DEVELOPMENT OF HYDROPHONE SYSTEM FOR AUTONOMOUS UNDERWATER VEHICLE (AUV) APPLICATION

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Bachelor of Mechatronic Engineering

May 2010

" I hereby declare that I have read through this report entitle "Development of Hydrophone System for Autonomous Underwater Vehicle (AUV) application" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronic Engineering"

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Date : 12/5/2010

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2010

I declare that this report entitle "Development of Hydrophone System for Autonomous Underwater Vehicle (AUV) application" 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 : MAZLEENDA BINTI MAINI

Date : 11TH MAY 2010

To my beloved mother and father

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ABSTRACT

This project is about developing a hydrophone system for the purpose of autonomous underwater vehicle (AUV) application. AUV is an underwater vehicle which travels underwater. Hydrophone is an underwater microphone which with the help of pressure impulses of acoustic waves converts them into electrical signals which in further are used for communication. It was designed to be used underwater for recording or listening to underwater sound. Hydrophone needs an audio recorder to analyze the spectrographic analysis, without necessary to carry the computer into hostile marine environment. Spectrogram is used to simulate the sound signal of underwater sounds. Spectrogram is a plot of the frequency component such an audio signal as function of time. In this spectrogram program, digital audio recording are analyzed to produce a plot of frequency versus time, with harmonic intensity represented by a variable color scale. Hydrophone acts as a medium to study of the underwater acoustics which is a propagation of sound in water and the interaction of the mechanical waves that constitute sound with the water and its boundaries. Then, the hydrophone system is tested by recording the underwater sound signals at the location to make sure that the system in good condition.

ABSTRAK

Projek ini adalah untuk membina sistem pembesar suara (mikrofon) dalam air untuk tujuan penggunaan kenderaan dalam air berautonomi (AUV). AUV adalah sebuah kenderaan dalam air yang mengembara dalam air. Hidrofon adalah sebuah mikrofon dalam air yang digunakan untuk merakam dan mendengar bunyi di dalam air. Dengan bantuan tekanan, gelombang-gelombang akustik akan menukar isyarat kepada isyarat elektrik dan akan digunakan untuk tujuan komunikasi. Untuk mengaplikasikan penggunaan hidrofon, perakam video diperlukan untuk merakam bunyi tanpa membawa komputer atau komputer riba ke lokasi. Perisisian Spektrogram digunakan untuk mensimulasi isyarat bunyi dalam air. Spektrogram adalah isyarat audio yang menggunakan fungsi masa dan kemudian dipaparkan dalam bentuk pelbagai warna dan keamatan harmonik. Kemudian, sistem hidrofon akan diuji dengan melakukan proses merakam dan menganalisis rakaman dalam air untuk memastikan sistem itu dalam keadaan baik. Kemudian, data- data yang diperolehi akan digunakan untuk membina bank data kehidupan laut dalam bentuk kadar frekuensi sampel.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS & TERMS

AUV	Autonomous Underwater Vehicle
MIMO	Multiple Input Multiple Output
ROV	Remotely Operated Vehicle
Hafmynd. Inc	Developer of Novel Underwater Technologies
OAL	Ocean Acoustic Laboratory
CSHEL	Coastal Sediments Hydrodynamics & Engineering Laboratory
LAN	Local Area Network
CEBC	Group Ecology of Birds and Marine Mammals
CNRS	Centre National Research Science
CIBRA	"Centro Interdisciplinare di Bioacustica e Ricerche Ambientali" or Interdisciplinary Center for Bioacoustics and Environmental Research
VARUN	Vehicle for Automation Research and Underwater Research
AUVSI	Association for Unmanned Vehicle Systems International
ONR	U.S Office of Naval Research
SPAWAR	U.S. Navy's Space and Naval Warfare Systems Centre
IMU	Inertial Measurement Unit
DAQ	Data Acquisition Card
B.R.A.I.N	Big Red Artificial Intelligence Navigator
FFT	Fast Fourier Transform
dB	Decibel
Hz	Hertz
NN	Neural Network
VOR	Voice- Operating Syatem

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.0 Introduction

An Autonomous Underwater Vehicle (AUV)[3] is a robotic device that is driven through the water by a propulsion system, controlled and piloted by an onboard computer, and maneuverable in three dimensions. This level of control, under most environmental conditions, permits the vehicle to follow precise preprogrammed trajectories wherever and whenever required. There are many applications of AUV which are use for commercial, military, and underwater research [3]. Thus, this project just focuses on the underwater or marine research for the future study. In primarily oceanographic tools, AUV carry sensors to navigate autonomously and map features of the ocean. A typical sensor includes compasses, depth sensors, sidescan, hydrophone, sonars, magnetometers, thermistors and conductivity probes.

Hydrophone is an electronic device or called it as underwater microphone which with the help of pressure impulses of acoustic waves converts them into electrical signals used for communication. It was designed to be used in underwater for recording or listening to underwater sound [4]. For this project, hydrophone system is used in AUV application for monitoring and surveying application.

The hydrophone system must be in excellent condition, so it proven by develops the hydrophone system including of the process to record and produce the database of underwater sounds in Malaysia. The difficulties occurring in such a process are discussed; possible methods and process models to overcome these problems are proposed and discussed.

1.1 Research Objective

In every project, there must be a reason why it was conducted. Objective defined as goal on how the project has been. It gives the benefits to organize the efforts toward accomplishing the desired project. Thus, the objective can be stated clearly in one single word that is:

"To develop hydrophone system for Autonomous Underwater Vehicle (AUV) for monitoring and surveying application"

1.2 Scope of Project

Scopes of project is the features and functions that characterize a product service or results [5]. For this hydrophone system for AUV application, several scopes for the whole project are outlined.
This project scopes are:

1. Research information about the hydrophone, AUV and underwater acoustic
2. Record the underwater sounds at the locations in Malaysia.
3. Analyze the underwater signal to produce the spectrogram analysis of underwater sounds.

1.3 Problem Statement

Human occupied an Autonomous Underwater Vehicles (AUV) for deep sea research since 1980s (Doyle, 1995). Nowadays, many universities all over the world are competing with custom made AUV to aiming and contribute with a submarine in the future. Therefore,

the hydrophone system is developed for monitoring and surveying applicationThere are the problems that may occur throughout the project which are:

1. One major drawback of the project is the denser of fluid of locations. Although a hydrophone can listen to sound in air, but it will be less sensitive if a hydrophone buried in the ground. It will give similarly poor performance due to the similarly bad acoustic impedance match. To solve this problem, the hydrophone must have 2 until 3 meters for work best.

2. Besides of those stated circumstances, to control the hearing range of marine mammals is complicated because of difference acoustic transmision. It is required to set ups exactly right for the particular situation. Each location produce different situation, but the efforts will be rewarded to provide clear sound pickup.

1.4 Research Methodology

In this project, the whole process will be separated into two parts; the first will be constructing the hydrophone system and the second will be developing program to simulate the spectrogram of underwater sound.The research work is undertaken in the followingfive developmental milestones or stages. For better understanding of research methodology process, flow chart of the project is shown in Figure 1.0.

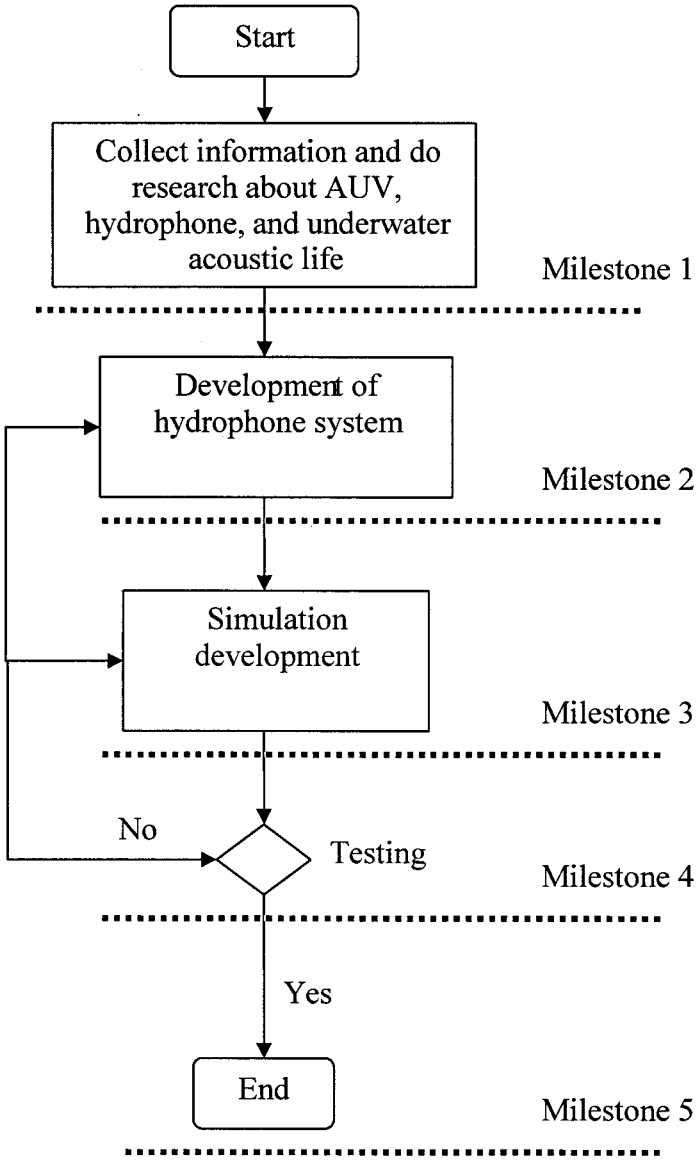

Figure 1.0 Flow chart of project

Milestones 1: Collect information and do research about AUV, hydrophone system, and underwater acoustic life

Before starting this project, the problem statements need to be analyze and the reason why the project is conducted. Problems that need to be identified would not only be the one which might occur during conducting this projectbut also with the system that is to be develop.

Thus, I have to study about AUV, hydrophone system, and underwater acoustic life in details from any references books, journals and from any internet sources.

Milestone 2: Hydrophone system development

Develop and construction of hydrophone system for autonomous underwater vehicle application. It is including of the type of hardware that be used in this project. The requirements for the platform were to be relative simple, easy to apply it at the locations and capable of recording the underwater sounds from any different location.

Milestone 3: Software development

In this stage, the software is developed to implement the sound signals. By using Spectrogram, the sounds signals can be analyzed in details compute it into frequency components data.

Milestone 4: Testing and Evaluation

This is the stage where the hydrophone system was tested in underwater and simulates the data by using Spectrogram. If the test run fails, the troubleshooting is needed to identify the faulty of the hydrophone system and from the simulation part of analysis. A variety of tests will be made during the project period, in order to determine if proper results were achieved or to confirm calculations and theories.

Milestone 5: Report Writing

This project will be presented and the final report will be written based on testing and evaluation made.

1.5 Organizations of the Report

This presentation report is divided into six chapters. Each of the following paragraphs generally described the contents of each chapter.

Chapter 1 explained the objectives, scopes, problem statement of this project, and summarized a general methodology and the main activities involved in this research.

Chapter 2 gives of the general description and overview of the autonomous underwater vehicles, hydrophone system, underwater acoustics life and AUV application. The literature review acts as the reference of the project will be reviewed.Some of the literature review on AUV and hydrophone system such as features, applications, and advantages is also discussed in this chapter.

Chapter 3 discussed the theory and basic idea to understanding the AUV application in the world. It is including of properties concept like material, transmitting signal and receiving signal, water depth and so on. In this chapter also explained detail about the hydrophone system and their basic parameters.

Chapter 4 discussed the process to develop the hydrophone system for AUV application. The description of the hardware and software that be used, and how both of them was operated.

Chapter 5 shows the preliminary results, analysis and discussion of the project.Future work is discussed in this chapter.

Chapter 6 gives a summarized work and conclusion for overall of this work. Suggestion for future improvements and advancements of this study are also discussed.

1.6 Summary

In this chapter, the introduction of the project is well discussed and described by stating its objectives, problem statement and research methodology which encouraged for this project to be conducted. Accordingly, literature review on AUV and the organization structure of the report are also discussed in the later chapter.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Hydrophone is an electronic device which with the help of pressure impulses of acoustic waves converts them into electrical signals In this project, the hydrophone systemis used for Autonomous Underwater Vehicle (AUV) application. It was designed to be used underwater for recording or listening to underwater sound. In order to develop any hydrophone system, it is essential to have strong background knowledge and fundamental concepts and theory about the processes and physical laws governing the underwater vehicle in its environment. The knowledge and fundamental concepts are very essential before developing the hydrophone system. With regard to AUV application, factors such as underwater acoustics, wave propagation, transductions in underwater, hearing range and hydrophone concepts have to be taken into consideration.This chapter introduces some of these fundamental concepts and ideas about hydrophone system that are as literature review. Also, some of these fundamental concepts and ideas about underwater vehicles, and also studies the general concepts and application of these vehicles is introduced.

2.1 MIMO Transceiver Systems on AUVs

In the year of 2008, a group of students and staff from University of Delaware developed a versatile, mobile acoustic MIMO[6] communication testbed on a small AUV at the frequency band of 8-50 kHz for data communication studies and making this system capable of use on various submerged platforms such as for ROV, moorings, fixed, observatory

nodes. It was apply to the University of Delaware's DORA vehicle that called "Gavia" class AUV as shown in Figure 2.0.

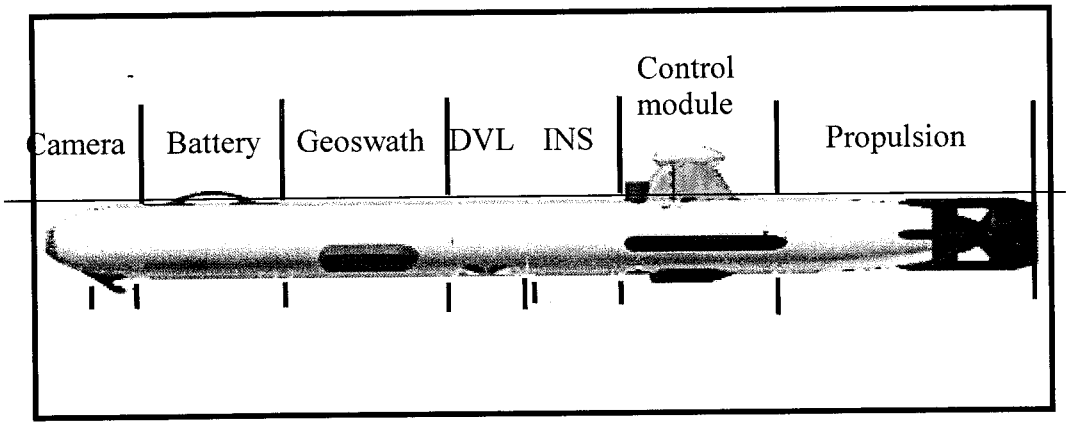

Figure 2.0: The Gavia AUV

In order to provide an enhanced communication system, it must deliver the same capability on an AUV that can move about freely within the marine environments. Because of that reason, the MIMO transceiver system on the AUV is designed for ease of use and low-cost deployment during at-sea experiments. The system under design can be attached to the AUV or potentially other platforms which have capability to conduct an acoustical sampling with or without single-element or multi-element source transmission.

This system consists of three components which are data transmission (acquisition) electronic unit, a hydrophone array, and a multi-element source. The electronic unit, housed in a payload module of the AUV, will conduct acoustic sampling from up to eight hydrophones and provide analog waveforms to four transducers. The several inter-related tasks that involves in this project including of AUV evaluations, development of data transmission/acquisition electronic unit, placement of transducers and hydrophones, AUV integration, laboratory tank studies, and field ground-truth tests. The completed and scheduled tasked are listed.