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Utilizing Optimized Fusion to improve underwater Image quality.

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ABSTRACT

Owing to light beam scattering and attenuation, underwater images usually lack contrast and suffer from color distortion. The presence of suspended particles in water, both organic and inorganic, causes light scattering, which reflects and deflects light in an unpredictable manner until it reaches the sensor, resulting in a low-contrast image. Water absorbs light readily as a medium, and different wavelengths of light absorb at different rates. Furthermore, the longer wavelength is absorbed first, resulting in a dominant green-bluish sound in the underwater world. The loss of underwater images is caused by light scattering and absorption, which is an atmospheric phenomenon. Here, we explain a fusion-based method for enhancing the visibility of underwater images. One hazy image to produce the contrast enhanced and color corrected versions of the original image. By applying weight maps to each of the derived inputs, it also eliminates distortion and improves the visibility of distant objects in the picture. To merge the inputs and weight maps, we used a multi-scale fusion technique, ensuring that each fused image contributes the most significant attribute to the final image. Here new approach is easy to follow and enhances the accuracy and visibility of hazy underwater images.

Keywords *— Image Denoising, Image Improvement, Underwater Image Restoration*

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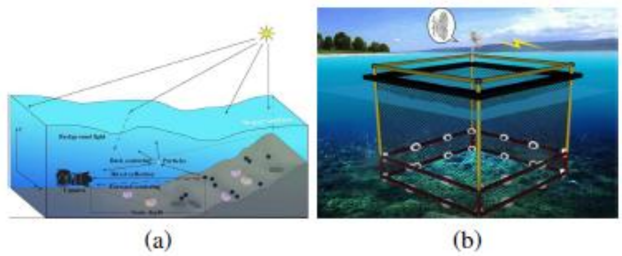
I. INTRODUCTION

For Underwater photography we have major two steps to considered, the first step in creating low contrast and haze-like effects is for suspended particles in the medium to absorb and disperse reflected light from an underwater scene before it reaches the camera. Second, depending on optical wavelength, dissolved organic components, and water salinity, light attenuation results in variable degrees of colour casts. Photographs taken underwater are usually bluish or greenish because red light, which has a shorter wavelength, is absorbed more than green and blue light by organic substances and water.

As light travels from rarer (air) to denser (water) media, it is absorbed and scattered, which are the main causes of haziness. [1] (water). The body's water content declines as a result of absorption. Light's course is altered by scattering [2]. As light enters a denser material, all sides of the light are reflected along with reflection. Light penetration into water is decreased due to the reflection effect, and this reduction is furthered by light scattering by particles. As the water level rises, the underwater image gets darker and darker due to the diminished light intensity [3].

Additionally, when light penetrates water farther, the colour associated with higher wavelengths gradually diminishes. The longest wavelength red colour disappears at a depth of about 3 metres, followed by orange at 5 metres, yellow at 10 metres, and green at 20 metres to the extent. Since blue has the shortest wavelength among all colours at the highest depth, the bulk of underwater photographs are bluish in colour. Light energy decay is depicted in Figure 2.



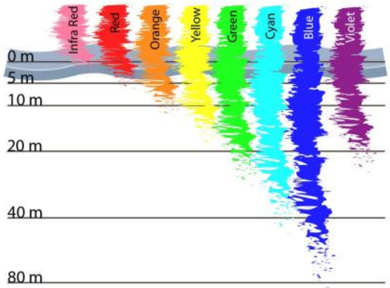


Figure 1. Underwater imaging and underwater image capturing light

Figure 2. Color absorption due to attenuation

The quality of underwater images can be lowered by scattering and absorption losses, which can produce low contrast, blurry, and noisy images. As a result, there are a lot of default colors in the data that was gathered from water. In disciplines like marine research, archaeology, oceanic engineering, and surveillance, scientists have recently demonstrated a strong desire to investigate the mysterious world beneath the sea.

The haziness of underwater images has recently been addressed using a variety of software and hardware-based techniques [6]. Software-based techniques like fusion, polarization, and histogram equalization are frequently used to restore the consistency of hazy images, in addition to specialized hardware like high-tech cameras.

They have shortcomings despite their efficacy. Specialized hardware is expensive, and setting up and implementing a fusion technique based on several picture solutions is quite challenging. Ancuti et al. successfully recover underwater images and videos utilizing the fusion technique by lowering the temporal coherent noise.

Iqbal et al. recommended a two-step process in which the image's color was altered using the HSI color space and the contrast was increased using contrast stretching [4].

Ancuti et al[6] 's main goal was to apply global min max windowing to fuse a contrast improved image with a colour corrected image. Schechner et al. increased the image quality by minimizing the impact of partial polarisation of light.

The mixed contrast limited adaptive histogram equalisation technique (CLAHE) and the Euclidean norm were suggested by Hitam et al. as a method for integrating HSV and RGB colour models [8]. For underwater photos, Chiang et al. introduced the wavelength compensation and image dehazing (WCID) method, which simultaneously addressed light scattering and the presence of artificial light sources while integrating wavelength compensation [9].

Recently [10]– [13], the idea of restoring fuzzy images using a single image has been applied by numerous researchers. Despite being helpful for improving the quality of underwater photos, the bulk of these strategies did not successfully enhance contrast by a substantial amount.

Utilizing a single degraded image from this research, here proposed a method to recover underwater photographs more effectively using the fusion theory. According to Figure 1, the original image is processed to create several independent images, each having a key feature, which are then combined to create the final output, which incorporates all of the key characteristics contained in the photos.

Experimental results computed with this methodology demonstrate that this method greatly enhances hazy images when compared to the existing method of Ancuti et al. [6].

The suggested study along with literature review is precisely described in Section II. Section III looks at the Proposed work for Optimized Fusion. Section IV gives details of complete methodology used to obtained enhance image. Section V shows detailed outcomes for the underwater hazy photos that were taken into consideration. Conclusion and References are given in Section VI and VII respectively.

II. LITERATURE REVIEW

The method of "image enhancing" involves enhancing an image's feature in order to raise its quality. This article compares and analyses various enhancing methods for these underwater photos. Due to the low contrast and resolution of the underwater image caused by the limited visibility, item identification has become a common task [1],[2],[3].

Processing underwater photographs is essential because, compared to images taken in a clearer environment, the underwater images' poor quality affects and causes certain major issues. Low contrast, poor visibility, natural light absorption, uneven lighting, small color variations, and the blur effect in underwater images cause a lot of noise. Because of all these factors, there are many ways to treat these underwater images. Various filtering techniques are also available in the literature for processing and enhancing underwater images.

We investigated many methods of underwater image improvement to improve the caliber of underwater images, and these methods included Color Stretching, USM filter, and Contrast enhancement.

This article suggests a useful technique for improving images using fusion and luminance histogram equalization. It features a setting that users can modify to match their own color scheme.In Divergent beam lidar imaging in turbid water published in 2002 by Duo-Min He et al., Lidar imaging is used in the approaches that employ specialized gear. It takes underwater pictures in murky water using laser technology. It requires a lot of power and is complicated and expensive to acquire.

Table:1 Literature Survey

Sr. No	Year	Author	Title	Remark
1	2002	Duo-Min He, Gerald G.L. 8eet	Divergent-beam Lidar imaging in turbid water	It is Complex , acquisition is very Expensive and power consuming.
2.	2007	Yoav Y. Scliechner Member, IEEE and Yuval Averbuch	Regularized Image Recoveryin Scattering Media	Polarization technique is not applicableto video acquision method is limited
3	2009	Jean-Philippe, Tarel Nicolas, Hauti’ere	Fast Visibility Restoration from a single color or gray level	New filter which preserves edges and comes of the image
4	2010	Kasliif Iqbal, Michael Odetayo, Anne James,	Enhancing the low qualiy images using Unsupervised ColourCorrechon Method	Enhanced illumination and contrast
5	2011	John Y. Chiang, Ying- Ching Chen	Underuzterimage enhancement by wavelength compensationandDehazing	Decrease in Implementalon tone

6	2012	JohnY. Chiang: mdYmg-Ching Chen	Underwater Image Enhancement by Wavelength Compensation and Dehazing	Foreground and background regions based on dark channel prior uses to remove the haze and color variations.
7	2013	Codruta OmianaAncuti:md	SingleImage DehazingbyMulti-ScaleFusion	Exploitssimilarities between light propogation in fog and underwater
8	2014	SMwmns, Thakare et al.	Comparative Analysis of various underwater image enhancement techniques	Different technics of underwater image enhancement to enhance the quality of underwater images. Techniques used Color Sketching, Contrastenhancement to enhanceimage

In the field of view, light polarization is only connected to backscatter. By using a polarizing filter attached to the camera, these techniques allow for the capturing of photos of the same scene with varying degrees of polarization. To control how noise is amplified by pixels, an adaptive filtering method [3] is presented. The regularization does not blur nearby objects, and this method for determining medium transmittance is automatic. Polarization filters have the drawback of not being usable for video acquisition, which prevents their use when taking into account dynamic scenes.

An explanation of how scene intensities are affected by homogenous weather conditions is provided in the method put out by Narasimhan and Nayar[2] through the use of a monochrome atmospheric scattering model. This model holds true for a variety of meteorological situations, including fog, heat, and haze. Deflation of contrast in outdoor photographs was discussed by Tarel and Hautiere[5]. A single image is used to conduct visibility restoration in this case. Image smoothing, tone mapping, and image restoration are all part of their suggested methodology. The algorithm's ability to process both colour and grayscale images gives it a distinct advantage. Dark Channel Prior (DCP)[6] was initially recommended for dehazing outdoor scenes and then applied to improving underwater photos.

III. PROPSOED WORK

In this work, an approach to enhance degraded underwater photos using a single image dependent fusion is presented. There are three steps to our plan: White Balanced and Contrast Enhanced Images are first assessed and used as inputs in the subsequent step before the original underwater image is taken into consideration for optimized fusion. the images were then subjected to the application of various weight maps (chromatic, brightness, and saliency), and finally, each input and weight map was blended together to create the enhanced image. In the last step, multiple photos are combined, each serving a different purpose, using the multi-scale fusion technique. As a result, a resultant image is created that contains all of the traits of its input images. Instead than collecting multiple photographs under various situations and then combining them into one, our strategy relies on using a single fuzzy shot. The foundation of the algorithm is the selection of inputs and weight maps. A quick explanation of the suggested measures is shown in following Flowchart Figure 3.

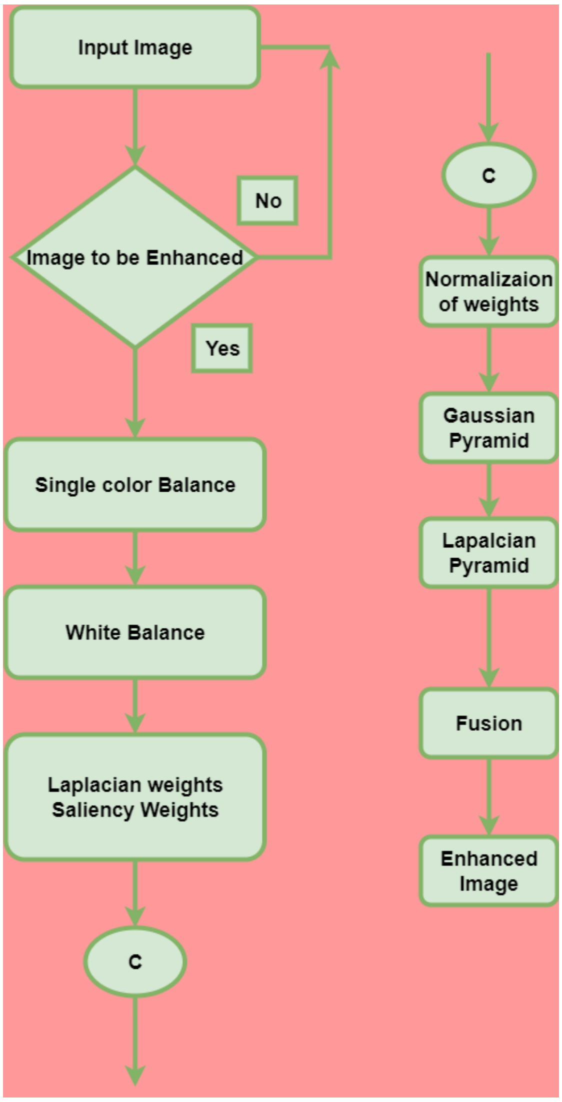


Figure 3. Complete Flowchart of Image Enhancement

IV. Methodology

Here the various steps are considered to obtained enhanced image –

Step 1. Simple Color Balance (Pre-processing): Method is based on the general concept of obtaining images from a hazy picture known as inputs. According to the findings, the main source of distortion in underwater photographs is the appearance of unrealistic colors and indistinguishable items (with no definite boundaries).

Step 2: White Balance: The absorption of colors with shorter wavelengths causes the image's RGB channels to become unbalanced. When the depth is greater than 20-25m, the majority of the colors are discarded, making it impossible to recover the distortion. We computed the white balanced image using the shades-of-gray color accuracy technique to remove atmospheric distortion.

Step 3. Contrast enhanced Image*:* The property of an image that distinguishes the presence of different objects in it is called contrast. Most light rays disperse in various directions due to the scattering effect, resulting in a reduction in the amount of light falling on the target. This light attenuation makes it difficult for the viewer to differentiate the image's objects from the background, resulting in low contrast. While histogram equalization is a popular contrast enhancement technique, it can often produce indiscriminate results by obscuring the unhazyareas. As a result, the adaptive histogram equalization technique is used [15] to solve this problem. By applying histogram equalization to the intensity values of different frames, this technique improves the contrast of each RGB channel separately.

Step 4. Weights: Improving the color and contrast of a hazy picture is not enough sufficient for restoring and improving the image's quality Furthermore, they can cause distortions in the remaining regions of the picture that was not blurred previously. In order to recreate the original image with better visibility and clarity, here three weight are described as

1. **Laplacian Contrast Weight:** This measure has the effect of enhancing the appearance of local contrast since it favors transitions in particular. Sections of the second input have been illuminated and shadowed. The The standard deviation between pixels (W_{LC}) is calculated. luminance level and the surrounding region's local average
$$W_{LC}(x,y) = ||I^k - I^k_{whe}||\text{.......................... (1)}$$
2. **Saliency Weight**: (WS) attempts to draw attention to distinguishing objects that are lost in the underwater scene.
3. **Expodness weight:** A metric that determines how well a pixel is exposed is called (WE). In the ideal case, this calculated accuracy enables an estimator to preserve a clear appearance of local contrast that is neither exaggerated nor understated.
$$W_E(x,y) = \exp(-I^k(x,y) - 0.5)^2/2\sigma\text{^}2\ )\text{.....................................(2)}$$

Step 5. Fusion Technique:

1. **Normalization:** To ensure that the final image's strength matches that of the input images, we first normalize the weight maps: Image that has been white balanced and has had its contrast increased.
$$W^{\check{}} = W/\frac{W}{\sum n\ W}\text{.. (3)}$$
2. **Guassian pyramid:** In the second step, we convert the inputs into Laplacian pyramids from white-balanced and contrast-enhanced images, and normalized weight maps into Gaussian pyramids from normalized weight maps.

3. **Laplacian pyramid:** We fuse the Laplacian and Gaussian pyramids of input images and normalized weight maps after obtaining them.

4. **Combining All Weight:** The final enhanced underwater image is created by repeating the above steps for each level of the pyramid.

5. **Reconstruct enhanced image:** This phase evaluates the final product.

V. RESULT ANALYSIS

The objective of returning underwater artefacts to their original transparency has been achieved. The particle scattering problem has been solved. The pictures seem to have been taken with a crystal medium. The tests are performed on a computer with a 1.60GHz and 1.80GHz Intel(R) Core(TM) i5-8250U Processor. On a 600 x 400 picture, it takes the shortest time. As a consequence, the algorithm's speed is sufficient. The absorption issue, on the other hand, has yet to be resolved. Following the process, it's easier to do color restoration using the clear images.

1. **Results Analysis based on Optimized Parameters:**

Table 2.Optimized Parameters

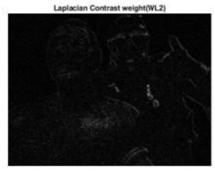
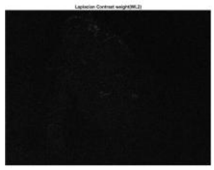
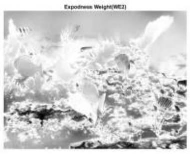
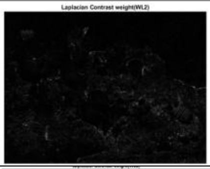
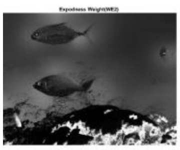
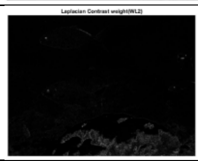
Optimized image enhancement -white balance-clahe-fusion						
File Name/Parameter	**uiconm**	**MeanRG**	**DeltaRG**	**MeanYB'**	**DeltaYB**	**uicm**
Ancuti1	0.621646	-24.6591	15.02539	16.77796	13.7592	2.431903
Ancuti2	0.577713	-27.7771	19.33209	9.045605	16.41533	3.23939
Ancuti3	0.666677	-16.8737	14.65498	-7.55844	20.07277	3.446215

Eustice4	0.65693	-60.1893	16.92765	-65.9063	16.40481	1.346575
Fish	0.41498	-135.545	78.45299	-70.7269	36.92866	9.654775

The results were investigated as shown in Table 2, using a quality assessment approach, and it was discovered that the picture's nature has greatly improved as a result of this strategy.

2. **Result Analysis based on Weight Maps:**Various Weight map used in the methodology and results are obtained on this weight maps separately, these results are shown in Table 3.

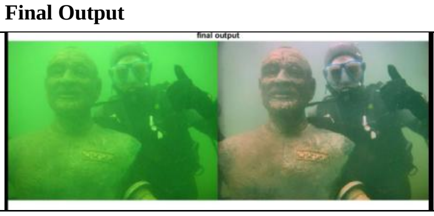
Table 3. Weight Maps

File Name/Parameters	White Balance	Weight Expoddness	Laplacian Weight
Ancuti1			
Ancuti2			
Ancuti3			
Eustice4			
Fish			

3. **Final Result analysis:**

Final results are compared with the fusion process with all detailed steps and are shown in Table 4.

Table 4. Resultant Output on standard images taken from available datasets

File name	Comparison	Final Output
Ancuti1		

Ancuti2		
Ancuti3		
Eustice4		
Fish		

Submerged images that have been tainted by shading are selected as information photos and used in the White balance weights calculation, which improves perceptibility as per results shown in table -4

All of the fusion parameters were tested separately on five databases taken from available given in references and then autonomously using a combination method at each scale size, the possible antiquities due to the sharp changes of the weight maps were seen to be limited in the yield.

VI. CONCLUSION

To improve the quality of degraded images here a fusion technique based on a single hazy image is considered. Images taken at sea, We've shown the importance of making the right decision. To improve the visibility of hazy underwater images, a variety of inputs and weight measures are needed. The effectiveness of the enhancement method is also improved by a powerful fusion technique that integrates critical features from each of the images. The proposed underwater Optimized fusion method reliably produces satisfactory and better results for all test images and restores dehaze image quality. In the future, we plan to expand our efforts to improve underwater videos while also increasing computational complexity.

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