UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY AND DEVELOPMENT OF 3D MONITORING SYSTEM FOR ROV BY USING ARDUINO WITH IMU SENSOR

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

by

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Tajuk: **STUDY AND DEVELOPMENT OF 3D MONITORING SYSTEM FOR ROV BY USING ARDUINO WITH IMU SENSOR**

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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 Electronics Engineering Technology (Industrial Electronics) With Honours. The member of the supervisory is as follow:

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ABSTRAK

Projek ini akan membentangkan Kajian Dan Pembangunan Sistem Pemantauan 3D Untuk ROV Dengan Menggunakan Arduino Dengan Sensor IMU. Sistem pemantauan merangkumi beberapa parameter seperti Roll, Pitch, Yaw dan Heading. Pemprosesan imej 3D juga termasuk dalam sistem pemantauan untuk memaparkan orientasi ROV. Sensor Unit Pengukuran Inersia 9DOF akan mengenal pasti dan memberikan output tiga data yang berbeza iaitu paksi-X, paksi Y dan paksi Z untuk mencapai orientasi ROV. Data ini akan digunakan untuk membuat pemprosesan imej 3D dalam Processing IDE dan bertindak sebagai input untuk perisian Multiwii. Pemprosesan imej 3D direka bentuk seperti ROV model CROV4 di Bumi Subsea SDN BHD. Dua platform berbeza bekerja sama untuk mencapai sistem pemantauan untuk membangunkan sistem integrasi untuk pemprosesan imej 3D. Analisis projek ini adalah untuk menentukan persamaan antara ROV sebenar dan pemprosesan imej 3D. Dua Unit Pengukuran Inersia akan menganalisis untuk mendapatkan kependaman dan ketepatan.

ABSTRACT

This project will present the Study And Development Of 3D Monitoring System For ROV By Using Arduino With IMU Sensor. The monitoring system includes several parameters such as Roll, Pitch, Yaw and Heading. A 3D image processing also included in the monitoring system to display the orientation of the ROV. 9-DOF Inertial Measurement Unit sensor will sense movement and give output of three different data which are X-axis, Y-axis and Z-axis in order to achieve orientation of the ROV. These data will be used to create 3D image processing in Processing IDE and act as input for Multiwii software. The 3D image processing was designed as similar as the actual ROV model CROV4 in Bumi Subsea SDN BHD. Two different platforms work together to achieve the monitoring system in order to develop the integration system for 3D image processing. The analysis of this project are to determine the similarity between the actual ROV and the 3D image processing. Two Inertial Measurement Unit will be analyse to obtain the latency and accuracy.

DEDICATION

This thesis is dedicated to:

My beloved parent,

Yahaya bin Abdullah and Zaiton Binti Abu Bakar

My supervisor,

IR. TS. Mohammad ‘Afif bin Kasno,

And all my friends,

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.

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Bumi Subsea

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Tuan,

KAJIAN AWAL UNTUK MEMBANGUNKAN SISTEM PEMANTAUAN 3D BAGI KENDERAAN KAWALAN JAUH DALAM AIR (ROV)

Saya merujuk kepada perkara di atas

Saya ingin memaklumkan bahawa syarikat Bumi Subsea Solutions Sdn. Bhd. sedang menjalankan satu kajian awal untuk membangunkan sistem pemantauan 3D bagi kenderaan kawalan jauh dalam air (ROV). Antara aktiviti penyelidikan ialah penggunaan kaedah elektronik seperti "image processing" dan memaparkan beberapa parameter secara digital bagi kenderaan kawalan jauh dalam air.

Pada peringkat awal ini, saya ingin menjemput pakar dari Universiti Teknikal Malaysia Melaka (UTeM) untuk menjalankan penyelidikan dengan para penyelidik dari syarikat Bumi Subsea Solutions Sdn. Bhd. Senarai pengawai dan pelajar yang dicadangkan ialah seperti di bawah :

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Kelulusan tuan mengenai perkara ini, saya mengucapkan terima kasih. Sekian.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ROV	– Remoted Operated Vehicle
UAV	– Unmanned Aerial Vehicle
GPS	– Global Positioning System
GIS	– Geospatial Information System
IMU	– Initial Measurement Unit
3D	– Three Dimensional
MEMS	– Micro-Electromechanical System
LiDAR	– Light Detection And Ranging
UAS	– Unmanned Aerial System
PWM	– Pulse Width Modulation
GUI	– Graphical User Interface
UUV	– Unmanned Underwater Vehicle
DOF	– Degree of Freedom
ADC	– Analog to Digital Converter
RC	– Remote Control
PID	– Proportional, Integral, Derivative
OSM	– OpenStreetMap
GND	– Ground

CHAPTER 1

INTRODUCTION

1.0 Overview

This project is focusing on creating and developing a 3D processing image and parameters for Underwater Remote Operate vehicle (ROV). The system will display a 3D image and information about heading, pitch, roll and yaw by using accelerometer with the help of magnetometer. The system will monitor the orientation of the ROV. Both of this sensors are important because it helps the system to give correct measurement. The gyroscope were also need to be included due to the need of the angular rate of the ROV. These three main sensors work together, the system on ready to monitor the orientation of the ROV. The sensors will be connected to a hardware Arduino Uno which will then connected to the software called MultiWii and Processing IDE to display the information. The project successfully developed and meet the early requirement needed by Bumi Subsea (M) Sdn Bhd.

1.1 Problem Statement

The use of ROV nowadays is widely used for serving a range of military, commercial and scientific needs. ROV can go deep into the water until 10,000 feet but it is quite rare to reach that level. Above 30 metres depth, ROV is more likely less visible due to the particles in the water and that is why most ROVs are equipped with at least one video camera and lights. The ROV did not include monitoring system that can show the orientation of the ROV in water, as the Bumi Subsea (M) Sdn Bhd, a

ROV operational company also facing the similar problem regarding the matter. Without the monitoring system, the user of the ROV have no idea where the ROV is heading to, the roll, yaw and pitch of the ROV.

1.2 Objectives

- To study on feasibility of integration between 9-DOF sensor, hardware and 3D graphical software development
- To develop the integration system for 3D image processing
- To analyse the performance of developed integration system for 3D monitoring system

1.3 Scope of work

This project will consist of creating a system that monitor the orientation of the ROV in the water. This project only display the parameters such as depth, roll, pitch, yaw and heading of the ROV by using a suitable and affordable microcontroller and sensors. This project also will present or display the 3D image processing of the ROV that will show real time operation of the ROV. Hence, a source coding will be design or create to achieve the stability to reduce the noise from the sensors and calculations for PID control tuning so that the parameters will be drifty. A test will be conduct for real time operation and do correction or improvement of the system both coding and hardware. Illustration below shows a clearer view about this project.

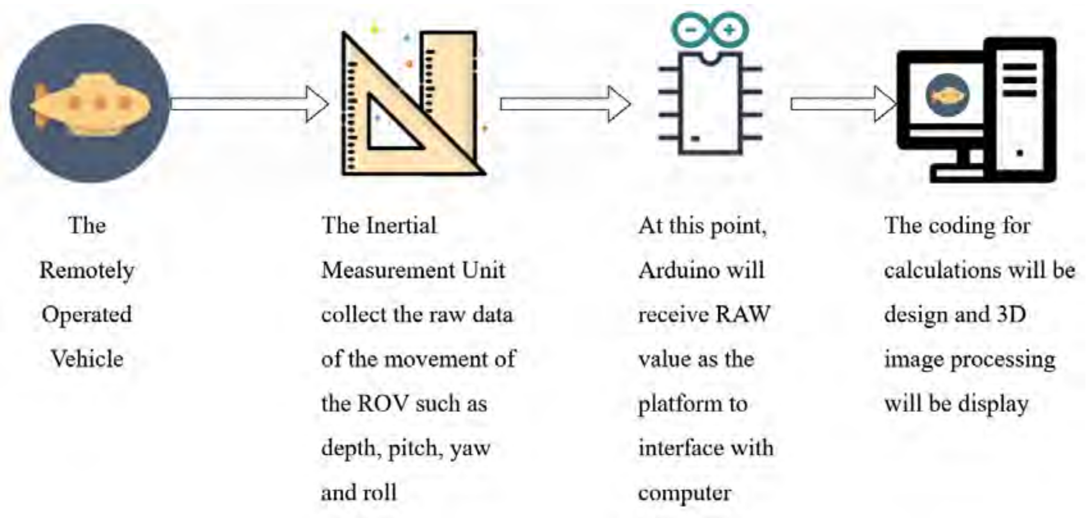

Figure 1.3: The overview of this project

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The literature review for this project will focuses on how the 3D special monitor operates and to be integrated with ROV parameter. To be able to develop the 3D image processing, the controller system is needed for it to operate the Fuzzy logic, algorithm, PID tuning etc. This project will use the interface by using the Arduino platform controller for the measurement of parameter ROV thus the research will consist of these criteria in order to meet the objectives.

2.1 History of 3D image processing

3D imaging or animated technology is something new, but the truth of this new invention is just with a study on how eyes illustrate the images that is done by Euclid, a Greek mathematician. Back to 300 B.C, the first noted achievement of putting Euclid's vision approach was done in the time of The Renaissance by Leonardo da Vinci who used painting ability that played with perception in imaginative ways.

In the mid-1800s, a device called stereoscopic which is used to display 3D images was invented by an English scientist named Charles Wheatston. He also invented a device called a "reflecting stereoscopic" that would grant for two different images to be viewed simultaneously by each eye. They achieved this trick by positioning each image and using mirrors to create an illusion of depth. At that point, arise of a leading development in the world of 3D imaging.

The advancements and industrial science fetched up speed with the invention of the first stereoscopic cameras and anaglyph glasses. Before the availability of colored photographs, these inventions were discovers in the early 1900s and sparked generic interest leading to the next world in imaging industrial science in the 1950s that allowing for pictures formed in full color. In 1952, Hollywood got engaged in 3D imaging and made its first 3D movie. It took momentous time and achievement to tackle out the glitches of 3D films, but with various movies created and theories tested those much needed improvements were made.

The gaming and computer industry got involved after the movie industry brought 3D imaging to the mainstream and pushing this technology to a "virtual reality" technology. Finally in 1998, accompany called Metabyte made their first stereoscopic 3D gaming solution called Wicked3D that enables all game developers to shift a normal 3D game into a stereoscopic one.

The technology establish farther as more companies developed interest in 3D imaging which where it is accessible in the most mainstream forms such as iPhone cases, magnets, business cards and any other variety of at home 3D content.

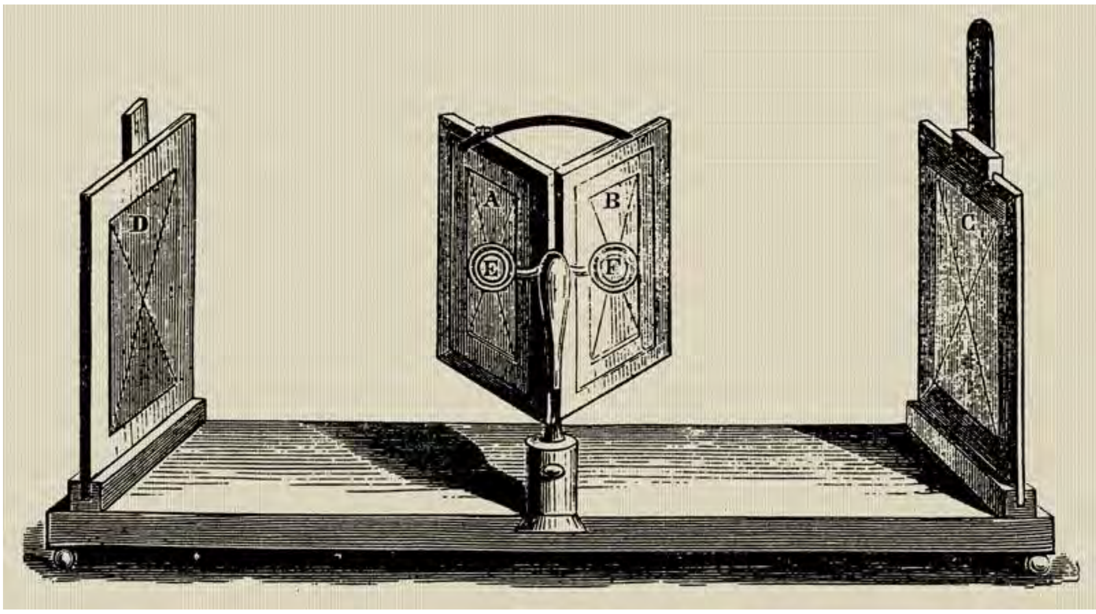

Figure 2.1: Charles Wheatstone mirror stereoscope

Figure 2.2: The first stereoscopic 3D gaming called Wicked3D

2.1.1 History of Inertial Measurement Unit

After the invention of gyroscope in 1852 by the French experimental physicist Leon Foucault, gyroscope were used in navy and aviation applications during WWI as a system for steering ship and self-guided missiles. Hence in 1930s, IMU was invented and used in aircraft navigation system and massive devices. Because of its size, price and power consumption, IMU is out of favor which where it is barred to mass application at that time that makes IMU is unwelcome to minor size devise and consumer applications.

While technology is rapidly expanding, micro-electromechanical system (MEMS) IMU is introduced and offer a big impact of a very interesting feature of low processing power, compact and also low cost. The demand become greater which makes a lot of manufacturers such as Invensense, Honeywell, STMicroelectronics and X-Sens competing each other on the outstanding designs of IMU. Hence, IMU is popular to wider area of usage. Since then, IMU is used to many applications for sensory system. People want to know more information on their movements and current position to work better and more productive.

2.2 CURRENT RESEARCH

2.2.1 TRACKING 3D MOVING OBJECTS BASED ON GPS/IMU NAVIGATION SOLUTION, LASER SCANNER POINT CLOUD AND GIS DATA

Based on Siavash Hosseinyalamdary(2015), Monitoring vehicular road traffic is a key component of any autonomous driving platform. It is difficult to navigate around objects and trying to figure out their locations with trajectories when detecting a moving objects. Even though laser sensors give a good results in observing the area, errors will be occur in terms of noises for the point cloud. A low quality of point clouds is obviously a major problem. This paper is about explaining about various input information and types of sensor that've been used such as Geospatial Information System (GIS) to detect a movement in certain area. OpenStreetMap (OSM) is a low quality GIS map that can give better accuracy in tracking object and also save time for the processing activities. In order to track the movement, Kalman filters was used. Besides that, to give a better orientation estimation movement of the object, a non-holonomic constraints is applied to the system. Based on Global Positioning System (GPS), Inertial Measurement Unit (IMU), Light Detection And Ranging (LiDAR) data and a coarse GIS map, the objects can be improved over time in terms of accuracy.

The advance in image and point cloud processing calculations has brought stronger in object tracking approaches. However, image and point cloud are prone to noise, mess, and impediment and, thus, tracking still remains a testing errand in self-ruling driving. There are some algorithms that discriminate moving objects and static objects in images. Accordingly, the movement of the stage ought to be estimated utilizing external sensors such as the integration of Global Positioning System (GPS) and Inertial Measurement Unit (IMU). The use of a GPS/IMU navigation is the solution that enables the transfer of local laser scanner data to the global coordinate system and allows the use of prior information. GPS system provides the position of the platform with respect to the global coordinate system. The accuracy of the GPS positioning relies on the current use technology.

IMU sensors can be utilized to appraise the position and tracking of the platform in the absence of GPS. However, IMU is prone to scale factor errors, noise, bias and its accuracy quickly deteriorates over time, especially for the cheaper IMUs. With the GPS that is applied in the system, statis objects can be seperated from objects that are move in images and laser scanner data. The position and tracking of the platform can be estimated by using statis objects.

Figure 2.2.1: The sensor configuration on the platform

2.2.2 EXPLORATION OF A LOW-COST AUTOPILOT SYSTEM FOR USE IN ACADEMY

According to Bryan J. Kissack(2012), autopilot system for UASs need to be develop and implement thus growing for higher education to perform their designed even with the industry that grow these autonomous unmanned aerial systems (UASs). Students need to be provide the hands-on experience even though there has been difficult in recent years to show that it is crucial to understand how the autopilot systems works with the complexity and inherent cost of the system. Even though many things that have been done to implement these system, the type of education is really important which can restricts the ability to modify or enhance the autopilot. The development of open software/hardware platforms was created when the technology is upgrading which where the components becomes lighter, cheaper and easier to handle which is a good news for the industry and platforms. An open software/hardware such as Arduino has come forefront as a leader in the autopilot system market. Whether or not Arduino can be a good system for implementing into higher education at a design level which is the goal of this study. In order to determine how difficult or easy it would be to access it to undergraduate studies, a flight test will be conduct to discover the weakness and strengths of this product. The Arduino-based Ardupilot-Mega controller has shown that it is fairly robust and has a wide range of functionality which conclude that it is worthwhile educational tool and also inexpensive alternative to proprietary autopilot system.

Mission Planner of version 1.0.84 will be used in the system in order to act as a control center while the aircraft is still flying or going to its route. The control center will provide a huge amount of information about the aircraft and the autopilot system while it's flying when the XBee modems is connected to each other. The trim setting, failsafe options, gains and some of the parameter's setting will be provided by the Graphical User Interface (GUI) of the Mission Planner. The project use a magnetometer where the current orientation's information will be provided by the autopilot system hence it will give information about the movement of the aircraft. The current orientation of the aircraft while dealing with crosswinds, the magnetometer will be required in order to maintain its current position. The autopilot will observe the movement of the plane as the plane is changing direction and it is done by using GPS. The instrument's technical communicating technical system will be monitored in terms of its performance while the autopilot system is enable. The vital components such as altimeter, telemetry, current sensor, gyros, GPS,