**A PRELIMINARY REPORT ON**

# "AN APPROACH FOR UNDERWATER IMAGE PROCESSING USING RASPBERRY PI"

**SUBMITTED TO THE SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE IN THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE.**

OF

## BACHELOR OF ENGINEERING (COMPUTER ENGINEERING)

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**2022-23**


# CERTIFICATE

This is to certify that the Project Report entitled

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# ABSTRACT

Researchers from all over the world have been researching ways to improve underwater image clarity over the past few years. Due to scattering and low light intensity, underwater photographs always have color casts and seem bluish, making color correction and augmentation difficult. The degradation of photographs taken underwater and the comparatively low contrast are caused by the dispersion and absorption of light in water. The red channel will disappear first as the distance between the imaging scene and the camera is increased. The red channel map is made darker, and the value of the red channel pixels decreases. This suggests that the color of the image be adjusted. There are numerous enhancing techniques to raise the level of picture of the ocean. Nevertheless, most of the techniques cause distortion in the final photos. As compared to all pervious methodologies our proposed model uses a raspberry pi model where the camera model will be trained in such a way that there will be no need for reconstruction of underwater images instead it will clear the images when they are captured under the water, the images captured under the water will be stored and simultaneously these images will be enhanced. There are four steps in the suggested underwater picture color enhancement process. The first step is to neutralize image cast. Gain factors, which are determined by considering the distinctions between the superior and inferior color channels, are used to enhance the inferior color channels. The dual- intensity pictures fusion based on the mean and median values average is proposed in the second stage. The relationship between these histograms greatly enhances the visual contrast. Next, the swarm-intelligence based mean equalization is suggested to enhance the output image's naturalness. Through the combination of A swarm intelligence method is used to narrow the gap between the mean values of poor and superior color channels. Finally, the entire image is sharpened using the un sharp masking approach.

**Keywords**: underwater photography, color enhancement, superior and inferior color channels, Histogram Equalization swarm-intelligence.

# INDEX

# LIST OF ABBREVIATIONS

| ABBREVIATION | ILLUSTRATION |
|---|---|
| CFA | Color Filter Array |
| MR | McCann Retinex |
| WB | White Balance |
| DCP | Dark Channel Prior |
| UIEB | Underwater Image Enhancement Benchmark |
| EUVP | Enhancing Underwater Visual Perception |

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# 1 INTRODUCTION

## 1.1 Overview

The problem of underwater image enhancement and color correction is difficult and has become more important recently. The color contrast of images captured underwater cannot be distinguished or noticed by the human eye. Using expensive equipment, we may capture underwater images that are bluish and greenish in color because more depth prevents light from reaching its full strength. Since there is less light intensity at a certain depth, the camera is unable to capture images using all three RCB values, which results in bluish or greenish images. Underwater images suffer from significant color distortion and the dominance of a heavy blue color. In order to improve these images, we created a system using IOT (Raspberry Pi) in which images clicked under water are improved and saved in a new folder. When compared to previous underwater enhancement techniques, our technique produces more natural underwater images.

In our system, images are taken underwater and saved in the input image folder on the local device. When the Python script is executed, all the captured images are processed simultaneously. We have used four methods to improve the images: 1. Neutralizing image cast 2. Histogram equalization 3. Swarm intelligence 4. Unsharp masking These techniques improve underwater images and result in a natural underwater image. The improved images are saved on the local device in the result folder.

As it concentrates on enhancing the contrast and color of underwater images through contrast stretching, the results imply that it enhances the quality of damaged underwater images. It employs the sharpening technique to bring out minute details in an image or to increase detail that has been lost due to low contrast and high scattering of light. Therefore, images generated by our technology are natural underwater images.

## 1.2 Motivation

The ocean contains various abundant resources. However, it has not been effectively explored and exploited by humans, especially in the underwater world. Underwater image processing plays an indispensable role in underwater operations by humans or underwater robots. Underwater image enhancement is an active researchproblem that deals with correcting image distortions to recover true pixel intensities

## 1.3 Problem Definition and Objectives

Underwater image enhancement and color correction are challenging tasks that have gained priority in recent years. The color contrast of underwater images cannot be distinguished or detected with clarity by the human eye. We get bluish and greenish underwater images while using expensive equipment since the intensityof light cannot be attained at higher depths. In contrast to all previous methodologies, our proposed model makes use of a hardware-based Raspberry Pi model, and the camera model will be trained so that underwater image reconstruction is not required because it will clear the images as soon as the image is captured. Thus, our problem description reads: A method for using a Raspberry Pi to improve the color of underwater images.

## 1.4 Project Scope and Limitations

The proposed model captures an image as the input and a sequence of operations such as naturalizing image cast, histogram equalization, swarm intelligence method, unsharp masking, etc. are performed on the input image. Finally, multi-scale images The fusion of the inputs is done to obtain the resultant enhanced image as an output. This will result in clicking images underwater which is believed to be a tedious task given the extreme absorption and scattering effects of the medium. Therefore, image improvement techniques are applied to get rid of image noise and improve overall color correction of an image.

Cost of hardware components. The model requires a Raspberry Pi and camera module, which are expensive. As the model is placed under the water to capture images, hardware components need to be protected from water and pressure.

## 1.5 Methodologies of Problem Solving

Four Strategy we have followed in our model:

### 1.5.1 Superior underwater color cast neutralization

This is the initial action. The first stage presents a novel strategy to remove the underwater color cast. It introduces a new approach to neutralize underwater color cast. Before color cast neutralization color channels are decomposed. The Natural Underwater Color Enhancement approach lessens the underwater color cast. By considering the variations between superior and inferior color channels, these gain factors are determined.

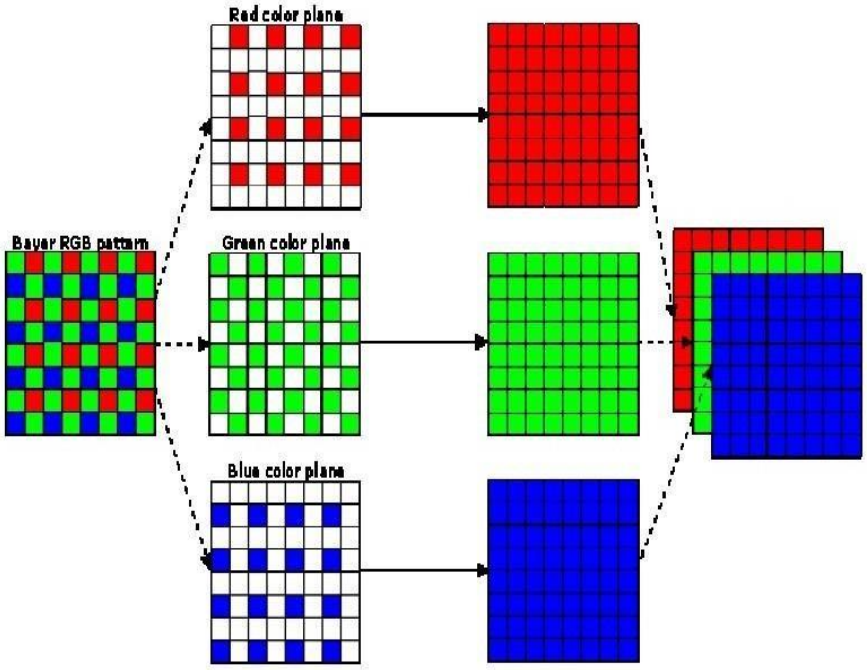



Figure 1.1: Superior underwater color cast neutralization

### 1.5.2 Fusion of dual-intensity pictures based on the mean and median values

Next the idea is to construct lower-stretched and upper-stretched histograms in the second stage using the dual-intensity images fused based on the average of mean and median values. The relationship between these histograms greatly enhances the visual contrast. Following the computation of the picture histogram's minimum, maximum, mean, and median values, the average point between the mean and median values is computed.

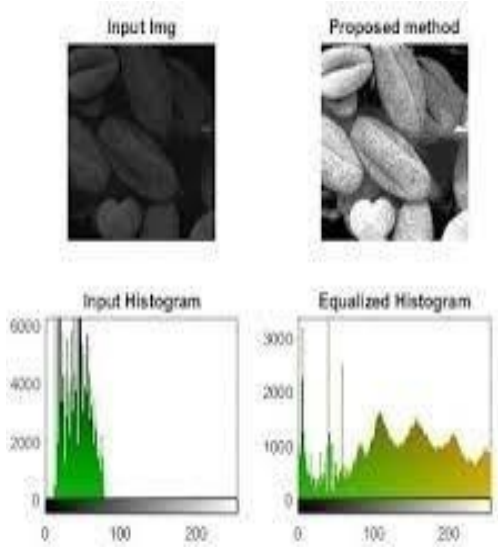



Figure 1.2: Fusion of dual-intensity pictures based on the mean and median values

### 1.5.3 Swarm-intelligence based mean equalization

Then, a mean equalization based on swarm intelligence is suggested to enhance the output image's naturalness. The mean values of inferior color channels are modified to be close to the mean value of superior color channels through the fusion of swarm intelligence algorithms. Based on mean values, color channels are classified as superior or inferior. Each pixel's fitness is assessed, and adjustments to its velocity and location are made until mean equality is achieved.

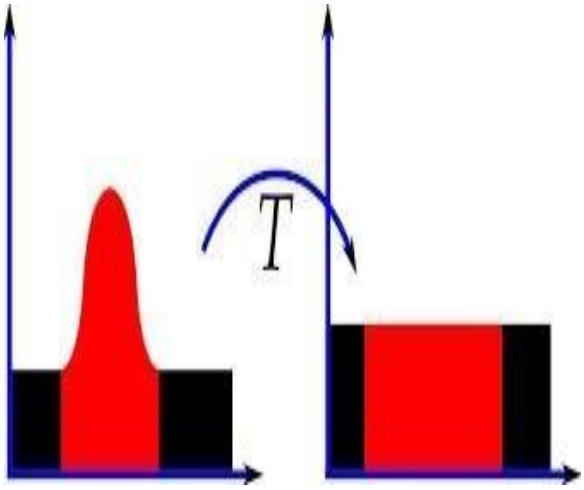



Figure 1.3: Swarm-intelligence based mean equalization

### 1.5.4 Unsharp masking

Lastly, the unsharp masking technique is applied to sharpen the overall image. Unsharp masking is the process of making a slightly fuzzy exposure of the original negative onto a brand-new rollof film. The unsharp mask filter method involves subtracting an unsharp mask from the sample image. An unsharp mask only produces a hazy image by spatially filtering the specimen image with a Gaussian low-pass filter.

Figure 1.4: Unsharp Masking

# 2 LITERATURE SURVEY

## 2.1 Related Work

### 2.1.1 Color Correction Based on CFA and Enhancement Based on Retinex with Dense Pixels for Underwater Images

Author : Changli Li, Shiqiang Tang

Published Year : 2020

Platform : IEEE Access

This paper proposed two methods:

1. Underwater image color correction method based on color filter array (CFA) .
2. Underwater image enhancement method based on retinex theory.

This paper dealt with underwater image color correction and underwater image enhancement methods. A color distortion correction is made for the red channel from the other two channels (blue and green), as for any RGB image captured by a camera with a color filter array, its RGB values are dependent. The linear function for adaptive histograms is used to improve the visual quality of the whole image. The result shows that the proposed method gives clearer, more uniform visual effects.

Advantages :

1. It effectively handles low brightness and blurred images.
2. The processed image exhibits clear details and a consistent visual impact across all RGB color channels.

Disadvantages :

1. The process is time-consuming.
2. The technique that was used (which contains particles) failed in a turbid environment.

### 2.1.2 Fast Underwater Image Enhancement for Improved Visual Perception

Author : Md Jahidul Islam , Youya Xia

Published Year : 2020

In his paper, he proposed another methodology for improving underwater image quality based on the generative adversarial network (GAN) model. Using information about an image's global color, local texture, and style, this approach creates a perceptual loss function. In addition to ensuring substantially faster inference times, it conducts extensive qualitative and quantitative assessments and user studies to demonstrate that the suggested model performs as well as and frequently better than state-of-the-art models. That shows how well it works to enhance the performance of under- water object detection and human body pose estimation.

Advantages :

1. It illustrates how effective it is at enhancing the capabilities of underwater object detection, saliency prediction, and human body pose estimation.
2. By evaluating image quality based on its global color, content, local texture, and style information, the suggested approach formulates a perceptual loss function.

Disadvantages :

1. When it comes to improving badly damaged and texture-less images, FUnIE-GAN is not particularly efficient. In these situations, noise amplification frequently causes the resulting images to be oversaturated.
2. Since FUnIE-GAN is intended to improve perceptual image quality, it cannot be guaranteed that true pixelintensities will be recovered.

### 2.1.3 Simultaneous Enhancement and Super-Resolution of Underwater Imagery for Improved Visual Perception

Author : Peigen Luo and Junaed Sattar

Published Year : 2020

In this paper, the simultaneous enhancement and super-resolution (SESR) problem is described and a productive learning-based underwater imaging solution is presented. It presents its com- prehensive training process, accompanying loss functions, and thorough network architecture. It carries out a number of qualitative and quantitative experiments that indicate Deep SESR: (i) offers SOTA performance on underwater image enhancement and super-resolution; (ii) exhibits significantly better generalization performance on natural images than existing solutions; (iii) provides competitive results on terrestrial images; and (iv) achieves quick inference on single-board plat- forms. Deep SESR is appropriate for usage in close to real time by visually guided underwater robots due to its impressive performance, computational efficiency, and accessibility of application-specific design options.

Advantages :

1. Compared to prior techniques, its generalization performance on natural photos is noticeably superior.
2. It provides quick inference on single-board systems and produces competitive results on terrestrial imagery.

Disadvantages :

1.Learning-based techniques frequently fall short of generalizing beyond supervised data due to the modelling of underwater picture distortions without scene depth and optical waterbody measurements being ill-posed.

### 2.1.4 An approach for underwater image enhancement based on color correction and de-hazing.

Author : Yue Zhang

Published Year : 2020

Platform : International Journal of Advanced Robotic Systems.

This paper has an improved approach for eliminating the local reddish effect and reducing image noise. As when light propagates in water, water medium, water particles and scatter light will absorb. Because of this underwater image present defects such as color deviation, low contrast, and blurry details. This paper includes two algorithms for color correction of underwater images.

1) White Balance Algorithm (WB): The main problem of underwater images are greenish-blue appearance due to scattering of waves when depth is increasing. As higher wavelength waves get absorbed first. So red will be absorbed first. Red channel is degraded first when it passes through water and green channel is almost safe because of its shorter wavelength compare to red channel. So, this white balance method mainly focuseson restore the colors which are degraded due to absorption of white light propagate through water.
2) Dark Channel Prior Algorithm (DCP): Dark channel prior algorithm is mainly proposed for image dehazing. But directly applying the DCP algorithm to underwater images does not provide a good enhancement effect. The dark channel value obtained based on the minimization and operation is likely to be the red channel component in the dark channel calculation process, which leads to a dark image after restoration.

Advantages :

1.Subsequent feature extraction and object recognition have been greatly impacted by images.

2.Technologies based on fusion can produce better results (a clear image).

Disadvantages :

1. DCP algorithm does not provide good enhancement effect.

# 3 SOFTWARE REQUIREMENT SPECIFICATION

## 3.1 Assumptions and Dependencies

- Our model depends on underwater image enhancement techniques where we have obtained differenttraining testing dataset from existing models.
- Our model also depends on raspberry pi for training the Machine Learning Model

## 3.2 Functional Requirements

### 3.2.1 Camera Interface

Camera is connected to the Raspberry pi and trained to capture and correct underwater images. Divers can capture the underwater images using camera interface.

### 3.2.2 Algorithms

We have used various algorithms such as NUCE algorithm and Histogram Equalization.

## 3.3 External Interface

### 3.3.1 User Hardware Interface

- Raspberry Pi

Raspberry Pi 4 Model B is the latest product in the popular Raspberry Pi range of computers. It offers ground-breaking increases in processor speed, multimedia performance, memory, and connectivity compared to the prior-generation Raspberry Pi 3 Model B+, while retaining backwards compatibility and similar power consumption. For the end user, Raspberry Pi 4 Model B provides desktop performance comparable to entry-level x86 PC systems.

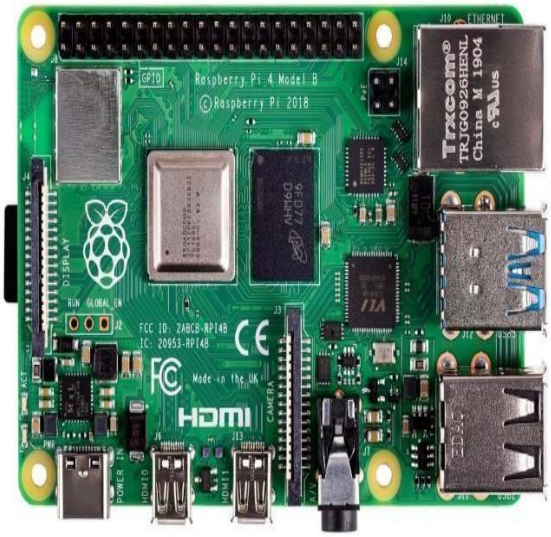



Figure 3.1: Raspberry Pi 3B

Specifications of Raspberry Pi 3B:

- Quad Core 1.2GHz Broadcom BCM2837 64bit CPU
- 1GB RAM
- BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board
- 100 Base Ethernet
- 40-pin extended GPIO

- 4 USB 2 ports
- 4 Pole stereo output and composite video port
- Full size HDMI
- CSI camera port for connecting a Raspberry Pi camera
- DSI display port for connecting a Raspberry Pi touchscreen display
- Micro SD port for loading your operating system and storing data
- Upgraded switched Micro USB power source up to 2.5A

Installing Raspberry Pi OS:

1) Open Raspberry PI website
2) Click on Raspbian
3) Flash OS into the SD Card

- Camera

Pi Camera module is a camera which can be used to take pictures and high-definition video. Raspberry Pi Board has CSI (Camera Serial Interface) interface to which we can attach Pi - camera module directly. This Pi Camera module can attach to the Raspberry Pi's CSI port using 15-pin ribbon cable.

Figure 3.2:Pi Camera

- 4k HD Camera module

4K Action Camera with 4X Zoom: Professional 4K/30FPS, 2.7K/30fps, 1080P/60FPS video and 16MP photo resolution enables you to capture exciting moment for you. This camera alsofeatures zoom range from 1.0X to 4.0X.6mm CS mount lenses and 16mm with C-mount are examples of all the compatible ones that exist. The high-quality camera offers an alternative to the camera module v2. 4k HD action camera features multiple functions including driving mode, image rotation, time-lapse, burst photo, loop recording, slow motion, drama shot, whitebalance, etc. Bringing this camera to more applicable conditions beyond your expectation.


Figure 3.3: 4K HD Camera Module

- Camera setup

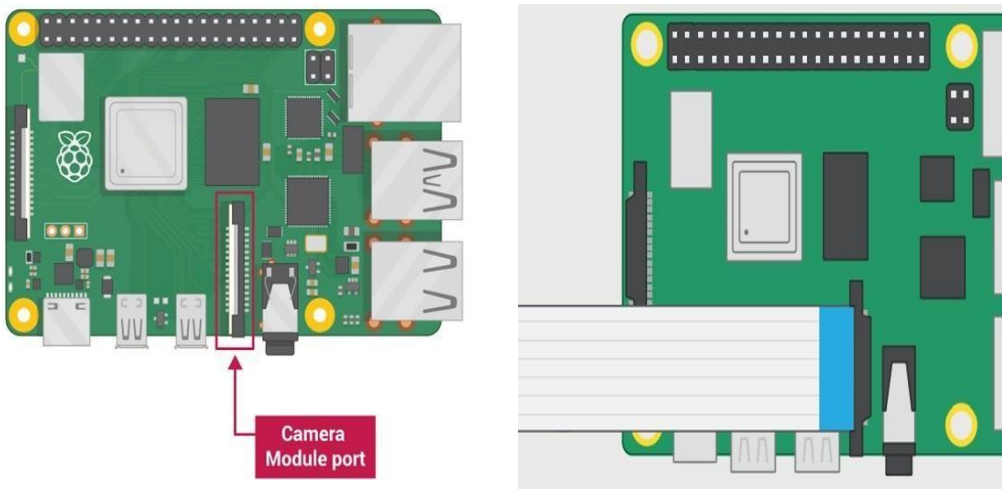



Figure 3.4: Camera Setup

- Final Camera Module with Raspberry Pi

Figure 3.5: Final Camera Module with Raspberry Pi

## 3.4 Non-Functional Requirements

### 3.4.1 Performance Requirements

Our project will need a Raspberry pi that is connected with camera module on where our proposed methodologies performance the execution one phase at a time all these methods are deployed on raspberry pi. This is necessary in order to click underwater image to get corrected image.

### 3.4.2 Security Requirements

Our module is compatible with all types of cameras such as pi camera, waterproof cameras and mobile cameras. User will be able to click underwater image with different mega pixel cameras. Our methods are compatible for all types of camera specifications.

### 3.4.3 Software Quality Attributes

Our model design in such a way that it will be helpful for underwater researchers and scuba divers for clicking underwater images and get corrected image under the water itself.

## 3.5 System Requirements

### 3.5.1 Database Requirements

We do not require any database, the output/resultant images are stored locally in the folder

### 3.5.2 Software Requirements (Platform choice)

- Operating System: Windows / Linux
- IDE: Jupyter Notebook, VS Code
- ML tools: TensorFlow, Keras, scikit-learn
- Data Handling and Visualization: Pandas

### 3.5.3 Hardware Requirements

- Processor: Intel Core i5 or i7 (recommended)
- RAM: Minimum 8 GB (recommended)
- GPU: An NVIDIA GPU with CUDA support and at least 12 GB of VRAM
- Raspberry Pi 3 Model B
- Camera 12.3 Megapixel or more
- SD card (32 GB min.)

## 3.6 Analysis Models: SDLC Model to be applied

### Incremental Model

Incremental Model is a software development procedure where requirements are split up into several independent software development cycle modules. Each module in this model undergoes the phases of requirements, design, implementation, and testing. The module's functionality is increased with each new release. Up till the full system is achieved, the process is continued.

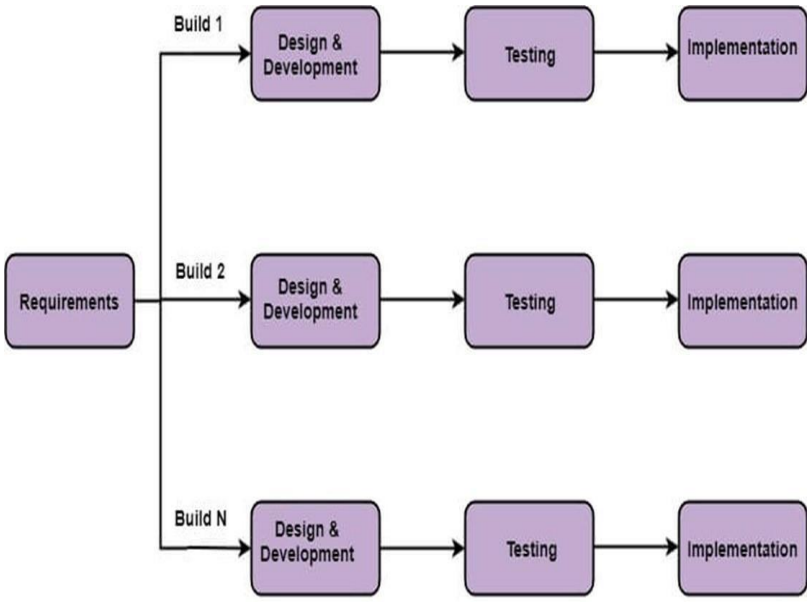



Figure 3.6: Incremental Model

The incremental model's many phases are as follows:

1. Requirement analysis: The product analysis expertise identifies the requirements in the first phase of the incremental model. The requirement analysis team is also aware of the functional needs for the system. This phase is extremely important for the incremental paradigm of software development.

2. Design Development: The design of the system functionality and the development methodology are successfully completed in this phase of the incremental model of SDLC. The incremental model uses style and development phase when software acquires new practicality.

3. Testing: In the incremental model, the testing phase evaluates the effectiveness of every function that already exists as well as newly added functionality. The numerous techniques are utilized to test each task's behaviorduring the testing process.

4. Implementation: The development system's coding phase is made possible by the implementation phase. In the planning and developing phase, it involves the final coding, and in the testing phase, it involves functional testing. Following the conclusion of this phase, the number of working products is updated and improved all the way up to the finished system product.

Advantages:

1) Errors are easy to be recognized
2) Easier to test and debug
3) More flexible
4) The Client gets important functionality early

Disadvantages:

1) Need for good planning
2) Total Cost is high
3) Well defined module interfaces are needed

# 4 SYSTEM DESIGN

## 4.1 System Architecture

The user will capture underwater images. As soon as images are captured, they get stored in input folder. Simultaneously python script will run for image processing. Processed images get stored in output folder.

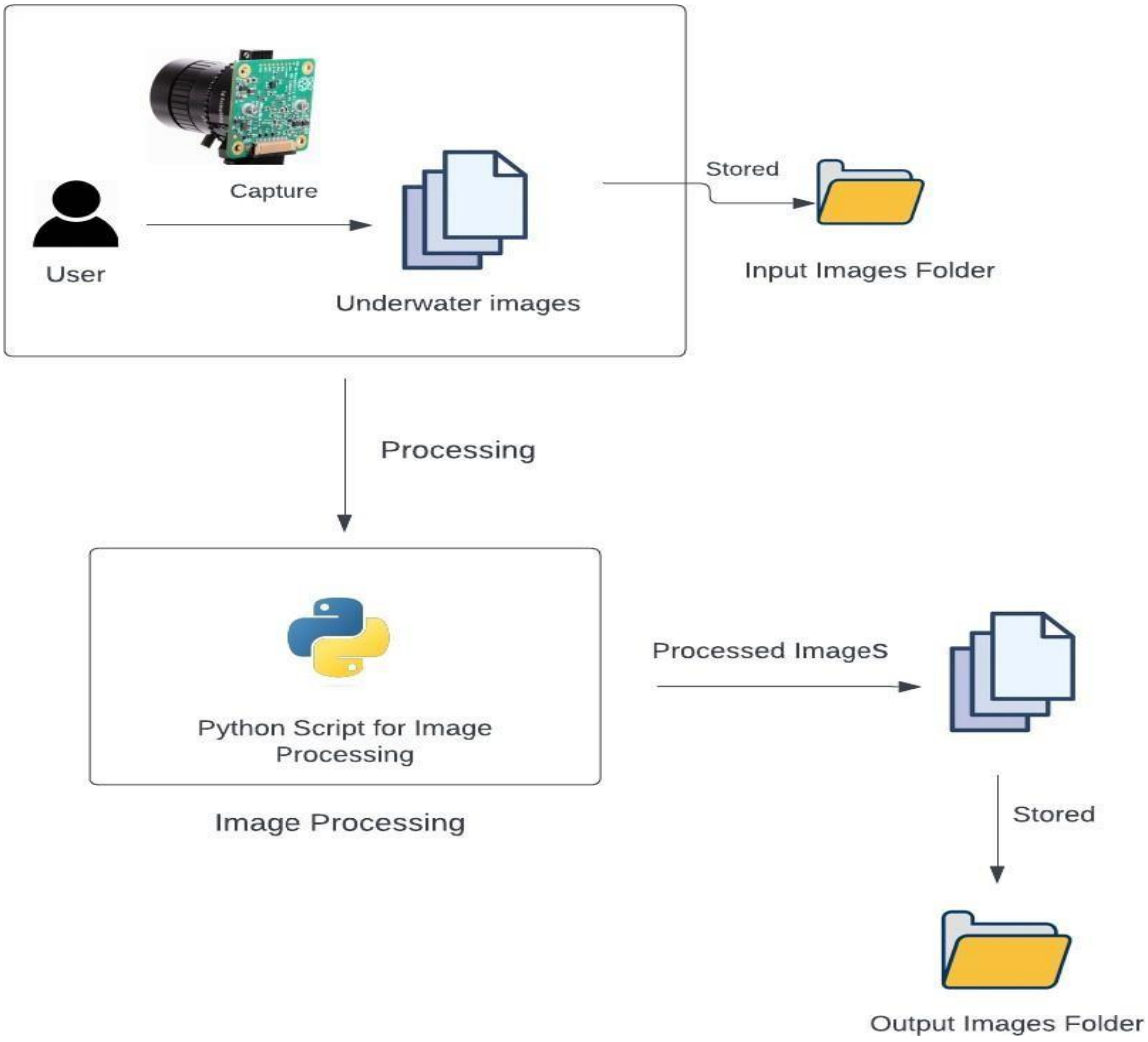



Figure 4.1: System Architecture(An Approach for Underwater Image Processing Using RPI)

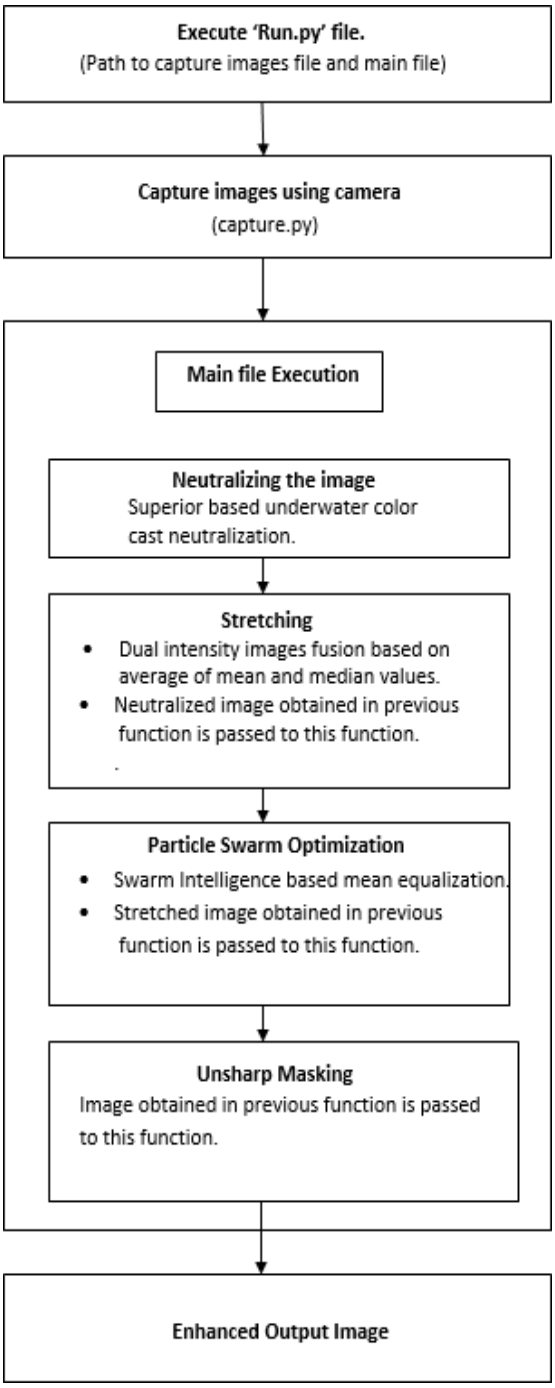



Figure 4.2: System Flow

## 4.2 Data Flow Diagram

A data flow diagram demonstrates the path that information takes through a system or process. It contains the numerous sub-processes the data flows through, data inputs and outputs, and data stores. Standardized symbols and terminology are used to construct DFDs, which define numerous sentities and their relationships.

1. DFD Level 0 –

Context Diagrams are another name for DFD Level 0. It provides a general summary of the entire system or process that is being studied or modelled. The system is displayed as a single, high-level process, togetherwith its relationship to external entities, in what is intended to be an overview view.

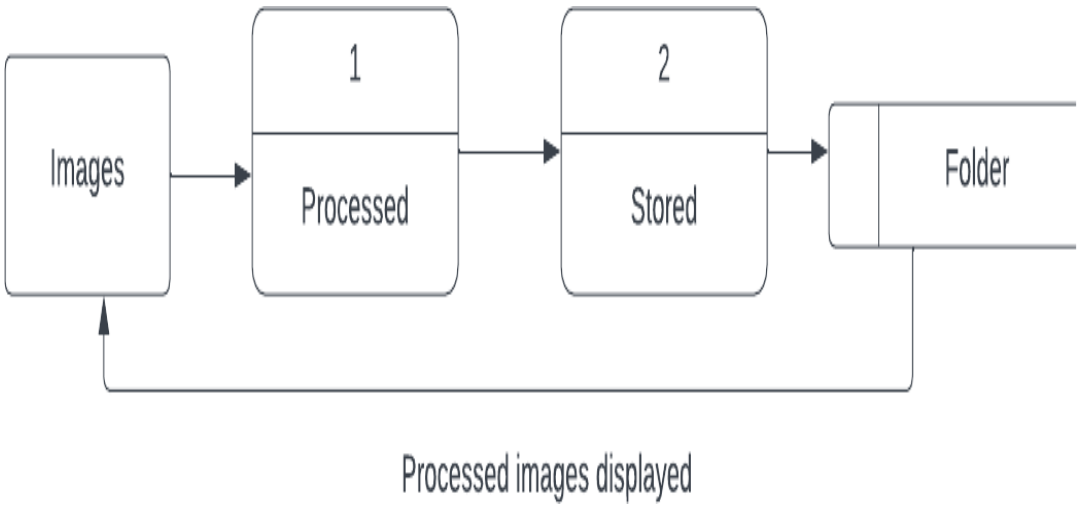



Figure 4.3: 0 Level DFD

2. DFD Level 1 –

While still providing a broad overview, Level 1 DFDs delve into greater detail than a context diagram.The single process node from the context diagram is divided into sub-processes in level 1 DFD. Thediagram will require more data flows and data stores when new processes are introduced to connect them.

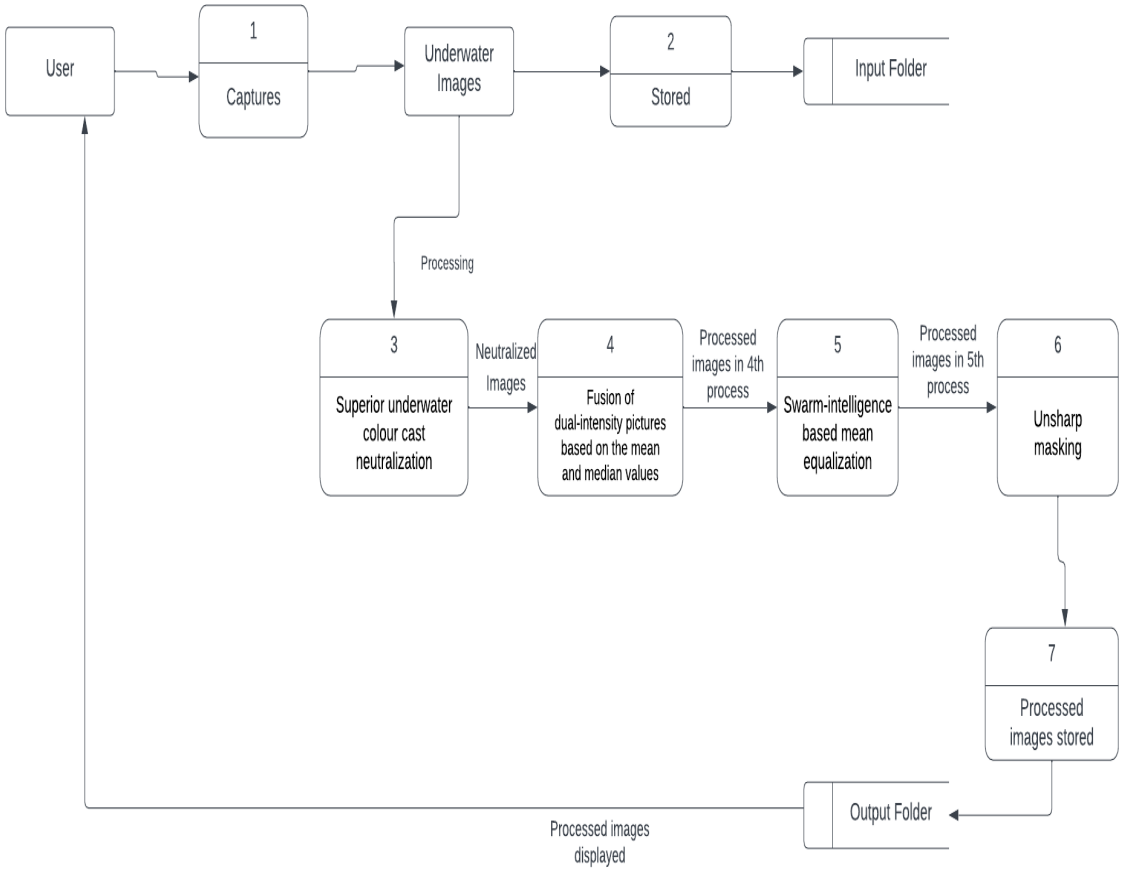



Figure 4.4: 1 Level DFD

## 4.3 Entity Relationship Diagram

Entity-Relationship model is referred to as an ER model. This data model is on a high level. The data itemsand relationships for a given system are defined using this model. It creates the database's conceptual design.Additionally, it creates a very straightforward and straightforward data view.

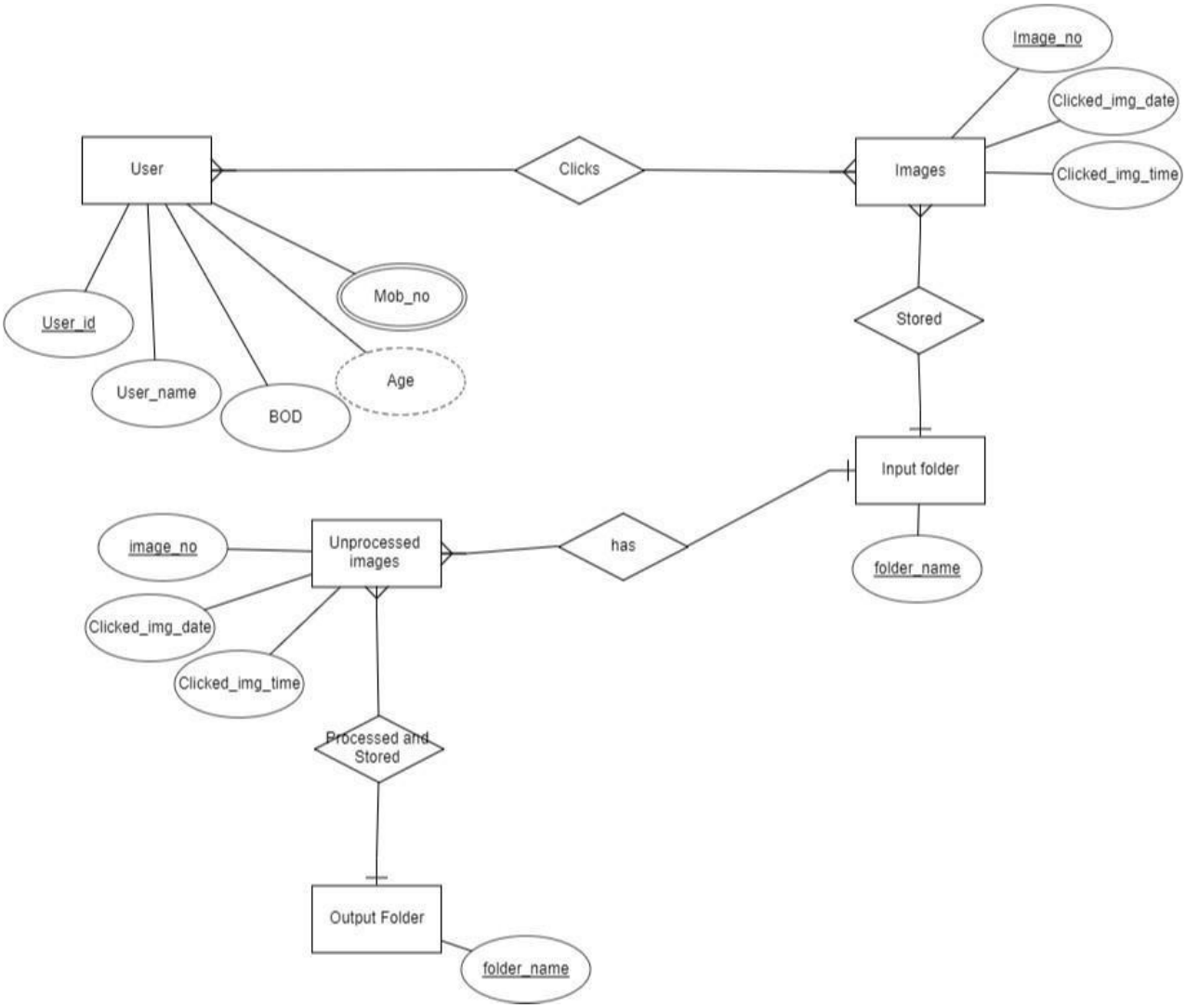



Figure 4.5: ER Diagram

## 4.4 UML Diagrams

For the development of software, the software industry uses various well-defined process models. The Software Engineering Process (SEP) or Software Development Process (SDP) is the name of this model. The Unified Software Development Process (USDP) is a widely used and commonly applied SDP in the industry.It is also known as the Unified Process (UP) in short. Unified Process (UP) deals with the process side of software development, while Unified Modelling Language(UML), a virtual language part of the system or project, coexists. The standard modelling notation and language for object-oriented analysis and design is UML. These notations, which are widely acknowledged by numerous software development organizations, are used to visualize system architecture.

### 4.4.1 Use Case Diagram

Use-case diagrams describe how a user interacts with a system. As a series of interactions be- tween the actor and the system, it is depicted. Both written and visual descriptions of use cases are provided. The system is presented as the user would see it. Use cases do not emphasize the system's internal operation or processing.Three system components are displayed in the use case diagram:

• Actors: Human-shaped sticks are used to represent actors. It might not always be a representation of the user.It can be used to represent a user, another system, or a device that communicates with a specific high-level feature (use case) of the system.

• Use case: Use cases essentially represent the system's top-level functions. An ellipse is used to symbolize a use case.

• System boundary: The system boundary is a container that holds use cases. Actors are beyond the queue. System boundaries are used to illustrate how a system's functionality is contained.

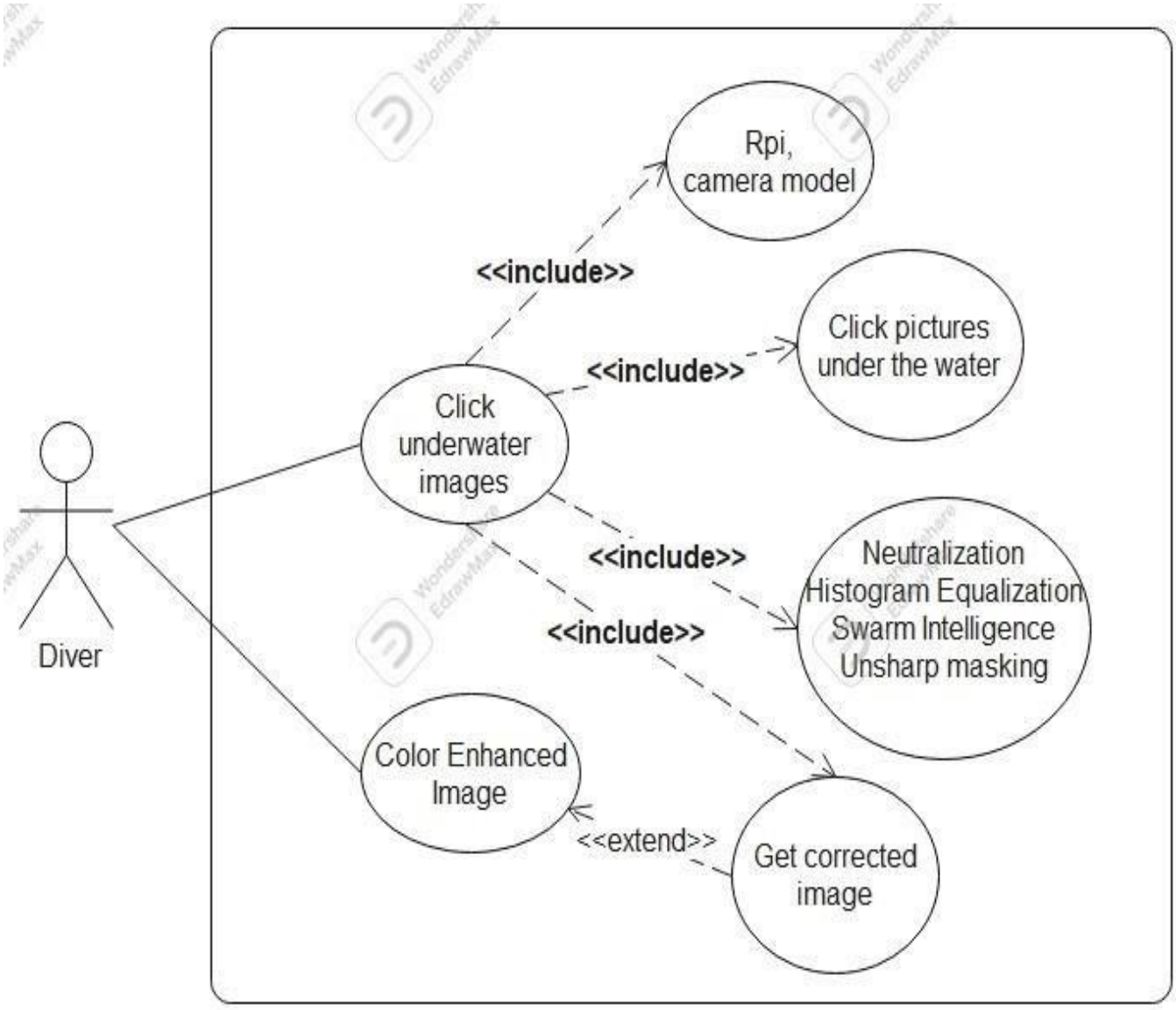



Figure 4.6: Use Case Diagram

### 4.4.2 Sequence Diagram

Sequence diagrams are used to display how objects interact once a system is operating. The orderof events is the sequence diagram's main concern. The timeline shows events as they happen from top to bottom in time. The item lifeline, a very distinctive element in the diagram, is used to represent how an object interacts with other objects in relation to its lifeline. The dashed line belowthe object instance is used to represent the instance lifeline. The point of control in a sequence diagram switches from one object to another as one object activates the other. The duration of theinstance across time is indicated by the complete line.

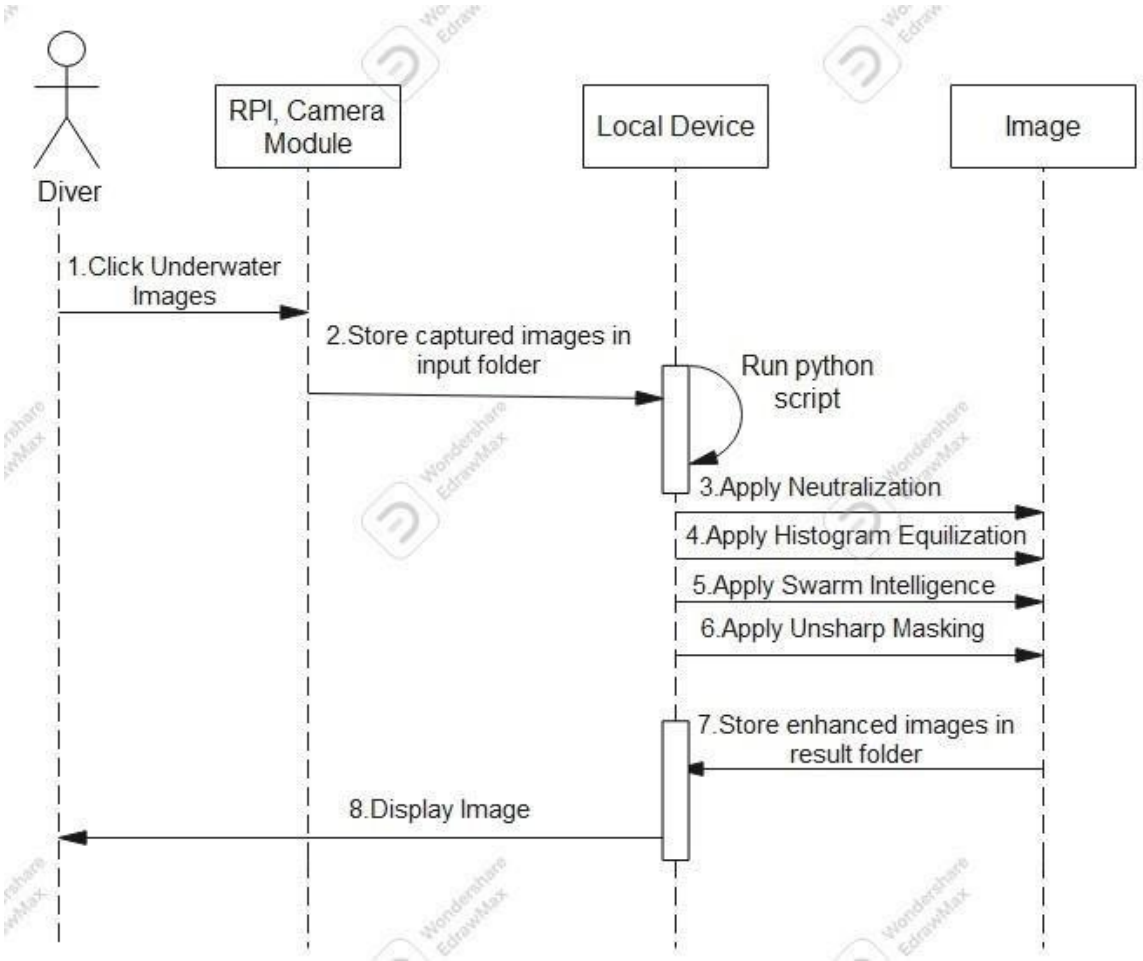



Figure 4.7: Sequence Diagram

### 4.4.3 Activity Diagram

Activity diagrams are used to represent flow of different activities in the system. It shows the flow of control and sequencing among different possible activities. Like use case, activity diagram also captures the user's perspective of the system. Activity diagrams do not explore system designor system's processing logic, instead focuses on flow of activities that a user of the system can experience. Activity diagram are mostly used for work flow modelling in Web Services and SOA (Service-Oriented Architecture) applications.

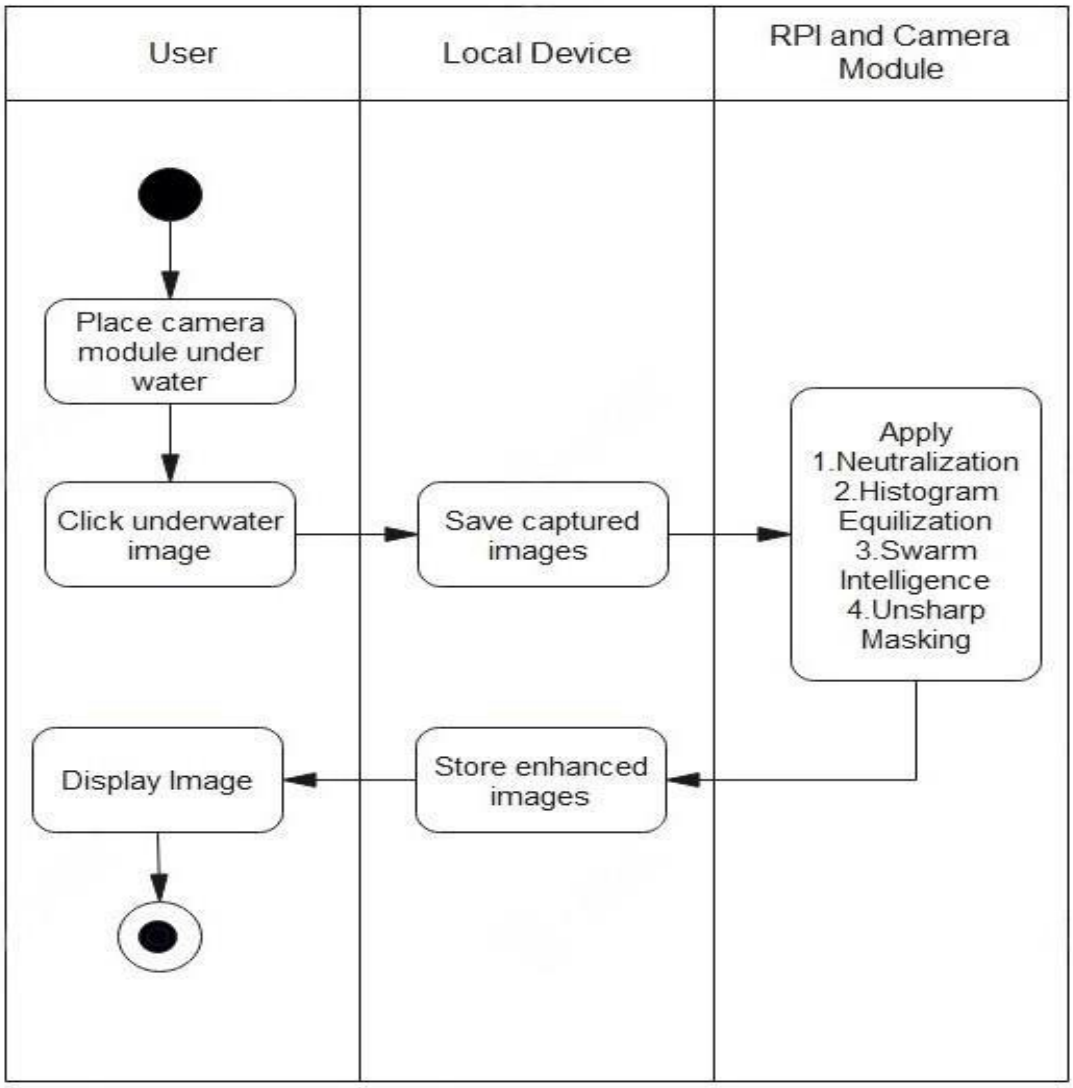



Figure 4.8: Activity Diagram

# 5 PROJECT PLAN

## 5.1 Project Estimate

| Sr. No | Software & Hardware Components | Cost |
|---|---|---|
| 1 | Raspberry Pi 3B or higher version | 5000+ /- |
| 2 | Camera | - Pi camera (5 MP) 400-500<br>- Waterproof Camera (4K 16 MP) 2000/- |
| 3 | HDMI Cable | 180/- |
| 4 | SD Card | 500/- |
| 5 | Our Proposed software cost | 6000/- (approx.) |
| 6 | Paper Publishing | 8K-10K (approx.) |
| | **Total =** | **7680** (excluding software cost & paper publishing cost) |

Table 5.1: Project Estimation

### 5.1.1 Reconciled Estimates

- Cost Estimate

There was no expenditure done for the project. The required data is made freely available byusing EUVP Dataset. The entire technology stack used by us is free and open source. Training of the Machine Learning models was done using free GPU access provided by Raspbian OS.

- Time Estimate

The time required to complete the project is dominated by the data preprocessing step. For researching existing systems, it took about 2 months. It required about 5-6 months of work and the modelling phase required 2-3 months. And for the UI development around 5-10 days. Total we developed whole system in 10-11 months from initial stage to working model.

### 5.1.2 Project Resources

- Hardware Resources
  - Storage: 4 GB (min.)
  - Memory: 8 GB (min.)

- Software Resources
  - Linux Operating System
  - Python 3.8 Programming Language
  - Google Chrome Web Browser
  - Python Thonny IDE

## 5.2 Risk Management

### 5.2.1 Risk Identification

The project risks were identified in the design as well as review phase. The answers to the following questions helped in this process:

1) Are the end-users enthusiastically committed to the system built?

Yes, this project caters to a very niche audience –diver's researchers who wish to study underwateror marine life and are looking to automate their workflow. This project helps them achieve the same.

2) Are requirements fully understood by the software development team?Yes,

the software development team has understood all the requirements.

3) Are the project requirements stable?

Yes, the project requirements were identified completely and finalized inthe requirements phase.

4) Is the number of people on the project adequate to do the job?

Yes, according to the project scope, the number of people on the development team are adequateto develop the software

### 5.2.2 Risk Analysis

Technical Risks

1) User data might leak.

Mitigation: User data such as uploaded spectra is not stored at all.

2) Data must be uploaded in any image format.

Mitigation: Both the leading data formats jpeg/jpg and png are supported.

3) A large dataset might not fit in memory during the preprocessing and modelling phase.

Mitigation: Data processing and training is performed in batches

4) Model results might be inaccurate.

Mitigation: Extensive modelling has been done to ensure that the classification results are near-perfect. Accuracy can be identified by analysis the histogram of images for comparing the results.

## 5.3 Project Schedule

### 5.3.1 Project Task Set

Major Tasks in the Project stages are:

- Task 1: Requirement Analysis.
- Task 2: Learning Astronomy.
- Task 3: Technology Study and Design.
- Task 4: Data Preprocessing.
- Task 5: Coding and Implementation.
- Task 6: Testing and Documentation.

### 5.3.2 Task Network

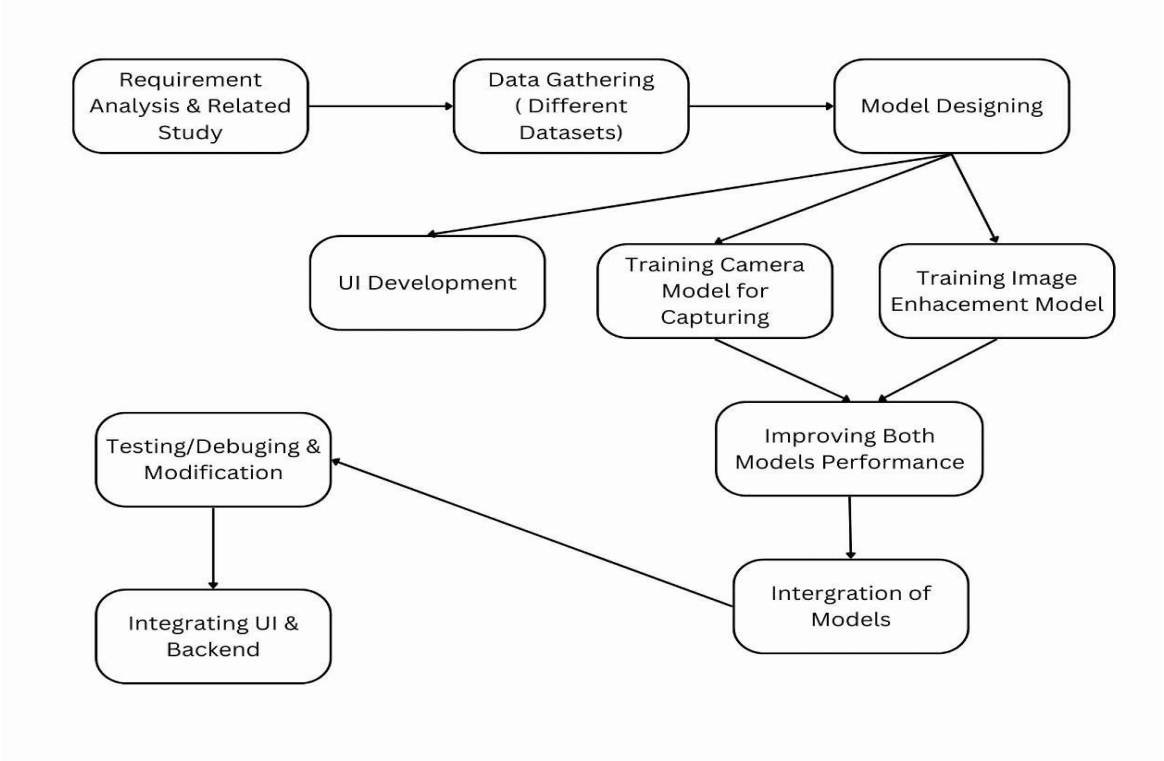



Figure 5.1: Task Network

### 5.3.3 TimeLine Chart

One of the most common and effective methods of displaying activities (tasks or events) displayedagainst time is a Gantt chart, which is frequently used in project management. A list of the activitiesis located on the chart's left side, and a suitable time scale is located along the top. A bar is used tosymbolise each activity, and the position and length of the bar correspond to the activity's beginning,middle, and finish dates. This enables you to quickly determine:

- What each of the activities entails
- When the start and finish of each action
- How much time is allocated to each activity
- Where and by how much some activities intersect with other ones
- The project's start and finish dates overall

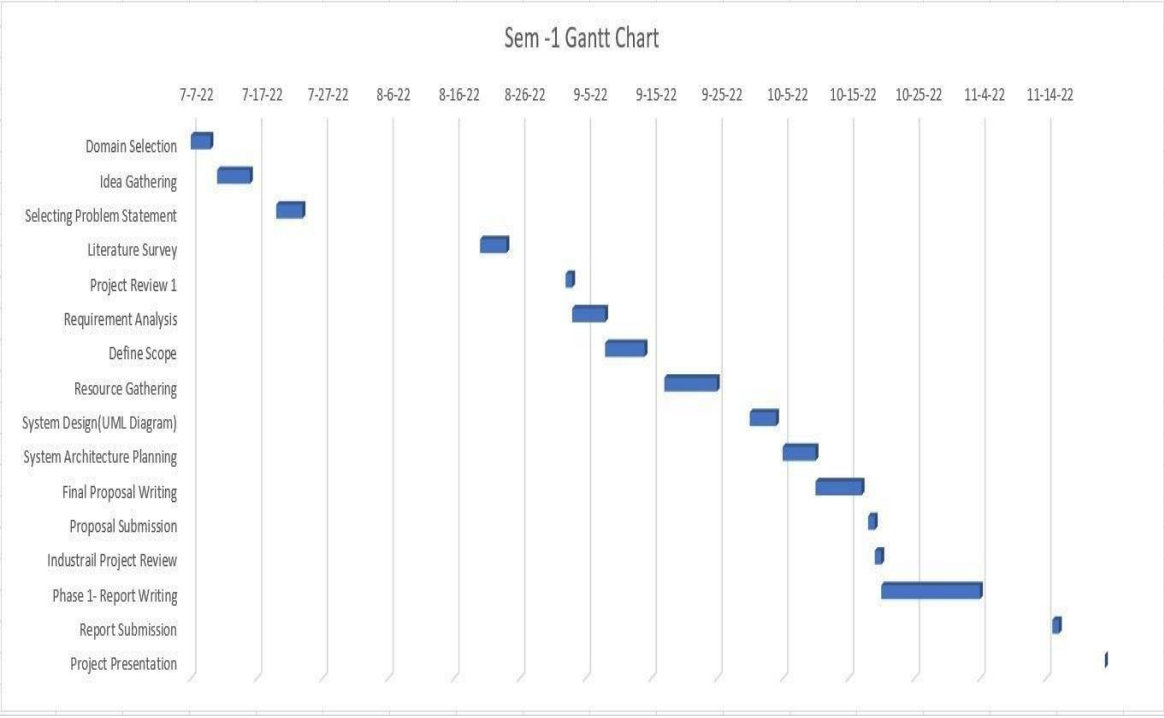



Figure 5.2: Gantt Chart for Sem 1

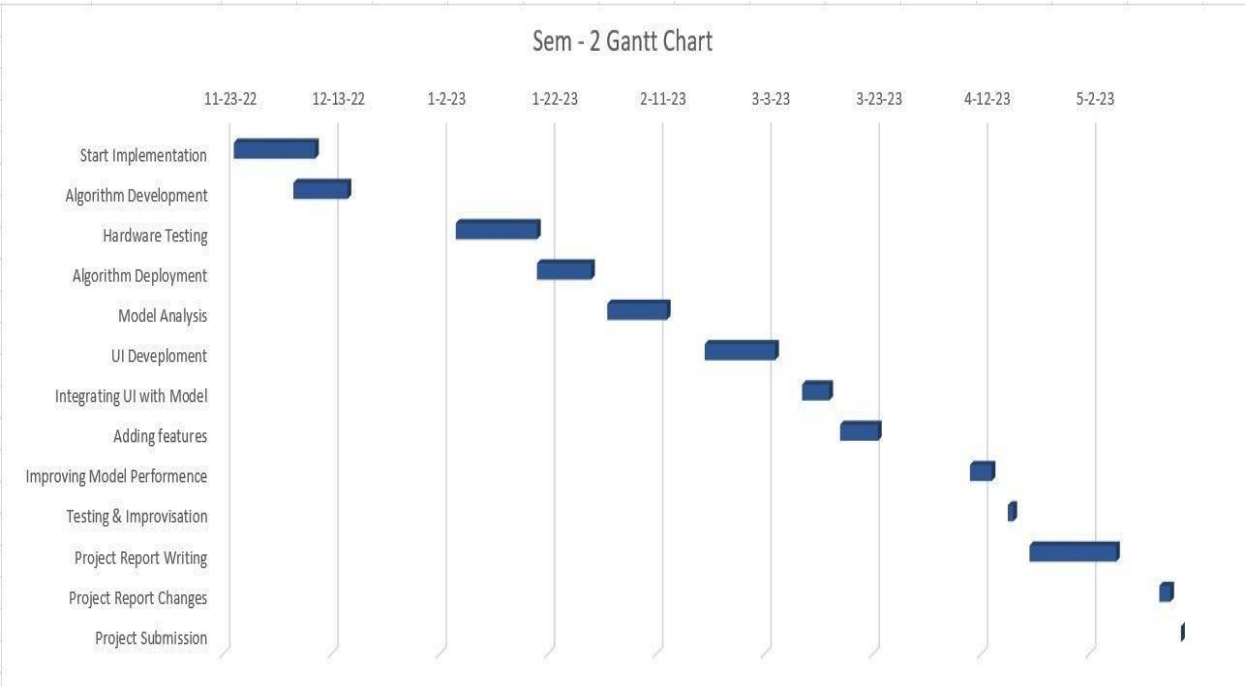



Figure 5.3: Gantt Chart for Sem 2

## 5.4 Team Organization

### 5.4.1 Team Structure

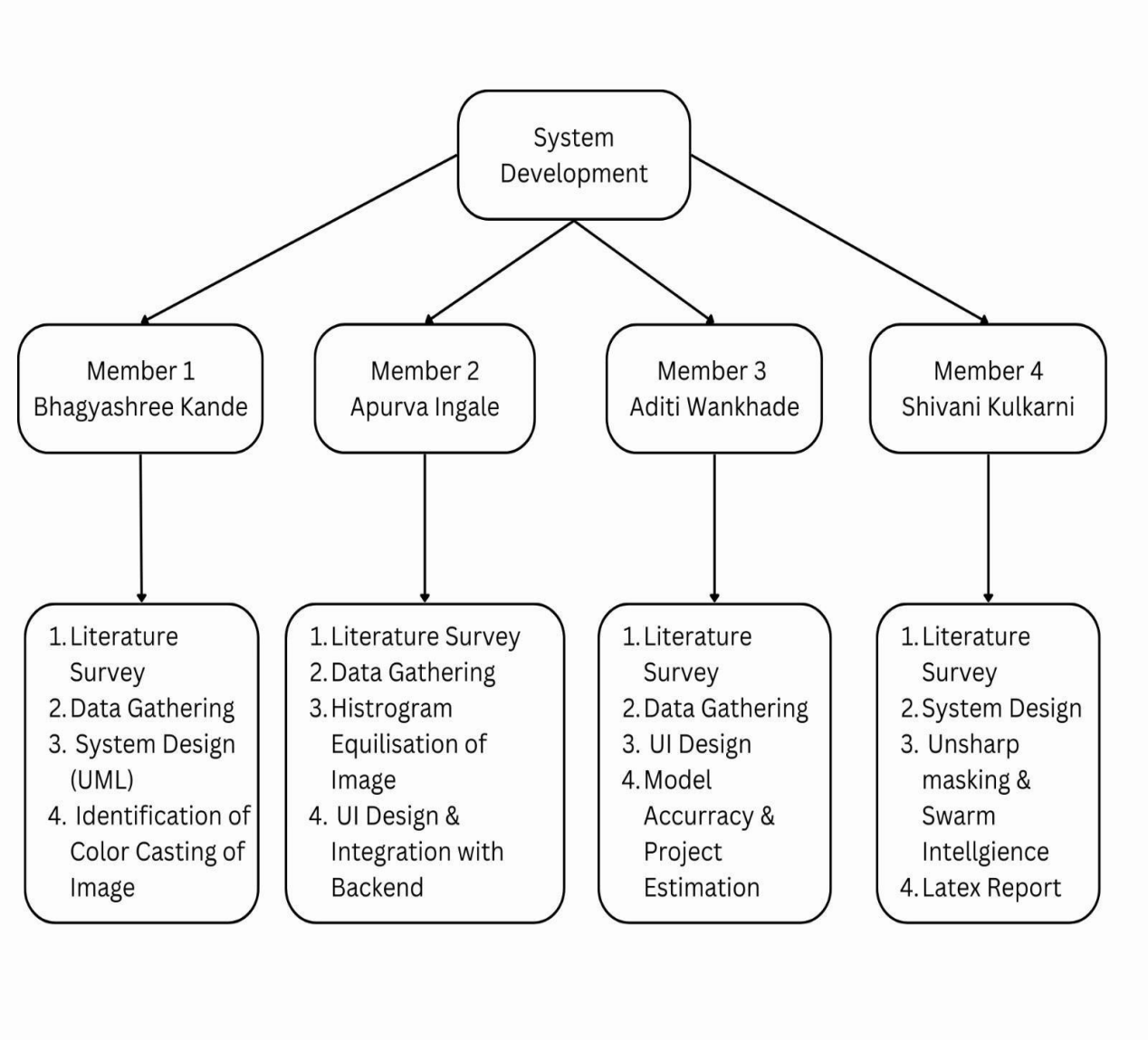



Figure 5.4: Team Structure

# 6 PROJECT IMPLEMENTATION

## 6.1 Overview of Project Module

We have developed a hardware based model using Raspberry Pi where the camera module is connected with raspberry pi and is used to capture underwater images . Python code is deployed inraspberry pi which is used to process and enhance the captured underwater images simultaneouslywhile capturing. The input underwater image will undergo processing to enhance the image. Thereare four algorithms which will run sequentially to produce the output image. .The input captured images will be stored in one folder and the enhanced resultant images will be stored in the results folder . After processing the images, a histogram of original input images and resultant images will be produced for comparing the difference.

## 6.2 Tools and Technologies used

### 6.2.1 Raspbian OS

The Raspberry Pi OS provides a desktop environment called PIXEL, which stands for Pi Improved Xwindows Environment, Lightweight, which is based on LXDE, which has a similar look and feel to several common operating systems, such as macOS and Microsoft Windows. There is a back- ground image on the desktop of the computer. In the top portion of the screen is a menu bar that contains shortcuts to a web browser (Chromium), a file manager, and a terminal that can be accessed from a menu bar. It is also possible to access the Bluetooth menu, Wi-Fi menu, volume control, and clock on the other end of the menu bar. Besides that, the desktop appearance can alsobe changed from the default one, for example, by repositioning the menu bar on the screen.

### 6.2.2 VNC Viewer

In the context of Virtual Network Computing (VNC), Remote Frame Buffer Protocol (RFB) is a method that allows you to control another computer through a graphical desktop sharing system. VNC is an application which allows you to connect to your Raspberry Pi’s graphical desktop re- motely using your keyboard and mouse input. It allows you to pass on keyboard and mouse input

from one computer to another over the network, relaying graphical updates. Getting started with VNC is pretty simple, but you will usually only be able to connect to your Raspberry Pi from anothercomputer that is on the same network as your Raspberry Pi when you set it up.

### 6.2.3 Python Thonny IDE

A free Python Integrated Development Environment (IDE) called Thonny was created specifically with the novice Pythonista in mind. It contains a built-in debugger that might be useful when you encounter ugly errors and, among other fantastic capabilities, it allows you to perform step throughexpression evaluation. Coding tools called Integrated Development Environments (IDEs) make authoring, debugging, and testing code simpler. Numerous offer beneficial features, like code completion, syntax highlighting, debugging tools, variable explorers, visualization tools, and many others.

### 6.2.4 Django

Django's main objective is to make it simpler to create intricate, database-driven websites. The ideas of don't repeat yourself, fewer code, less coupling, and component reusability and pluggabilityare strongly emphasized by the framework. Python is used everywhere, including in settings, files, and data models. Additionally, Django has a dynamically constructed administrative creation, read,update, and delete interface that is customizable.

Some key components of Django are: –

1) A small, independent web server for testing and development.
2) A framework for form serialization and validation that can convert between HTML forms and val-ues appropriate for database storage.
3) A template system that makes use of the object-oriented programming idea of inheritance.
4) A framework for caching that supports several cache technologies.
5) Support for middleware classes that can perform custom functions and interfere at different pointsduring the processing of requests.
6) An internal dispatcher system that enables events to be communicated between application com-ponents using pre-defined signals.

7) A method for internationalization that includes language translations of Django's own components.
8) A serialization system that can create and read representations of Django model objects in XMLand/or JSON.
9) A system for increasing the template engine's functionality.
10) An interface for the unit testing framework that comes with Python.

## 6.3 Algorithm Details

### 6.3.1 NUCE

NUCE refers to natural-based underwater image color enhancement used to enhance underwater images.

- In order to reduce the underwater color cast, the proposed NUCE method enhances the inferior color channels by utilizing gain factors in order to enhance the inferior color channels. As a result of recognizing the differences between superior and inferior color channels, thesegain factors can be calculated.

- Using dual-intensity images for fusion with each other, the proposed method improves the contrast of the image by averaging averages of mean and median values for the two intensity images. In order to produce lower-stretchedand upper-stretchedhistograms, theaveragepoint is determined and selected as the point of separation for each of the two types of histograms.

- The third step of this method is to propose the use of swarm-intelligence based mean histogram equalization as an important step towards improving the naturalness of the output im-age. The mean values of inferior color channels are adjusted through the fusion of the swarmintelligence algorithm to be close to the mean values of superior color channels by the swarm intelligence algorithm.

### 6.3.2 Histogram Equalization

We use histogram equalization to improve contrast. Contrast does not necessarily need to be raised in this. Histogram equalization may sometimes be detrimental in certain circumstances. Thecontrast is lessened in that instance. The majority of the pixels' intensities range from 0 to 50. Eventhe tiny portion of the image that the human eye can distinguish as white is black (albeit not entirely).In other words, the image's white portion is "less black" than its black portion, which is black. Whatif we could intensify the representation of the white portion without significantly altering the black portion? We can increase the contrast in the image by doing this. This technique is nothing but Histogram Equalization.

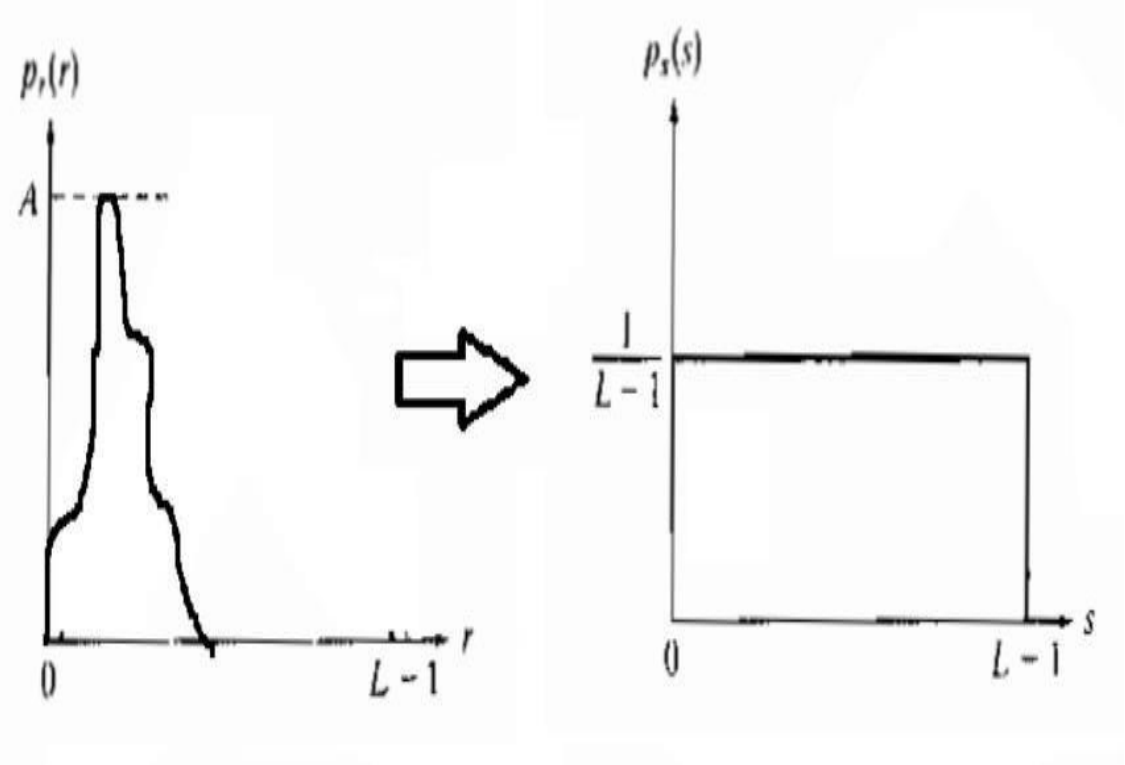



Figure 6.1: Histogram Equalization

# 7 Software Testing

## 7.1 Types of Testing

Following are the testing types Performed on IoT model:

### 7.1.1 Functional Testing

1) Unit Testing - It tests each module or component of an application. The IoT development team usually performs this task.
2) Integration Testing - When modules are integrated, it is essential to see how they work together.
3) End-to-End testing - This type involves running tests for the entire software product.
4) Smoke testing - This kind of testing enables the assessment of the software's stability.
5) Regression testing - Programme adjustments result from each new module that is added. If the IoT device's firmware needs to be updated, this could result in system changes as well. After each update, it is imperative to confirm that all components are still functioning properly.
6) Interface Testing - Testers verify the GUI meets the Specified Requirements and specifications.

### 7.1.2 Non-Functional Testing

1) Compatibility testing

Compatibility tests should be done first since IoT systems are created using a variety of hardware and software configurations. This is because this is the most important stage of IoT testing. To ensure maximum compatibility, this process often entails testing multiple hardware, browsers, operating systems, and communication methods. It establishes compatibility between a target product that implements a standard specification and other products that implement the specification exactly. Each piece of software must be able to recognize input from other programmes, manage theworkload necessary for it to play its part in the architecture, and produce outputs that are useful and accessible.

2) Performance testing

The second phase of IoT software testing begins with validating the performance-related implementation. Some of the key factors that the performance testing process typically deals with include:

-Performance under maximum load or data.

-Testing system for several devices at the same time.

-Communication tests between devices.

-System usability such as RAM load, battery usage, power consumption.

-Testing the device under various network conditions and environment factors.

3) Connection testing

The third testing stage ensures uninterrupted connectivity even when users cannot have a complete set of data. The stability of the IoT system depends on how well the devices and the hub are connected. After all, if it loses the connection for at least one second, it can cause data inaccuracyand system instability. Flawless connectivity, besides data recovery, is one of two critical features ofconnectivity testing.

Test Results: All the test cases mentioned above passed successfully and no defects/errors were encountered in the process.

## 7.2 Test Cases and Test Results

1. Module ID: 01

Module to be tested: hardware Testing

| Test Case Id | Description | Result |
|---|---|---|
| 101 | Raspberry Pi compatibility testing | Verified and correct |
| 102 | Camera module connection with raspberry Pi | Verified and connected |

Table 7.1: Test Cases for Hardware Testing

2. Module ID: 02

Module to be tested: Image Enhancement at different depth

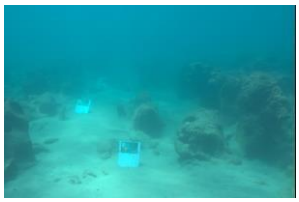
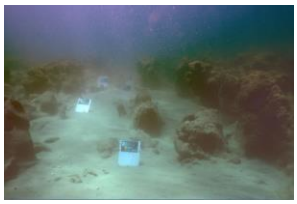
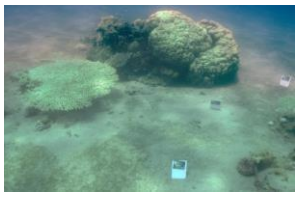
| **Test case Id** | **description** | **input** | **output** | **Result** |
|---|---|---|---|---|
| 201 | Image captured at depth of 2.8-5 m |  |  | Pass |
| 202 | Image captured at depth of 3-8 m |  |  | Pass |
| 203 | Image captured at depth of 5-10 m |  |  | Pass |

Table 7.2: Test Cases for images at different depth

3. Module ID: 03

Module to be tested: Images Storage

| Test case Id | description | input | Actual output | Expected Output | Result |
|---|---|---|---|---|---|
| 301 | Input images should be saved in input folder | 1.jpg | Saved in input folder | Should be saved in input folder | Pass |
| 302 | Processed images should be saved in result folder | 1.jpg | Saved in result folder | Should be saved in result folder | Pass |

Table 7.3: Test Cases for Image Storage

4. Module ID: 04

Module to be tested: Processing the given input

| Test case Id | description | input | Actual output | Expected Output | Result |
|---|---|---|---|---|---|
| 401 | Given input should be processed and expected output should be obtained | Image | Processed and saved in output folder | Processed and saved in output folder | Pass |
| 402 | Given input should be processed and expected output should be obtained | video | Invalid input | Should be processed and saved | Fail |

Table 7.4: Test Cases for processing the input

5. Module ID: 05

Module to be tested: Algorithm testing

| Test case Id | description | input | Actual output | Expected Output | Result |
|---|---|---|---|---|---|
| 501 | Given darken input should be processed and accuracy should be obtained |  |  | Input should be enhanced and accuracy must be obtained | Pass |
| 502 | Given brighter input should be processed and accuracy should be obtained |  |  | Input should be enhanced and accuracy must be obtained | Fail |

Table 7.5: Test Cases for algorithm testing

# 8 RESULTS

## 8.1 Outcomes

In this project, we have developed a hardware based model using Raspberry Pi where the cameramodule is connected with raspberry pi and is used to capture underwater images. Python code is deployed in raspberry pi which is used to process and enhance the captured underwater images simultaneously while capturing .The input captured images will be stored in one folder and the enhanced resultant images will be stored in the results folder . After processing the images a histogram of original input images and resultant images will be produced for comparing the difference.

## 8.2 Screenshots

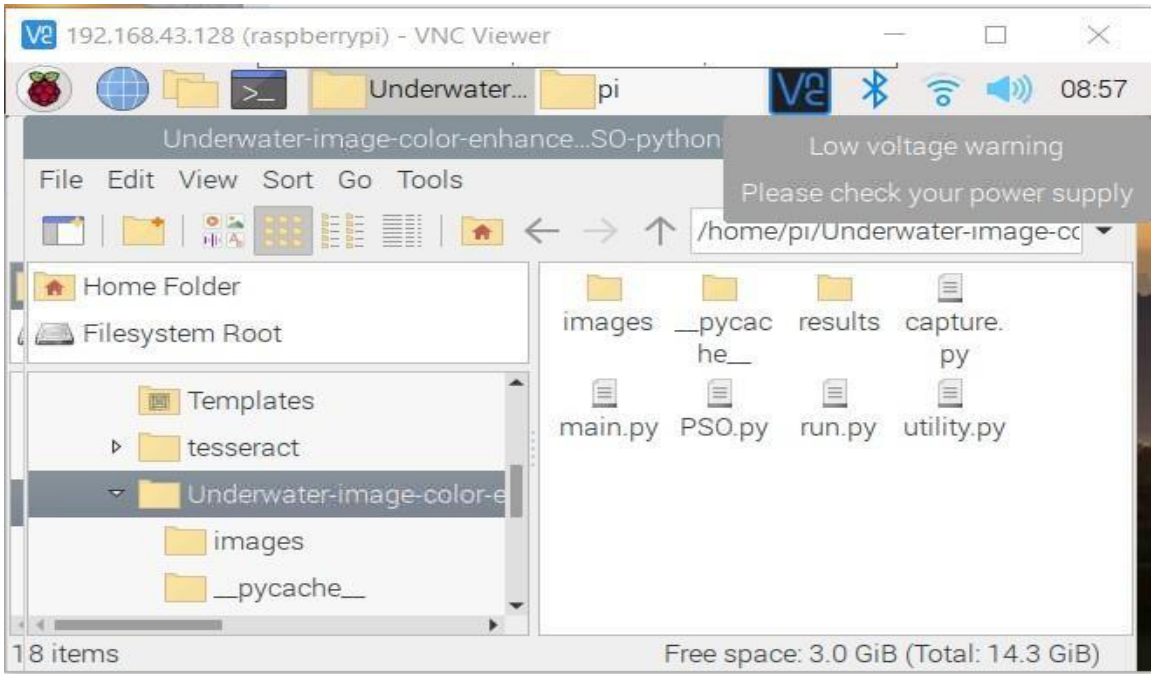



Figure 8.1: Project folder

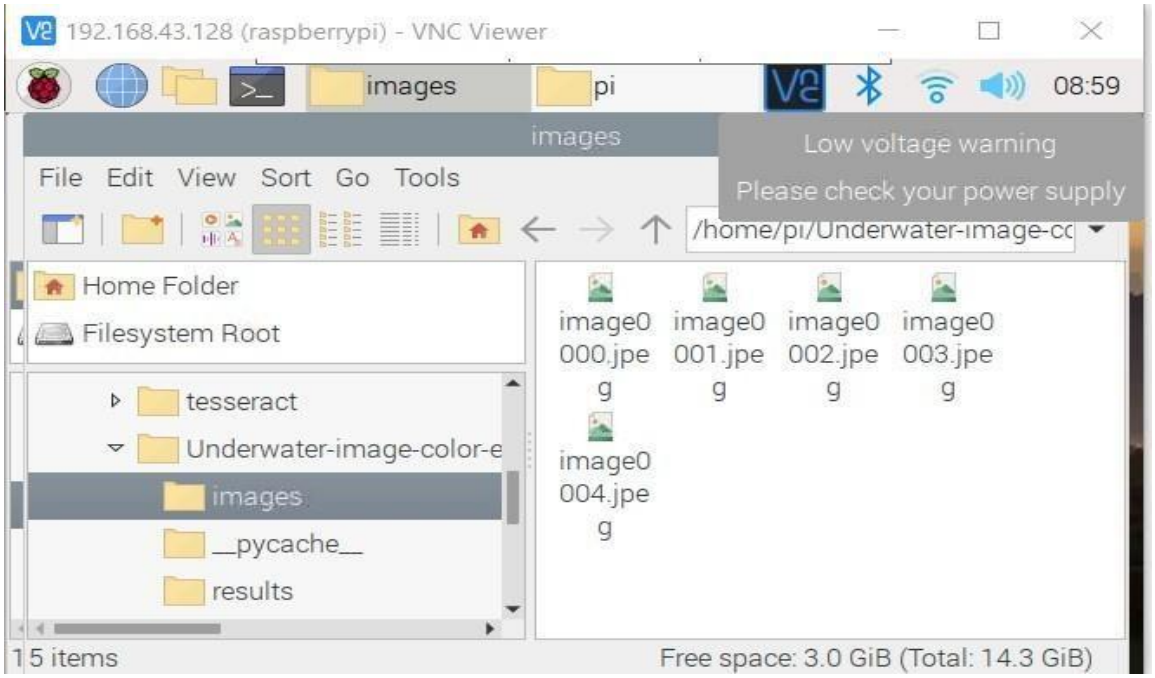



Figure 8.2: Input images folder

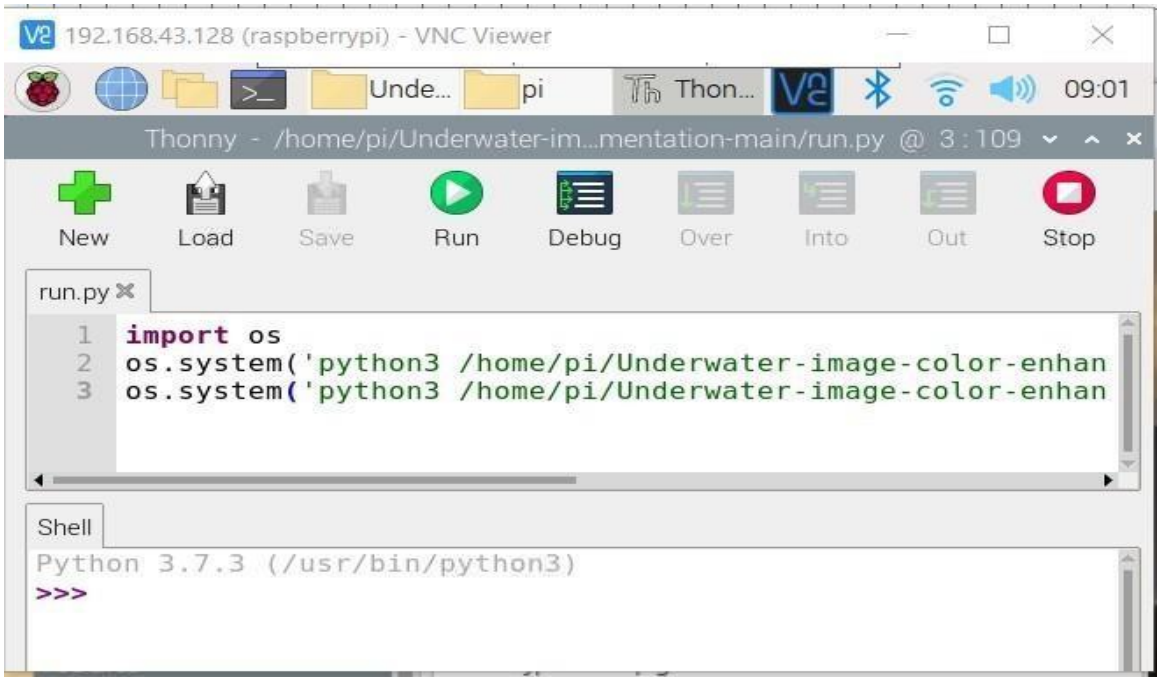



Figure 8.3: Run.py file

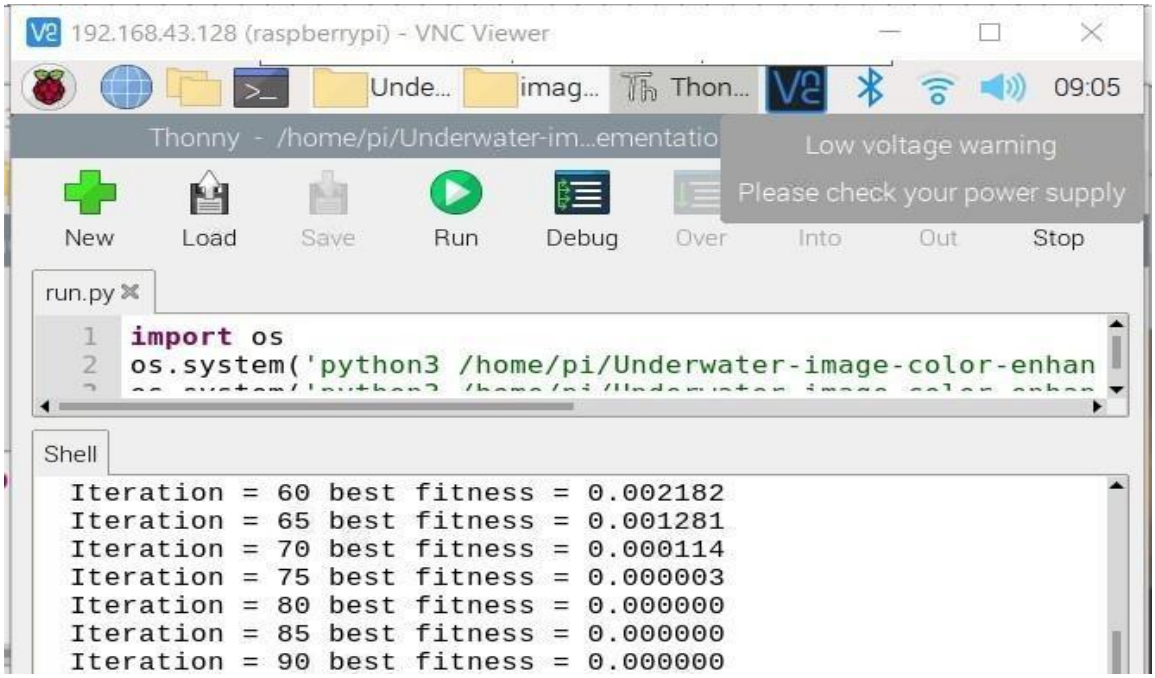



Figure 8.4: Iterations performed for processing

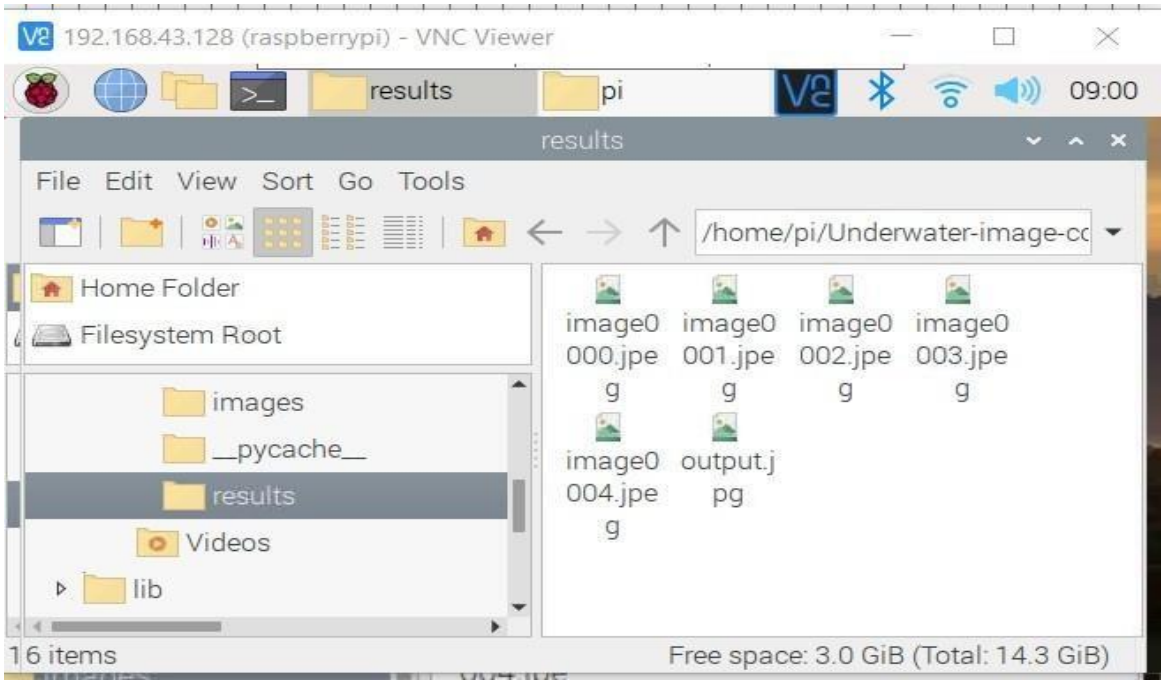



Figure 8.5: Result folder of project where processed and enhanced output images are stored

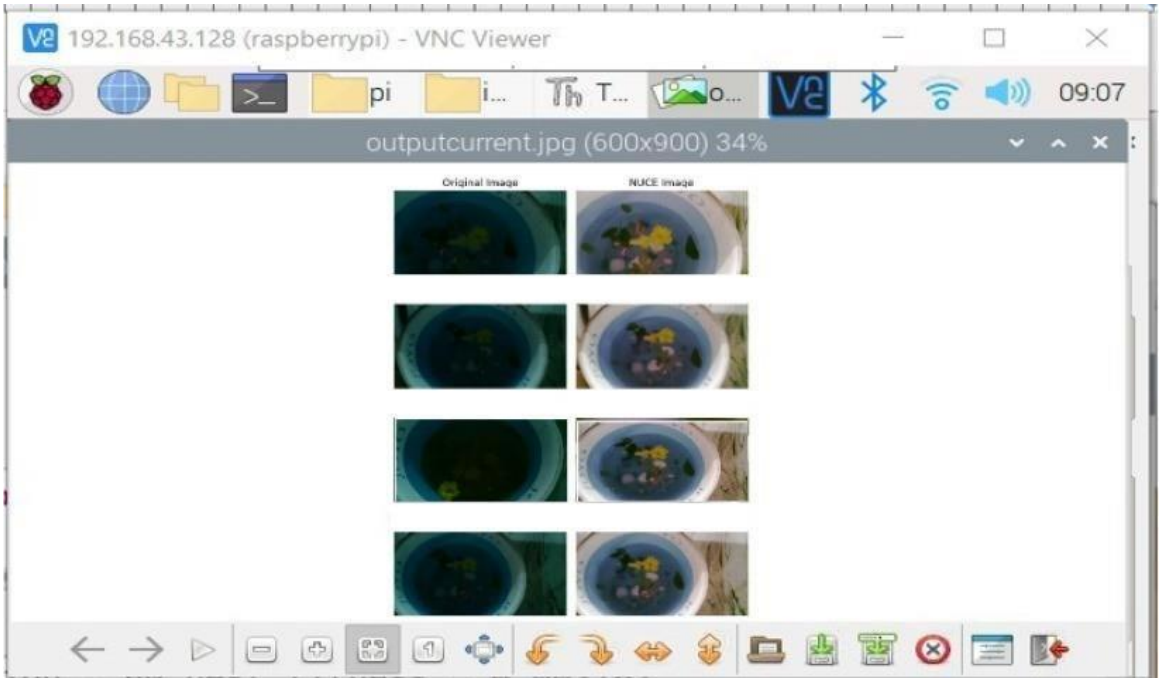



Figure 8.6: Histogram for comparison

## 8.3 Results by Comparing Pre-existing models

For the purposes of testing the effectiveness of our method, a large number of raw underwater imageswere used, primarily from the Underwater Image Enhancement Benchmark (UIEB) and Enhancing Underwater Visual Perception (EUVP) dataset, to verify that it was effective. A comparisonwas made between the proposed method and several Pre-Existing methods for improving and enhancing underwater images that have recently been proposed, including Deep SESR-Master and Funie-Gan Method.

In figure 8.7 There are several raw underwater images in the dataset which were captured under different underwater scenes, which are compared with their processed counterparts which have been processed using different methods. Using Figure 8.7 (a), there is a lot of variation in the colors of the raw images and some are turbid, while others are showing plenty of fogon the surfaces of the objects. In Figure 8.7 (b), the Deep SESR approach may effectively increasecontrast and brightness, but the enhancement effect is ineffective and results in color distortion.

The method described in figure 8.7(c) that is Funie-GAN has outstanding effectiveness when deal-ing with different types of underwater distorted images, and it can successfully fix the distortions which was seen in Figure 8.7 (b) but, considering the color difference, the photos after processing appear a touch dark. On the contrary, in figure 8.7(d) the method we use can not only enhance contrast and correct color deviation, but also standardize brightness distribution, which will ultimately end up in an improved visual effect.

The Deep SESR model can be used to recover colors and textures from unseen natural images, aswell as producing HR images and saliency maps based upon these images. As far as this model is concerned, although it claims to formulate a multi-modal objective function which evaluates the degree to which chrominance-specific color degradation, sharpness loss, and low-level feature representation can be achieved, it does not manage to overcome accurately the color distortion that occurs in underwater images.

Funie-GAN has been observed to have some challenging cases, which have been illustrated by theexample of an image. First, we observe that Funie-GAN is not very effective at enhancing severely degraded and texture-less images. In such cases, the generated images are often over saturated due to the noise amplification process that occurs. The color and texture recovery are generally poor even though the hue rectification is generally accurate.

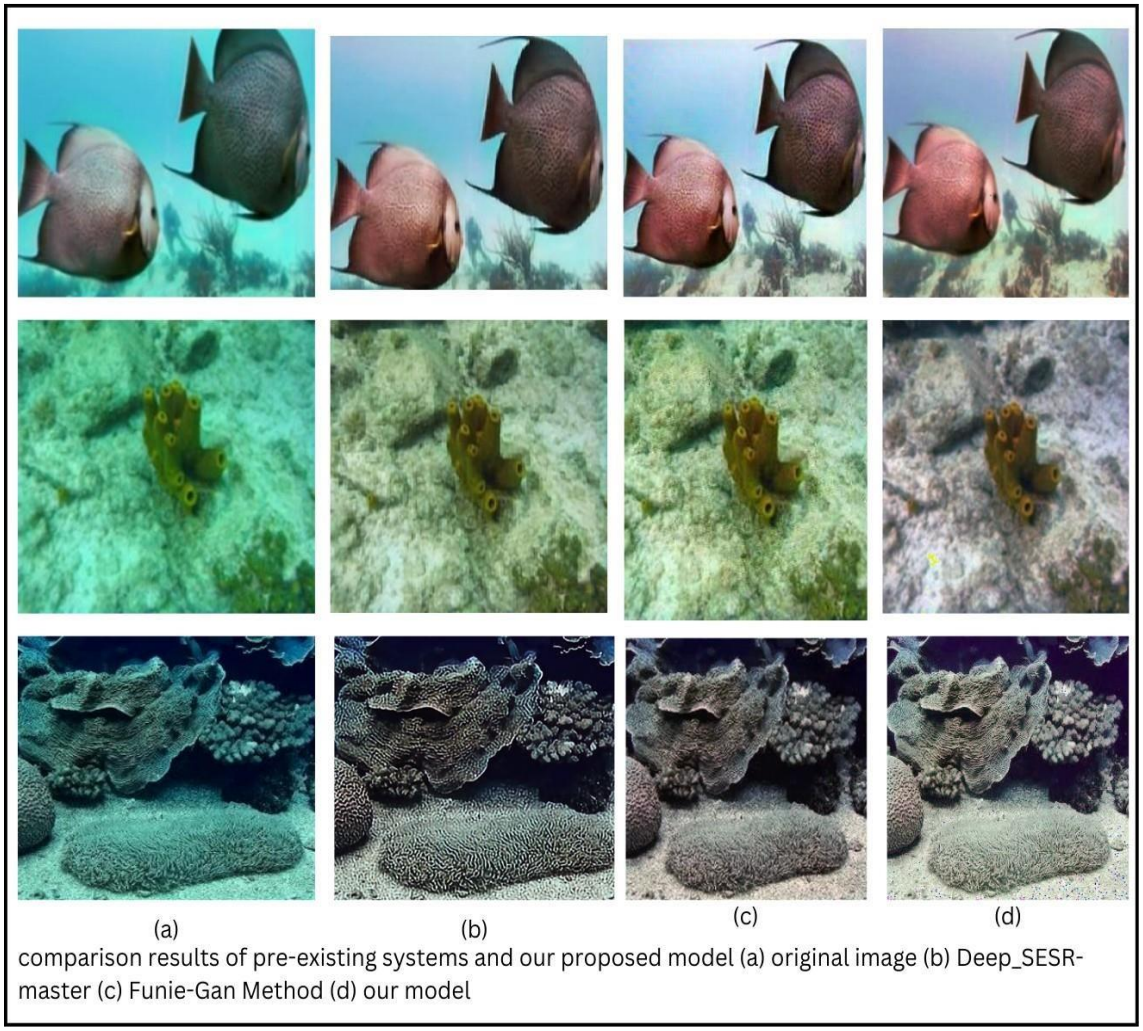



Figure 8.7: Results

# 9 CONCLUSIONS

## 9.1 Conclusion

Considering the characteristics of underwater imaging and the limitation of directly processing underwater images, in our proposed system, an improved and cost-effective approach for underwater image enhancement is proposed. It is a hardware- based model where the camera module is trainedto improve quality of underwater image for better visibility using python code which is deployed in raspberry pi and enhanced image is stored in a folder. As evidenced by the results, the proposed method can enhance diverse underwater scenes with high clarity in addition to significantly minimizing the underwater color cast. Color Cast is reduced by regulating inferior and superior color channels. In order to improve the naturalness of the image in the output, a measureof average histogram equalization based on swarm-intelligence is put forward.

Existing methods have not been able to deal with the problems arising due to light scattering and light attenuation effectively, particularly when the images are captured deep beneath the surface of the ocean. By comparing various pre-existing models we can obtain better and more precise results without reducing the originality of the real captured image.

## 9.2 Future Scope

As part of the future scope of our model, we intend to train it to work as a mobile application for easy accessibility in the future. It is intended that the application would be accessible and downloadableon public applicationstoressuchas the Google Play Storeand/or the Apple App Store. By enhancing the testing methods more accuracy could be acquired. For the better accuracy of the model, Itcould be trained to perform bright channel so that the if the input is brighter in nature the algorithm should work and produce accurate outputs. As opposed to visual methods, testing could be done by numerical methods, by doing research on the subject and finding a numerical figure that can beused as an accurate and representative indicator of the results, rather than visual methods.

Further models could be trained for object detection using machine learning or deep learning techniques. This could be used for locating instances of underwater objects in images. Recognizing andidentifying names of underwater bodies of interest and exploring the underwater world. An under- water clear video capturing feature should also be considered for future scope to make underwaterfilm shooting a painless task.

## 9.3 Applications

1) Underwater scuba divers capture images of underwater bodies and explore underwater environments such as lakes , rivers, quarries , kelp forest and coral reefs.
2) Underwater researchers perform submarine experiments and scientists need to examine objectson the seafloor over time.
3) Underground mining images clearing used to identify and extract ore from below the surface.

# APPENDIX A

## Feasibility

1) Operational Feasibility

- Operational feasibility is a measure of how well a proposed system solves the identified problems, and takesadvantage of theopportunitiesidentifiedinthescope of research. The systemshouldalsosatisfythe requirements identified in the requirement analysis phase of system development.
- The system provides liberty to the user for choosing the best fit algorithm to be implemented on captured image for correcting and processing the image.

2) Technical Feasibility

- The feasibility study is an influencing factor that contributes to the analysis of system imple- mentation. The software components used are open source and freely available to reuse
- Technical feasibility study is carried out to determine whether the proposed system has the capability, in terms of software, hardware, personnel, and expertise to handle the completionof a task.
- The hardware components being used are of latest version and consists of all the upgraded technologies.

3) Economic Feasibility

- The financial resources to build this project are feasible as the product is going to be made with the help of open source software. Hardware components are expensive. The project onlyconsists production cost and implementation cost are almost negligible.
- There is a need in the market for such a product as no such product exists and therefore therewill be a demand for this product.

## Problem Type

According to our research and analysis, the system will give an output in polynomial time Thereforethe problem statement is of P Type.

# APPENDIX B

No Paper Published.

# APPENDIX C: PLAGIARISM REPORT

Plagiarism Checker X - Report

Originality Assessment

**14%**

**Overall Similarity**

**Date:** May 19, 2023
**Matches:** 1085 / 7892 words
**Sources:** 31

**Remarks:** Low similarity detected, check with your supervisor if changes are required.

**Verify Report:**
Scan this QR Code

## Sources

| | | |
|---|---|---|
| 1 | https://www.sciencedirect.com/science/article/abs/pii/S1568494619305915#:~:text=The proposed natural-based underwater image color enhancement (NUCE),differences between the superior and inferior color channels. | INTERNET 2% |
| 2 | https://relevant.software/blog/iot-testing-importance/ | INTERNET 2% |
| 3 | https://forums.raspberrypi.com/viewtopic.php?t=288483 | INTERNET 1% |
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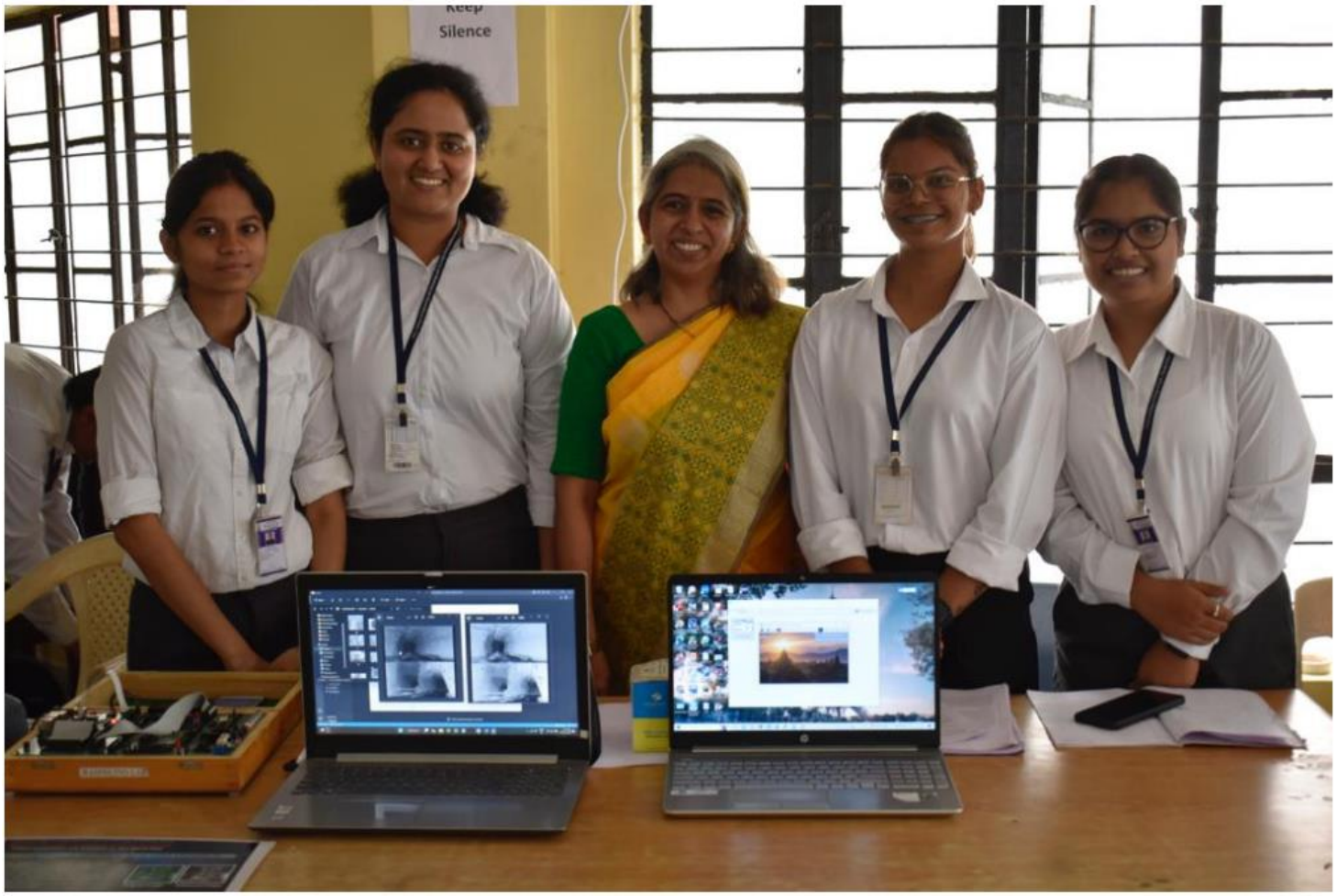


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