Design and Development of a Remotely Operated Underwater Vehicle

A Thesis Submitted
In Partial Fulfilment of the Requirements
for the Degree of
Bachelor of Technology

by

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to the

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April 2022

CERTIFICATE

It is certified that the work contained in the thesis entitled "***Design and Development of a Remotely Operated Underwater Vehicle***", by "*Mr. Durgansh Mishra*", "*Mr. Khairnar Sanket Narendra*", and "*Ms. Monika Poonia*", has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

Dr. Biranchi Panda

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

The mankind's need to explore the earth makes it necessary to use technology and ROVs come in handy when we want to explore the underwater environments. This report includes the research work we have done till now for making improvements to an already existing ROV. This is a record of the various implementation methods we adopted to design and test various techniques related to designing an ROV including waterproofing, volume estimation, electronics, etc. The report also explores existing underwater image processing techniques and discusses the ones that are feasible for our case. The algorithms are implemented using MATLAB software and corresponding results are obtained. Apart from this, it also contains the analysis of the literature survey done on a number of research papers published containing novel ideas on the matter.

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Acknowledgment

We would sincerely like to express our gratitude towards our supervisor, Dr. Biranchi Panda, for giving us the opportunity to work on this wonderful project. We also thank him for guiding us throughout the course of this project. Right from introducing us to ROVs to constantly motivating us to learn new things about it and working on some new ideas to implement on our project, he has been a great mentor and we will forever be indebted to him for this. We would also like to thank Mr. Avilash Sahoo for his useful insights for this project.

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Chapter 1

Introduction

1.1 What is an ROV?

ROVs are remotely operated underwater vehicles that are controlled by a crew either offshore or aboard a ship. These are highly maneuverable. These underwater robots are extensively used for scientific research, military purposes, and broadcasting aquatic environments. Additional sensors, cameras, etc., can be added to collect and analyse the critical data. Exploring, understanding and investigating underwater activities of images are gaining importance for the last few years. However, the area is still lacking in image processing analysis techniques and methods that could be used to improve the quality of underwater images. [ROV (2020)]

1.2 Motivation

With the growing need of ROVs for research purposes, our aim is to make an ROV which can easily traverse underwater environments. The ongoing research in this field mainly focuses on ROVs for commercial purposes. We focus on developing an ROV which can perform tasks like capturing pictures, taking samples, etc. under the water. Computer Aided Design is being used to simulate the design and perform various kinds of analysis to replicate underwater environment. For image processing, various tools like Python, MATLAB are used. We have made use of MATLAB for performing our analysis.

1.3 Objectives

Our main objectives for this phase of the project is:

- Inspecting and testing the working condition of the existing ROV Model
- Making changes in the CAD model based on the actual dimensions and calculating physical parameters to perform flow simulation on the existing model
- Optimising the position, orientation and validating the specifications of the thrusters
- Testing the waterproofing of the existing model and devising new methods to improve it
- Checking feasibility of different hull designs as per our requirements
- Implementing and testing the underwater image processing methods

1.4 Recap of the Previous Work

In the previous semester we worked on the following:

- Performing literature survey on ROVs and image processing methods
- Proposing changes to the model based on the literature survey
- Proposing utilitarian design additions to the model like mechanical arm, rotatable thrusters, etc.
- Finalizing the main objectives of our project

1.5 Organization of the Report

This paper is organized as follows: Firstly, we discuss our objectives, the previous work that we did, etc. followed by a thorough literature survey of existing solutions of our objectives. We then move on to study different methods for waterproofing and volume estimation of the model. We also discuss various image processing methods and the algorithms we used. We finally talk about our proposed solutions and work which we plan to do further as we move ahead with the project.

Chapter 2

Literature Survey

2.1 Volume Estimation

Archimedes principle can be used to accurately determine the volume and weight of objects. A little-known method of measuring the volume of small objects based on Archimedes' principle is hydrostatic weighing with suspension, which involves suspending an object in a water-filled container placed on electronic scales.In hydrostatic weighing an object is weighed in air and then in a fluid (usually water). The volume of the object is given by the difference between the weight in air and water divided by the difference between the densities of air and water [Hughes (2005)]. Rather than weighing an object in air and then in water we can suspend the object in a container of water placed on an electronic balance. With the help of Archimedes principle accurate volume calculation will be done and the CAD will be rechecked for errors.

2.2 Waterproofing Methods

2.2.1 Why do we Need it?

As we are discussing an underwater vehicle here, waterproofing becomes a necessity given the ROV houses multiple electronics and it has space in it which can get flooded in case the water gets inside. While waterproofing the components, things to be kept in mind is that the methods used are technically & economically feasible at our level. Referring to industry standards, following are the industry standards for waterproofing:

Water Protection Rating:	Description:
IPX1	Protected against vertically falling drops of water. Limited ingress is permitted.
IPX2	Protected against vertically falling drops of water with enclosure tilted up to 15 degrees from the vertical. Limited ingress permitted.
IPX3	Protected against sprays of water up to 60 degrees from the vertical. Limited ingress permitted for three minutes.
IPX4	Protected against water splashed from all directions. Limited ingress permitted.
IPX5	Protected against jets of water. Limited ingress permitted.
IPX6	Water from heavy seas or water projected in powerful gets shall not enter the enclosure in harmful quantities.
IPX7	Protection against the effects of immersion in water at 1 m depth for 30 minutes.
IPX8	Protection against the effects of immersion in water under pressure for long periods.

Figure 2.1: Industry Standards of Waterproofing [UNG (2018)]

We will limit our analysis to IPX7 standard only, since it is within the operational target of our ROV. Water protection can be done in many ways using adhesives (semi-permanent methods), welding (permanent methods), foams, etc. [UNG (2018)]. We will explore all these options for various levels of waterproofing in our vehicle.

2.2.2 Available Solutions

Figure 2.2: Our Current Model

In the above figure, we can see there's an outer lid. We need to waterproof that part in addition to adding a gasket for closing the hull. This gasket will protect the electronics, we can also apply hydrophobic coatings on the electronics to protect it from the water [Sahoo et al. (2017)].
For waterproofing the above mentioned components, we analyzed various materials and methods which are commonly used. [Talib et al. (2015)] [UNG (2018)] [Zhangyl & Ulbosyn (2017)] [Lianhui Li & Zhang (2017)] [Pierce (2012)]

- Glass Fiber with Epoxy resin
- Silicone Sealant
- Asphalt Resin Paraffin Deposits with Polyethylene
- Welding
- Gasket
- Liferproof^{TM}
- Silicone Coating
- Various waterproofing methods used in roof leakages like Construction sealants, Bitumen's torch membrane, Foam grout, etc.

While the most commonly used method of waterproofing is Glass fiber with Epoxy resin, we went on to survey all the methods. Welding is a permanent method of sealing/waterproofing. Applying fibers, resins, etc. are very common and generally easy to use too. Glass fiber can be used and applied on the product very easily just by applying a layer of fiberglass followed by a layer of resin and repeating this process until you get required amount of material deposited [McGuinness (2020)]. Gasket is an easy to assemble method and is easy to remove too. Elastomers are better suited for designing a gasket due to their elastic properties, which is assembled by interference fit. [UNG (2018)] Hydrophobic materials like Liferproof^{TM}, etc. are used for application over surfaces which needs to be protected from directly coming in contact with water. Liferproof^{TM} is applied using Vacuum Deposition process [Pierce (2012)]. Silicone coatings can be applied to surfaces using a brush [Dalchem (2020)]. Our final method i.e., the materials used for construction and repair purposes in homes can also be considered given they have excellent water repelling properties and they are very well suited in preventing seepage and leakage of water. Their application is easy too and most of these methods don't require any machinery or skills for their application [Talib et al. (2015)].

2.3 Image Processing

The underwater image processing area has received considerable attention within the last decade, showing important achievements. In underwater situations, clarity of images is degraded by light absorption by the water and scattering. This causes one colour to dominate the image. The images we are interested in can suffer from one or more of the following problems:

- Limited range visibility
- Low contrast
- Non-uniform lighting
- Blurring
- Bright artifacts
- Color diminished (bluish appearance) &
- Noise

The image processing can be addressed from two different points of view: as an image restoration technique or as an image enhancement method. The image restoration technique aims to recover a degraded image using a model of the degradation and of the original image formation. Image enhancement uses qualitative subjective criteria to produce a more visually pleasing image and they do not rely on any physical model for the image formation. [Yang et al. (2020)][Codruta O. Ancuti & Bekaert (2018)][Shah & Surya K (2019)][Kumar V et al. (2019)]

Chapter 3

Methodology

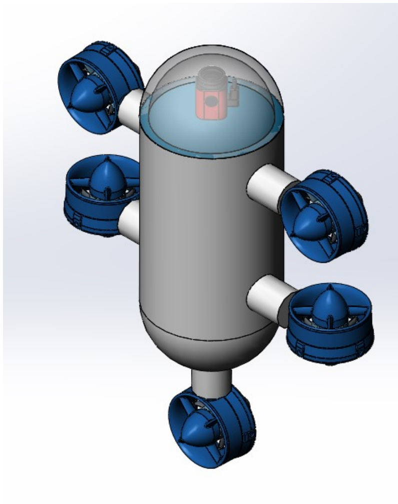
3.1 Changes in the Design

Some new designs were proposed. Thruster positions were changed according to the updated objectives

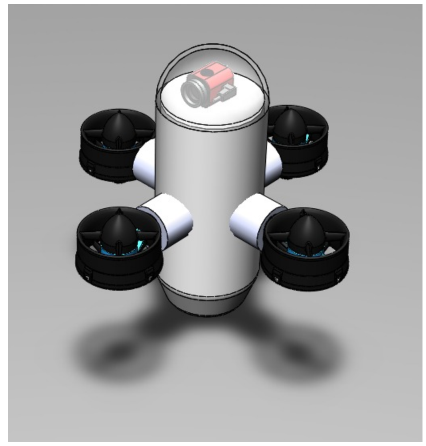
The original model, due to a lot of factors, differs from the proposed CAD. Since all calculations were based on the proposed CAD, to obtain correct specifications and fulfil new requirements, changes were made in the existing design.

3.1.1 Positions of thrusters

Designs with same hull but different positions of thrusters were designed in solidworks.Their feasibility was checked. Finally according to the objective of only verticle motion, original positions were finalized except now, the thrusters for horizontal motion are rotated by 90 degrees for verticle motion and stability of the ROV. (Fig 3.1) shows one of the proposed designs.



(a) Rejected model

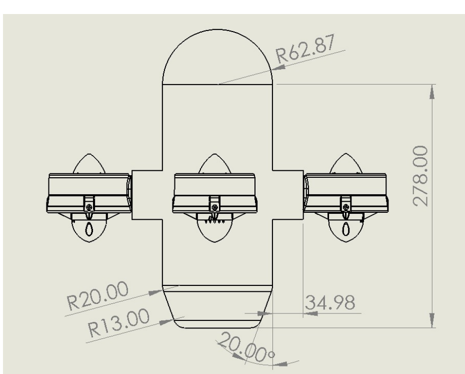


(b) Updated CAD Model

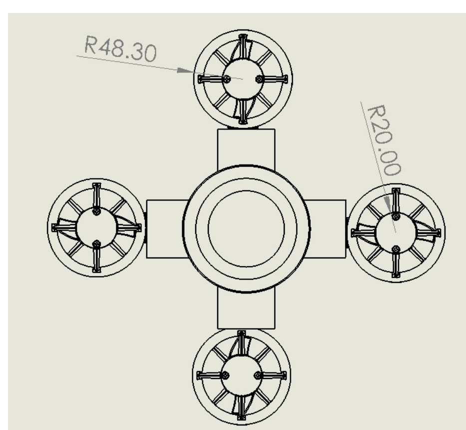
Figure 3.1: CAD Models

3.1.2 Dimensions

It was found that the proportions of the physical model were significantly different from the CAD. Therefore, dimensions of the ROV were measured using thread and meter scale. Using those measurement a new accurate CAD was developed as shown in the (Fig 3.2).



(a) Front View



(b) Top View

Figure 3.2: CAD Drawings

3.2 Calculation of Physical Parameters

Weight of the ROV was measured using normal weighing machine of least count 100 gm. Total weight of the ROV without the LiPo came out to be,

$$\mathrm{W} = 3 \text{ kg}$$

Weight of Lipo,

$$\mathrm{W}_l = 1.163 \text{ kg}$$

Therefore, total weight of ROV with Lipo,

$$\begin{aligned} W_T &= 4.163kg \\ &= 4163gm \end{aligned} \tag{3.1}$$

Volume of the ROV was calculated from the CAD. Further validation will be done after waterproofing by Archimedes method. Volume as obtained from the CAD,

$$V = 4950.022cc \tag{3.2}$$

From above calculations, overall density of the ROV can be determined,

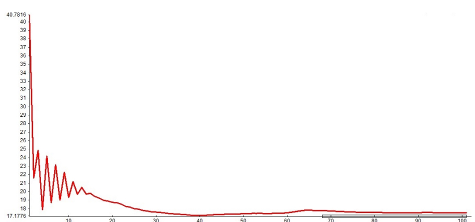
$$\begin{aligned} \rho &= W_T/\mathrm{V} \\ &= \frac{4163}{4950.022} \\ &= 0.841gm/cc \end{aligned} \tag{3.3}$$

Since density of water, $\rho_W = 1$ gm/cc which is greater than ρ, the ROV will float. Therefore, dead weight required,

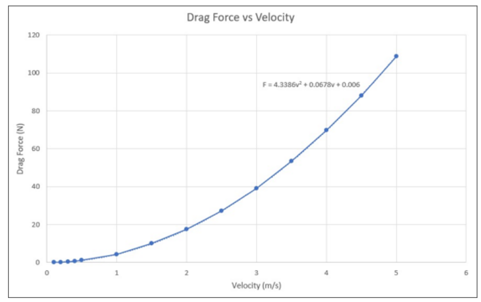
$$\begin{aligned} W_D &= 4950 - 4163 \\ &= 787gm \end{aligned} \tag{3.4}$$

3.3 Drag Calculation

With the Flow Simulation feature of Solidworks, drag force analysis was done on the updated model to validate the thruster specifications. Drag force was calculated with velocities ranging from 0.5 m/s to 5 m/s (see fig 3.3(a)). A graph of Drag Force vs Velocity was plotted and relation between them was obtained. Further, since maximum thrust force is known, maximum velocity of the ROV in both directions was calculated.



(a) Drag force variation with ROV velocity = 2m/s



(b) Drag Force vs Velocity

Figure 3.3: Plots for Drag force

From the graph (fig 3.3(b)), polynomial equation obtained,

$$F = 4.3386v^2 + 0.0578v + 0.006 \tag{3.5}$$

Now, maximum forward thrust for a single thruster,

$$T = 22.96N$$

Maximum forward thrust for four thruster system,

$$\begin{aligned} T_{max(forward)} &= T \times 4 \\ &= 91.82N \end{aligned} \tag{3.6}$$

Equating T_{max} with Drag force, we get the maximum velocity by solving the quadratic,

$$v_{max(forward)} = 4.65m/s \tag{3.7}$$

Similarly,

$$v_{max(backward)} = 4.08m/s \tag{3.8}$$

3.4 Waterproofing Methods

As we already discussed the possible solutions in the literature survey, we will now move on to our approach towards deciding the final selected solution.

3.4.1 Electronics

We will firstly discuss hydrophobic coating on the electronics part; while Liferproof^{TM} & other such products are excellent options, they require Vacuum deposition process for their application which is way beyond the scope of our research [Pierce (2012)]. Silicone coatings can be applied using a brush and don't require any additional skill, plus they are easily available [Dalchem (2020)].

3.4.2 Inner Lid

For the next part i.e., the inner lid (see Fig 3.4), it needs to be kept in mind that this part needs to be constantly disassembled. Gasket was seen as the best option. Materials used for making gaskets are generally various types of rubbers, corks, etc. The seal design must be easy to manufacture, affordable, easy to assemble, resistant to twisting, extrusion pressures, corrosion, and compression set, but also compliant enough to conform to rough surfaces or surface irregularities such as dust and fiber particles [UNG (2018)].

3.4.3 Outer Lid

Moving on to the next part which is the outer lid, the previous discussed methods were pondered upon. While choosing the best suited material, points to be kept in mind is that it should be technically possible at our level to apply it in addition to being economical. Also, a good waterproofing material has a water absorption (by weight) less than 2%, and elongation at breaking no less than 100%. [Zhangyl & Ulbosyn (2017)] The ARPD composite is not easily available as it is still a relatively new material and much research needs to be done upon it. Fiberglass with epoxy glue is quite commonly used and easier to apply too. For the construction materials, foams and silicone sealants are the best options which we thought upon based on availability and the physical properties discussed earlier.

Figure 3.4: Inner lid used to protect the electronic housing

3.5 Underwater Image Processing

Given the underwater image formation mechanism and the attenuation of light propagation in the water, an improved LCC method with a multi-scale image fusion strategy is proposed in this thesis. The underwater image is compensated using the red channel, and the color compensated image is processed by a white balance. Then, two versions of the image input are generated: the LCC image and the sharpened image. Next, the Laplacian contrast weight, saliency weight, and saturation weight of the LCC and sharpened images are calculated, and the two groups of weights are normalized. Finally, LCC images and sharpened images and their corresponding normalized weights are fused. The multi-scale fusion method is also adopted to avoid artifacts. The algorithm flow is shown below (see Fig 3.5)[Gao et al. (2021)].

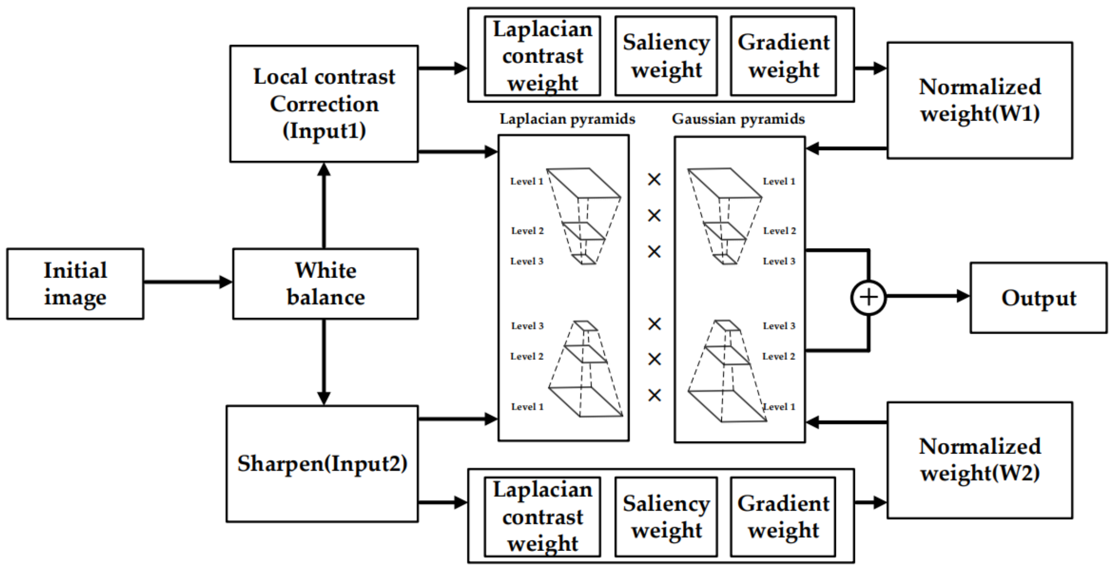


Figure 3.5: Details of the proposed method[Gao et al. (2021)].

3.5.1 Underwater Image White Balance Based on Red Channel Compensation

Given the physical characteristics of light propagation in water, red light is absorbed first, and underwater images are mainly blue and green. White balance is an effective way to improve the tone of an image. It eliminates unwanted colors created by various lighting or light attenuation characteristics. The Gray-World algorithm is an effective white balance processing method for outdoor images. However, due to its characteristics, the red channel will be overcompensated in the underwater environment where the red attenuation is severe, resulting in red artifacts in the image. The red channel compensation method is used to solve this problem. (Fig 3.6) shows the comparison between original image and white balanced image.

Figure 3.6: Original Image — White balanced Image

3.5.2 Improved Local Contrast Correction Method

In addition to color aberration and blurring due to their characteristics, underwater images are usually interfered with by natural light or artificial light, which makes local areas of the image too bright. The white balance processing of the image will also lead to excessive brightness, so introducing the contrast correction method is necessary to solve this problem. The contrast reflects a measurement of the brightness level between the brightest and darkest areas of an image. Gamma correction is widely used as a global contrast correction method. It changes the image brightness by changing the value of a constant index gamma. (Fig 3.7) illustrates this relationship. The three transformation curves show how values are mapped when gamma is less than, equal to, and greater than 1.

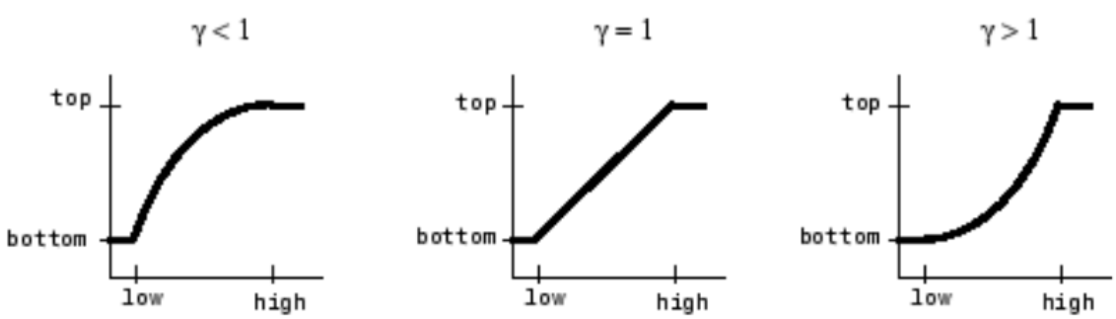


Figure 3.7: Plots Showing Three Different Gamma Correction Settings. (In each graph, the x-axis represents the intensity values in the input image, and the y-axis represents the intensity values in the output image [MATLAB (2015)].)

(Fig 3.8) shows the output of the implementation of Gamma Correction method.

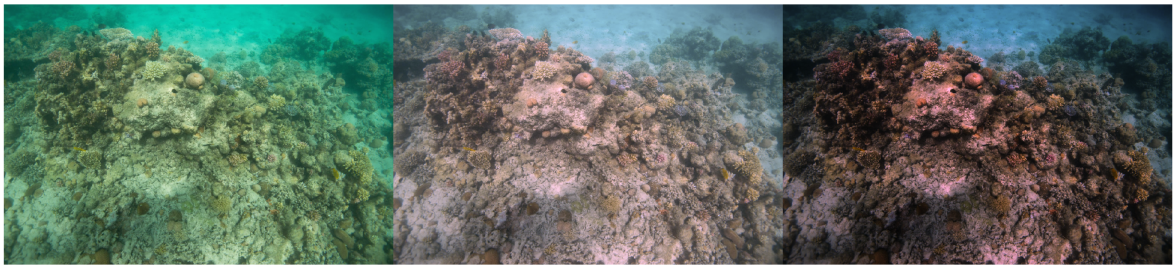


Figure 3.8: Original Image — White Balanced Image — Gamma Corrected Image

3.5.3 Image Sharpening

Contrast correction can improve overexposure and underexposure of the image. It can also repair the missing color area. However, the underwater image is usually fuzzy, and the details are not obvious. Thus, the sharpening version of underwater images is introduced using Gaussian Filter method. It is typically used before edge detection and aims to reduce the level of noise in the image.

The result obtained by implementing image sharpening method using MATLAB are shown in (Fig 3.9).

Figure 3.9: Original Image — Gaussian filtered image — Sharpened Image

3.5.4 Multi-Scale Fusion

Using a weight graph in the fusion process can highlight the pixels with high weight value in the result. For the selection of weight image, the Laplacian contrast, saliency, and saturation features of the image are used in the solution. Laplacian contrast (WL) weight estimates the global contrast. It calculates the absolute value of the Laplacian filter applied to each luminance channel. This filter can be used to extend the depth of field of the image because it can ensure that the edges and textures of the image have high values. However, this weight is not enough to restore contrast because it cannot distinguish between the ramp and flat regions. Therefore, saliency weight is also used to overcome this problem.

Saliency weight (WSal) can highlight objects and regions that lose saliency in underwater scenes. The regional contrast-based salient object detection algorithm can produce a full resolution saliency map.

Saturation weight (WSat) makes the fusion algorithm adapt to the chromatic information through a high saturation region. After the weight estimates of two different input versions are obtained, the three weight estimates of each input version are combined into one weight in the following way: for each input version n, the resulting WL, WSal, and WSat are linearly superimposed to obtain the integrated weight. Then, N aggregated maps are normalized on a pixel-per-pixel basis. The weight of each pixel in each map is divided by the overall weight of the same pixels. The comparison between all the three weights for each input i.e., Input1 and Input2 is shown in the output images below. First row of images represent Laplacian Weight, Saliency Weight and Saturation Weight respectively for Input1. Next rows shows the similar weights for Input2 image.

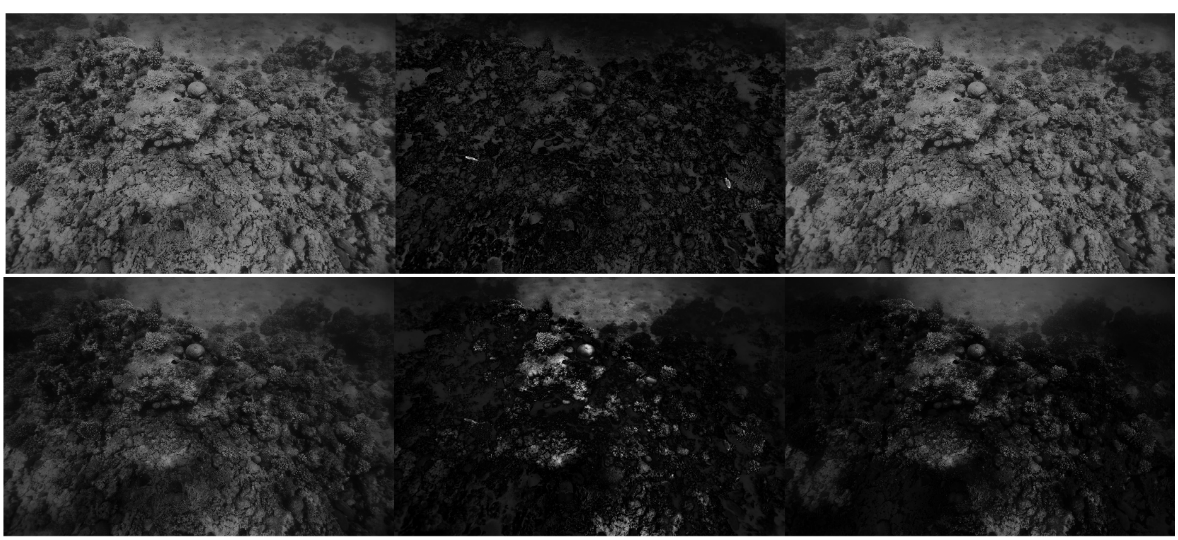


Figure 3.10: Laplacian Weight — Saliency Weight — Saturation Weight for LCC image and Sharpened image respectively.

However, this simple fusion will lead to artifacts in the resulting images. Thus, the fusion method based on multi-scale Laplacian pyramid decomposition is adopted. The Laplace operator is applied to get the first layer of the pyramid for the input image version. Then, the second layer image is obtained by down sampling the layer, and so on. A three-tier pyramid is set up. Similarly, the normalized weight version Wn, corresponding to each layer of the Laplacian pyramid, filters the input image using the low-pass Gaussian filter kernel function to obtain the Gaussian pyramid of the normalized weight image. The (Fig 3.11) compares the images obtained from simple fusion and multi-scale fusion method.

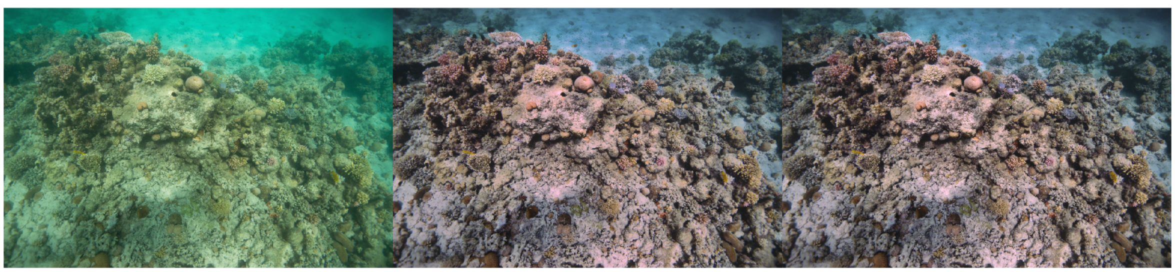


Figure 3.11: Original Image — Simple fusion — Multi-scale fusion

3.5.5 Implementation of Method Using MATLAB

```
close all;
clear all;
clc;
rgbImage=double(imread('sample_4.jpg'))/255;
grayImage = rgb2gray(rgbImage);
Ir = rgbImage(:,:,1);
Ig = rgbImage(:,:,2);
Ib = rgbImage(:,:,3);
Ir_mean = mean(Ir, 'all');
Ig_mean = mean(Ig, 'all');
Ib_mean = mean(Ib, 'all');
alpha = 0.1;
Irc = Ir + alpha*(Ig_mean - Ir_mean);
alpha = 0;
```

```
Ibc = Ib + alpha*(Ig_mean - Ib_mean);
I = cat(3, Irc, Ig, Ibc);
I_lin = rgb2lin(I);
percentiles = 5;
illuminant = illumgray(I_lin,percentiles);
I_lin = chromadapt(I_lin,illuminant,’ColorSpace’,’linearrgb’);
Iwb = lin2rgb(I_lin);
figure(’name’, ’Underwater White Balance’);
imshow([rgbImage, I, Iwb])
Igamma = imadjust(Iwb,[],[],2);
figure(’name’, ’Gamma Correction’);
imshow([Iwb, Igamma]);
sigma = 20;
Igauss = Iwb;
N = 30;
for
iter=1: N
Igauss = imgaussfilt(Igauss,sigma);
Igauss = min(Iwb, Igauss);
end
gain = 1;
Norm = (Iwb-gain*Igauss);
for n = 1:3
Norm(:,:,n) = histeq(Norm(:,:,n));
end
Isharp = (Iwb + Norm)/2;
figure(’name’, ’image sharpening’);
imshow([Iwb,Igauss,Norm, Isharp])
IsharpLab = rgb2lab(Isharp);
IgammaLab = rgb2lab(Igamma);
R1 = double(IsharpLab(:, :, 1)) / 255;
WC1 = sqrt((((Isharp(:,:,1)) - (R1))^2 + ...((Isharp(:,:,2)) - (R1))^2 + ...((Isharp(:,:,3)) - (R1))^2)/3);
```

$WS1 = saliency\_detection(Isharp);$

$WS1 = WS1/max(WS1, [],' all');$

$WSAT1 = sqrt(1/3 * ((Isharp(:, :, 1) - R1)^2 + (Isharp(:, :, 2) - R1)^2 + (Isharp(:, :, 3) - R1)^2));$

$figure('name',' Image1weights');$

$imshow([WC1, WS1, WSAT1]);$

$R2 = double(IgammaLab(:, :, 1))/255;$

$WC2 = sqrt((((Igamma(:, :, 1)) - (R2))^2 + ...((Igamma(:, :, 2)) - (R2))^2 + ...((Igamma(:, :, 3)) - (R2))^2)/3);$

$imshow(WC2);$

$WS2 = saliency\_detection(Igamma);$

$WS2 = WS2/max(WS2, [],' all');$

$imshow(WS2);$

$WSAT2 = sqrt(1/3 * ((Igamma(:, :, 1) - R1)^2 + (Igamma(:, :, 2) - R1)^2 + (Igamma(:, :, 3) - R1)^2));$

$figure('name',' Image2weights');$

$imshow([WC2, WS2, WSAT2]);$

$W1 = (WC1 + WS1 + WSAT1 + 0.1)./...$

$(WC1 + WS1 + WSAT1 + WC2 + WS2 + WSAT2 + 0.2);$

$W2 = (WC2 + WS2 + WSAT2 + 0.1)./...$

$(WC1 + WS1 + WSAT1 + WC2 + WS2 + WSAT2 + 0.2);$

$R = W1. * Isharp + W2. * Igamma;$

$figure('name',' NaiveFusion');$

$imshow([I, Iwb, Isharp, Igamma, R]); img1 = Isharp;$

$img2 = Igamma;$

$level = 10;$

$Weight1 = gaussian\_pyramid(W1, level);$

$Weight2 = gaussian\_pyramid(W2, level);$

$R1 = laplacian\_pyramid(Isharp(:, :, 1), level);$

$G1 = laplacian\_pyramid(Isharp(:, :, 2), level);$

$B1 = laplacian\_pyramid(Isharp(:, :, 3), level);$

$R2 = laplacian\_pyramid(Igamma(:, :, 1), level);$

$G2 = laplacian\_pyramid(Igamma(:, :, 2), level);$

$B2 = laplacian\_pyramid(Igamma(:, :, 3), level);$

$fork = 1 : level$

$Rrk = Weight1k. * R1k + Weight2k. * R2k;$

$Rgk = Weight1k. * G1k + Weight2k. * G2k;$

$Rbk = Weight1k. * B1k + Weight2k. * B2k;$

end

$R = pyramid\_reconstruct(Rr);$

$G = pyramid\_reconstruct(Rg);$

$B = pyramid\_reconstruct(Rb);$

$fusion = cat(3, R, G, B);$

$figure('name', 'Multiscalefusion');$

$imshow([I, fusion]);$

Chapter 4

Results & Discussion

4.1 Physical Parameters

1. Volume of ROV, $V = 4950.022cc$
2. Weight of ROV, $W_T = 4163gm$
3. Density of ROV, $\rho = 0.841gm/cc$
4. $v_{max(forward)} = 4.65m/s$
5. $v_{max(backward)} = 4.08m/s$

4.2 Waterproofing methods

As already discussed in the previous section regarding the constraints for selection of suitable methods for waterproofing. For the inner lid, Silicone rubber was chosen because of its low compression set values within the operational temperature range of our ROV as well as low creep values over time. In addition, Silicone is also hydrophobic making it the most suited material. Its low elastic modulus and high elongation values makes it suitable for being applied using interference fit. More analysis needs to be done for Silicone and this will be done in the upcoming semester.[UNG (2018)]

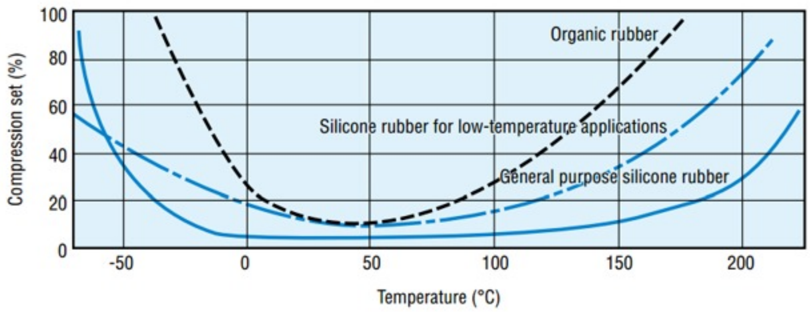


Figure 4.1: Silicone compression set values at various temp [UNG (2018)]

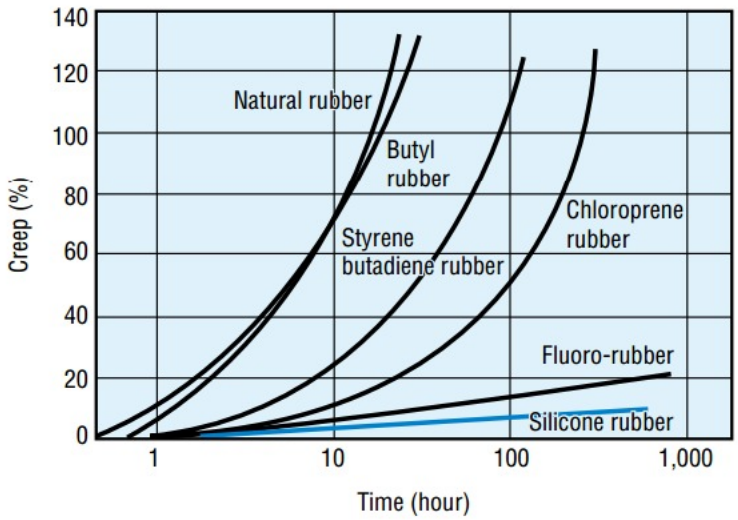


Figure 4.2: Silicone creep values[UNG (2018)]

For the waterproofing of the electronics, silicone coating is chosen because of its ease of availability and application. Silicone coatings are very commonly used to protect PCBs and ESCs from getting damaged by water[McGuinness (2020)][Pierce (2012)] because of their excellent hydrophobic characteristics.

For the outer lid, fiberglass with epoxy resin was chosen. Other materials are comparatively newer which makes them less accessible and some of them require special methods to apply which are not within the technical skills that we possess, hence those solutions were discarded.[Talib et al. (2015)][Dalchem (2020)][Zhangyl & Ulbosyn (2017)] Additionally, significant literature and experimentation is available for fiberglass making it a better suited and easier option to work upon. Hence, we'll move ahead with the following:

- Outer lid- Fiberglass with Epoxy resin
- Inner lid- Silicone rubber gasket
- Electronics- Silicone coating

4.3 Image Processing

The underwater image data used in the experiment are all real underwater scene and images are derived from freely available resources. The contrast experiments are carried out from the aspects of colorfulness recovery and contrast enhancement. The figure 4.3 below shows the comparison between original images and final images obtained using MATLAB.

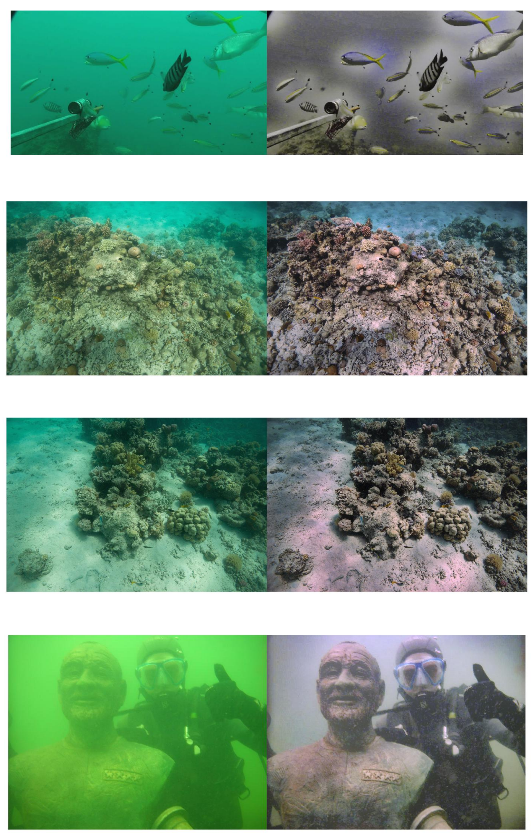


Figure 4.3: The left ones are the original image and right side shows the output images after processing

Chapter 5

Conclusion & Future Work

5.1 Conclusion

This semester we mainly focused on verifying the calculations of the model. We performed experiments to make near to accurate CAD replica of our model which was used for Drag calculation. We got the Drag v/s Velocity characteristics which came out approximately to be a polynomial of second order. It was used to calculate terminal velocity values.

We also worked on the waterproofing aspect, which will be needed once we decide to physically test our ROV.

Various algorithms for image processing, mainly including White Balancing, Gamma Correction, Sharpening and Fusion were explored and tested for underwater images from internet. Satisfactory results were obtained for some of them while in some cases there were issues with the components being too bright or edge detection going haywire.

5.2 Future Work

We have decided on the following set of targets for the upcoming semester:

- Waterproofing the outer lid and the electronics

- Analyze the gasket design for inner lid and manufacture it
- Repair damages in the current model
- Rotate the thrusters so that all of them face upwards
- Once waterproofed, move ahead with verifying the volume using Archimedes' Principle
- Recalculate all the physical parameters and procure/manufacture components based on the final values
- Fitting the electronics and work to start on the control part
- Optimising the existing methods for image processing and enhancement. Start work on ML models for better processing of images

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