UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT OF SMALL SIZE REMOTE OPERATED VEHICLE (ROV).

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours.

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APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Remotely operated underwater vehicle (rov) merupakan robot yang mampu bergerak didalam air dan dikemudi dari darat, digunakan utk memantau kedalaman air laut. Berkomunikasi dan brtukar data melalui isyarat elektrik utk kawalan, penggunaan kabel wayar atau penambat menjadi pengantara antara rov dan pusat kawalan. Berkonsepkan rekaan saiz yang minimal dan senang dikawal, memudahkan utk beroperasi ketika di tapak operasi. Menjadi lebih manfaat apabila dapat menggantikan penyelam utk merentasi kawasan yang sempit dan sukar utk dilalui tambahan dengan kesuntukkan masa yang dihadapi oleh penyelam. Bagi mengenalkan kepada pelajar seluruh Malaysia tentang kecanggihan teknologi ini, satu pertandingan telah dilancarkan oleh pihak IIUM. Ini bertujuan membuka mata pelajar akan luasnya peluang kerjaya dalam bidang teknologi khususnya ROV dan dalam pada masa yang sama juga memberi sokongan kepada kejuruteraan maritim.Selain direka utk beroperasi di kawasan yang sempit, Ia juga direka utk membantu manusia melaksanakan misi yang berisiko tinggi didalam air. ROV untuk projek ini mestilah mempunyai saiz yang kecil dan struktur ROV ini direka menggunakan pengisian CAD 3 dimensi seterusnya dicetak mengunakan pencetak 3D dengan ketepatan millimeter. Brushless motor yang berskala kecil digunakan supaya ROV kelihatan kecil tambahan pula brushless motor ini mempunyai ciri yang ringan. Selain itu, brushless motor juga boleh mengawal kelajuan putaran motor yang dapat membuatkan ROV bergerak dengan lebih tepat. ROV ini juga mempunyai 6 darjah kebebasan pengerakan seperti surge, heave, sway, roll, pitch dan yaw. Dua sensor MPU9560 dan BMP180 ditambah bagi memudahkan ROV ini membuat pembaikian secara automasi. Sensor ini digunakan dalam mengukur altitude ROV dan kedalaman. Seterusnya, microcontroller esp32 yang menggunakan kernel FreeTOS digunakan bagi mengabungkan semua data dan sensor dengan cekap dan tepat. Dalam pencapaian kajian ini, sebuah ROV yang bersais kecil dan mudah dikendalikan telah dibentuk. ROV ini telah mencapai prestasi yang baik untuk dari segi mekanisma penyedut digunakan untuk mengagkat dan letak guli.dalam masa 6 minit seperti yang dinyatakan di peraturan IRC2019. Akan terapi, pengendali ang mahir sangat diperlukan untuk mengendalikan ROV dengan lancar.

ABSTRACT

A Remotely Operated Underwater Vehicle (ROV) is a highly maneuverable underwater robot that can be used to explore ocean depths while being operated by someone at the water surface. Use of cables, or tether, connects the ROV to the station, sending electrical signals to communicate and transmit data to control station or vice versa. There is also an ROV with a compact design and easy to use, that can be deployed immediately on the operation site. This is highly beneficial in emergencies where time is limited, and in areas that are too narrow or difficult to reach by divers. IIUM has made an event to bring together a student from all around Malaysia to introduce students to this fascinating technology so that they can explore career opportunities in this field. It also can support marine engineering early on through fun-filled activities. Therefore, ROV with a small body and mechanical part that can operate at tight space is developed to assist a human in performing a high-risk mission underwater. This project ROV is mainly created for a limited task, which is a pick and place a small object. The custom ROV structure is designed using 3d CAD and 3D printed with millimeter presision. Small brushless motor is used to keep the size small despite this motor characteristic is small and light. Brushless motor also has more control and constand of rotation speed that needed to move the ROV precisely. ROV has 6DOF of freedom movement consist of surge,heave, sway,roll, pitch and yaw. To add the auto correction feature in the ROV, 2 sensor is added. MPU9250 and BMP180 is used to measure attitude of ROV and Depth. For software controller, ESP32 that used FreeRTOS kernel is used to combine all the sensor and data together efficiencly. In this project, a small size ROV that easy to control has been developed. This ROV have meet the best performance of sucker to pick and place a small marble within 6 minutes as clarify in IRC2019 rules. However, experience is the most importance to operate ROV effectively.

DEDICATION

With this thesis, my expression of special gratitude is for my family and friends. Also, to all people who support me. I am thankful and appreciate the motivation and constant for finishing this Bachelor Degree Project (BDP). I do not get to this stage without them.

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D, d	-	Diameter
F	-	Force
g	-	Gravity = 9.81 m/s
I	-	Moment of inertia
1	-	Length
m	-	Mass
N	-	Rotational velocity
P	-	Pressure
r	-	Radius
T	-	Torque
V	-	Velocity
w	-	Angular velocity
x	-	Displacement
z	-	Height
q	-	Angle
Hz	-	Hertz
Kv		RPM of the motor per volt
rpm		Rotation per minutes

LIST OF ABBREVIATIONS

ROV	Remote Operated Vehicle.
ADC	Analog Digital Conversion.
ESC	Electronic Speed Controller.
PWM	Pulse Width Modulator.
AFHDS	Automatic Frequency Hopping Digital System
PLA	Polylactic acid
CB	Center of Buoyancy
CG	Center of Gravity
USB	Universal Serial Bus
DOF	Degree of Freedom
UWTV	Under Water TV System
AUV	Autonomous Underwater Vehicles
MAC	Media Access Control
TDD	Time Division Duplex
USAAN	Underwater Small Area Acoustic Network
OFDM	Orthogonal Frequency Division Multiplexing
IMU	Inertial Measuring Unit
GPS	Global Positioning System
MEMS	Micro Electro-Mechanical System
PID	Proportional Integral Derivatives
ABS	Acrylonitrile Butadiene Styrene

TCP	Transmission Control Protocol
IP	Internet Protocol
SPI	Serial Peripheral Interface
PWM	Pulse Width Modulation
TDD	Time Division Duplex
UART	Universal Asynchronous Receiver-transmitter
RPM	Revolution Per Minute
GUI	Graphical User Interface
PCB	Printed Circuit Board

LIST OF PUBLICATIONS

CHAPTER 1

INTRODUCTION

1.1 Background

In the present era, Remotely Operated Vehicle (ROV) widely used across many industry sectors. A single operator or driver must use this type of Underwater Vehicle (UV). This UV can also save human life compared to conventional methods that require humans to dive into conducting research, making observations, or performing an underwater task (Azis et al. 2012). The human body can withstand diving to a depth of up to 30 m before the toxic reaction within the body starts to react. Hence, to overcome this limitation, for the exploration of underwater locations deeper than 30 m without endangering its driver, the ROV can be utilized. The concern with the new ROV working class is that they are expensive because they cost more than RM 200,000 (Aras et al. 2015). A smaller-scale ROV with the cheaper price are needed for research and study purposes. The ROV of small scale must have the same behavior as the ROV of industry class. Also, this concept ROV has autonomous depth control, which does not vary from the ROV used for monitoring of underwater pipelines.

The motivation of this projects is based on the previous competition IIUM Robotic Competition 2019 (IRC2019) that take place in the International Cultural Centre (ICC), International Islamic University Malaysia (IIUM). This event was joined by a student from FTKEE robotic Club (HERO) under category Remotely Operated Underwater Vehicle (ROV). This team developed a simple ROV prototype to complete the competition task and manage to be a champion due to maintenance of the ROV by teammates and consistency of

running the ROV without fail. Each successful round collects the score that able for the team to continue to the final round. However, during that event, a few weaknesses have been found by the team. The ROV did not have much torque and speed compare than the other competitor, and the manipulator mechanism that use griper method is hard to use. The ROV needs to reach the object closely to make it able to grab. Therefore, a better manipulator mechanism, higher torque motor and improved movement degree of freedom (DOF) control design need to develop for better performance ROV.

1.2 Problem Statement

From the previous competition, the IRC2019 at IIUM held in September 2019, there are several modifications that can be made to enhance the capabilities of the first ROV prototype. Even the required tasks can be performed, and it was still difficult to control ROV stability to get the highest marks within 6 minutes. The movement is very sluggish and hard to control. Additionally, high body rotational error and displacement error has occurred. This error causes high water flow interference because of prop washes in tight spaces and unbalanced thrust from each propeller. Therefore, this project aims to design and develop a better manipulator mechanism, higher torque motor and improved movement degree of freedom (DOF) control design.

1.3 Objective

The objectives of this project are as follows:

i. To develop a functional Remote Operated Vehicle (ROV) with a small scale.

ii. To apply sensor fusion to stabilize the ROV during hover at a specific depth.

iii. To analyse the ROV performances to complete a mission as regulated in IRC 2019 competition rules.

1.4 Scope

Several requirements are suggested by narrowing the expectations for this project to ensure that this project accomplishes its objectives. For this project, the scopes covered are:

i. A design of ROV structure is used up to a total of 6 brushless motors for omnidirectional force motor position.

ii. Design of a sucker system to pick and place a small sphere marble.

iii. A design of with ROV with overall maximum dimension of 30cm (width) x 30cm (length) x 30cm (height).

iv. An IMU sensor consists of 3-axis gyroscope, 3-axis accelerometer and 3axis magnetometer is used to control ROV attitude stabilization

v. A barometric sensor is used to control ROV depth and to hover while performing a task.

vi. A 10 degree of freedom (DOF) sensor fusion technique have been applied for sensing the movement of ROV respective to its environment.

vii. Analyse the stability of ROV attitude and altitude control.

viii. Analyse the performance of sucker to pick and place a small marble within 6 minutes as IRC2019 rules.