UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF SEMI-AUTOMATIC SYSTEM FOR UNDERWATER REMOTE OPERATED VEHICLE (ROV) BY USING ARDUINO

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia MELAKA (UTeM) for the Bachelor of Electronics Engineering Technology (Industrial Electronis) with Honours

By

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of **Bachelor's Degree in Electronics Engineering Technology (Industrial Electronics) with Honours**. The member of the supervisory is as follow:

………………………………

(IR MOHAMMAD „AFIF BIN KASNO)

ABSTRAK

Laporan ini akan membentangkan Sistem Semi-Automatik untuk ROV bawah air dengan menggunakan Arduino. Kenderaan Beroperasi Jauh bawah (ROV) bawah laut digunakan terutamanya untuk pemantauan di kedalaman di bawah lautan di mana mustahil manusia menyelam pada tahap yang mendalam. Kadang-kadang, ROV juga dapat melakukan pembaikan untuk mengelak kebocoran pipa bawah air dengan lengan robotik yang dipasang pada ROV. Aplikasi ROV dalam air membuktikan boleh menjadi potensi untuk membantu dan membantu manusia dalam persekitaran laut dengan sistem yang boleh dikawal secara manual dan automatik. Sistem separuh automatik ROV akan dibina berdasarkan kamera pixy sebagai pemproses imej, sensor IMU 9DOF dan manipulasi program mikrokontroler Arduino untuk membolehkan pelaksanaan tugas diberikan. Sensor 9DOF akan mengawal pengimbangan dan menyelam atau menimbulkan tindakan ROV sementara tujuan kamera pixy adalah untuk mengenal pasti objek di hadapan dan menavigasi ROV untuk membolehkan tugas yang diberikan oleh pengguna untuk dilaksanakan. Analisis untuk projek ini adalah untuk menentukan keberkesanan ROV projek dan akan dibandingkan dengan sistem ROV sebenar. Sistem ini juga akan mengkaji bagaimana keadaan bacaan pengaturcaraan mempengaruhi keputusan tugas ROV.

ABSTRACT

This report will present the Development of Semi-Automatic system for underwater ROV by using Arduino. The underwater Remote Operated Vehicle (ROV) used mostly for monitoring at the depths below the ocean where it is impossible for humans to dive on that deep level. Sometimes, the ROV also able to make a repair to seal the leakage of underwater piping with its robotic arm attached to ROV. The underwater ROV applications prove can be potential to help and aid the humans in marine environment with system that can be manually and automatic controlled. The semi-automatic system of the ROV will be build based on the pixy camera as an image processor, the 9DOF IMU sensor and program manipulation of Arduino microcontroller to enable the execution of task given. The 9DOF sensor will control the balancing and dive or rise up action of the ROV while the pixy camera purpose is to identify the object in front and navigate the ROV to enable the task given by the user to be executed. The analysis for this project are to determine the effectiveness of the project ROV and will be compared it with an actual ROV system. The system also will be study on how the programming reading conditions affect the ROV task output.

DEDICATION

This thesis is dedicated to:

My beloved parent,

Mohd Ramli bin Mohd Daud and Masilah binti Atan

My supervisors,

IR Mohammad „Afif bin Kasno and A.Shamsul Rahimi bin A.Subki

And all of my friend.

Thank you for their encouragement and unconditionally support.

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Firstly, I would like take this opportunity to express my deepest appreciation to my supervisor, IR Mohammad „Afif bin Kasno for giving me his encouragement, guidance, support and motivation throughout this whole project. Under his supervision, I acquired a lot of valuable knowledge and suggestion as well as confidence to complete this project. Despite he is busy with his job and duties, he still managed to guide me along to achieve this project. Therefore, here I am to show my appreciation to him for teaching me patiently and I am grateful to have him as my supervisor.

Besides, I would like to thank to my fellow friends who always ready to help me when I needed. In addition, my appreciation to them for has assisted me and share a lot of good ideas that help to accomplish my project.

Finally yet importantly, my deepest gratitude goes to my parent, Mohd Ramli bin Mohd Daud and Masilah binti Atan for supporting me mentally and financially throughout the entire studies in UTeM. Their endless support has extended to me throughout this degree study and my life in general.

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CHAPTER 1

INTRODUCTION

1.1 Overview

This project is focusing on creating the Semi-automatic system for underwater remote operate vehicle (ROV). The system will be first will do balancing control to itself to reach stability when under water by using accelerometer. Then the automatic system will command the ROV to move in direction with help of the magnetometer. Both of this sensors are important because there help the system to be able to auto correct from measurement and be controlled by it. The gyroscope were also need to be included due need of the angular rate of the ROV especially when to turn in specific angle. With all three main sensors work together, the automatic system on ready to comply and the system also design to avoid the obstacle in ROV forward direction. When the object or obstacle (assume it floating) been sensed, the automated ROV will choose to re-route then continue heading towards the destination points and will remain static after reaching the point. Other than that, when the automated system sense obstacle or barrier in all direction, the system will command the ROV to static position as well after certain time that have been set. The re-route concept may refer the ROV to be dive under obstacle and submerge at the other side of it or by simply turn 90 degree route and turn back to original position to heading destination.

1.2 Problem Statement

There are few problem statements that need to be highlighted when need to conduct this ROV system project.

- First of it is how the system will be function such as stability control and how to design the ROV for its motors and water proof seal. The system will be using sensor that enable balancing by using angle of x,y,z axis (Roll. Pitch, Yaw) also to determine direction movement of ROV.

- Next, to design the system that will be using based on a certain sensors that able to provide the suitable measurement for the ROV.

- Next, after completing the measurement part, must able to test all the measurement testing and the method use also troubleshooting the system, the ROV system will be put into the test and create the coding or method of how to avoid the obstacle from the front view with semi-automatic control.

1.3 Objectives

The objectives will based on the on how to able to achieve for semi-automatic control system of the ROV. The first objective is to study how the semi-autoutomatic of ROV works and the proper way to design the ROV. Next, to able to develop the system for stability of the ROV and its movement behaviour. The third focus objective is to make an analysis of the ROV semi-automatic system when assigning the task from the user.

1.4 Project Scopes

i. Criteria/Variables

   The Cost of the Control Circuit including Arduino Interfaces and the type of sensors that suitable for the Automatic System.

ii. Task/Works

To able to understand manually control of the Underwater ROV and observe its characteristics when under water. Also, create the source coding for semi-automatic system for each consideration of the ROV such as stability and speed of the rotor on the vehicle. Conduct analysis and calculation for PID control tuning so that can be apply to the auto system on ROV.

Conduct test on real time operation include varies of environment on water and do comparison with the manual ROV control and do correction or improvement of the system both coding and hardware. Record the final complete result of the automatic system and do final analysis to support any theoretical evidence. If there are more time for the project, the system can be upgrade by adding the pixel camera to the front view of the camera for clearer vision detection of the obstacle. Illustration below shows the task for the ROV and to be control by the system.

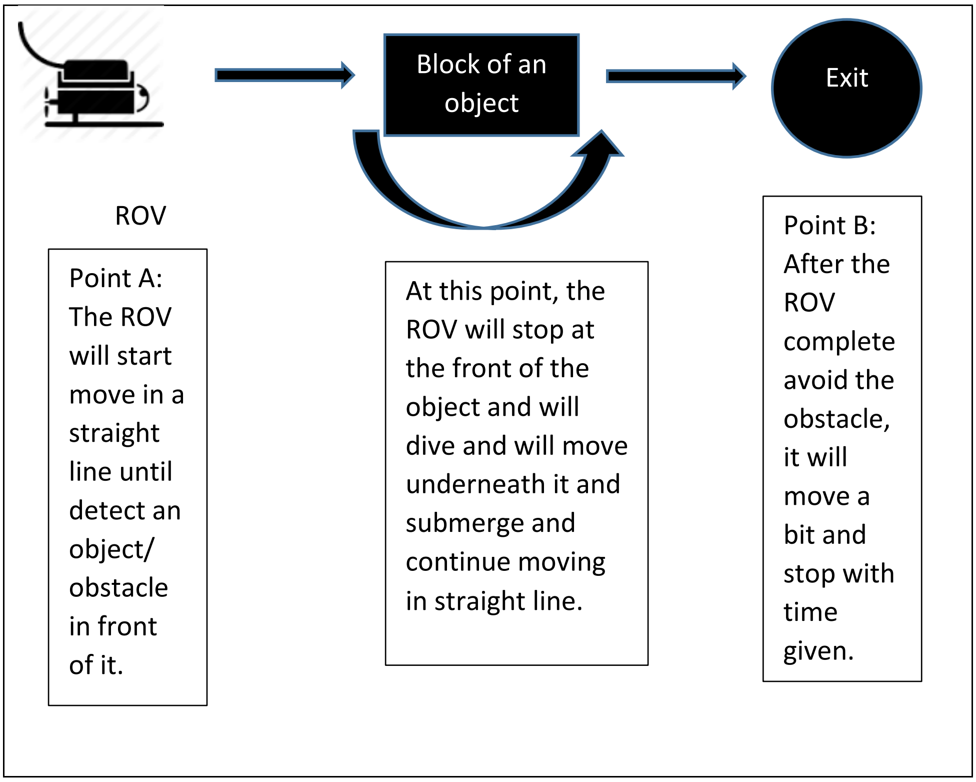

Figure 1.1: Task for the ROV

iii. Administration

The meeting with the supervisors will be held every week for its required to give weekly progress or reports consisting of the source code for semi-automatic system, the analysis of the interface between Arduino control and underwater ROV.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

The literature review for this project will focuses on how the ROV operates manually and to be implemented for autonomous system. To able to operate the Remote Operated Vehicle in automatic system, the controller system is needed for it operate for example type of controller system are PID tuning, Fuzzy logic or an algorithm etc. This project will use the interface by using the Arduino platform controller for the ROV became an autonomous vehicle thus the research will consists of these criteria in order to meet the objectives.

2.1.1 History of the ROV

R.O.V. Remotely Operated Vehicle is the name used to refer to the wire-guided robot submarines used in the maritime industry. They are highly maneuverable, are driven by skilled operators on board vessels or platforms. The French scientist, engineer and explorer Dimitri Rebikoff, in 1953 invented the first robot called “Poddle”. In 1960, the United States developed and it took the new technologies ROV to carry out important work, recovering atomic bombs in the Spanish coasts.

The ROV gave rise to the ability to perform potentially dangerous operations in ultra deeps retrieving objects from the seabed. In 1970, the Oil & Gas industry produced the Work–Class vehicles to enhance their application in the offshore field, but were seen as a supplement to divers, until in the 90s began to be used to cover the majority of the work while minimizing risks to the man. This enhancement was achieved thanks to the excellent results obtained by the new technologies ROV and the limitations of the divers in operating over 200 meters deep.

With ROVs working as deep as 10,000 feet in support of offshore oil and other tasks, the technology has reached a level of cost effectiveness that allows organizations from police departments to academic institutions to operate vehicles that range from small inspection vehicles to deep ocean research systems.

It was once thought that something thrown into the ocean was lost and gone forever, however, organizations such as Mitsui and JAMSTEC in Japan have ended that vision. With the development of their ultra-deep ROV Kaiko, they have reached the deepest part of the ocean - the Challenger Deep in the Mariana Trench, at 10,909 meters. A record to be tied, but never exceeded.

JAMSTEC ultra-deep ROV Kaiko

Figure 2.1: ROV Development during 1980s

2.2 Current Research

2.2.1 Development, Depth Control and Stability Analysis of Underwater Remotely Operated Vehicle (ROV)

Based on Nima Harsamizadeh(2010), the underwater robots especially Remotely Operated Vehicles (ROV) are designed to perform different tasks in extreme conditions in depth of oceans all over the world. The utilization of such robotic vehicles has gained an increasing importance in many marine activities. The purpose of this paper is to explain the design, stability analysis and the problem of depth control of "DENA" the ROV from underwater robotics team of Isfahan University of Technology. "DENA" is a small size; low cost, and an educational proposes ROV, which has six thrusters, one manipulator arm with a unique electrical design, which makes it easy to handle different equipment in future. As the importance and the complexity of the tasks performed by ROV increase, the need for automatic control schemes that guarantee high performances in motion and positioning has become a basic issue in underwater automation. At this regard, a control schemes, based on PID technique for Auto depth Control and the equations for Roll & Pitch stability are proposed.

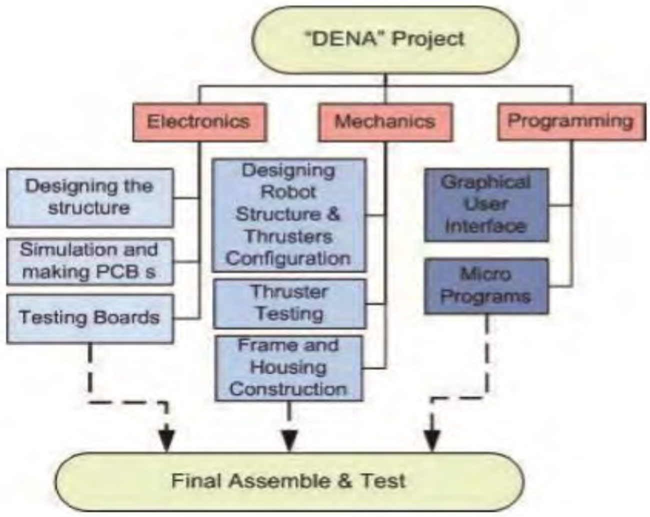

Figure 2.2: ROV major parts for designing

2.2.2 Dynamic vision for ROV stabilization

According to S.Wasielewski(1998), the important capability for various functions involving the operation of undersea vehicles. This involves an accurate estimation of the vehicle displacement. In this paper we propose a monocular vision system for determining the motion of an underwater Remotely Operated Vehicle. The camera motion is estimated with a feature-based method which requires the extraction and the matching of relevant features. The performance of the algorithms is presented with simulated and synthetic images.

The correlation techniques are based on computation of the likeness of image sections. One image section is correlated with many other image sections in order to obtain a correlation surface. It allows to determine the section of maximum correlation. This information can be used to estimate the camera motion. These methods present several drawbacks. They use information from a large portion of the image but at the expense of more computation. Moreover, they implicitly assume that there is no significant changes in the scene. Motion recovery is difficult when all the motion components are a priori unknown; so complementary sensors are generally required to eliminate the motion ambiguities.

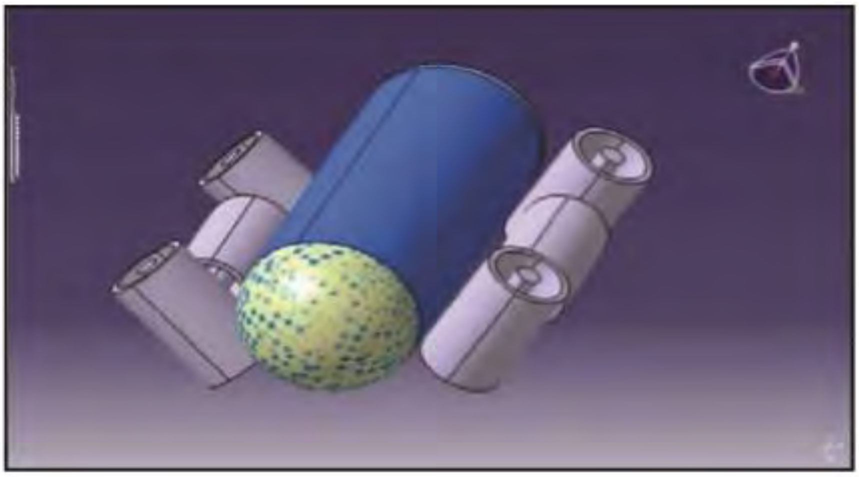

Figure 2.3: ROV Thruster Configuration

Figure 2.4: Dc Motor Housing

2.2.3 Modelling, Design and Robust Control of a Remotely Operated Underwater Vehicle

Based from the author Matthew Johnson Roberson 2009 explained that the Underwater Remotely Operated Vehicles (ROVs) play an important role in a number of shallow and deep water missions for marine science, oil and gas extraction, exploration and salvage. In these applications, the motions of the ROV are guided either by a human pilot on a surface support vessel through an umbilical cord providing power and telemetry, or by an automatic pilot. In the case of automatic control, ROV state feedback is provided by acoustic and inertial sensors and this state information, along with a controller strategy, is used to perform several tasks such as station-keeping and auto immersion/heading, among others. In this paper, the modelling, design and control of the ROV is presented by using the complete six degrees of freedom, non-linear hydrodynamic model with its parameters. Also the hardware and software architecture, numerical simulations in Matlab or Simulink platform of a model-free second order sliding mode control along with ocean currents as disturbances and thruster dynamics, a virtual environment to visualize the motion of the ROV and experimental results of a one degree of freedom underwater system.

One of the main trends for ROVs is “autonomy” for some specific tasks, such as position tracking, dynamic positioning (or station-keeping), auto-heading and auto depth control. Hence, there are two main challenges associated with ROV control which are parametric uncertainty (as added mass, hydrodynamic coefficients, etc.). This problem increases with the modular capability of the current ROVs. Next, the highly dynamic nature of the underwater environment, which presents significant disturbances to the vehicle in the form of underwater currents and interaction with waves in shallow water applications, among others.

Exponential convergence of position and velocity, without overshooting, is ensured. The controller performance was evaluated by means of numerical simulations and real-time experiments with a six DOF ROV dynamics and in a one DOF physical system. Firstly, the complete nonlinear hydrodynamic model of six DOF was used, wherein only four DOF were actuated. Secondly, a one DOF underwater system was developed to validate in real-time the proposed controller. Both, simulations and experimental results reveal the excellent performance of the proposed controller. Finally, some relevant aspects about the ROV design and construction are given.

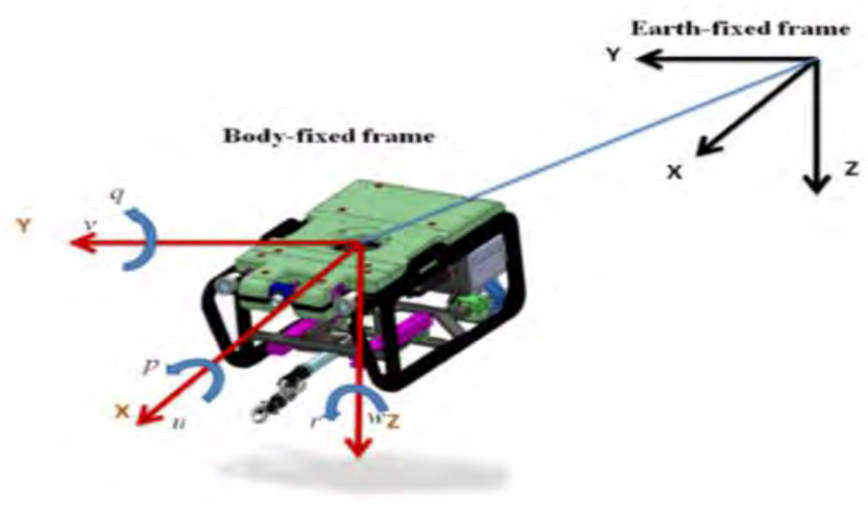

Figure 2.5: Frames Coordinate of an underwater vehicle

2.2.4 ROV technological advances allow for more precision, efficiency

Kevin Kerins (2016), An ROV‟s tasks can be viewed as sequences of smaller, simple, step that can be easily automated. Unexpected environmental conditions or a crippling failure would cause the execution of the step to halt, break the sequence, and return control to the human operator. Most of the desired actions of the ROV can be constructed from these smaller steps. By utilizing the human in the decision making control loop, the program is broken down into steps issued as commands by the pilot. These steps can be commanded individually or as sequences with linking logic that tests for successful completion of a step before proceeding to the next one.

ROV manipulators typically have six degrees of freedom: three Cartesian (x, y, z) and three angular (pitch, roll, yaw).A modern spatially correspondent (master/slave) manipulator allows the operator to simultaneously control all six degrees of freedom in real time, but, for many tasks, Cartesian and angular motions are somewhat mutually exclusive, and it is not always desirable to control both at the same time.

The result is a proprietary kinematics software system that allows the operator to select which of the six degrees of freedom he or she wishes to control. This essentially allows the operator to control Cartesian motion while the software automatically controls orientation or vice versa. The result is a proprietary kinematics software system that allows the operator to select which of the six degrees of freedom he or she wishes to control. This essentially allows the operator to control Cartesian motion while the software automatically controls orientation, or vice versa.