as a tool to measure and detect obstacles at a required range.
2. To investigate the performance of laser distance finders in terms of range (distance between obstacles), accuracy and material detected.

3. To analyze the performance of underwater sensors on obstacle detection and distance measurement in underwater.

1.4 Scopes

1. This study is tested in lab which has a rectangular tap water pool. The dimension of the rectangular tap water pool is 2.57 meter length × 1.35 meter width × 1.00 meter height.
2. This study is focuses the range for laser distance finders.
3. Materials to be detected are wood, metal and mud.
4. Obstacle is needed at least 30 centimeters away from the UUV in order to prevent collision.
5. The microcontroller used is Arduino Nano.
6. Performance of the laser sensor is dependent on intensity of reflected light received. Therefore, shiny white obstacle,white obstacle, black obstacle and grey obstacle are used to demonstrate obstacle avoidance mechanism.
7. This study is in indoor environment which is in the lab under fluorescent lamp because the laser sensor is UV light dependent sensor. Under sunlight environment, the output voltage and the analog reading of the laser sensor might be deviated aggressively.

1.5 Summaries on introduction

Based on this chapter, some important parameters in completing this project has been initially identified. These important parts that has been considered first are the motivation for this project, problem statement occurs that encourage to do this project, objectives of this project and scope it covers.

CHAPTER 2

LITERATURE REVIEWS

2.0 Introduction

In this section, the literature review will be discussed from journals or conference papers which related to this project. The important information on a particular subject will be extracted from these papers. In this literature review, the area that will be discussed will be very important in able to design a sensor that will fulfill the requirement of this project which is able to avoid obstacle by using laser distance finder. There are some journals that have been studied in order to achieve the goal in develop a laser sensor for this Final Year Project. Those journals are about problem analysis of the obstacle detection and avoidance of UUV, motion guidance of laser distance finder, navigation of Autonomous Underwater Vehicle, Light Emitting Diode (LED) as photodiode and absorption spectrum of light in water.

2.1 Problem Analysis of the Obstacle Detection and Avoidance of UUV

From [5], the journal is consisting of three main parts which are an analysis of the "Obstacle Detection and Avoidance" problem for AUV, information extraction techniques and avoidance strategies. This journal focuses on the Military Underwater Vehicles (AUV). As we know, Military Underwater Vehicles (AUV) shall be able to execute survey missions successfully in either known or unknown environments in order to detect any potential threat. Not only that, they also should allow to achieve Exploration and Reconnaissance missions on dedicated areas before the Navy operations begins. However, in order for this type of underwater vehicle to be able to perform the required task, of course there are a lot of challenges that occurs. For example, underwater environment is often badly known, hardly understandable, changing, and even a hostile. Regardless of the limited size of the AUV, it will be very difficult for it and sensitive to the unexpected events such the emergence of either a fixed or even a moving obstacle that appeared on its way. In this journal, it is also said that there are several classes of obstacles which are:

1. Deep obstruction (important bottom rising, rock plates, undersea hills, structures from industrial or manned activity, wrecks, tethered mine, chains, ropes, etc…)
2. Drifting objects in the water column (wood balls, nets, school of fish, marine mammals,
   seaweed, divers, and potentially submarines or other robots)
3. Near surface obstacles (buoys, surface ships, handmade objects, icebergs, etc…)

Meanwhile, similar type of obstacles can also be encountered in harbour area, but due to the port installations such as pillars, wedges, chests and more, additional obstruction may occur. On top of that, some obstacles will occur more frequently as for example bottom laying object, and boats that are sailing since the traffic in that area is considered more challenging than the traffic at the sea. AUV's primary mission is data acquisition and collection. Thus, the security of the AUV is also need to be guaranteed. Therefore, in order to guaranty its security, it must

be able to know in advance its environment to be able to detect the any unexpected obstacle, to analyze then and to react.

For the first part of this journal, the obstacle detection and avoidance problem for AUV have been analyzed. In underwater robotics, AUV have a limited size and weight and each AUV is different from one another. Nowadays, looking for a robust detection and avoidance capability for AUV is considered a hot topic [10]. The operation of an "obstacle detection and avoidance" system can be divided in several stages and each stage have its associated complexity (sensor, signal and information processing, vehicle behavior). Furthermore, the importance of every stage can be different from different AUV. Those processing steps are as follows:

- **Forward Imagery:** resolution capability in relation with the object size at the maximum safe distance
- **Automatic detection** : of representative echoes and/or acoustic shadows
- **Shape analysis**: echoes association and acoustic shadows characterization in order to estimate the shape or the extend of the obstacle
- **Echo tracking :** to confirm the detection on images sequence and to reduce false alarm (non - consistent echoes with time)
- **Classification :** selection between hazardous obstacles (net, obstruction in the water column, unexpected and rapid seabed rising, wreck, underwater structure), or non - dangerous obstacles (school of fish, seaweed)
- **Localization** : localization of obstacles (on the seabed, in the water column) in order to inform the vehicle supervisor in real time about the precise position of the hazard
- **Re-acquisition** : eventually with another sensor if a confirmation strategy has been defined
- **Avoidance** :eventually, if an avoidance strategy has been defined