Faculty of Mechanical Engineering

THE DEVELOPMENT OF UNDERWATER MANIPULATOR FOR MINI-ROV APPLICATION

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THE DEVELOPMENT OF UNDERWATER MANIPULATOR FOR MINI-ROV APPLICATION

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DECLARATION

I declare that this project report entitled "The Development of Underwater Manipulator for Mini-ROV Application" is the result of my own work except as cited in the references.

Signature : NgAnnQi

Name : Ng Ann Qi

Date : 16/01/2019

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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Date : 16/01/2019

ABSTRACT

Manipulator is an important tool for remotely operated vehicle (ROV) to perform various tasks such as picking up object from the ocean bed, grasping and transferring equipment underwater and joining parts. This paper presents the designing and development of underwater manipulator for BlueROV2 application. This study also aimed to conduct a testing of manipulator in the water. The details design of manipulator are developed by using CATIA software. The characteristics of new design of manipulator are low cost, low complexity of structure, high portability, ease of handling and ease to manufacture. The position of manipulator on the BlueROV2 is at the center that under the vehicle (inside of Payload Skid). The center position of manipulator can vertically align the center of buoyancy and the center of gravity thus balance the vehicle. This paper also presents the determination of the gripping force of the gripper by using different mass of load. As the mass of load increase, the gripping force is also increase. In addition, the testing results also show low coefficient of friction causes the high force is required to grasp the object by gripper. The maximum gripping force of gripper is obtained in this paper. The testing result based on functionality of manipulator in water is presented. The manipulator is able to grasp and hold the load in water without continuous force generated by motor. The design of finger of gripper enable the manipulator to reach the load at the corner and perform the grasping task underwater successfully.

ABSTRAK

Manipulator merupakan alat yang penting untuk kenderaan beroperasi jarak jauh (ROV) untuk melaksanakan pelbagai tugasan seperti mengambil objek dari katil lautan, menggenggam dan memindahkan peralatan di dalam air dan menyambungkan bahagian. Kertas ini membentangkan reka bentuk dan pembangunan manipulator untuk aplikasi BlueROV2 di dalam air. Kajian ini juga bertujuan untuk melakukan pengujian manipulator di dalam air. Reka bentuk manipulator dikembangkan dengan menggunakan aplikasi CATIA. Ciri-ciri reka bentuk manipulator baru adalah kos rendah, kerumitan struktur yang rendah, mudah untuk dialihkan, mudah untuk mengendalikan dan mudah untuk menghasilkan. Kedudukan manipulator pada BlueROV2 adalah di tengah-tengah di bawah kenderaan (di dalam Payload Skid). Kedudukan manipulator di tengah-tengah adalah untuk menegak pusat keapungan dan pusat graviti secara vertikal supaya mengimbangi kenderaan. Kertas ini juga membentangkan penentuan daya mencengkam penggenggam dengan menggunakan jisim objek yang berlainan. Apabila jisim objek meningkat, daya mencengkam juga meningkat. Di samping itu, keputusan ujian juga menunjukkan pekali geseran yang rendah menyebabkan daya tinggi diperlukan untuk mencengkam objek oleh penggenggam. Kekuatan gripper maksimum telah diperolehi dalam kertas ini. Hasil ujian berdasarkan fungsi manipulator di dalam air dibentangkan. Manipulator dapat mencengkam dan menahan objek dalam air tanpa daya yang berterusan yang dihasilkan oleh motor. Reka bentuk jari penggenggam membolehkan manipulator menyentuh objek di sudut dan berjaya melaksanakan tugas menggenggam objek di dalam air.

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LIST OF ABBEREVATIONS

UVMS	Underwater Vehicle Manipulator System
ROV	Remote Operated Vehicle
DOF	Degree of Freedom
PVC	Polyvinyl Chloride

LIST OF SYMBOLS

ρ	=	Density
μ	=	Coefficient of friction

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, the underwater vehicles which is considered as useful and efficient equipment are widely utilized in underwater exploring and research. Unmanned underwater vehicles, can be addressed as UUVs, are unoccupied underwater vehicles that are able to submerge underwater without the occupying of a human physically. These underwater vehicles may be divided into two main categories: Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs).

Remotely Operated Vehicle (ROV) is used in this study and the type of ROV used is BlueROV2. The BlueROV2 as shown in Figure 1.1 is the world's most affordable high-performance ROV. It consists of the 6-thruster vectored configuration and strong static stability which ensure the vehicle smooth, stable and highly maneuverable. It is able to navigate to a standard 100m and up to 300m depth. The whole rig weighs about 22 lb (10 kg) in the air, provided a 100-m tether adds around 10 lb (4.5 kg) depending on the intensity of use (BlueRobotics, n.d.).

Figure 1.1: BlueROV2 (BlueRobotics, n.d.)

The underwater vehicle can only perform various survey tasks when equipped with underwater manipulator (UWM). Manipulator is defined as arm-like mechanism on a robotic system. It is composed of revolute and prismatic joints, as well as other mechanism such as slider, that can move and manipulate objects under human control **(**Ya'akob, 2010)**.** With the manipulator, the underwater vehicle are able to perform various tasks such as picking up object from the ocean bed, grasping and transferring equipment underwater, joining parts and even part assembly.

In this study, the manipulator is designed to be fixed on BlueROV2. This is due to there is no manipulator for BlueROV2 to perform grasping task underwater. The manipulator is designed by modifiying the robot arm trainer [model is MR-999CP] as shown in Figure 1.2. The robot arm trainer is comprised of five main components which are gripper, wrist, elbow, shoulder and base arm. It is capable to perform a lot of works with high flexibility of movement (EK JAPAN, 2008).

Figure 1.2: Robot arm trainer [MR- 999R] (EK JAPAN, 2008)

In this project, the gripper of the robot arm trainer is modified and utilised as the manipulator for BlueROV2. The gripper is able to open and close its finger up to 50 mm. The gripper is fixed with the semi-transparent arm and LED lights. During operation, the LED light attached on gripper will light up. This will be useful for users to observe its arm movement clearly when it is used in shallow water.

The underwater manipulator is helpful for human as no direct contact with the items underwater is required if the items is radioactive and hazardous. It also can control and manipulate materials in inaccessible places. The maximum depth it can reach underwater and the pressure it can withstand definitely better than human. It also can perform better than human from the aspect of visibility underwater. Therefore, the development of underwater manipulator (UWM) is important in the marine science and engineering field.

1.2 Problem statement

Nowadays, the improvement of ROV has been carried out to ensure it consists of multiple function. For the BlueROV2 that sold in the market, it is one type of ROV that required an operator to control its navigation underwater. However, it is a type of ROV without any manipulator. It is unable to perform multi tasks underwater without a manipulator. Therefore, this underwater manipulator project is proposed in order to increase the functionality of BlueROV2.

1.3 Objectives

The objectives of this project are as follows:

1. To design and develop underwater manipulator for mini-ROV application.
2. To conduct the testing in the aspect of functionality for manipulator in water.

1.4 Scopes

The scopes are identified based on the objectives of this project. The scopes are:

1. To design and fabricate a small scale of underwater manipulator for BlueROV2 model.
2. To determine the gripping force of the gripper by using different mass of load.
3. To test the functionality of manipulator in water and to investigate whether it can perform tasks underwater successfully.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to underwater vehicles

The underwater vehicles can be categorized into two types as shown in figure below: Manned Underwater Vehicles and Unmanned Underwater Vehicles (UUVs). The constant operator attention is needed for ROV with the use of tether or cable for power, video, and controls (Soffar, 2016). The AUV, is free from a tether and can run either a pre-programmed or logic-driven course. Figure 2.1 shows the taxonomy of underwater vehicle.

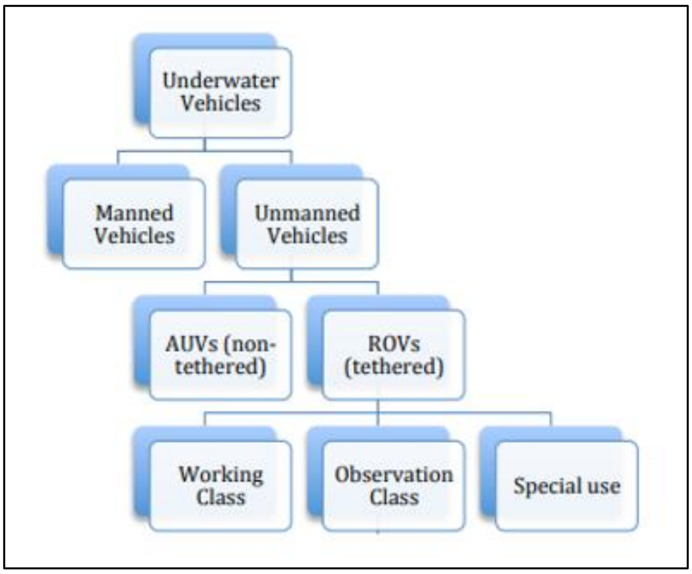

Figure 2.1: Underwater Vehicle Taxonomy (Chris and Wernli, 2007).

2.1.2 Remotely Operated Vehicle (ROV)

A Remotely Operated Vehicle (ROV) is unoccupied and highly maneuverable underwater robot connected with a series of cables to the ship. Generally, there are five types of underwater which are: small electric ROVs, high-capability electric ROVs, general class ROV, work class ROV and heavy class ROV. Different type of ROV has different properties and different application. The remote navigation of ROV is performed by transmitting the command and control signals through cables. The functions of ROV include: search, inspection, equipment repair, scientific analysis, and surveying. If in deep or rough water, the usage of robust umbilical cable of ROV is high. The ROV can be equipped with things such as video camera, lights, sonar systems, an articulating arm and a wide range of sampling options (NOAA, 2018). The limitations of human divers and human-occupied diving vehicles can be overcome by developing the ROV. Figure 2.2 shows one of the small work-class ROV system called COMANCHE.

Figure 2.2: Small work-class ROV system- COMANCHE