AQUABOT: Hydro view Real-Time Video Streaming Remotely Operated Vehicle

Project ID: 15-005

Project Proposal Report

B. Sc. Special Honors Degree in Information Technology
Department of Information Technology
AQUABOT: Hydro view Real-Time Video Streaming Remotely Operated Vehicle

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Authors

<table>
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<tr>
<th>Name</th>
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<tr>
<td>Nagodagamage S.K.</td>
<td>IT12518074</td>
<td></td>
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<tr>
<td>A.M.D.C. Attanayaka</td>
<td>IT12052448</td>
<td></td>
</tr>
<tr>
<td>G.S.C. De Silva</td>
<td>IT12057016</td>
<td></td>
</tr>
<tr>
<td>M.S.R. Perera</td>
<td>IT11100744</td>
<td></td>
</tr>
</tbody>
</table>

Supervisor : Mr. Anuradha Jayakody

Supervisor’s Signature : ________________________________

Co-supervisor : Ms. Shashika Lokuliyana

Co-supervisor’s Signature : ________________________________

Date of Submission : March 2015
Declaration

We hereby declare that the project work entitled “AQUABOT: Hydro view Real-Time Video Streaming Remotely Operated Vehicle” submitted to the Sri Lanka Institute of Information Technology is a record of an original work done by us, under the guidance of our Supervisor Mr. Anuradha Jayakody. This project work is submitted in the partial fulfillment of the requirement for the award of the degree of Bachelor of Science in Information Technology. The results embodied in this report have not been submitted to any other University or Institution for the award of any degree or diploma. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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Abstract
This paper presents, a real time-video streaming, position keeping **Remotely Operated Vehicle (ROV)**. The research mainly focuses on real-time video streaming. The problems that ROV technology face is lagging of the real time video, the drifting of the ROV due to water currents, and low clarity of images due to absorption of colour of light by water. There have been many researches to solve these problems, many of them exceeding the price range of normal middle class and some even exceeding the upper class citizens’ price range, only to be owned by governments and organizations. Each of these problems will be taken into account and solutions will be presented.
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1 Introduction

People have reached even the highest places in the world. But man still has not reached most of the places underwater. Because of this reason most researches have been terminated or halted which were conducted about underwater creatures, i.e. bacteria, algae, water samples etc. The remotely operated underwater vehicle, commonly referred to as a **Remotely Operated Vehicle (ROV)**, proposed to be implemented will help a lot of the people who wish to observe or research underwater. Other than researches, it could be used as a tool for tourism as well. Now a days there are ROVs with cameras and video recorders which have designed to capture underwater scenes. The proposed ROV which will be able to perform position, maintaining tasks by its own without user interference.

In Sri Lanka as this technology is not accessible; researchers have to dive underwater for their researches. But there are limitations for a diver, such as the amount of oxygen carried limits the time the driver has underwater. Third world countries do not have access to technologies such as ROVs at disposal for a reasonable price. So the aim of this project is to come up with a low cost solution for this problem.
1.1 Background

In 1950s the Royal Navy used “Cutlet”, a remotely operated submersible, to recover practice torpedoes. [10]

![Figure 1.1-1 A Royal Navy ROV (Cutlet) first used in the 50s](image)

In the 1960s, most of the early ROVs was funded by the US Navy; what then was called Cable-Controlled Underwater Recovery Vehicle” (CURV), now referred to as CURV me. It was designed to recover test ordinance around the San Clemente Island, at depths up to 2000 feet. This became famous in 1966 due to its recovery of an H-bomb under 2800 feet underwater near Spain. CURV is a pioneer of undersea teleoperators. [8]

![Figure 1.1-2 CURV I](image)

Since then there have been several CURVs, which includes the CURV III the most sophisticated ROV in its time till it was replaced with CURV-21 in 2007. CURV III is the fourth generation of CURV. Its initial depth was 10,000 feet, it was upgraded to 20,000 feet by the US Navy's Supervisor of Salvage in 1973 for rescuing two man crew of a Canadian commercial submersible which was stranded at a depth of 1,575 feet (480m). The 76-hour multinational rescue effort resulted in the deepest sub rescue in history. [9]
Taking CURV as a base design, the offshore oil and gas industry crated the work class ROVs. In the 1980s, when most of the offshore development exceeded the reach of the divers, ROVs became essential. Since oil industry was the main technological developer for ROVs, the ROV development immobilized during the mid-1980s due to drop in the price of oil and a global economic recession. Development of ROVs has accelerated since then. And today ROVs perform various tasks, from observing eco-systems for construction of sub-sea structures.

ROVs have been used to locate many historic shipwrecks, including the RMS Titanic. ROVs were used to recover material from the sea floor and bring it to the surface. [11]

Summarized below are some of the more popular, low-cost and easily deployed models in the market.

**OpenROV** [1]
OpenROV is an open-source underwater robot for exploration and education. It's also a passionate community of professional and amateur ocean explorers and technologists.

<table>
<thead>
<tr>
<th>Operating system</th>
<th>Linux</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>720 MHz (BeagleBone ARM Cortex-A8 processor)</td>
</tr>
<tr>
<td>Memory</td>
<td>256 MB DDR2 (BeagleBone)</td>
</tr>
<tr>
<td>Camera</td>
<td>HD USB webcam with 2 LED light arrays on servo-tilt able platform</td>
</tr>
<tr>
<td>Connectivity</td>
<td>10 Mb Ethernet data tether</td>
</tr>
<tr>
<td>Power</td>
<td>8 C batteries (~1.5h run time)</td>
</tr>
<tr>
<td>Dimensions</td>
<td>30 cm (12 in) x 20 cm (7.9 in) x 15 cm (5.9 in)</td>
</tr>
<tr>
<td>Weight</td>
<td>2.5 kg</td>
</tr>
</tbody>
</table>

Table 1.2.1-1 OpenROV Specs

Price $899.00 Upwards.

**Aqua 2** [2]

![Aqua2](image)

Figure 1.1-5 Aqua2 [2]

The Aqua2 is an amphibious Hexapod robot capable of propelling itself on land or through the water. The use of six independently controlled thrusting surfaces makes the unit very maneuverable and produces minimal disturbance to the surrounding environment.

The Aqua2 is programmable and configurable, can be deployed for tethered or untethered use, and is an ideal platform for submersible robotics projects, environmental monitoring, and propulsion research.

<table>
<thead>
<tr>
<th>CPU</th>
<th>1.4 GHz Processor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>CF Memory</td>
</tr>
<tr>
<td>Camera</td>
<td>HD USB cam</td>
</tr>
<tr>
<td>Connectivity</td>
<td>Ethernet</td>
</tr>
<tr>
<td>Power</td>
<td>28.8 V, 7.2 Ah @ 2 amps (~8 hours (standard), 3 - 4 hours (optional run time))</td>
</tr>
<tr>
<td>Dimensions</td>
<td>30 cm x 44 cm x 64 cm</td>
</tr>
<tr>
<td>Weight</td>
<td>16.5 kg</td>
</tr>
<tr>
<td>Speed</td>
<td>1.0 m/s in water</td>
</tr>
<tr>
<td>Available Sensors</td>
<td>Depth, IMU Resolution</td>
</tr>
</tbody>
</table>

Table 1.2.1-2 Aqua2 Specs
The HydroView is another remote controlled underwater vehicle which records live video and captures still photos in high definition. With Aquabotix's innovative iPad or laptop applications, users can "fly" the HydroView through the water viewing the live video feed from the safety and comfort of deck, dock or shore.

<table>
<thead>
<tr>
<th>Operating system</th>
<th>Linux</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Dual Core Cortex-A9 Processor at 1 GHz</td>
</tr>
<tr>
<td>Memory</td>
<td>1GB DDR Ram</td>
</tr>
<tr>
<td>Camera</td>
<td>720p HD</td>
</tr>
<tr>
<td>Connectivity</td>
<td>Fiber Optic</td>
</tr>
<tr>
<td>Power</td>
<td>Lithium, 15V 15.6 A (~3h run time)</td>
</tr>
<tr>
<td>Dimensions</td>
<td>37 cm x 48 cm x 30 cm</td>
</tr>
<tr>
<td>Weight</td>
<td>5.9 – 6.8 kg</td>
</tr>
<tr>
<td>Sensors</td>
<td>Orientation Sensor, Depth Sensor, Temperature Sensor</td>
</tr>
</tbody>
</table>

Table 1.2.1-3 HydroView Specs

Price $4,950.00 Upwards.
1.2 Literature Survey
There are many successful Underwater Remotely Operated Vehicle (ROV) research projects conducted worldwide. In order to build a relatively low cost, easy to use ROV a through reading was done of several similar researches done previously to understand the limitations and expectations of the project.

Related Previous Researches

1.2.1 Real-time Vision-based Station Keeping for Underwater Robots \[^{[5]}\]
By Sjoerd van der Zwaan (sjoerd@isr.ist.utl.pt) and Josh Santos-Victor (jasv@isr.ist.utl.pt)

Instituto de Sistemas e Robótica,
Instituto Superior Técnico,
Av. Rovisco Pais,
Torre Norte 7.26,
1049-001 Lisboa,
Portugal.

This research has been conducted by Sjoerd van der Zwaan and Josh Santos-Victor on behalf of Instituto Superior Técnico for automatic vision-based station keeping of an ROV using image processing. This research project mainly focuses on position, maintaining of ROVs using natural textures in the images. The proposed system used onboard camera and image processing to detect a suitable reference texture for position stabilizing. For more accurate control the camera is mounted on a rotatable pan to keep the visual landmark constantly in view during manoeuvres.

1.2.2 The Visual Servoing System “CYCLOPE” Designed for Dynamic Stabilization of AUV and ROV \[^{[6]}\]
By M. Perrier (Michel.Perrier@ifremer.fr)

Ifremer Mediterranean Center,
Underwater Systems Department,
Zone Bregaillon,
83500 La Seyne sur mer,
France.
(Oceans Europe 2005)

This research has been conducted by M. Perrier on behalf of the Ifremer Mediterranean Center for dynamic stabilization of Unmanned Underwater Vehicles (UUVs) using image processing.
This research project mainly focuses on optical stabilization of ROVs. The proposed system used a camera located onboard the ROV and OPTIC_DP Software® developed by Ifremer to perform the video image processing and the control computation. To optimize the computation time of the image processing Regions of Interest (ROIs) are defined and used for the image processing. Within the OPTIC_DP Software® an innovative technique is implemented in order to identify the Center Of Gravity (COG) of a suitable ROI. The COG is then used as the reference point for position stabilization.

![Image 1](image1.png)

**Figure 1.2-1** Image collected by CYCLOPE during optical stabilization [6]

![Image 2](image2.png)

**Figure 1.2-2** Same image processed to compute COG of ROI [6]

The above two research projects presents solutions to the position keeping problem by identifying a fixed point in the environment captured by the camera and adjusting the ROVs’ position in relation to those points. The reference points are identified using image processing and other technologies. These technologies require additional processing power for these tasks. In the Aquabot project Accelerometer and Gyrometer is used for position identification. These do not require nearly as much processing power as the image processing software.

1.2.3 Advances in High Brightness Light Emitting Diodes in Underwater Applications [13]
By K. R. Hardy, M. S. Olsson, B. P. Lakin, K. A. Steeves, J. R. Sanderson, J. E. Simmons, P. A. Weber

DeepSea Power & Light®,
4033,
Ruffin Road San Diego,
CA 92123 USA (2008).
This research focused on the behaviour of high brightness LEDs in underwater. They go through some important metrics associated with LEDs as follows. High brightness LEDs produce light in the 70-120/lumen per watt range and that lights are about five times more efficient than incandescent lamps. Reliability of the LEDs are higher than other bulbs. Most of the LEDs have a life span up to 50,000 hours.

Researchers say multi chip LEDs allow for more light from a single package while operating at the most efficient current.

![Figure 1.2-3 MCE multi chip LED](image)

High Brightness LEDs are the most suited for underwater lighting systems with all above factors. LED lights provide safety, flexibility, efficiency and cost effective with underwater products. But in this research paper they don’t talk about murky or turbid underwater vision. All types of water have to be considered.

1.2.4 Colour Registration of Underwater Images for Underwater Sensing with Consideration of Light Attenuation [14]
By Atsushi Yamashita, Megumi Fujii and Toru Kaneko

IEEE International Conference on Robotics and Automation Roma,
Italy
(10-14 April 2007)

Because of the light intensity decreases with the distance from objects in water by light attenuation the colours of objects observed in underwater environments are different from those in the air. Because of this reason recognition method which are used in air based on image processing techniques may become invalid in water due to light attenuation. So here they have proposed a colour registration method for under water image processing.
The method they have proposed estimates underwater environments where images are acquired, in other words, parameters essential to colour registration, by using more than two images. After estimating parameters, colour registration is executed with consideration of light attenuation. Experiments will verify the effectiveness of the proposed method.

They have identified three difficulties occurs with observations of underwater:

1. View-disturbing noises
2. Light refraction effects
3. Light attenuation effects

Here they have concerns about the third problem which they were identified. The third problem is about the attenuation effects of light. The light intensity decreases with the distance from objects in water by light attenuation depending on the wavelength of light. However, as to the third problem, there are few methods that can investigate objects’ colours in aquatic environments where different colours are observed by light attenuation effects from aerial environments.

Here they have explained about two main points.

- The principle of the light attenuation
- Observed colors in liquid

They have explained about two theories. One of them is Light Attenuation in Liquid and the other one is Light Reflection in Liquid. They have explained about colour registration methods under below two topics.

- Relationship between Two Images
- Estimation of Unknown Parameters

Also, they have mentioned about the experiment part under two topics.

- Experimental Condition
- Colour Registration under Known Condition

As their conclusion they have proposed a colour registration method of underwater images with consideration of light attenuation. The proposed method estimates parameters essential to colour registration, by using more than two images. After estimating parameters, colours of these images can be corrected with consideration of light attenuation.
They have mentioned that the effectiveness of this proposed method has been verified through their experiments. And also they have mentioned that as the future works, classification or recognition method of objects in underwater images that are under the influence of light attenuation, and cannot classify or recognize them without colour registration. They have adopted a stereo camera system for the robust colour registration and 3-D measurement of objects in underwater environments.

![Color Registration](image)

**Figure 1.2-4** Color Registration [14]

This research has used image processing technologies to clear the image taken. But to clear a video in real time using image processing may not be feasible for a low cost ROV, since a greater processing power will be needed for image processing.
1.2.5 Application of Concurrent Subspace Design to Shape Design of Autonomous Underwater Vehicle [23]

By Peng Wang, Baowei Song, Yonghu Wang, and Lichuan Zhang

College of Marine,
Northwestern Polytechnical University,
Xi’an,
China

wp970311@163.com

Here they have reviewed the optimization process of the concurrent subspace design algorithm in details. They have carried out in the framework of the shape design of autonomous underwater vehicle and also carried out what are the disciplines and how they are divided. A Multi objective, Multidisciplinary Design Optimization (M&MDO) model of the shape design of the AUV is developed. Analyzing of an optimal design example of a certain AUV I based on CSD method. And also the approach is applied to shape the design of AUV for validation. Finally, comparisons with the present experimental data are made. They have shown that the analytical result shows that the drag and noise of optimal shape are greatly improved, and the CSD method has some important implication for AUV design.
1.3 Research Problem

No matter how well a ROV works above water once it is underwater it faces several problems. The first of which is the drop of the thruster rotations per volt, due to the drag of water. Designers must consider this drop while designing. If not the ROV may not even have the power to submerge.

Second is the visibility of the water. There are systems that use processing power to correct the colour of underwater images using image processing technologies. To use such technologies the ROV has to be equipped with a larger processor. The lighting systems installed in present ROVs are rudimentary, containing only bright white LEDs. Water absorbs the colours from light passing through it.

![Figure 1.3-1 Comparison of penetration of light of different wavelengths in the open ocean and coastal waters [15]](image)

As shown in the figure the colour of the water depend on the depth the image was taken and any additional substances that may be added into the water. The colour that best penetrate the water is the light with the same colour as the water.

The best colours to use for visibility in the water was shown by Luria et al. and quoted from Adolfson and Berghage below: [15]
A) For murky, turbid water of low visibility (rivers, harbours, etc.)
   1) With natural illumination:
      a) Fluorescent yellow, orange, and red.
      b) Regular yellow, orange, and white.
   2) With incandescent illumination:
      a) Fluorescent and regular yellow, orange, red and white.
   3) With a mercury light source:
      a) Fluorescent yellow-green and yellow-orange.
      b) Regular yellow and white.
B) For moderately turbid water (sounds, bays, coastal water).
   1) With natural illumination or incandescent light source:
      a) Any fluorescent in the yellows, oranges, and reds.
      b) Regular yellow, orange, and white.
   2) With a mercury light source:
      a) Fluorescent yellow-green and yellow-orange.
      b) Regular yellow and white.
C) For clear water (southern water, deep water offshore, etc.).
   1) With any type of illumination fluorescent paints are superior.
      a) With long viewing distances, fluorescent green and yellow-green.
      b) With short viewing distances, fluorescent orange is excellent.
   2) With natural illumination:
      a) Fluorescent paints.
      b) Regular yellow, orange, and white.
   3) With incandescent light source:
      a) Fluorescent paints.
      b) Regular yellow, orange, and white.
   4) With a mercury light source:
      a) Fluorescent paints.
      b) Regular yellow, white.

The most difficult colours at the limits of visibility with a water background are dark colours such as grey or black. The most common colours are red and green coloured water.
Third is the position estimation and position maintaining. Unlike in a pool where water is still, in the ocean water constantly moves due to water currents and other occurrences. If the operator left the ROV unobserved for several minutes under the sea the ROV could be several miles from the position the operator finally left idle. To remedy this problem the ROV must always know its position. Then, once it ceases to receive instructions from the operator (not due to connection loss) it must be able to maintain its position utilizing its thrusters. For maximum control and cost efficiency this ROV is given six thrusters, two for forward, backward motions and turning, three for up, down and tilt motions, and one for side motions.

Figure 1.3-1 ROV motions
2 Objective

2.1 Main Objective

2.1.1 Underwater Live video streaming Robot Vehicle

The main task of this project is to discover a solution for real time video streaming ROV with minimized lagging. Most of the existing products use expensive systems to reduce lag. But the main objective of this project is to try to develop a system for minimizing the lagging time without using expensive devices.

Most of the existing UROVs are using batteries to power them. So their exploration time is limited to a few hours, to increase the operating time, the ROV is directly powered through a power line and a backup power source in case of an emergency.

2.2 Specific Objectives

2.2.1 Light system for underwater vision

Because of the light reflection and absorption the weather differs from air, cameras are unable to get clear videos and photos of underwater. It is difficult to always expect clear waters for ideal underwater videos and photos. Therefore, it is important to have a better lighting system. None of the products mentioned above have a lightning system which is able to clearly illuminate the area to be captured in algae or muddy water. So one of the sub objectives of this project is to develop a quality lighting system for underwater use.

2.2.2 Autonomous Functions

2.2.2.1 Connection lost reaction

The ROV will be controlled and powered through a wired connection. There can be instances where the power or control connections can be severed. The ROVs actions will be automated in the event of the control connection being severed or disconnected. In this case the ROV will be programmed to wait a set period of time to see whether the connection will be reconnected, if not the ROV will ascend to the surface. In case of power connection failure the backup power bank will fulfil the role of the power source, and the operator will be notified immediately of the connection loss.

2.2.2.2 Position Maintaining

Since the main purpose of the ROV is to be an observational instrument, it is important for it to be relatively stationary. As there are many factors in the water that disturb the satiation of the ROV (i.e. Water currents, waves, etc.), It may disturb the observing atmosphere. As a
solution the ROV will be programmed to maintain its position where the user last directed, and return to that position if the ROV is forcibly moved to another position.

2.2.3 Control Panel Software
The user has to control the ROV from on land or on a boat. For that purpose an application for PC or Laptop will be created to control the ROV. This application will facilitate the controls to the thrusters the lighting system, and the camera. Additionally, this application will display the real time camera footage, the sensor readings power and connection status.

2.2.4 Relatively small ROV
The shape and the weight are two of the most important aspects of an ROV. The agility and speed of the ROV as well as its mobility depends on its shape and weight. One of the project's goals is to build the ROV compact; with an ideal volume to weight ratio that the ROV is naturally buoyant.

2.2.5 Low cost product
Most of the ROVs in the market are very expensive; most of them costing upwards of hundred thousand rupees (above $800) without being assembled. The reluctance to use ROVs in oceanic explorations is mostly due to the high initial cost and the high deployment cost. Another of the project's goals is minimizing the overall cost of the ROV.
3 Methodology

3.1 Structural Design of the UROV

Large underwater vehicles such as submarines, have specific shapes and designs. But those designs are not feasible for small Underwater Remote Operate Vehicles (ROVs). So ROVs has many different shapes and designs as a result of many researches. This design should be efficient, compact and add mobility and agility to the ROV.

![Basic Submarine Design](image)

Figure 3.1-1 Basic Submarine Design [7]

When underwater vehicles are made, it is necessary to consider about the following factors,

- Water types (fresh water, salt water, etc.)
- Average water density
- Pressure under the water

Most of the electrical components will not be damaged if they are submerged in “pure water” and dried out. But water in natural environment contains minerals and other particles that conduct electricity, this will cause the circuitry to short circuit. It may also cause the metal components to rust, this will render the components useless. To solve this problem a waterproof container will be constructed to contain all of the circuitry. Its front panel will be clearly transparent, for the camera to have a clear view, or a separate container will be built for the camera.

Brushless motors are used as thrusters due to these motors having less exposure of unprotected metal to the water. Brushless motors are typically made of aluminum, and the internal components are coated with a protective coating. For maximum control and cost six thrusters
are used, two for forward, backward motions and turning, three for up, down and tilt motions, and one for side motions.

Figure 3.1-2 thruster placement

3.2 Electronic Circuit Design
When building the ROV a lot of consideration must be done about the power system as this robot works under the water. Since the ROV is powered by a cable from above water the power convention circuitry will be above the water. The backup power supply will be included in the waterproof container. The sensors do not have to be exposed to the elements for their readings, so they also will be housed within the container. The electronic speed controllers (ESCs) for the brushless motors will also be housed in the container. The connections to the PC, power cable and the motor cables will all be exiting the container from the rear of the ROV.

3.3 Program the Processing Unit
Program the processing unit to be able to control the ROV by the Application. The ROV should be able to manoeuvre up, down, forwards, backwards, sideways, and turn left or right when a command is given. Automated position keeping of the ROV should be implemented through the processing unit. And also have to implement a method to measure the depth and the pressure of a particular place by using this processing unit. Images captured by the camera will be streamed through the Processing unit to the PC.

3.3.1 Position Maintaining
The processing unit will monitor the ROVs movements constantly, how far the ROV has moved from the release point will be sent to the PC for the operator’s convenience. Once the
operator stops the ROV in a position the processing unit takes note of it and returns to that point utilizing the thrusters, if the ROV moves without the operator input. Then when the operator commands the ROV to move the voltage to the thrusters will increase from the values that are keeping the ROV stable. For an example, the ROV is supplying the rear two thrusters 10V each to move forward to keep the ROV stationary, now the operator wants the ROV to move forward. Then the power supplied to the thrusters will be >10V. If the ROV to be moved backwards the power supplied to the thrusters will be <10V.

3.4 Develop the User Application

The user interface for the ROV should be developed to be user friendly and intuitive. This interface has to be implemented by a method to capture the real time videos which is streamed through the processing unit. And the ROV movements will be controlled through this interface.

![Figure 3.4-1 A sample user interface](image)

3.5 Lighting system

The lighting system will contain bright white, blood orange and green LEDs. Since the best lighting scheme underwater is to match the color of the water with the lights, green can be used to light in the deep sea, blood orange at muddy rivers.
Light rays bend when they travel from one medium to another; the amount of bending is determined by the refractive indices of the two media. If one medium has a particular curved shape, it functions as a lens. The cornea, humours, and crystalline lens of the eye together form a lens that focuses images on the retina. Our eyes are adapted for viewing in air. Water, however, has approximately the same refractive index as the cornea (both about 1.33), effectively eliminating the cornea's focusing properties. When our eyes are in water, instead of focusing images on the retina, they now focus them far behind the retina, resulting in an extremely blurred image from hypermetropia.\cite{15}

Due to the above factors, there is a huge problem using normal lighting systems thereby this system have to be build up with a special lighting system that suites up at different water conditions.
3.6 Block Diagram

Figure 3.6-1 Block Diagram
### 3.7 Hardware and Software Specification

#### 3.7.1 Hardware Units

##### 3.7.1.1 Processing Unit – Raspberry Pi 2 Model B

<table>
<thead>
<tr>
<th>Device</th>
<th>Image</th>
<th>Software</th>
<th>Hardware</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arduino</td>
<td>Figure 3.7-1 Arduino[27]</td>
<td>Arduino IDE, Eclipse</td>
<td>ATMEGA328</td>
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<tr>
<td>Propeller</td>
<td>Figure 3.7-2 Propeller[28]</td>
<td>Propeller/Spin Assembly</td>
<td>P8X32A-M44</td>
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<td>Beagle Board</td>
<td>Figure 3.7-3 Beagle Board[29]</td>
<td>Eclipse, Android ADK, Scratchbox</td>
<td>TI DM3730 (ARM)</td>
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<td>Raspberry Pi</td>
<td>Figure 3.7-4 Raspberry Pi[30]</td>
<td>OpenEmbedded, QEMU, Scratchbox, Eclipse</td>
<td>Quad Core ARM Cortex-A7</td>
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**Platform**

<table>
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<tr>
<th>Variant</th>
<th>Operating System</th>
<th>Dev. Environment / Toolkits</th>
<th>Programming Language</th>
<th>Architecture</th>
</tr>
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<td>Uno</td>
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<td>Arduino IDE, Eclipse</td>
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<td>PropStick</td>
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<td>Python, C, etc</td>
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<td>Raspberry Pi 2 Model B</td>
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<td>DVI-D, S-Video</td>
<td>HDMI, NTSC or PAL</td>
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<td>8 processors for parallel tasking</td>
<td>SD/MMC, RS-232, JTAG, USB OTG, LCD</td>
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Considering the cost, processing power and memory Raspberry Pi is the most suitable processing unit for this project.

### 3.7.1.2 Motors

Since the ROVs are used underwater all the metallic parts are prone to corrosion. There are two types of motors Brushed and Brushless. Brushed motors have a rotating armature and a fixed, permanent magnet around it. Resulting the need for brushes to supply power to the armature. Brushless motors on the other hand has a fixed armature. There are two types of brushless motors, inrunner which contains its rotating magnets inside the fixed armature and trainer which has a fixed armature attached to the base and the magnets attached to the outer rim.
Figure 3.7-5 Brushed DC motor [19]

Figure 3.7-6 Brushless Inrunner motor [17]
Inrunners has a high RPM per volt, but it lacks torque (moment of force). Outrunners are slower than the inrunners but it produces far more torque. Outrunner outer shell rotates with the axle so it is ideal to attach ROV thruster fins.

3.7.1.3 Camera

USB cameras or webcams are low cost cameras that streams images in real time through a computer to a computer network. Despite its low cost they offer a range of resolutions from 240p to 1080p (320*240 – 1920*1080).

3.7.1.4 Backup Power Unit

Power Bank 1000mAh / 12V

In case of a power failure the ROV must have a backup power supply. Rather than attempting to create a rechargeable power supply from scratch, installing an expertly made power available in the bank market is cost effective, space saving and efficient. A power bank is a collection of
rechargeable batteries either 18650 or Li-Polymer to a set capacity. They are varying in capacity usually from 2600mAh to 14400mAh. They usually have one input and one output or one input and two outputs.

![Power Bank](image)

Figure 3.7-9 Power Bank [32]

3.7.1.5 Sensors

3.7.1.5.1 Depth & Pressure Sensor - MS5803-14BA

- Senses down up to 130m depth
- Precision to about 2cm of depth
- Integrated temperature sensor precise to about 0.1°C

![Pressure Sensor](image)

Figure 3.7-10 Pressure Sensor - MS5803-14BA [33]

3.7.1.5.2 Accelerometer [21]

An accelerometer measures proper accelerations. For example, an accelerometer at rest on the surface of the Earth will measure an acceleration g = 9.81 m s\(^{-2}\) straight upwards. This is useful to measure changes in velocity and changes in position (by integrating the signal). They are usually used for measuring small movements. Also note that gravity acts like a continuous acceleration upward (via Einstein's equivalence principle), so a multiple-axis accelerometer can also be used as an absolute orientation sensor in the UP-DOWN plane.
3.7.1.5.3 Gyrometer

A gyroscope measures either changes in orientation or changes in rotational velocity. Combining the inputs to these sensors allows for quick and accurate position and orientation determination with a low amount of drift over time. Gyrometer was based on the gyroscope.
3.7.2  Software Details

3.7.2.1  Operating System

3.7.2.1.1  PC – Ubuntu

Ubuntu is a Debian-based Linux operating system. It is a free and open-source software. Since almost all the OSes available for Raspberry Pi is Linux based using a Linux based OS for the PC will reduce the cross-platform translation time and resources.

3.7.2.1.2  Raspberry Pi – Noobs → Raspbian

NOOBS is designed to make it easy to select and install operating systems for the Raspberry Pi without having to worry about manually imaging your SD card. Noobs let the user to install one or several OSes in to a SD card restore them if damaged or remove them easily.

Raspbian is a free os based on Debian optimized for the Raspberry Pi hardware. However, Raspbian provides more than a pure OS, it comes with over 35,000 packages, and pre-compiled software bundled into a format that is easy for installation on Raspberry Pi [20].

3.7.2.2  Control Panel

3.7.2.2.1  QT Creator (C++) [12]

“Qt Creator” is an integrated development environment (IDE) that provides you with the tools to design and develop applications with the Qt application framework. Qt is designed for developing applications and user interfaces once and deploying them across several desktop and mobile operating systems. Qt Creator provides you with tools for accomplishing your tasks throughout the whole application development life-cycle, from creating a project to deploying the application on the target platforms. As an IDE, Qt Creator differs from a text editor in that it knows how to build and run applications. It understands the C++ and QML languages as code, not just as plain text.

QT Creator Provides following facilities.

- Managing Projects
- Designing user interfaces
- Coding
- Building and running
- Debugging and analyzing
- Publishing
To improve hardware performance, use of low level programing language for coding the user control panel is one of the best approaches.

3.7.2.3 Processing Unit Programming Language

3.7.2.3.1 Python [16]

Python is a widely used general-purpose, high-level programming language. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than would be possible in languages such as C++ or Java. The language provides constructs intended to enable clear programs on both a small and large scale.
3.8 Gantt chart

![Gantt Chart Image]

Figure 3.8.1 Gantt chart
4 Evaluation and Testing

This system is tested on three main factors:

The initial check up’s of the application control keys entered by the computer.

- Initially the ROV is powered-up and the application is also turned on the computer.
- The control key parameters can be taken to assess the ROV to move in specific directions as the user enters.
- Time taken to recognize control key entered by the PC.
- Check the control key recognized timing for the ROV to move.
- Based on these results a final conclusion can be made as to whether the recognition control key is successful.

The self-stabilizing of the ROV.

- Check with the application for the Fusing key is properly recognized by the ROV.
- How many times the system failed to recognize self-stabilizing button.
- Maintaining the position of the ROV and making it stay at one point in water.

Lighting system for the underwater travel.

- Create an unclear water like environment for this system to be tested.
- Define various obstacles along the ROV movement for user observation. (Visibility Check)
- Next get the failing times and improving it by changing lighting system.
- Based on the visibility check the system could be framed to category, the ROV is able detect the matter.

Testing on the Test Maze – (Pool)

- The ROV is tested in a pool for the final evaluation, in this scenario the system would be tested in a Pool and the video of the test results would be taking in weekly basis and documented. As the final result, with an overall investigation of the results an improved system would be the final result.

Note: To test on unclear water, the pool water is made dark with some matter so that the system could be tested completely.
## Description of Personal and Facilities

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<th>Implementation</th>
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As the ROV works under the water, it should be a waterproof craft. It is a main feature of this UROV. When creating the ROV, the density of the water, the density of the ROV and the shape of the ROV must be considered as it will float on the water if the density of the robot is
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- Develop the Position Stabilisation Algorithm

Unit, Integration and System testing

Documentation

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System Design

Implementation

- Electronic Circuit Design

- Develop the Position Stabilisation Algorithm

Unit, Integration and System testing

Documentation
## 6 Budget and Budget Justification

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7 References


