Survey Paper on Visibility Restoration of Underwater Optical Images and Enhancement Techniques

Khushboo Saxena¹ and Yogesh Kumar Gupta¹

¹Department of Computer Science, Banasthali Vidyapith Niwai, India

E-mail: kskhushboosaxena26@gmail.com

Abstract. We have investigated the problem of underwater hazy image enhancement and restoration in this paper studied. Underwater image processing has several applications in the field of oceanic research work and scientific applications such as archaeology, geology, underwater environmental assessment, laying of long distance gas pipelines and communication links across the continents which demand geo-referential surveying of the oceanic bed and prospection of ancient shipwreck. There are many difficulties for undersea optical imaging. To submerging a camera in underwater enough space is required. The maneuvering of the camera with the help from remote place or in person at the site is likewise a complex task. However, the major challenge is imposed by underwater medium properties. Underwater haze image enhancement has gained widespread importance with the rapid development of modern imaging equipment. Though, the contrast enhancement of single underwater hazy image is a cumbersome task for scientific exploration and computational application. At extreme depth, because of attenuation in light propagation, the underwater images are susceptible to inferior visibility.

1. Introduction
A large part of our planet’s surface is covered by oceans and the health of our planet is governed by these water resources. The study of underwater flora and fauna is just an indispensable part of oceanic research work [1]. Underwater surveys feature in scientific applications such as archaeology [2], geology [3], underwater environmental assessment [4], and laying of long-distance gas pipelines and communication links across the continents, demand geo-referential surveying [2] of the oceanic bed. Oceanic exploration is also concerned with prospection of ancient shipwreck [4]. So underwater optical imaging science has become critical and moreover a challenging area of research. In the past, Sonar based equipment had been widely used by marine researchers to locate shallow water fish, wrecks etc. The images that are generated from Sonar imaging system suffer from clarity issues and prevalent noise, which demand selective filtering [3][5][6]. Though it offers long distance visibility and efficient target detection, the resolution aspect for short-range is limited [7]. The noisy environment, especially in the sonar sub-band, added its own complications. But certain imaging applications demand high resolutions at shorter distances, so optical imaging devices have started finding a foothold. However, in spite of high resolution, the optical imaging too has its own shortcomings on account of the image formation and degradation process in the underwater scenario.
Capturing underwater images is more difficult than acquiring conventional outdoor scene images. The first underwater picture was taken by W. Thompson in 1856 in England [7][8]. The photographer lowered a camera in housing in Weymouth Bay and the shutter was operated from an anchored boat. The exposure time used was 10 minutes. This experiment resulted in flooding of the camera, however the film was salvaged. Today, such underwater photography is performed using advanced cameras with scuba diving. There are many difficulties for undersea optical imaging. To submerging a camera in underwater enough space is required. The maneuvering of camera with the help from remote place or in person at the site is likewise a complex task. However, the major challenge is imposed by underwater medium properties. The two foremost underwater phenomenon affecting the outcome and visual aspect is light attenuation and scattering [9][6]. As the distance between camera and object increases, the scattered light renders lower screen contrast in underwater images. As evident, scattered light component does not carry any scene information and thus underwater optical imaging becomes tedious. Research has been carried out to gauge the wideband attenuation coefficients per color channel in underwater images. However, these findings are relatively limited, as the parameters become sensitive to the original color and the distance between object and camera [10][11][12]. The parameters of scattering play a vital role in recovering the dehazed image. But, it has implications as these values tend to vary for the same type of water body at different places on account of turbidity, temperature, salinity and turbulence to name a few, which further demands precise calibration. For clean shallow water bodies, ambient light is sufficient to capture quality images. But, for deep sea underwater imaging, an artificial source of lighting is must to capture images. This source of light results in two problems. The first is a color cast of illumination source formed on the captured image, which requires a suitable white balancing approach to address the problem. Second, this artificial source of lighting tends to create non-uniform illumination, with a bright spot at the center which radially decreases from the center of the image. Underwater optical imaging suffers from light attenuation, which results on account of light absorption by water which increases exponentially with the depth and affects all the wavelengths to varying degrees [2]. The effect of wavelength dependency for gradual color attenuation is as shown in Figure 1.

![Figure 1. Illustration of the Color Attenuation for Different Wavelength at Varying Depths in Underwater](image-url)
2. Literature Review

Rajni Sethi et al. [1], proposed YUV color space based turbid underwater image enhancement using filtering approach in the frequency domain. The YUV color model is defined in terms of one luma (Y) and two chrominance (UV) components. The technique is comprised of numerous independent algorithms. In the first step repetitive wave patterns are removed using filtering based on spectral analysis. The problem of non-uniform lighting is corrected using homomorphic filtering followed with wavelet noise reduction. The resultant image requires smoothing yet preserving the edge information. This is performed by applying anisotropic filtering. Further, the image intensity is enhanced by contrast stretching. The image is subsequently transformed back to RGB color space followed with color normalization. However, the resulting image exhibits distorted output in terms of color fidelity.

Fengle Han, Jingieng Yao et al. [13]. CNN's comprehensive approach to the discovery and collection of marine life, which was widely known as the fastest way to find an object, was proposed. Underwater vision is limited, and objects remain scattered and shaded, and CNN's (Conventional Neutral Network) solution to the problem of using a high RGB method and a combination of gray shadows to achieve improved water visibility was then mapped to illuminate the solution drawing. After image processing, a comprehensive approach to water acquisition and CNN integration was proposed, using two advanced programs to transform CNN's deep structure, according to the visibility of water visibility. In the first project, a 1 * 1 kernel converting element 26 to 26 of the drawing is applied, and a sample drop layer is applied to produce a product of 13 13. In the second process, a sample reduction layer is applied first, and a network conversion layer is introduced, resulting in that the final product is integrated. The recovery speed is approximately 50FPS (independent per second), and mAP (average average rate) is 90%.

Sajna Dasneem S et al. [14]. Every other novel Cascade Convolution Neural Network (R-CCNN) was nominated for high quality images. The proposed approach focuses on a single professional model, which is considered a visual filter that can eliminate all types of sounds. This method has the advantage of being more complex. It is very difficult for a previously proposed recovery network to require a certain number of parameters. The proposed R-CCNN method provides the appropriate number of these parameters and suggests an unconventional approach, which is why we only need a limited number of parameters. The exact values of these parameters are obtained using the Flower Pollination Algorithm (FPA), a standard operating method. The results obtained show that the proposed model is more profitable than other high-quality retrieval methods by testing the composition of high signal-to-noise-rate (BSNR) and homogeneous direction (SSIM).

Saeed Anwar et al. [15]. Excessive viscosity under water, the absorption of bright light and scattering reduces visibility, leading to slight distortion and color distortion. To solve this problem, a photo-enhancing model based on image modification, i.e., UWCNN, was well-trained using an underwater photographic database. Unlike existing works to set up static frames that require the limitation of a water-based model or work only in specific scenarios, our model creates a clear underwater image by directly combining automatic recording and data processing. In this way, for the first time, enter the information details of ten different marine images. After that, train multiple UWCNN models for each type of underwater image creation. Experimental results of real-world photography and real-world art show that this approach is prominently introduced in a wide range of underwater environments and exceeds existing approaches in both quality and quantity. In the proposed approach, the system contains only ten layers of 16-resolution maps and includes maps with the final layer, providing fast and effective training and testing on GPU platforms.

H. Wang et al. [16], introduced the ICM model, in which the underwater image is strongly integrated over the RGP color space, followed by hue intensity concentration (HIS) due to the different image proportions of I and S. This method is simple and effective and is best suited for underwater films with minimal fog. Color rendering negotiations were performed by converting red and green channels into
the RGB color space using the Van Cris hypothesis, followed by a different modification of the Unauthorized Color Model (UCM) algorithm.

Y. Wang et al. [3] presented a PDSCC technique for underwater image contrast enhancement based on a 3D rotational technique to shift underlying image pixel distribution. This technique extends the 3D rotational matrix method. Basically it is a color correction method wherein the authors employ a shifting process on the pixel distribution of a color image to correct its white reference point and ensure the white reference point is achromatic. However, the method fails to improve the overall contrast significantly. Another drawback of this system is that it relies on conventional color estimation processes such as Gray World and White Patch algorithms. Though, not specifically designed for underwater scenario, but authors in their research article have implemented the algorithms for some underwater images.

Durde, F. et al. [17]. Explain the novel's method of enhancing underwater images by burning the image. As mentioned earlier, color-correction techniques and color correction are two of the biggest problems in underwater thinking. Dispersion is caused by large volatile particles such as turbulent water containing many particles called sea ice. Color distortion reaches the level of light emitted by underwater waves in different waves, translating underwater areas reduces the blue tone. Proposed model with significant contributions to block the proposed method and to accelerate the concept of integrated trigonometric filtering method.

A. Caltron et al. [7]. The accepted and expanded functioning of DCP is mainly aimed at removing atmospheric smoke by restoring the annoying image using the RGP red channel because the red channel is a major refuge and contributes significantly to the creation of a black channel image in the DCP. The authors suggested a process of locating the affected part of the image at the scene with artificial lighting. The big problem with this algorithm is that it thinks red is the most affected channel. On the other hand, if we look at the size of underwater images in a different set, we find that in some cases the length of the sky is a very reduced channel. It can therefore be considered a serious shortage of this work.

C. Ankutty et al. [18]. Underwater image creation and video enhancement are used to combine various weighted images using ingenuity, brightness and chrominance by filtering. This underwater development project has used a connectivity system based on the Laplacean pyramid. The authors have specifically confirmed the selection of a white measurement method for underwater images. Although the differences in output images appear to be growing, the accompanying problem is that, as shown in the results section, the processed images are not made differently and do not look natural.

D. Pelebi et al. [19]. We suggest a simple and effective way to start removing bulk from a single installation image. The beauty of this model is that it determines the size of the batch to get a free fog image. This method is similar to the statistics of free films. The fact that many local clips in unlimited images have their own low power pixels in the same color channel is supported by important observations. As the authors point out, this model will fail if the fog model is not physically functional. But in any case, the distribution of the involved channels will not be the same, so a different approach should be taken in such cases. This approach has been followed by various investigators to amplify the underwater image of a complex remote map, especially in the novel, blurring, dynamic recovery, and so on.

U.J. Yi Chiang et al. [5]. Describe underwater video and photo development strategy. It takes less time to calculate and brings higher written results. The authors use a variety of comparisons in a proposed way to improve image brightness and make color changes to balance each channel's color channels. The color of the underwater film is not accurately measured, and bright blue or green can be pressed at this point without looking at absorbers. Continuing to write underwater object estimates, the authors explain that both assets represent the recommended number and the average click on the histogram scale.
L. Chao et al. [6]. He presented his research on the dynamic reduction between the various color channels. Whenever light is diffused, it should be applied and evenly distributed. When fine particles are detected on the tongue, the effect of light distribution can be reduced. The researcher suggested a way to ignore the effects of light scattering, more commonly known as underwater images. An important proposition that uses a strong contrast in the reduction between these three color channels is an important contribution. But in the previous project there was a problem determining the depth of large solid objects with the same color as the bad card. The authors also describe an additional compensation plan for reduction rather than dissolution. It is formed as a result but suffers from heavy smoke [20].

3. Image Fusion

Image fusion has played a vital role in the field of image processing in regards to medical imaging, remote sensing, military application and machine vision. The objective of image fusion is to combine significant information from various images into a single image. The advantage of image fusion is to achieve relatively better situation assessment which otherwise may not be possible using any of the sensors individually.

Figure 2, illustrates the block diagram of a DWT based image fusion. This figure, illustrates that image is an input which may be either categorized as picture or video frame and outcome of the image being processed shall be an image or a set of characteristics pertains to the image. In this diagram input image 1 and image 2 are taken from visible and infrared camera. Basic requirement of effective image fusion is to correctly align the images i.e., pixel-by-pixel basis.

![Figure 2. Block Diagram of DWT Based Image Fusion](image)

4. Methodology

It is the image background part that contributes to haze as seen. So separating the two regions, has a tendency to enhance the image in a better way. As we have discussed earlier, the image is subdivided into the foreground and background parts and dehazing is applied individually to each of the parts and then combined at the final stage. In this chapter, we propose segmentation of the underwater image into foreground and background component based on k-means clustering using intensity profile. It is widely used techniques for the segmentation of a data range into k groups.

The k-means algorithm works well in underwater oceanic images if the nonhomogeneous haze is distinct or well separated from each other. The term nonhomogeneous haze refers to the condition where in haze quantity is not equally distributed across the entire image. Rather, in realistic scenario we can observe that some portion of the image is laden with more haze content and in certain areas the amount of haze is minimal. So this clustering approach work efficiently if the haze coverage portion is distinct and which
can be visually distinguishable so as to decide the number of clusters to be formed. The only shortcoming of this algorithm is that it requires apriori specification about the number of clusters, and as such at the same time the number of such clusters for image segmentation possible should be few for efficient implementation. In our case, we have partitioned the image into two parts. The partitioning of an image and dehazing process is as shown for one underwater image in Figure 3.

![Figure 3. Segmentation of Underwater Image and Dehazing](image)

5. Conclusion
The main challenges in the field of underwater image restoration are the attenuation of color profiles and scattering on account of suspended particles otherwise known as marine snow. We have attempted to address the underwater vision restoration and enhancement issues. Underwater image processing is a comparatively new area of research and lots of things are yet to be explored. Regarding the course of future work, there are numerous problems to be tackled which will help ocean engineering science in a big way. Understanding the profile of turbidity still remains the major task. It is a challenge to develop an underwater image formation model taking into consideration a turbidity effect, which will be a complex topic to be solved.

6. References

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