“I hereby declare that I have read through this report entitled “1 DOF (pitch) handheld haptic device” and found that it complies the partial fulfillment for awarding the degree of Bachelor of Mechatronic Engineering”

Signature	:	…………………………………………
Supervisor’s name	:	…………………………………………
Date	:	…………………………………………

1 DOF (PITCH) HANDHELD HAPTIC DEVICE

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor Mechatronic Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

I declare that this report entitled "1 DOF (pitch) handheld haptic device" 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	:	………………………………………
Name	:	………………………………………
Date	:	………………………………………

To my beloved mother

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ABSTRACT

In this modern era, underwater remotely operated vehicles are developed from time to time for maritime industry such as subsea exploration, maintenance operation, inspections and security. This thesis proposed the solution in developing the feedback from human interface with ROV motion. In this research, the objective is to develop a handheld haptic device that is able to give haptic feedback for ROV pitch motion. Hence, the research also assesses the performance of the develop haptic device in sensor accuracy, actual force delivered and transparency. A one degree of freedom (1 DOF) pitch handheld device are developed for controlling the pitch angle orientation of haptic feedback. The microcontroller for this device is Arduino Uno and all programming for this system was written and compiled using Arduino Uno. The sensor to capture the orientation of angle is MPU6050. The software use in this research is Solid Work, MATLAB and Arduino Ide. The result obtained for this research is the sensor accuracy between two MPU6050 and the actual force delivered to the motor. This research is obtained to have both the device and the ROV are in sync when operated.

ABSTRAK

Dalam zaman moden ini, kenderaan di bawah air yang dikendalikan dari jauh dikembangkan dari semasa ke semasa untuk industri maritim seperti penerokaan bawah laut, operasi penyelenggaraan, pemeriksaan dan keselamatan. Tesis ini mencadangkan penyelesaian dalam membangunkan maklum balas daripada antara manusia dengan gerakan ROV. Dalam penyelidikan ini, matlamatnya adalah untuk membangunkan alat haptik pegang tangan yang dapat memberi maklum balas haptik untuk gerakan gerak ROV. Oleh itu, penyelidikan juga menilai prestasi peranti haptik yang dibangunkan dalam ketepatan sensor, daya sebenar dan ketelusan. Satu tahap kebebasan (1 DOF) peranti pegang tangan pitch dibangun untuk mengawal orientasi sudut pitch maklum balas haptik. Mikrokontroler untuk peranti ini adalah Arduino Uno dan semua pengaturcaraan untuk sistem ini ditulis dan disusun menggunakan Arduino Uno. Sensor untuk menangkap orientasi sudut adalah MPU6050. Penggunaan perisian dalam kajian ini adalah Kerja Pepejal, MATLAB dan Ide Arduino. Hasil yang diperolehi untuk kajian ini adalah ketepatan sensor antara dua MPU6050 dan daya sebenar yang dihantar ke motor. Kajian ini diperolehi untuk mempunyai kedua-dua peranti dan ROV disegerakkan apabila dikendalikan.

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LIST OF ABBREVIATIONS

ROV	~	Remotely Operated Vehicle
UUV	~	Unmanned Underwater Vehicle
DOF	~	Degree of Freedom
BLDC	~	Brush Less Direct Current

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CHAPTER 1

INTRODUCTION

1.0 Motivation

"HAPTIC", is the term derived from the Greek word, "haptesthai", which means "sense of touch". Haptic is defined as the "science of applying tactile sensation to human interaction with computers". Haptic permits users to sense ("feel") and manipulate three dimensional virtual objects with respect to such features as shape, weight, surface textures, and temperature. Underwater Remotely operated vehicle (ROV) is technologies have been developed rapidly from time to time. There are many inventions for unmanned project to study the ocean and also called underwater drones to observe underwater easily. For design system using feedback is based on haptic feedback such as kinesthetic or tactile feedback. Haptic feedback system is a bilateral system. The feedback allow user to feel virtual object in a simulated project and broadly refers to touch interaction between real object and human hand, machine interaction with real and variety of combination of human. Haptic feedback can provide value in several ways, such as accessibility, uninstructive feedback, and motor skill training [1].

The uses of ROV are increasing and become more sophisticated[2]. The technology is used for hazardous place, underwater search and bomb disposal. The design, modelling and control are presented in 1 degree of freedom (DOF). 1 DOF is the interaction between the measure operators position and applies forces to the operator along one spatial dimension. Moreover, this research is to control the ROV in pitch up and down for a certain degree, when the ROV give the feedback to human and the controller, the haptic device is feel the force feedback at human input. There are many types of devices such as grounded, handheld, mobile grounded and body based. A handheld can be any portable device of this controller is use such as joystick, steering wheel enough to be held and used in one or both hands. As a field of study, haptic has parallel rise and evolution of automation and can consider haptic value in terms of functionality, emotion and aesthetic.

The haptic feedback is one of the appropriate method in the handheld application for controlling the ROV. Based on this research, the price of haptic device in the market is too high because the device consists of control system and feedback system. This thesis proposes a new lower cost design of handheld haptic feedback device. The research should look the implementing the haptic feedback in the system. This thesis would highlight how our research addressing these issues such as handheld device by having haptic feedback in the system. The whole block diagram in Figure 1.1 shows the overall component from haptic feedback and ROV controller.

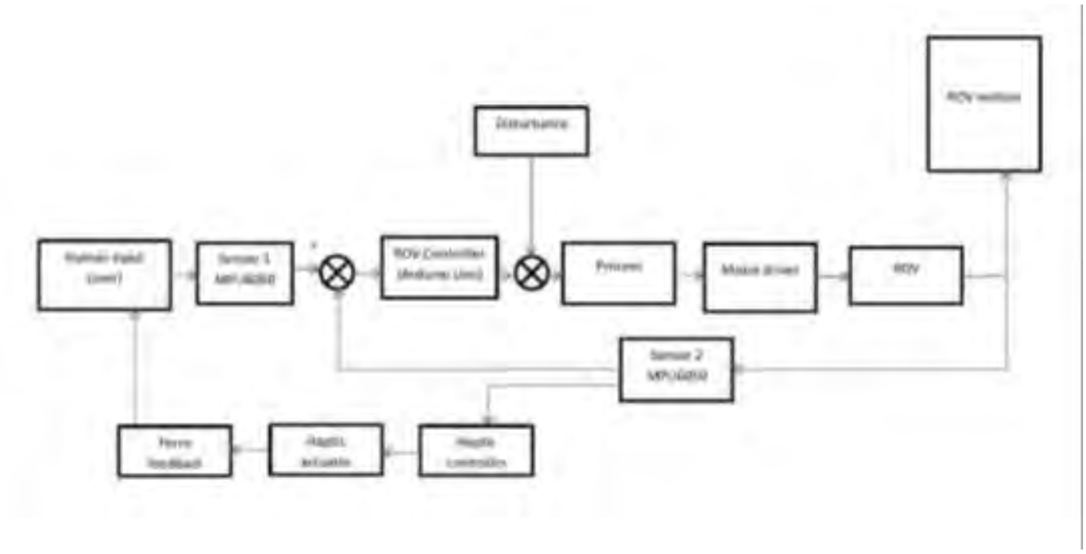

Figure 1.1: Block diagram for overall operation

1.1 Problem Statement

The problem of delivering force feedback on ROV pitch angle is to provide proper amount of force feedback regarding the change of the vehicle orientation. Although cameras are installed on the ROV, the operator still does not know the real situation and motion of the ROV. Haptic feedback helps the operator by giving force feedback to guide the operator based on the orientation of the ROV. This work is to propose a solution in developing feedback by quantify the different between operator handheld device orientation and ROV current orientation.

1.2 Objectives

The objectives of the project are;

a) To develop a handheld haptic device that able give haptic feedback for ROV pitch motion.
b) Assess the performances of the sensor accuracy and actual force delivered for handheld device.

1.3 Scope

This project consists of hardware which is a handheld device, Arduino microcontroller, vibrator and the electronic circuit of the system. There are several scopes of this project:

a) Focus more on haptic feedback
b) Only for 1 DOF (pitch) of the ROV
c) Using Arduino UNO as microcontroller
d) Using MPU6050 sensor to detect orientation angle
e) Using two IMU sensor, one in the ROV and the other one mounted on the haptic device
f) Using two brushless motor to give force feedback to user.
g) Analysis the performance criteria such as sensor accuracy and actual force delivered for handheld device
h) Using MATLAB software to analysis the simulation
i) Using the actual fabrication or physical test of handheld device to analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 Theoretical Review

Theoretical review is the fact of the research that have found in the article, journal, book and about the title of this thesis.

2.1.1 Type of Haptic

There are two types of haptic feedback that generally divided into two different classes that is Tactile and kinesthetic. The difference between the two feedback is quite complex but at a high level. Kinesthetic feedback concept is relating to the feeling in motion. It is related to sensations originating in muscles, joint and tendons. Imagine you holding a coffee –mug in your hand. Kinesthetic feedback tells your brain the approximate size of the mug, its weight and how you are holding it relative to your body. Tactile feedback concept is pertaining to the cutaneous sense, but more specifically the sensation of pressure rather than temperature or pain. They allow your brain to feel things such as vibration, pressure, touch, texture and etc. Table 2.1 show the type of haptic feedback occurs in the real life.

Table 2.1: Type of haptic feedbck

Kinesthetic feedback	Criteria	Tactile feedback
Movement or force in the muscles and joint, exchange force between the user and virtual environment.	Feedback	Also known a touch screen, Stimulating the nerve receptors.
The interface is attached to a base embedded into a fixed place (desk, floor, wall and ceiling)	Types of haptic device	The type can be more easily be wearable generally large-scale devices that contrast to the small portion of skin over which they act
Steering wheel that provides forces for driving for driver	Example	Friction on finger by effect of coulomb forces

2.1.2 Benefit of Feedback

2.1.2.1 Advantages of Haptic Interfaces

For every new technology invented, there has always been a debate as to whether it will do well within the industry, or whether it won't. The advantages of haptic technology will create a special type of communication which would be focused upon touch and it takes advantage of the user's sense of touch and feeling. Furthermore, intuitive way for a human user to interact with a computer or other haptic device is a haptic technology, and have that device display information back into the real world.

2.1.2.2 Disadvantages of Haptic Interfaces

The disadvantages of such technology are as follows: With regards to the implementation of this new technology are the costs associated with it, sometimes companies cannot afford such equipment within their organization and consequently will not implement it. Since this technology is still being rapidly introduced, it has not become very common; therefore, it is still relatively expensive and may not be affordable to the average income homeowner and small business. Moreover, for many companies the cost can outweigh the benefits given to the company and we already know that if something "worth its cost", It would be a good idea not to implement it.

2.1.3 Weber's Fraction Law

Weber's law state that changes in stimuli will be only noticeable as a ratio of the original stimulant. The ratio of magnitude of a stimulant to the quantity which importance must be altered in effort for the modification to be interpreted is a constant. Weber's law of 1834, $\Delta S/S=c$ for the just noticeable difference (jnd), can be written as

$$S+\Delta S=kS,\ k=1+c. \tag{1}$$

It follows that the stimulus decrement required to elicit one jnd of sensation is

$$S-\Delta S^{*}=k^{-1}S. \tag{2}$$

The solution is generalized to arbitrarily many dimensions by substituting the sin and cos in the generalized Weber law by the standard coordinates of a unit vector. The relationship between exploration force **F**, moment of inertia **I,** and angular acceleration a provides some basic insights into the sensory information needed to perceive moment of inertia. In the present task, with the rotation axis fixed through the center of mass of the rod, this relationship is as follows:

$$k.F = I.a \tag{3}$$

The k is a constant that represents the moment-arm of the force. The equation illustrates 2 things: First, an increase (or decrease) in the exploration force entails a corresponding increase (or decrease) in the magnitude of the rod's angular acceleration. Second, in order to estimate moment of inertia the nervous system requires information about both forces and angular accelerations. Crucially, this information is encoded in neural signals that are subjected to noise [9].

2.1.4 General Haptic Devices

Haptic device is a manipulator with sensors, actuators or both that has variety of haptic devices have been developed for their own proposed. The most popular are tactile based, pen-based, and 3 degree of freedom (DOF) force feedback devices.

2.1.5 Force Feedback

Force feedback is the technology that user to feel the power and movements. The basic idea of a force feedback (haptic feedback) is to move the stick junction with onscreen action. For example, the park that is dynamic in the movie in the film as a moving screen, move the chair forward speed and sense of the conflict that their audience will feel Characteristic of force feedback is a rumble. For a controller, force feedback is rumble. Basically, force feedback means that the wheel applies force when you turn it (newton's third law).