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)

SUBMITTED BY

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CERTIFICATE

This is to certify that the Project Report entitled "**AN APPROACH FOR UNDERWATER IMAGE PROCESSING USING RASPBERRY PI** "

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ABSTRACT

Over the last few years, researchers all over world have been studying about underwater image enhancement and the ability to obtain crystal clear image. Color correction and enhancement for underwater images is challenging due to scattering and low light intensity, underwater images always suffer from color castes and look bluish. The scattering and absorption of light in water leads to degradation of images captured under the water and makes the contrast relatively low. This degradation includes diminished colors, low brightness, and undistinguishable objects in the image. Crystal clear images can be resulted by contrasting RGB values. When the distance from the imaging scene to the camera is being increased, the red channel will disappear first. The red channel map is darkened, and the value of the pixels in the red channel becomes small. In this regard, the color of such image should be corrected. Inspired by the success of color transfer techniques, it is found that clear template image-assisted color transfer is a promising strategy for underwater image enhancement, including not only color correction but also contrast and visibility improvement. Our proposed method is very simple and straightforward that contributes greatly in uplifting the visibility of underwater images. To improve the quality of degraded images, we have proposed fusion based underwater image enhancement technique that focuses on improving of color contrast of the image underwater using raspberry pi, our camera model will be trained is such a way that the captured input image will add the required resolutions and effects to the image. Thus, our model will result the underwater images.

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

LIST OF FIGURES

1 INTRODUCTION

1.1 Overview

The problem of underwater image enhancement and colour correction is difficult and has become more important recently. The colour 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 colour 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 colour distortion and the dominance of a heavy blue colour.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 of 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 colour 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 research problem that deals with correcting image distortions to recover true pixel intensities

1.3 Problem Definition and Objectives

Underwater image enhancement and colour correction are challenging tasks that have gained priority in recent years. The colour 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 intensity of 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 colour 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 colour 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 colour cast neutralization

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

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.

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 colour channels are modified to be close to the mean value of superior colour channels through the fusion of swarm intelligence algorithms. Based on mean values, colour 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.

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 roll of 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.

2 LITERATURE SURVEY

2.1 Reference Papers

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 colour correction and underwater image enhancement methods. A colour 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 colour 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.

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 colour, 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 underwater object detection and human body pose estimation.

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 comprehensive 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 platforms. 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.

2.1.4 An approach for underwater image enhancement based on color correction and dehazing.

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 images 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 focuses on 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.

CHAPTER 3

3 Software Requirement Specification

3.1 Introduction

3.1.1 Project Scope

The proposed model captures an image as the input and a sequence of operations such as arranging RGB values, white balancing, gamma correction, sharpening etc are performed on the input image. Finally multi scale image fusion of the inputs is done to obtain the resultant crystal clear image as an output. This will result in clicking images underwater which is convinced 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.This Model will be a hardware-based model which will implement all these operations in the camera itself using raspberry pi. Raspberry pi and camera module will be used to integrate software code which will be in Python and MATLAB for image processing. Our model is straightforward and contributes greatly in uplifting the visibility of underwater images.

3.1.2 User classes and characteristics

The intended audience for this documentation are mainly divers, under water researchers, etc. but also relevant to developers and users with research interests. Underwater researchers make use of camera to research and investigate underwater medicinal plants such as coral reef, and find some new species.

3.1.3 Assumptions and Dependencies

- Our model depends on underwater image enhancement techniques where we have obtained different training testing dataset from existing models.

- Our model also depends on raspberry pi Google Colab 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 Machine Learning Model

We are looking at various Machine Learning Algorithms like Color Filter Array, Gamma Correction, White Balance to generate clear image under water itself.

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.

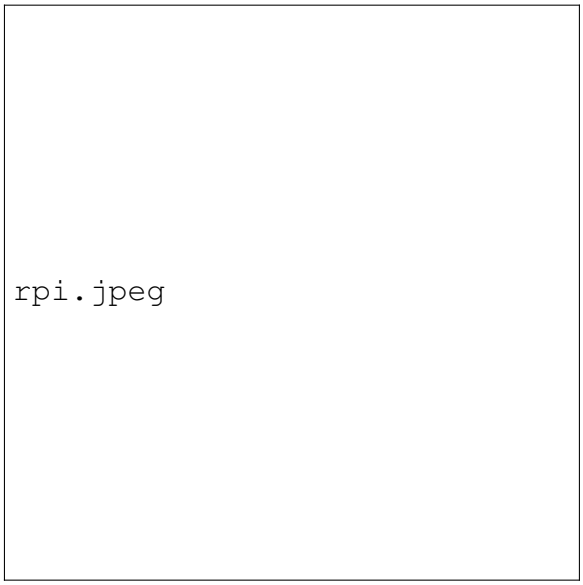

Figure 3.1: Raspberry Pi

- 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-campere module directly. This Pi Camera module can attach to the Raspberry Pi's CSI port using 15-pin ribbon cable.

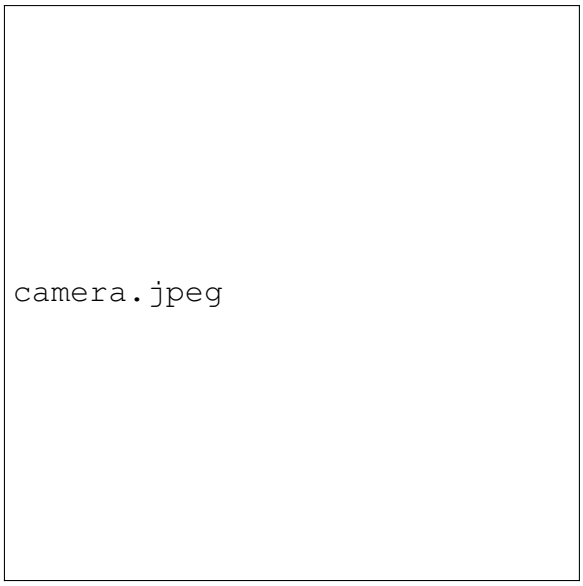

Figure 3.2: Camera

- HQ Camera module

  This module is the latest Raspberry Pi camera accessory. It offers higher resolution (12 megapixels, compared to the previous 8 megapixels) and sensitivity (approximately 50 percent more area per pixel for improved performance in low light conditions) than the existing v2 camera module, and is designed to work with interchangeable C and CS mount lenses. Other lenses can be used using adapters.

  6mm CS mount lenses and 16 mm with C-mount are examples of all the compatible ones that exist. The high-quality camera offers an alternative to the camera module v2.

  For industrial and consumer applications, including security cameras, that require the highest levels of visual fidelity and / or integration with specialized optics. It is compatible with all Raspberry Pi models, the latest version of software.

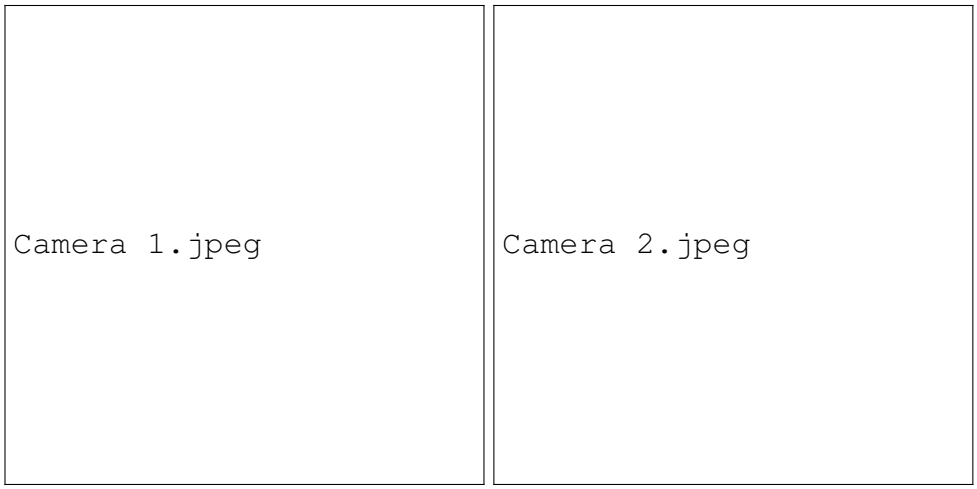

Figure 3.3: HQ Camera Module

- Camera setup

Figure 3.4: Camera Setup

- Final Camera Module with Raspberry Pi

Figure 3.5: Final Camera Module with Raspberry Pi

3.4 Nonfunctional Requirements

3.4.1 Performance Requirements

Our project will need a Raspberry pi that is connected with camera module on which three algorithms (color filter array, gamma correction, white balance) are deploy.This is necessary inorder to cilck underwater image to get corrected image.

3.4.2 Security Requirements

Our module is compatible with three different algorithms (color filter array, gamma correction, white balance) which are deployed on it. User will not be able to click underwater image other than these algorithms.

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

SQL database or relational database is a collection of highly structured tables, wherein each row reflects a data entity, and every column defines a specific information field. Relational databases are built using the structured query language (SQL) to create, store, update, and retrieve data

3.5.2 Software Requirements (Platform choice)

- Operating System: Windows / Linux
- IDE: Jupyter Notebook, VS Code 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 process of software development where requirements divided into multiple standalone modules of the software development cycle. In this model, each module goes through the requirements, design, implementation and testing phases. Every subsequent release of the module adds function to the previous release. The process continues until the complete system achieved.

Figure 3.6: Incremental Model

The various phases of incremental model are as follows:

1. Requirement analysis: In the first phase of the incremental model, the product analysis expertise identifies the requirements. And the system functional requirements are understood by the requirement analysis team. To develop the software under the incremental model, this phase performs a crucial role.

2. Design Development: In this phase of the Incremental model of SDLC, the design of the system functionality and the development method are finished with success. When software develops new practicality, the incremental model uses style and development phase.

3. Testing: In the incremental model, the testing phase checks the performance of each existing function as well as additional functionality. In the testing phase, the various methods are used to test the behavior of each task.

4. Implementation: Implementation phase enables the coding phase of the development system. It involves the final coding that design in the designing and development phase and tests the functionality in the testing phase. After completion of this phase, the number of the product working is enhanced and upgraded up to the final 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

3.7 System Implementation Plan

Project implementation plan decides on project scope and time frame along with capability of project developers. Implementation means carrying out activities described in plan as per defined time frame.

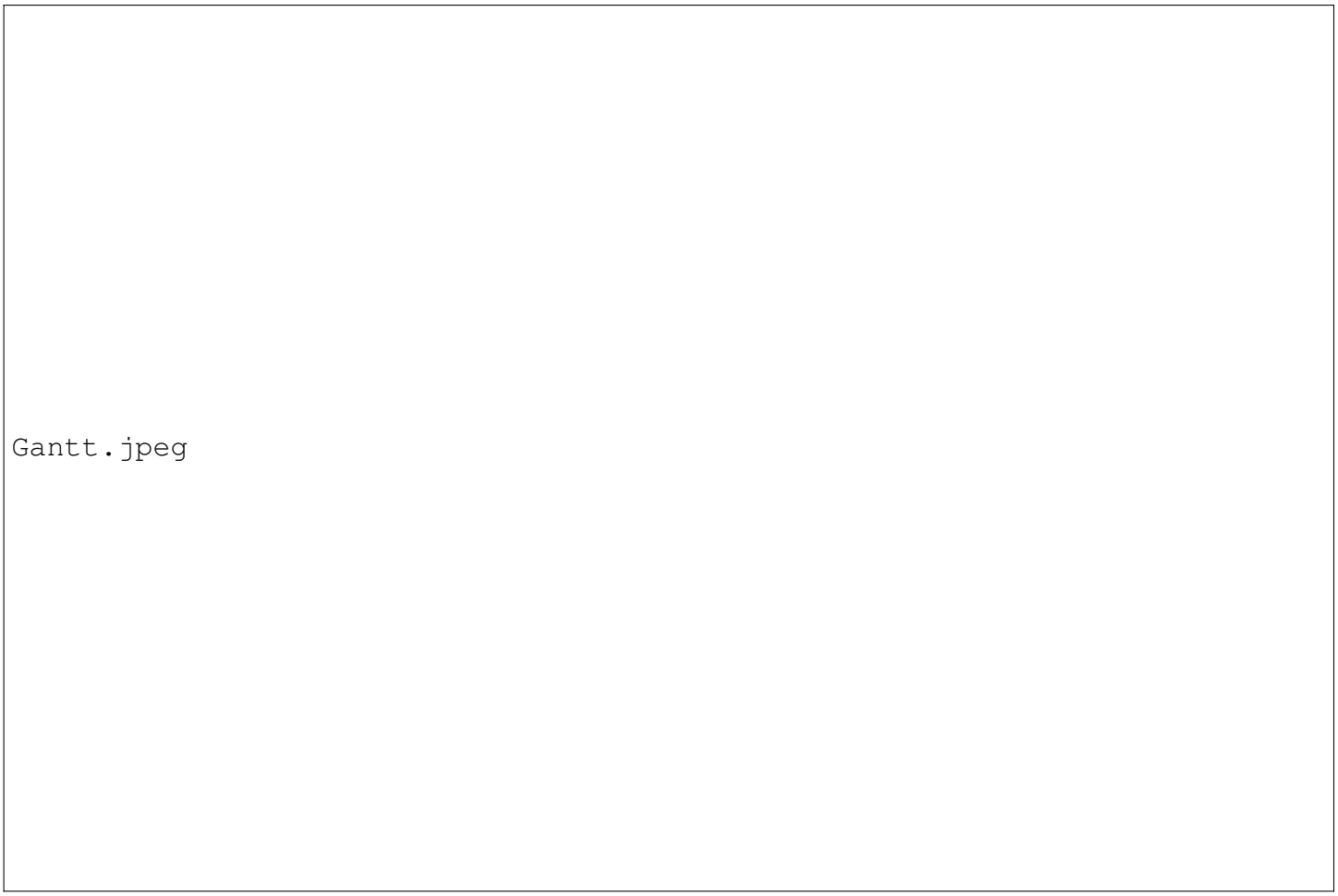

Figure 3.7: Gantt Chart

4 SYSTEM DESIGN

4.1 System Architecture

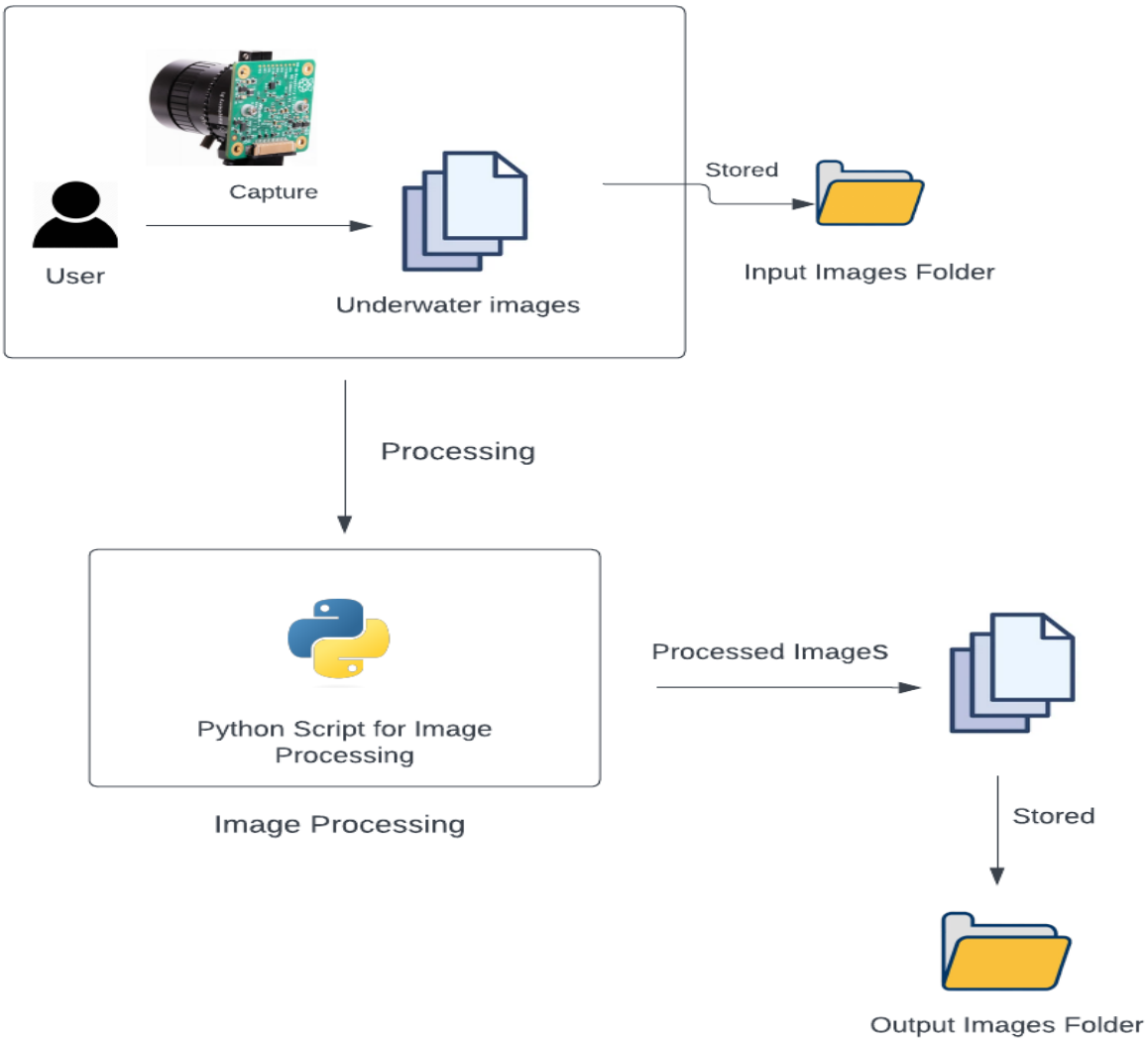

Figure 4.1: System Architecture

4.2 Data Flow Diagram

A data flow diagram shows the way information flows through a process or system. It includes data inputs and outputs, data stores, and the various subprocesses the data moves through. DFDs are built using standardized symbols and notation to describe various entities and their relationships.

1. DFD Level 0 –

DFD Level 0 is also called a Context Diagram. It's a basic overview of the whole system or process being analyzed or modeled. It's designed to be an at-a-glance view, showing the system as a single high-level process, with its relationship to external entities.

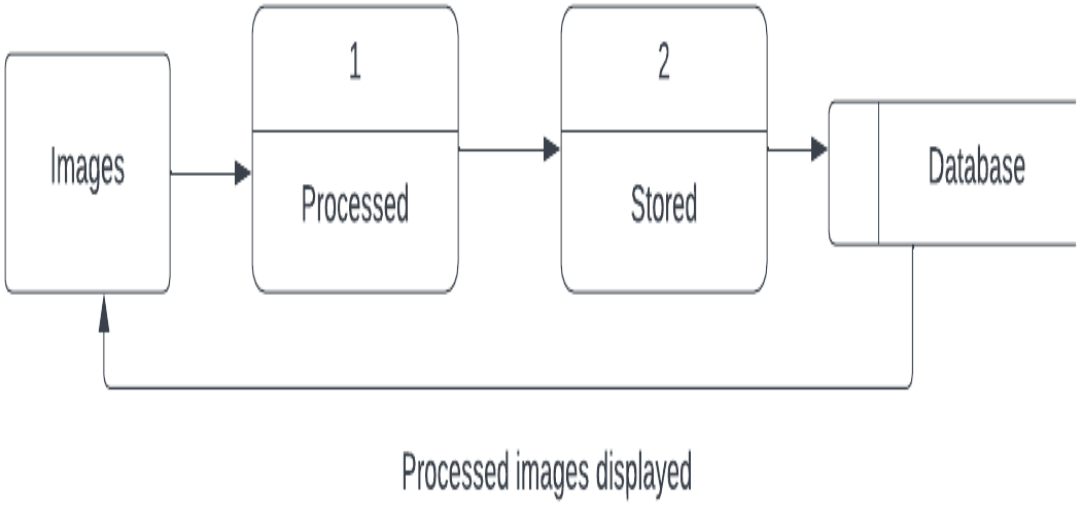

Figure 4.6: 0 Level DFD

2. DFD Level 1 –

Level 1 DFDs are still a general overview, but they go into more detail than a context diagram. In level 1 DFD, the single process node from the context diagram is broken down into sub-processes. As these processes are added, the diagram will need additional data flows and data stores to link them together.

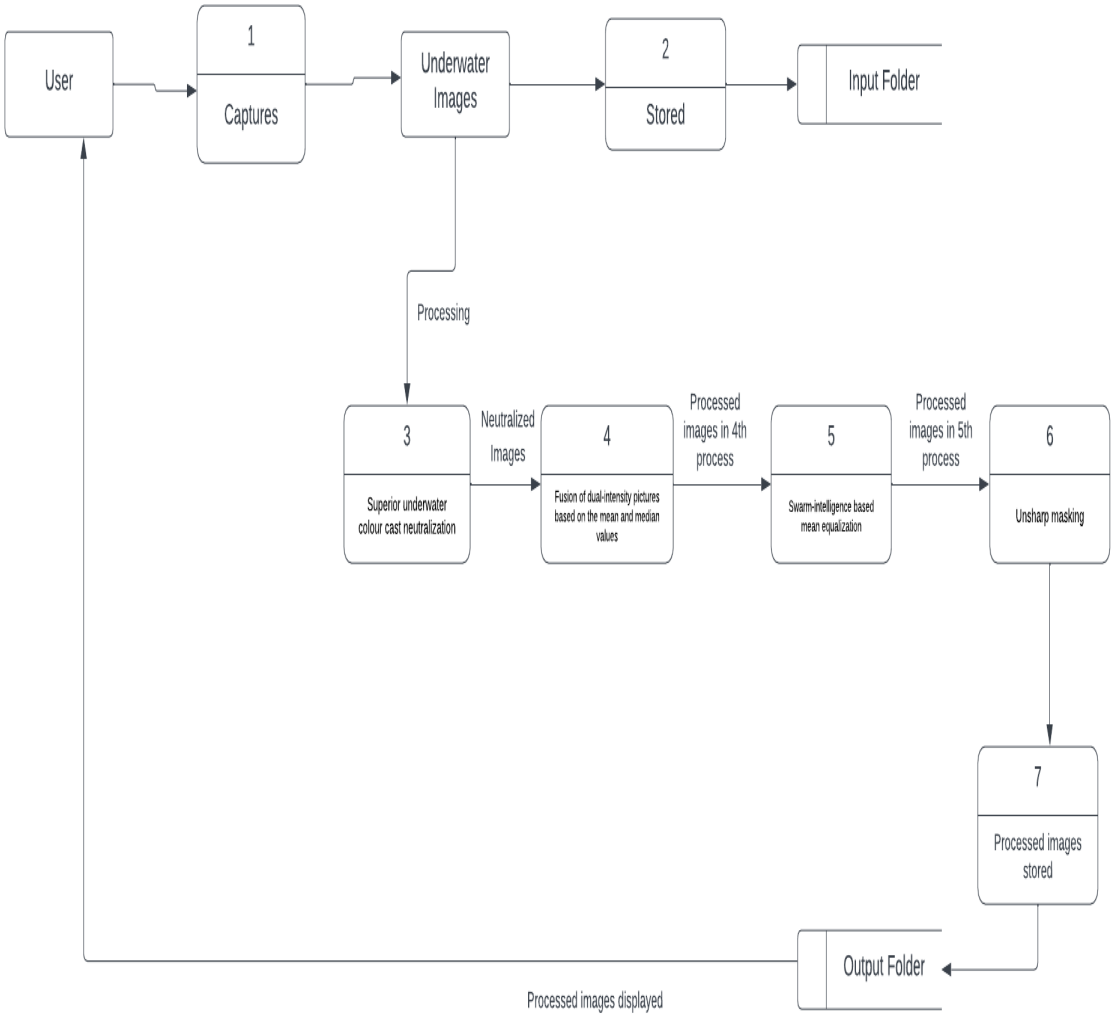

Figure 4.7: 1 Level DFD

4.3 UML Diagrams

Software industry uses some well-defined process model for developing software. This model is called Software Engineering Process(SEP) or Software Development Process (SDP). The unified Software Development Process (USDP) is a popular, widely used industry standard SDP. In short it is also called as Unified Process (UP). Unified Process co-exists with Unified Modelling Language (UML) which is a virtual language part of the system or project, UP addresses the process part of software development. UML is standard modeling language and notation for object oriented analysis and design. These notations are used to visualize the design of system and widely accepted among the software development organizations.

4.3.1 Use Case Diagram

Use case diagram represents the interaction of the user with the system. It is represented as a sequence of interaction between actor and the system.

Figure 4.8: Use Case Diagram

4.3.2 Sequence Diagram

Sequence Diagrams are used to show the interaction between objects when system becomes operational. The primary focus in a sequence diagram is the sequencing of events. Time runs top to bottom and events take place in the time line. The diagram contains a very unique element called the object lifeline and shows the object's interaction with other objects with respect to the object's lifeline. Instance lifeline is denoted by sketching the dashed line below the object instance. In a sequence diagram, the focus of control shifts from one object to another as one object activates the other. The entire line denotes the duration of instance over time.

Figure 4.9: Sequence Diagram

4.3.3 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 capture the user's perspective of the system. Activity diagrams do not explore system design or 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.

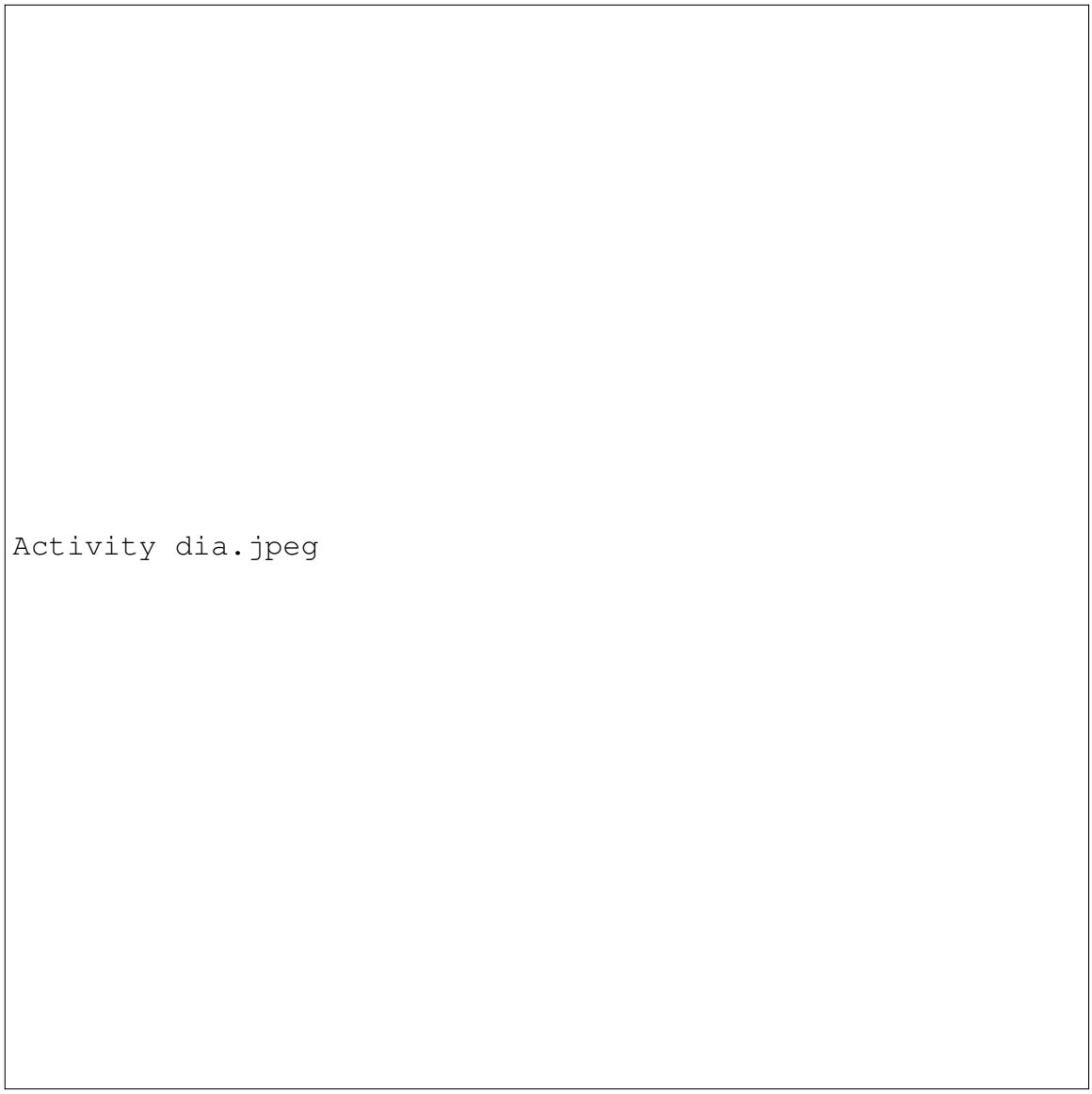

Figure 4.10: Activity Diagram

CHAPTER 5

5 Other Specification

5.1 Advantages

1) Our Proposed model will be a hardware-based model that Capture underwater images and improve the quality of degraded images under the water itself.
2) Model is focusing to reduce human efforts and time.

5.2 Limitations

1) Cost of hardware components. Model requires Raspberry pi and camera module which are expensive.
2) As model is placed under the water to capture images and so hardware components need to be protected from water and pressure.

5.3 Applications

1) Underwater Scuba divers to capture images of underwater bodies explore underwater environments such as lakes, rivers, quarries, kelp forests and coral reefs.
2) Underwater researchers perform submarine scientists need to examine objects on the seafloor over time

CHAPTER 6

6 Conclusion and Future Scope

6.1 Conclusion

According to the existing model we are planning to get one step ahead by deploying the existing approach directly on hardware component (raspberry Pi, Camera module) instead of correcting the image using software our proposed will directly correct the image underwater itself. Our model will capture underwater images and improve the quality of degraded image. The model focusses on improving the contrast and colour of underwater images using contrast stretching and auto white balance. Performs gamma correction operation to correct global contrast for white balancing the image. Also, applies sharpening technique to highlight fine details in an image and to enhances details that has been blurred due to low contrast and high scattering of light.

The results show that the proposed approach has the characteristics of white balancing, image sharpening, improved contrast, and natural appearance. This will result in clicking images underwater which is convinced 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 colour correction of an image.

6.2 Future Scope

As our project focuses on three main Image correction algorithm Color filter array, gamma correction and white balancing. But our project promises to use one algorithm at a time for image correction as per users requirement. User will be given freedom to choose algorithm to be implemented on the captured image. For the future reach of the project the model could be trained as it should implement all the three algorithms on the captured image to produce clear image and reduce human efforts.

Further model 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 and identifying names of underwater bodies of interest and exploring underwater world. And underwater clear video capturing feature should also be considered for future scope to make underwater film shooting a painless task.

APPENDIX A

Feasibility

1) Operational Feasibility

- Operational feasibility is a measure of how well a proposed system solves the identified problems, and takes advantage of the opportunities identified in the scope of research. The system should also satisfy the 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 implementation. 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 completion of a task. 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 only consists 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 there will be a demand for this product.

Problem Type

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

APPENDIX B

1. C. Li, S. Tang, H. K. Kwan, J. Yan and T. Zhou, "Color Correction Based on CFA and Enhancement Based on Retinex With Dense Pixels for Underwater Images," in IEEE Access, vol. 8, pp. 155732-155741, 2020, doi: 10.1109/ACCESS.2020.3019354.
In this paper, we propose an underwater image color correction method and an underwater image enhancement method based on the color filter array(CFA) and retinex theory.

2. H. Li, P. Zhuang, W. Wei and J. Li, "Underwater Image Enhancement Based on Dehazing and Color Correction," 2019 IEEE Intl Conf on Parallel Distributed Processing with Applications, Big Data Cloud Computing, Sustainable Computing Communications, Social Computing Networking (ISPA/BDCloud/SocialCom/SustainCom), 2019, pp. 1365-1370, doi: 10.1109/ISPABDCloud-SustainCom-SocialCom48970.2019.00196.
This paper has an improved approach for eliminating the local reddish effect and reducing image noise by using white balance(WB) algorithm and dark channel prior(DCP).

3. Yang, H., Tian, F., Qi, Q.,Wu, Q.M.J., Li, K.: Underwater image enhancement withlatent consistency learning-based color transfer. IETImage Process. 16, 1594–1612 (2022).
https://doi.org/10.1049/ipr2.12433.
In this paper, they propose a new underwater image enhancement strategy with learning-based color transfer. Unlike traditional deep learning-based enhancement approaches, they turn to learning the latent consistency between the given templates and the input raw image in order to pick out a proper template for color transfer.

4. Sarma, Kaushik Pandi, Vigneshwaran. (2022). Underwater Image Enhancement Using Deep Learning. 10.1007/978-3-030-84760-938.
The main objective of this paper is to improve the object quality using filters, image segmentation using wavelet filters, image classification using Deep Neural Network and underwater image detection using Deep Neural Network.

APPENDIX C: PLAGIARISM REPORT

- Page Count: 34
- Word Count: 5887
- Character Count: 43056
- Unique: 92.7 %
- Plagiarism: 7.3 %

REFERENCES

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