

UNDERWATER IMAGE PROCESSING USING MACHINE LEARNING

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in

Electronics and Telecommunication Engineering

by

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**DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION
ENGINEERING**

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INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Dhivya A (Reg.No.37250004)** who carried out the project entitled “ **UNDERWATER IMAGE PROCESSING USING MACHINE LEARNING** ” under my supervision from November 2020 to April 2021.

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ABSTRACT

The full-flavoured recovery of lost colours in underwater images remains a challenging task for every researcher. It was shown that this challenge was partly because of the widespread use of the atmospheric image formation model for underwater images and a physically accurate model was proposed. The revised model showed: 1) the signal's attenuation coefficient isn't uniform across the scene but it depends on object range and reflectance, 2) the coefficient which governs the increase in backscatter with distance known as backscatter coefficient differs from the signal attenuation coefficient. Here, the method that recovers colour with revised model, using RGBD images is presented. The Sea-thru method involves in the estimation of backscatter using the darkest pixels and their known range information. Then, the spatially varying illuminant is used to obtain the attenuation coefficient which is range-dependent. It is shown that this method with the revised model outperforms the models which were using the atmospheric model. The consistent removal of water will cause the opening up of large underwater datasets for creating technological development and creating exciting opportunities for exploration underwater and also for the conservation with the help of powerful computer vision and machine learning algorithms.

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LIST OF ABBREVIATIONS

RGB	Red-Green-Blue
RGBD	Red-Green-Blue-Depth
DCP	Data Collection Platform
3D	Three Dimension
RLSCD	Removing Light Source Color And Dehazing
PSF	Point Spread Function
CNN	Convolutional Neural Network
SFM	Structure From Motion
AI	Artificial Intelligence
IFM	Image Formation Model
AUV	Autonomous Underwater Vehicle
ROV	Remotely Operated Vehicle
OpenCV	Open Source Computer Vision Library
WPy64 - 3870	Winpython64 bit Portable OS
BSD	Berkely Software Distribution license

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CHAPTER 1

INTRODCUTION

Colour reconstruction in underwater images is a task which was challenging for which no widespread algorithm currently exists. It was recently shown that the commonly used image formation model was partly responsible , because it had been derived for the atmosphere and therefore the strong wavelength dependency of light underwater was neglected. A revised model has been proposed that shows: 1) direct signals and backscattered signals are governed by distinct coefficients (the old model assumed them to be the same), and 2) each of those coefficients has dependencies on factors aside from the optical properties of the water (the old model ignored them). The revised model is physically more accurate but it has extra parameters which makes the application difficult. Here, the method that outlines how to estimate the parameters for better scene recovery known as Sea thru method is presented.

1.1 MOTIVATION

Large image datasets like ImageNet have been instrumental in igniting the artificial intelligence boom, which fuelled many important discoveries in science and industry in the last two decades. The underwater domain, which has no shortage of large image datasets, however, has not benefited from the full power of computer vision and machine learning methods which made these discoveries possible, partly because water masks many computationally valuable features of a scene. A photo which is taken underwater is the equivalent of a photo which is taken in air, but it will be covered by thick, colored fog, subject to an illumination whose white point and intensity changes as a function of distance. For different optical conditions such as the global ocean, it will be very difficult and tedious to train the learning-based methods because calibrated underwater datasets are expensive and logistically difficult to acquire. The methods which are already existing tries to reverse the degradation of the images due to water but they may either be too sensitive and unstable or may work only for too short range images. Thus, the analysis of enormous underwater datasets typically needs pricey manual effort. On average, a human expert spends over 2 hours

identifying and counting fish in a video that is one hour long. The Sea-thru method aims to remove water from underwater images, so that the large underwater datasets can be analyzed with increased efficiency. It works on RGB-D image and estimates the backscatter coefficient from the tactic of Dark Channel prior (DCP) that was developed for haze, however utilizing the identified range map. Next, it uses an optimization framework to estimate the range-dependent attenuation coefficient using an illumination map obtained using local space average colour as input. It is shown that the distance-dependent attenuation coefficient can be modelled as a 2-term exponential, which greatly reduces the unknowns in the optimization step.

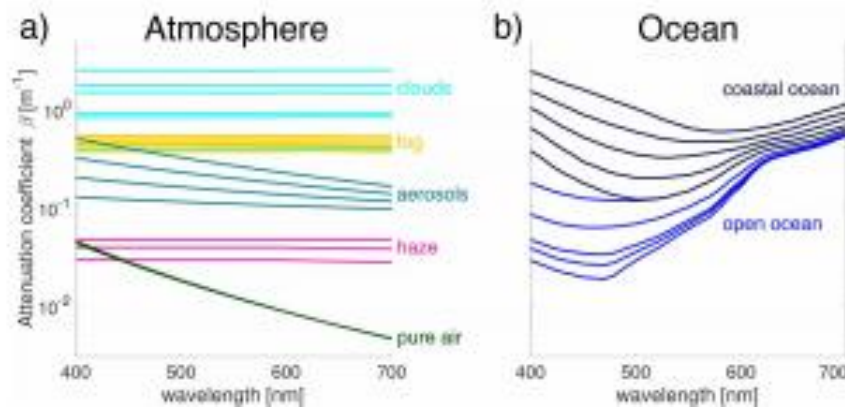


Figure 1.1 Attenuation coefficient in Atmosphere vs Ocean

The image formation model for bad weather was developed by Nayar and Narasimhan. It was assumed that the scattering coefficient is constant over the camera sensitivity range in each colour channel, resulting in a coefficient per wavelength. This model then became extensively used for bad weather, and later adapted for the underwater environment. For scene recovery, these methods required more than one frame of the scene, or extra information such as 3D structure. This model includes only one attenuation coefficient, which is uniform across all colour channels, as it is simplified in such a way. This was done to enable recovery from single images in haze and later used also for underwater recovery. While using the same coefficient for all colour channels in underwater scenes is a very crude approximation, using a coefficient per channel can yield decent results. Nevertheless, as we further show their accuracy is inherently limited by the model. Backscatter was previously estimated from single images

using DCP, some variants of it. Attenuation coefficients will be measured by ocean optics instruments like transmissiometers or spectrometers. However, they can't be used as-is for imaging due to variations in spectral sensitivity and acceptance angle. Plus, these instruments are high-priced and cumbersome to deploy.

1.2 RESEARCH SURVEY

It is best to calculate the attenuation coefficients straight from images. The most basic method for that is to photograph a calibration target at known distances. Coefficients are taken from the estimated veiling-light, ignoring the illumination color. In the attenuation coefficients per channel were calculated using the grey-world assumption. Others alleviate this problem by using fixed attenuation coefficients measured for just one water type. Known intervals slightly simplify the problem and were used to calculate backscatter combined with attenuation by attaching data from multiple images to the image formation model. Deep networks were recently used for reconstructing underwater scenes. Their coaching, however, depends on purely synthetic data, and thus highly depends on the quality of the simulation models. All the techniques so far presume the attenuation coefficients are only properties of the water and are constant across the scene per color channel, but as we showed, this is an incorrect assumption that results in errors in regeneration. Underwater images normally appear as green-blue because these color components are last absorbed. The occurrence of color absorption triggers the captured underwater images to have low color and contrast performance. Additionally, the key information from the image is also lost. To reinstate the contrast, color, and lost information from the pictures, the implementation of computer vision and image processing are acquiring importance.

1.3 UNDERWATER IMAGE DISTORTION

In this section we will see what the reasons that cause underwater image distortions are. When objects are measured in liquid, image distortion is triggered by the refraction of the light on the interface between the two mediums, air and liquid. A picture of the sea base observed through a rough surface is uncertainly distorted by the refraction of light. The two important reasons of underwater image

distortion are light scattering and color change effect. We will discuss these two reasons in this section.

First, Light scattering is a type of scattering in which light is the form of propagating energy which is scattered. When camera light incident on objects then it gets reflected and deflected multiple numbers of times by particles present in the water before reaching the camera, this process is known as a light scattering. This light scattering results in a low visibility and low contrast in the underwater image. Light scattering is dependent on the frequency or wavelength of the light which is being scattered. Forward scattering generally leads to blurring of the image and results into the low contrast of image. For the past several years, the attention of more and more scholars was attracted to the section of underwater images development and regeneration. Due to scattering and absorption, underwater pictures always suffer from the difficulties of low contrast, blur, and color distortion. So, underwater image regeneration and development has been a challenging area. High quality pictures are needed in many fields which use the underwater images to achieve some particular objectives, such as the tracking of underwater objects, 3D regeneration of underwater articles, underwater archaeology, underwater biological research, and sea floor exploration.

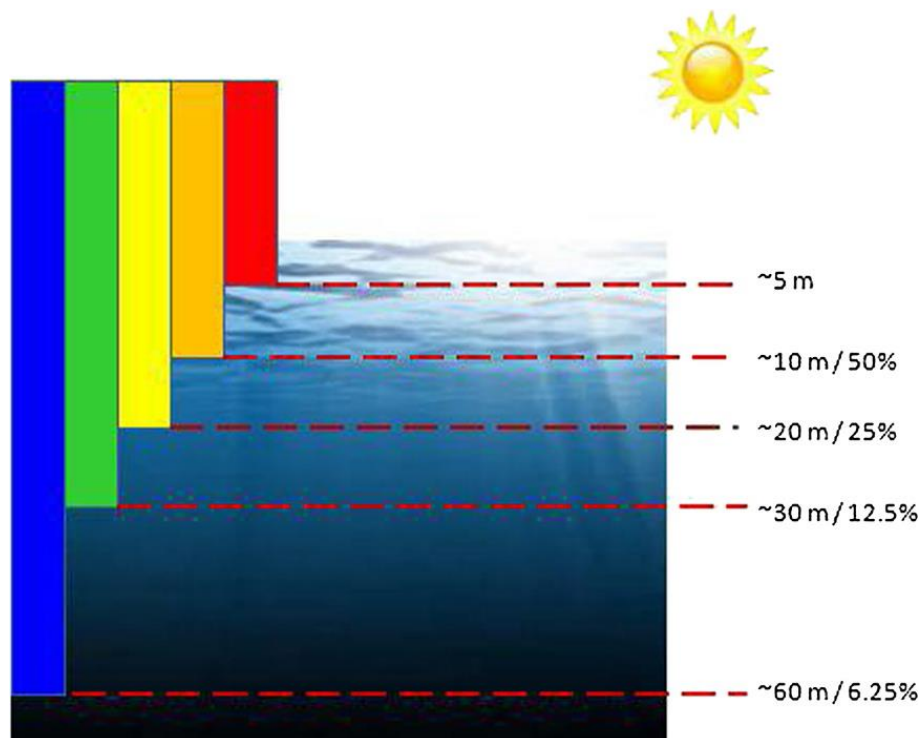


Figure 1.2 Visual illustration of diminishing underwater colour

For achieving high quality images, scholars projected various approaches which could be sorted into two categories. One is the image regeneration and the other one is image development. The image development technology does not take into account the physics model and it can upgrade the image quality by image processing techniques simply. The image regeneration technology is built on the physics model of image formation. Still this technology is not good at managing with the color distortion. Since the two technologies have their own merits and demerits, in this paper, we mixed the two technologies and gained satisfying results.

1.4 IMPORTANCE OF THE UNDERWATER IMAGE PROCESSING:

For the picture dehazing queries in atmosphere, some professors projected the method which needed several images obtained under different weathers to get the image without fog. Lately more and more researchers have started to focus on single image dehazing. Tan in dehazed images by maximizing the local contrast of restoration images. The outcome of this technique was satisfying, but the saturation suffered from over improvement. Fatah in used one single image to obtain a transmittance image and used this transmittance image to dehaze the image. He et al. in proposed the dark channel prior to acquire the transmittance image. He found that of the three channels (R/G/B) of images one without fog and sky areas normally had less intensity.

If sky or foggy areas existed in images, this occurrence would be invalid. He established this statistics occurrence and then proposed the dark channel prior in proposed one single image dehazing method by linear transformation. Put ahead only one image dehazing technique which makes use of the detailed prior information. For undersea habitat, by noticing the relationship between the blurring degree and the imaging distance, implemented the blurring technique to the imaging formation model and calculated the distance between the scene and the camera and then removed the fog.

Making use of the image fusion technique to eliminate the fog; up to now this technique may be the best method on visual perception. Taking into account the characteristics of underwater habitat they used the noteworthy variations of attenuation among various channels to calculate the depth of the scene. Galdran et al. introduced an automatic red channel underwater image restoration method, and this method could be regarded as the deformation of the dark channel prior method. Wen et al. used the blue and green channel without the red channel to redefine a new dark channel that fitted the underwater image. This moderately modified dark channel initial build method was successfully implemented to underwater images.

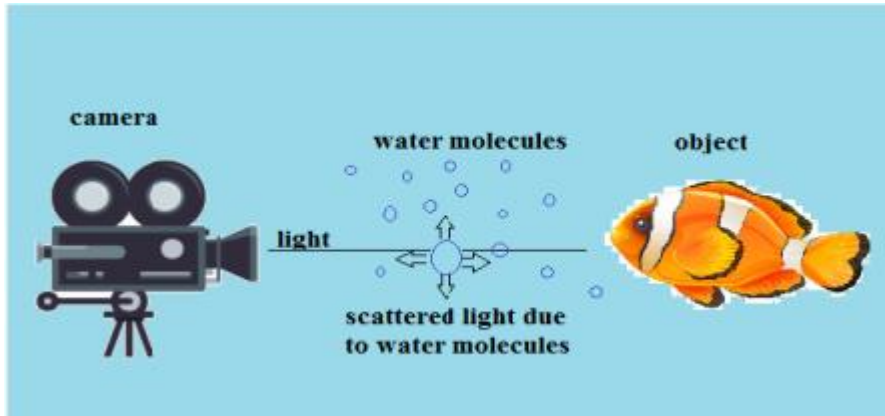


Figure 1.3 Underwater Imaging and Scattering of light

In this paper, we projected a new regeneration and improvement technique for underwater images. One brighter channel prior based technique that varies from the method projected in this manuscript has been reported in. In the bright channel prior, it seems to be the opposite of the dark channel prior in. Experiment outcomes showed that the projected method was of validity to all images of various scenes, and in a certain degree our method could rectify the color distortion. All parameters of different images were same in our experiment.

CHAPTER 2

LITERATURE SURVEY

Raimondo Schettini & Silvia Corchs(2010) have summarized that the underwater images suffer from one or more following problems such as non uniform lighting, blurring, bright artifacts, color diminished (bluish appearance), noise, low contrast and limited range visibility. Therefore, Underwater Imaging requires dealing first with these problems added in these standard computer vision techniques. Thus they have compared various Image Enhancement Image Restoration Techniques and Algorithms in a very detailed manner.

Jichang Guo and Chongyi Li Tianjin (2015) proposed an approach based on dehazing and color correction algorithms for underwater image enhancement. First, a simple dehazing algorithm is applied to remove the effects of haze in the underwater image. Second, color compensation, histogram equalization, saturation and intensity stretching are used to improve contrast, brightness, color and visibility of the underwater image.

Furthermore, bilateral filtering is utilized to address the problem of the noise caused by the physical properties of the medium and the histogram equalization algorithm. In order to evaluate the performance of the proposed approach, we compared our results with six existing methods using the subjective technique, objective technique and color cast tests. The results show that the proposed approach outperforms the six existing methods. The enhanced images, as a result of implementing the proposed approach, are characterized by relatively genuine color, increased contrast and brightness, reduced noise level, and better visibility.

Xiangyu Deng , Huigang Wang (2019) have proposed an underwater image enhancement method based on Removing Light Source Color and Dehazing(RLSCD). Scene depth is first estimated with minimum inverse red channel attenuation or the saturation attenuation among three color channels, to pick the farthest pixels correctly for the further estimation. The proposed background light based on gray open operation and scene depth, which is used to

alleviate the disturbance of the white objects and artificial lighting, can effectively increase contrast.

Simultaneously, the transmission map can also be estimated with scene depth for removing haze more completely. With the estimated background light and transmission map, the dehazed image is achievable. In contrast to the previous methods, which mainly focus on removing scattering effects, color loss and exposed light are also considered in our study. Then the dehazed image is applied to the Lambertian model to remove light source color attenuation to correct color distortion and light overcompensation. Extensive experiments demonstrate that the RLSCD method can produce better visibility and outperforms state-of-the-art methods in terms of relatively genuine color, natural visibility and improved brightness, which can be used for unveiling more details and valuable information.

Miao Yang , Jintong Hu¹, Chongyi Li⁴, Gustavo Rohde , Yixiang Du¹, Ke Hu¹, (2019) have discussed the existing methods for underwater image enhancement and restoration were introduced and the common problems in these methods were summarized. The effects of the typical underwater image enhancement and restoration methods on bluish, greenish, yellowish, offshore, and deep-sea images were compared, which provided a reference for the selection of most suitable method for underwater image enhancements under various cases. The various algorithms or Method discussed in this paper were as follows: (1) Point spread function (PSF) based restoration methods, (2) Jaffe-McGlamery model based restoration methods, (3) Turbulence degradation model based restoration methods, and (4) Image dehazing, (5) Filtering based methods, (6) Color correction based methods, (7) Image Fusion based method.

Poonguzhali E, Aravindhar S, Natesa Kumar V (2020) worked on a good technique to reinforce the pictures taken underwater and tarnished because of the medium scattering and immersion. It builds on the blending of two images that are directly derived from a color compensated and chromatic adapted version of the first degraded image. Image fusion methods supported NonSubsampled Contourlet Transform (NSCT) and perform alright for gray scale images. In this paper, a replacement method multi-focus image fusion is proposed that's suitable for color images using NSCT and Pulse Coupled Neural Network (PCNN).

Proposed justification also verifies that our algorithm is fairly autonomous of the camera settings, and progresses the accuracy of several image processing applications, like image segmentation and key point matching.

Various other techniques have also been implemented for underwater images to get the improved results which have been displayed in the following table:

Table 2.1 Comparison of various Underwater Image Processing Techniques

COMPARATIVE TABLE I				
YEAR	AUTHOR	TITLE	APPROACH	RESULT
2014	Pooja Sahu, Neelish Gupta ,Neetu Sharma	A Survey on Underwater Image Enhancement Techniques	RGB Color Level Stretching	Enhance the color contrast of the object in underwater and remove different noise particles
2013	Pulung Nurtantio, Andono, Ketut Eddy Purnama, Mochamad Hariadi	Underwater Image Enhancement Using Adaptive Filtering For Enhanced Sift-Based Image Matching	Adaptive Filtering For Enhanced Sift-Based Image Matching	success of SIFT increased by 41% compared to the reference method
2012	Chiang, J.Y.; Ying-Ching Chen	Underwater Image Enhancement by Wavelength Compensation and Dehazing	Wavelength Compensation and Dehazing	Dehazing and improvement in quality in deep water.
2011	Hung-Yu Yang; Pei-Yin Chen Chien-Chuan Huang; Ya-Zhu Zhuang; Yeu-Horng Shiau	Low Complexity Underwater Image Enhancement Based on Dark Channel Prior	Dark Channel Prior	Decrease in implementation time
2010	Dr.G.Padmavathi, Dr.P.Subashini, Mr.M.Muthu Kumar and Suresh Kumar Thakur	Comparison of Filters used for Underwater Image Pre-Processing	Filtering method	Enhance and smoothen the image

CHAPTER 3

SYSTEM DESIGN

3.1 EXISTING SYSTEM

Due to the importance of underwater exploration for the development and utilization of sea resources, underwater autonomous operation is more and more necessary to avoid the harmful high-pressure sea environment.

In an underwater setting, weak illumination and low-quality image development, as a pre-processing procedure, is important for underwater vision.

The following paper, a mix of max-RGB technique and shades of gray technique is applied to realize the development of underwater vision, and then a CNN (Convolutional Neural Network) technique for finding the feeble well-lighted issue for underwater pictures is proposed to coach the mapping relationship to get the illumination map.

After the processing of the image, a deep CNN technique is projected to perform the underwater detection and classification, in accordance with the characteristics of underwater vision, 2 improved schemes are applied to change the deep CNN structure.

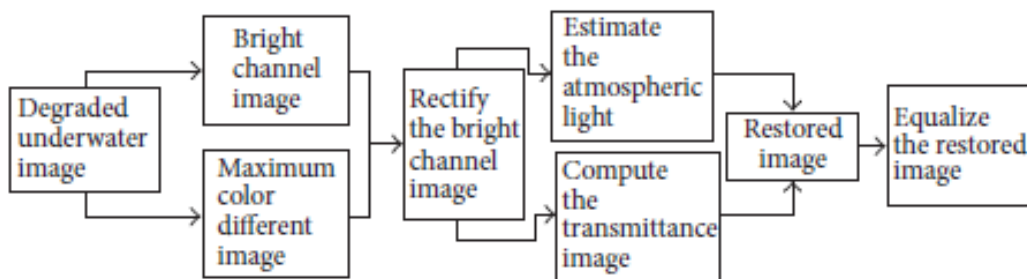


Figure 3.1 Existing System Block Diagram

3.1.1 BRIGHT CHANNEL IMAGE

The dark channel images in air are not the same as of underwater images. The Distant scenes or the sky areas in air have bright dark channel always, but this phenomenon is not valid for the underwater images which are of dark channel. To Conclude, for the underwater degraded image the dark channel prior failed to work.

With different wavelengths, the scattering effects of visible lights are normally the same, but the absorption effects in water and air are different. With the wavelength increasing in water, the absorption effect in water is stronger than the absorption effect in air, and it will become more serious. So the red channel intensity will be low in the whole picture and they are usually blue or green in the images captured in water; this leads to the problem that the dark channel image of degraded underwater image will not change with the imaging distance and the transmittance image is not related to the dark channel image.

The dark channel prior works for degraded images in air since the degraded image in air does not suffer from the problems of color distortion . In short, because of the low intensity of the red channel the dark channel prior fails to work in degraded underwater images

The bright channel images will always have higher intensity in case of the non degraded underwater images, while the bright channel intensity of the near scene is high in the degraded underwater images. Otherwise the bright channel in distant scene is low, particularly in the scenes of pure water areas. So it is supposed that the distant scenes and the bright channel intensity of the underwater images without pure water areas would be approximately equal to 1..

3.1.2 RECTIFYING THE BRIGHT CHANNEL IMAGE

It is found that the transmission that is obtained will be smaller than the real one, since in bright channel prior it is assumed that the non degraded image bright

channel will be approximately equal to 1. We rectify the bright channel image using the maximum color difference in order to increase the stability.

The Equation for rectification is,

$$\text{light}_{\text{correct}}(x) = \lambda * \text{light}(x) + (1 - \lambda) * \text{bgsubr}(x),$$

Where,

$\text{Light}_{\text{correct}}(x)$ - rectified bright channel image,

$\text{Light}(x) = \max_{y \in \Omega(x)}(\max_{c \in \{r, g, b\}} I_{\text{newc}}(y))$ - the non rectified bright channel image of the degraded underwater image,

$\text{bgsubr}(x)$ - the maximum color difference image and

λ is the proportional coefficient.

In this experiment it is found that the bright channel should be the major part in order to produce the rectified bright channel image and λ should be higher than 0.5

3.1.3 ESTIMATING ATMOSPHERIC LIGHT AND TRANSMITTANCE IMAGE

To produce the variance image (V), the gray image of the degraded underwater image. The Variance within a block which centers at this pixel point is computed for each pixel in the gray image. The Evenness of this block was shown by the variance of each pixel in one block. Following that in the bright channel the top one percent darkest pixels is picked out. These pixels are generally most haze opaque. The Pixel with the lower value in the variance image V is been selected among these pixels as the atmospheric light. The Initial transmittance image of each color channel is computed, after obtaining the atmospheric light and rectified bright channel image.

3.1.4 RESTORATION AND EQUALISATION OF RESTORED IMAGES

The Average Intensity value is computed for each channel; then the three means are multiplied with the three coefficients ($\lambda_1, \lambda_2, \lambda_3$) the three coefficients may or may not be the same. Now the three products are compared with 255. And the smaller one is chosen as the specific value. As a result the histogram

equalization method is obtained on the restoration images. On rectifying the color distortion it is seen that the effect of histogram equalization is obvious.

3.2 PROBLEM STATEMENT

Existing techniques that try to restore lost colors and contrast perform poorly and, eventually, the analysis of most underwater imagery requires expensive manual effort that affects the pace at which marine science proceeds forward.

Huge underwater image datasets are produced every day that capture necessary information regarding the state of our oceans, but they cannot be profitably analyzed with powerful computer vision and machine learning algorithms because water degrades pictures too severely for automated analysis

3.3 PROPOSED SYSTEM:

Sea-thru eliminates the visual deformation that occurs as light travels through the water to produce a color-exact image. And the outcomes are not only remarkable but also a physically accurate rectification.

Sea-thru's image analysis components in the physics of light absorption and scattering in the air, compared to the ocean, where the particles that light communicates with are much larger. Then the algorithm effectively reverses image deformation from water pixel by pixel, restoring vanished colours.

The cause for the blue-green tint in underwater images is the way by which light travels through deep water, where blue and violet wavelengths are sucked up least compared to the other wavelengths.

Sea-thru's image analysis components in the physics of light absorption and scattering in the air, compared to the ocean, where the particles that light communicates with are much larger.

Then the image distortion from water pixel by pixel is reversed by the program effectively, by restoring the lost colors.

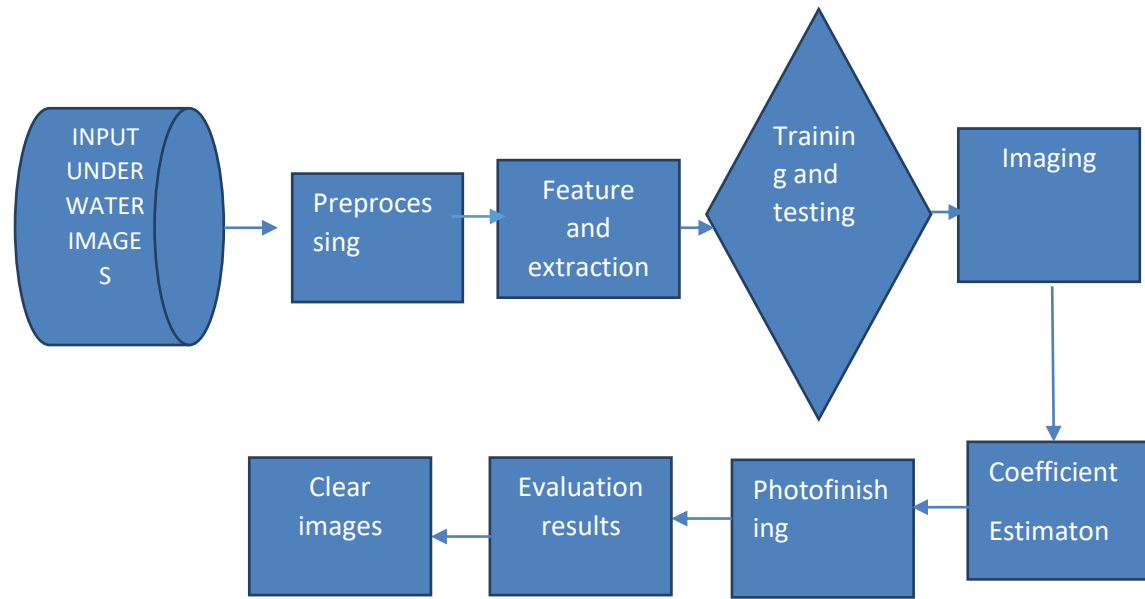


Figure 3.2 Block diagram of proposed Algorithm

3.3.1 ALGORITHM DESCRIPTION

Sea-thru works on underdone pictures or videos taken with natural lighting, eliminating the necessity for costly and difficult to set-up artificial underwater lighting. It also helps in regenerating images of objects that are further away from the light source, where the underwater strobes do not reach.

Underwater RGB-D images are reconstructed using the computer vision algorithm which is a physics-based color reconstruction algorithm specially designed for underwater RGB-D images, where D stands for the distance between the camera and the object.

The distance between every pixel in the scene from the camera is required by the sea-thru algorithm, as more or less all parameters which govern loss of colors and contrast depend on distance in little non-linear way.

For her research purpose, Akkaynak created a distance (range) map by capturing different images of the same scene. She captured the pictures with only one camera from slightly different angles so that all of them overlap.

A color chart placed by the object of interest is included in the image. Then, a commercial photogrammetric software which is called as AgisoftMetashape Professional is used and with that the 3D reconstruction of each scene from these

images is built by the Sea-thru and the distance maps were exported on the completion of 3D reconstruction.

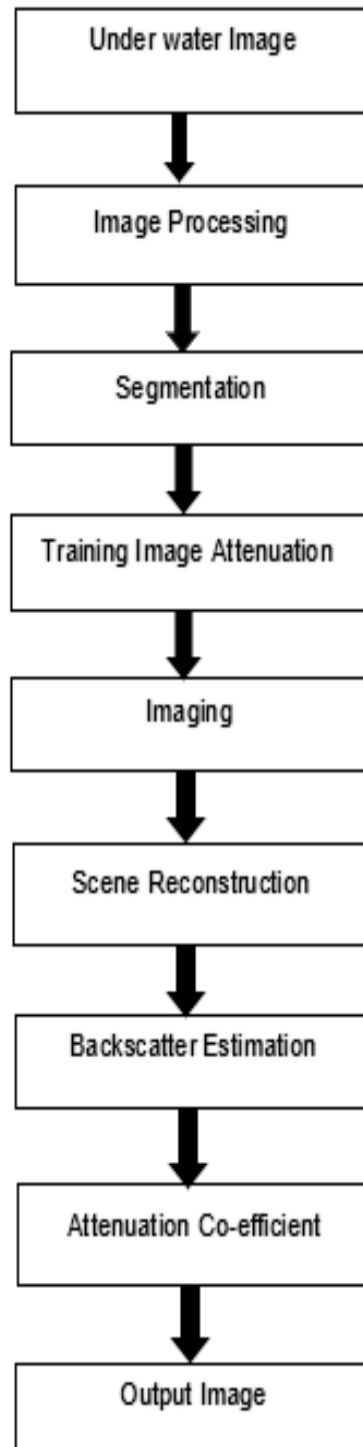


Figure 3.3 Flow diagram of proposed Algorithm

3.3.2 UNDERWATER IMAGES AND THE PARAMETERS INVOLVED

The Backscatter is estimated in a inspired way from the DCP (Dark Channel Prior) developed from haze, from the given RGBD image, but the range map is utilized. Following that an optimization framework is used in order to estimate the range-dependent attenuation coefficient by using the local space average color as an input. It is shown that the distance-dependent coefficient can be of two-term exponential in which the unknowns in optimization step is greatly reduced.

Underwater image formation is governed by:

$$I_c = D_c + B_c, \text{ -----} > (1) \text{ where}$$

- $c = R, G, B$ - the color channel,
- I_c - the image captured by the camera (with distorted colors),
- D_c - the direct signal which contains the information about the (attenuated) scene, and
- B_c - the backscatter, It is an additive signal that degrades the image due to light reflected due to the suspended particles in the water column

The expanded form of Eq. 1 is given as [1]:

$$I_c = J_c e^{-\beta_c^D(\mathbf{v}_D) \cdot z} + B_c^\infty \left(1 - e^{-\beta_c^B(\mathbf{v}_B) \cdot z} \right),$$

- z_i - range (distance) between the camera and the objects in the scene along the line of sight,
- B_c^∞ - veiling light, and
- J_c - the unattenuated scene that would be captured at the location of the camera had there been no attenuation along z .

Vectors $vD = \{z, \rho, E, Sc, \beta\}$ and $vB = \{E, Sc, b, \beta\}$,represents the dependencies of the coefficients β_{cD} and β_{cB} on

- range z ,
- reflectance ρ ,
- spectrum of ambient light E ,
- spectral response of the camera Sc , and
- The beam attenuation coefficients and the physical scattering of the water body, b and β , all of which are functions of wavelength λ .

The components D_c and B_c are governed by these two distinct coefficients β_{cD} and β_{cB} , which are wideband (RGB) attenuation and backscatter coefficients, respectively.

3.3.3 FEATURE EXTRACTION AND TRAINING

λ denotes the proportional coefficient. In this experiments, to produce the rectified bright channel image the bright channel should be the main part, and λ should be higher than 0.5; at the same time, It is found that could satisfy this requirement, so

λ is captured as follows:

$$\lambda = \max (\max (S)) ,$$

where,

S - the saturation channel image of the degraded underwater image in HSV color space.

The first max operation means the maximum value of each column is picked out for the saturation image, and the second max operation means, the maximum value is computed for these maximum values picked out.

If the potency value of one pixel in one of the three color channels is different from the atmospheric light in this channel , then the difference will become maximum. This can enlarge the contrast of the image, but it can also lead some questions. In the maximum color channel, if the potency of one point is

larger than the atmospheric light value, the potency of this point will become much larger (this makes the color distortion problem more serious). In the minimum color channel, if the potency value of one pixel point is lesser than the atmospheric light value, the potency of this point will become much smaller (this brings to the losing of some detailed information in low potency district). So the pixel points whose potency values are lesser than the atmospheric light are computed by using in the maximum color channel. The pixel point whose potency value is larger than the atmospheric light is computed by using in the less color channel.

3.3.4 COEFFICIENTS ESTIMATION:

When the Backscatter and attenuation is placed between the camera and the chart both are neglect fullness since the distance z between the chart and the camera was small, yielding $I_c \rightarrow J_c$. In this, the color loss is due to the effective attenuation coefficient happening in the vertical distance d from the sea surface, and is captured in the white point of ambient light W_c at each depth.

Now the search for the darkest RGB triplets apart from that finding the darkest pixels independently in each color channel and we do not form a dark channel image. Our method identifying the number of unconnected pixels are sufficient, because the corresponding range information is available, and a physical model of how B_c behaves with z .

3.3.5 ADVANTAGES:

A new technique for defogging underwater under-exposure images is projected, which is better than the latest method for defogging and keeps edge details.

- The algorithm implemented in this paper is simple and the computational efficiency is higher than other methods.
- The main focus of underwater image processing is on the dehazing, denoising, and enhancement of color and edge details.

3.3.6 APPLICATIONS

- Marine systems
- Underwater autonomous vehicle based application
- Research peoples
- Unmanned underwater vehicle systems

CHAPTER 4

ALGORITHM DESCRIPTION

4.1 METHODOLOGY:

The Proposed Algorithm involves the following steps to accomplish the task of providing the enhanced underwater images without much loss of information.

- Imaging
- Scene Reconstruction
- Backscatter Estimation
- Attenuation Coefficient Estimation
- Photofinishing

4.1.1 IMAGING:

We require having a range map of the scene, which we obtain, using structure-from motion (SFM), commonly used underwater to measure structural complexity and in archaeology.

As our method requires absolute value of z , we are placing objects of known sizes in this scene but the SFM only provides range only up to scale. Their Navigation sensors can provide altitude or velocity when imaging from the underwater vehicles.

An alternative is stereo imaging which requires the use of two synchronized cameras, and a straightforward in-water calibration before imaging survey begins.

Sea-thru is a new AI algorithm which helps to revolutionize the world of underwater photography. It was developed by oceanographer and AI engineer Derya Akkaynak, This algorithm can able to remove the visual distortion caused by water, creating crisper and clearer photographs.

4.1.2 SCENE RECONSTRUCTION

In Underwater images since the light is scattered and absorbed they often suffer from low contrast and color distortion. They can be shot in various lightning

conditions since the images are with different color tones making the enhancement and restoration difficult.

Based on the image light absorption and blurriness a depth estimation method for underwater scenes has been proposed, that can be used in the Image Formation Model (IFM) to enhance and restore the underwater images. Due to lightning conditions in underwater images they are frequently invalidated leading to the poor restoration results.

Underwater scene depth is been estimated more accurately in this proposed method. The Experimental results on restoring synthesized and real underwater images shows that the proposed method outperforms other IFM based restoration methods of the underwater image.

The Challenging problem in underwater photography is - the colors are distorted. The Sea-thru method of color correction performs to "remove the water" to reveal images with all the saturation, inherent vibrancy and color restore.

The Photographs taken under seawater is difficult correcting its color because the coefficients to be tweaked have dependencies on factors other than the optical properties of the seawater. The Water masks many computational valuable features of scene and so it hinders the application of computer vision and machine learning methods to the underwater image datasets respectively.

Sea-thru utilizes the image analysis features which are been stored in order to filter out the scattering and light absorption that occurs in the atmosphere of the ocean. The Software used is capable of effectively removing the image distortion on pixel-by-pixel basis, reversing the washed out appearance and restoring the color of photographs. It is a big deal for the marine biologists and other scientists interested in the studies of ocean, as it will make easier for them to engage in tasks, such as classification of the species and counting in the underwater images. The Possibility that Coral Scientist could use computer vision and Machine Learning in the identification process is opened up by Sea-thru respectively.

There are still some of the logistic issues which Sea-thru must overcome, though. For instance, the software needs distance information in order to work and in order to collect sufficient information for Sea-thru to work the magic, the

developers have to take many number of photographs of the same scene from various angles. But this can be overcome by the process of Photogrammetric in which the ocean scientists who already catch the distance information on a regular interval of time. Akkaynak has started a program which seems to be circumnavigating some of these logistic issues by working perfectly and adequately with such photographs.

4.1.3 BACKSCATTER ESTIMATION

Backscatter is the reflection of light waves bouncing on particles in the water and going into the camera, considering the underwater environment deflecting them from their original direction. It illuminates these water particles and can frequently obstruct the object.

- Sea-thru's image analysis factor with the physics of scattering and light absorption in the atmosphere, compared with that in the ocean, where the particles that light interacts with them are much larger.
- Then the program effectively reverses image distortion from water pixel by Backscatter estimation, pixel, restoring lost colors.

It uses an estimate of the spatially varying illuminant calculated in the training phase of the model to obtain the underwater range-dependent attenuation coefficient. To find the backscatter value and reverse it, start partitioning the range map into 10 clusters covering all the possible values of z (distance), estimated previously. Using the captured image and known distance of the object, find the perfect z correlation.

Based on the underwater image formation model an algorithm was been proposed and validated. Sea-thru algorithm will successfully remove water from underwater images in an objective, repeatable and rapid way, creating exciting opportunities for the future of underwater conservation and exploration.

4.1.4 ATTENUATION COEFFICIENT ESTIMATION:

We proposed a revised model that showed:

- 1) Back scattered and direct signals are governed by the distinct coefficients (Assuming the same for old model),
- 2) Each of these coefficients have dependencies on these factors other than the optical properties of the water (the old model ignored them). It has extra parameters making its application difficult, while the revised model is physically more accurate.

Here, Sea-thru method is presented that outlines how to estimate these parameters for better scene retrieval. Initially the footage is cleaned up then fed to the machine learning algorithm, which will help to pick out the little nuances, ticks and motions of the cichlid's behaviour. By this awesome pattern finding ability, the algorithm can then help Jordan better understand what's happening in cichlid's social lives. Machine learning requires consistent, clean data to learn from — which underwater images are not. If it is needed, algorithm to track this fish and not that fish, the water conditions can make it difficult. Say the underwater images one day are of a black and white fish in a brown world; the algorithm will learn that. Then on the following day an algae bloom hits and the fish is now green and gray in a yellow world! Respectively.

The data is been standardized by Sea-thru and eliminates the water conditions that make underwater images and humans to analyze difficult for algorithms. Not only are the Marine Biologists the only researchers who need their underwater images clear as day. Archaeologists relying on the underwater photography to document and research important findings, and use video to survey and capture shipwrecks, artifacts, and other remnants of humanity which are scattered under the sea.

4.1.5 PHOTOFINISHING

The camera pipeline manipulation is used in the platform described in to convert Sea-thru algorithm outputs to a standard color space, following that it is been inserted into the pipeline before the Step 6 and an identity matrix for white

balance is specified. Although some of the reviews of underwater image restoration and enhancement have been published, these tend to only concentrate on the certain aspects of underwater processing. For instance, Kaeli et al. Focused on algorithms color correction of underwater image; Sahu et al. introduced limited underwater image enhancement methods. Lu et al. and Han et al. reviewed more aspects of underwater optical processing, including underwater image restoration, underwater image de-scattering, underwater image quality assessments, and future trends and challenges in processing and designing underwater images.

Nonetheless, most of the issues are not totally addressed: 1) The existing classifications are not complete, and miss the very latest improvements based (for instance) on deep learning; 2) Specific method leads to improving image quality while it remains unclear the extent and how. In this project, the above problems are been addressed, providing a broader review, an experimental-based comparison of key methods, and providing an up-to-date pictures of future directions and challenges. Only the quality improvement algorithm for single underwater image focused is to be marked.

The Contributions to the study of quality development of underwater images are multi-fold: (1) the quality improvement methods of underwater images are categorized into two broad classes: IFM-free image enhancement methods and IFM-based image restoration methods, from the perspective that these increase image quality either through the optical imaging physical model or not. The categories of the reviewed methods are shown, which will help better understanding which models are suited best for which problem domain. (2) On some representative algorithms from both IFM-based and IFM-free categories experimental based comparisons are carried out by providing different quality metrics based evaluation. Single Underwater image quality improvement categories. (3) The Issues that raises in estimating the parameters of Image restoration were revealed for which a critical evaluation of Image restoration methods based on out prior knowledge. (4) The Lessons learnt are shared in this area, revealing the problems and latent difficulties faced in the improvement of underwater image quality.

4.2 OVERCOMING THE OBSTACLES:

A Modified version of DCP was been proposed by Akkaynak and Treibitz which takes backscatter and absorption in account from the water. Anyhow the formulas to do this are needed to known distance as input variable and it is impractical expecting users to take such measurements for each picture. Luckily Photogrammetric experts have developed techniques already to deal with this problem. For instance, the distance can be derived by scaling if the size of the object is known.

Using Videogrammetry the potential for a more elegant solution is presented in the Muli-lens cameras, which are in the modern smartphones. The Depth can be measured by using the same distance between the cameras and taking pictures of same image in two or more angles. These measurements and calculation making in real time capability are already available in the phone. The Potential to revolutionize the Computer Vision for Videography and Underwater photography is the end result produced.

4.2.1 BACKSCATTERING

The Increased light will be more blinding than helpful when the high-beams are turned on while driving in dense fog. This happens due to reflection of more light back because of the water particles. The Similar phenomenon happens in case of capturing images underwater, thus it skews the color accuracy of the captured scenes. Backscatter intensity increases if the distance from the focal object increases.

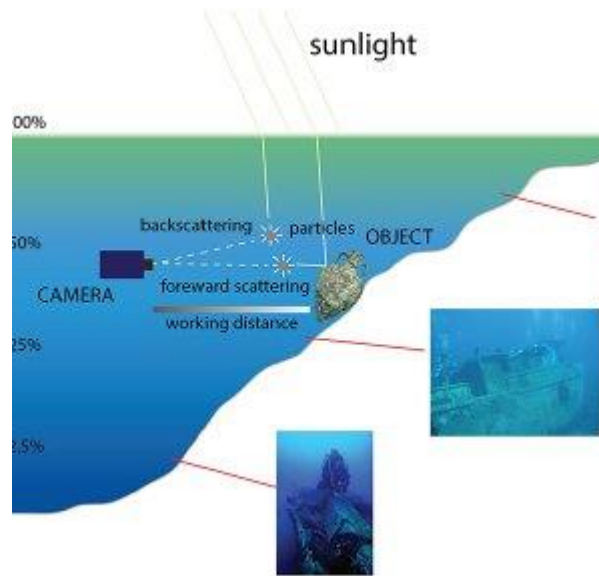


Figure 4.1 Backscattering

4.2.2 ILLUMINATION

In air, light comes from the entire hemisphere on the cloudy days, and it is dominated by the sun. Whereas for the water the lightning comes from a finite cone above the scene. This phenomenon is called Snell's window.

4.2.3 LIGHT ATTENUATION

Opposite to the air, water attenuates the light exponentially. As a result it produces very low contrast images called hazy images. Light absorption and light scattering are the main reasons for light attenuation (Energy is removed from light here), Due to which the direction of light is changed. Further, Light scattering can be categorized into forward scattering which will result in backward scattering and increased blurriness that limits the contrast and is responsible for the characteristic veil of the underwater images. By the amount of organic matter dissolved in the water both scattering and attenuation are heavily influenced.

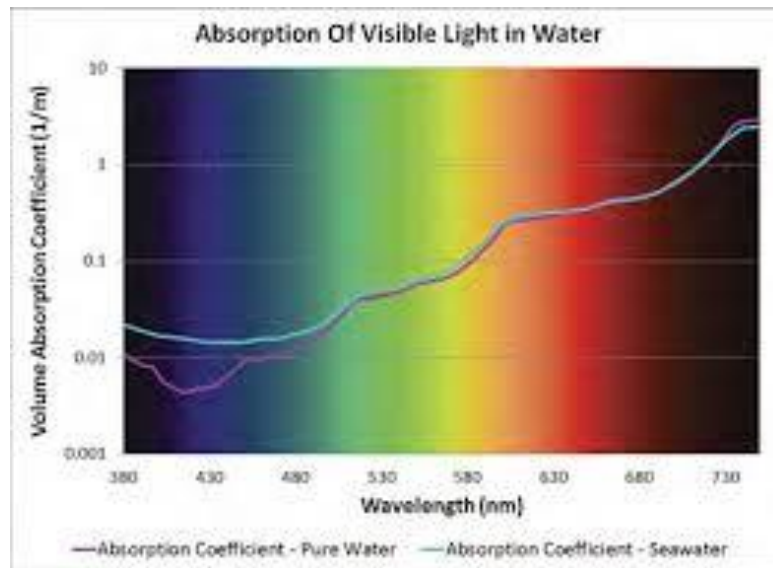


Figure 4.2 Absorption of Visible Light in Water

Light attenuation, a function of wavelength is the problem with water. This means by leading to color degradation the different color get attenuated faster than others. Orange and Red light are the first ones to be attenuated, followed by greens and yellows. Less attenuated wavelength is Blue.

4.3 CHALLENGES:

Human structures are mostly used as image features for matching of image in various applications in the high level computer vision. Making it difficult to find the correspondences in two images, the sea lacks such kind of features.

A watertight housing is required in order to be able to use a camera in the water. Anyhow refraction will take place in the water-glass and glass-air interface due to the differences in the density of the materials. As a result it introduces an effect of non-linear deformation.

Another special challenge is the motion of vehicles. Due to currents and phenomena the underwater vehicles will move constantly. Thus introducing another uncertainty to the algorithms, in which small motions appear in all directions. In Video tracking this is especially important. Image stabilization algorithms may be applied in order to reduce this problem.

4.4 FREQUENT METHODS:

4.4.1 IMAGE RESTORATION

Modelling the degradation process and then inverting it, then obtaining new image after solving is the aim of Image restoration. It requires plenty of parameters varying between different water conditions which has a general complex approach.

4.4.2 IMAGE ENHANCEMENT

Without taking the Physical image formation process the enhancement of the image on the opposite will only try to provide a visually more appealing image. These methods are usually less computational intensive and simple.

4.4.3 COLOR CORRECTION

For performing automatic color correction there exists different algorithms. The Unsupervised Color Correction, For instance it will do the upcoming steps: Initially by equalizing the colour values it reduces the color cast. Following that it improves the contrast by stretching the red histogram of the image towards the maximum and at the end Intensity and Saturation components are been optimized.

4.4.4 UNDERWATER STEREO VISION

Generally it is assumed that stereo camera are been calibrated previously by radio metrically and geometrically. This further leads to an assumption of corresponding pixels should have same color respectively. Because of Backscatter and Dispersion this cannot be guaranteed in an underwater scene as mentioned earlier. However there is possibility for modelling this phenomenon and a virtual image can be created with those effects removed.

4.5 OTHER APPLICATION FIELDS:

Imaging Sonars have become more accessible and gained resolution as a result of delivering better images. Complete Maps of regions of the sea floor which stitches together the sequences of Sonar images. Due to noise, attitude changes of the AUV/ROV carrying the sonar or non uniform beam patterns the sonar images are degraded by artefacts and distortions and also often lack proper

contrast. Comparatively low frame rate of those sonar images is the common problem with sonar computer vision.

CHAPTER 5

SOFTWARE DESIGN

Python Version:

WPy64-3870 - Win python 64bit portableOS:

OS

Windows10

Additional Packages:

numpy

scipy

OpenCV-python

tqdm

5.1 PYTHON

Python programming language is a high-level programming language which is widely used for general purpose. Its design philosophy improves the code readability, and the syntax allows Users to express their concept in fewer lines of code than would also be possible in other languages like C++ or Java. For both small and large scale this language provides constructs intended to enable clear programs respectively.

Python programming language supports multiple programming paradigms, which includes object-oriented, imperative and procedural styles or functional programming. It is having a standard large and comprehensive library which is featured with dynamic tape system.

For the installation on many operating systems python interpreters are available, which allows Python code to execute on a wide variety of system. Using third-party tools, such as Py2exe or Pyinstaller, The Codes can be packaged into stand-alone executable programs for operating systems which are most popular, and allows for the distribution of Python-based software to use on those environments which does not require a python interpreter for installation.

CPython which is a python reference implementation, is a free and open-source software and also it has a community-based development model, as they all of the nearly alternative Implementations. It is been managed by the Python Software Foundation which is a non profit one.

The exact syntax and semantics of the Python language were described by the python language reference, the standard library that is distributed with Python is manually described by the library reference and also Optional components are described by them which are commonly included in the python distributions. The Python's standard library offers a wide range of facilities which is very extensive. It provides access to system functionality like file input or output that would otherwise be not accessible to Python users, as well as modules written in Python that provide standardized solutions for many problems that occur in everyday programming as it contains built-in modules (Written in C program).



Figure 5.1 Python

To encourage and enhance the portability of Python programs by abstracting away platform-specifics into platform-neutral APIs, some of these modules are explicitly designed. The Installers of python for the Windows platform usually consists of the entire standard library and often also includes many additional components. It may be necessary to use the packaging tools provided with operating system to obtain some or all of the optional components since Unix-like operating systems python will be normally provided as collection of packages. There is a growing collection of several thousand components in addition to the standard library, available from the python package index for the individual

programs and modules to packages and for the development of entire applications and frameworks.

5.2 ADDITIONAL PACKAGES:

5.2.1 NUMPY

Numpy is a Python library which is a general purpose array-processing package that provides a simple yet a powerful data structure that is n-dimensional array. This package provides a multidimensional array object and tools for working with these arrays. It is the fundamental package for scientific computing with Python.

5.2.2 SCIPY

Scipy is a scientific library and an open source python library which is used to solve scientific and mathematical problem. It is a BSD-licensed library for mathematics, science and engineering. The Scipy library is built on NumPy extension and allows the user to manipulate and visualize data with a wide range of high-level commands.

5.2.3 OpenCV-PYTHON

OpenCV-Python is a library of Python bindings designed to solve computer vision problems. It is used for all sorts of image and video analysis. It is a highly optimized library for numerical operations with a MATLAB-style syntax. All the OpenCV array structure is converted to and from Numpy arrays.



Figure 5.2 OpenCV

5.2.4 TQDM

Tqdm package is one of the more comprehensive package for progress bars with python and is handy for those instances it is needed to build scripts that keep the users informed on the status of the application.

CHAPTER 6

RESULT AND DISCUSSIONS

6.1 EXPERIMENTAL RESULTS

The method proposed in this paper systematically illustrates how to transform an underwater image full of noise, underwater fog and dim light into a high-quality image that can be clearly read by people from two aspects of image restoration and enhancement.

Among them, it is better than other methods in defogging underwater under-exposure images, enhancing image color, maintaining and enhancing local edge details.

Sea-thru is an important step towards opening up huge underwater datasets to powerful computer vision and machine learning algorithms, and will help boost underwater research at a time when our oceans are increasing pressure from pollution, overfishing, and climate change.

The following images are the sample input and output Underwater Images which has been enhanced by the proposed algorithm.



Figure 6.1 Sample Input - 1



Figure 6.2 Sample Output - 1



Figure 4.3 Sample Input - 2



Figure 4.4 Sample Output - 2



Figure 6.5 Sample Input - 3

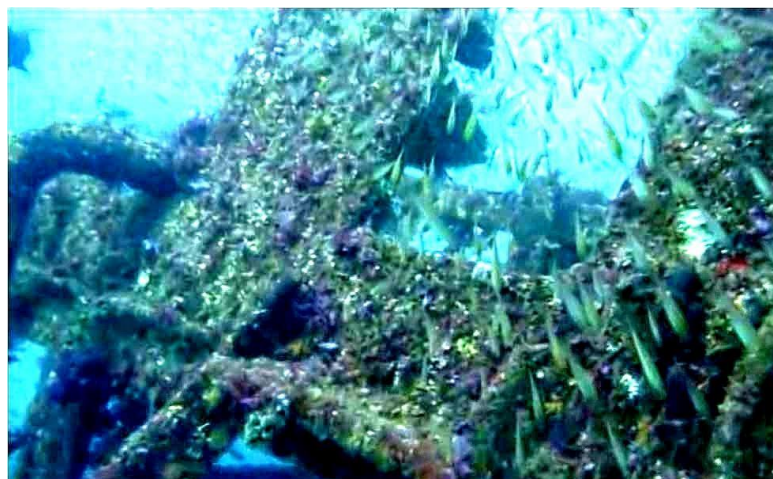


Figure 6.6 Sample Output - 3

It is very difficult to assess the performance of an underwater image restoration algorithm, since there is no ground truth or uniform measure standard available. The visual results of the Proposed system has been provided and the comparison is made in terms of the speed of getting the results and the memory of data being used.

The datasets of the images and depth map being used in the existing methods are occupying much memory and most of the systems are less compatible to compute the results and also the time taken to compute the result will be too long in most of the systems. Thus the proposed system will be able to produce the results in a less time and the memory used will be also be very less compared to the existing datasets.

CHAPTER 7

CONCLUSION AND FUTIRE WORK

7.1 CONCLUSION

Thus the major problem in the underwater image processing, which is the low value of contrast is being corrected. The contrast correction for normal atmospheric images can be done in a simpler way but it is too difficult to correct the contrast of the underwater images which is being achieved by this method without much loss of information. The time and memory is also managed in computing the output with less loss of information.

7.2 FUTURE ENHANCEMENT

Gaining its strength or power from an image formation model derived for the ocean, Sea-thru offers a glimpse into the underwater world without skewed colors.

We concentrated on retrieving the z-dependency as it is the most important, but in the future plan to also retrieve the p-dependency to improve rectification. As retrieving these intricate dependencies is extremely challenging, deep nets should perform better than the calculation techniques we used.

Given that ground-truth cannot be gained for this habitat their coaching has to be conducted with cautiously designed simulations based on the correct image formation models. Attentive simulations can also help with an additional challenge that arose in this work; the evaluation of outcomes.

The limitation of loss of information can also be reduced in the future algorithms and also a standard for comparing the results of the output images of various techniques can also be introduced in the future.

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