REVIEW ON ENHANCEMENT OF UNDERWATER IMAGES

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ABSTRACT

Underwater vision is a significant issue in ocean engineering. Atmospheric images and underwater images undergo from medium scattering and light distortion, leading to the low contrast and visibility of images. However, there are some different characters of the underwater images. Firstly, catching pictures submerged is troublesome, because of the weakening caused by light that is reflected from a surface, and is avoided and scattered by particles. Meanwhile absorption substantially lessens the light energy. The irregular lessening of the light is the primary cause of the cloudiness appearance while the assimilation of light make the submerged pictures not quite the same as the air right of passage pictures since the splendor dispersion is completely changed. In this paper, an audit on underwater image enhancement is presented covering basic enhancement techniques, issues and challenges and existing algorithms for underwater image upgrade.

Keywords: Underwater image enhancement, Hazing image, Restoration, Light attenuation.

1. INTRODUCTION

Underwater image corruption is caused both by light proliferation in water and the optical imaging framework configuration, including focal points and recording gadgets. Quick decay of signals because of absorption leads to poor signal-to-noise ratio (SNR), solid backscatter by the water itself together with
underwater particles which overwhelmingly incites the blurring of the image. Also, the inherent
characteristic of imaging framework realizes the extra noise on the underwater image. Image improvement
and rebuilding keeping in mind the end goal to broaden the imaging range is vital for some non-military
personnel and military applications, including target discovery, inquiry and save, and jumper perceivability
[1].

Conventional strategy for image enhancement and restoration concentrates without anyone else highlights.
However, in underwater environment, without knowledge of any in-water transferring process involved or
the optical properties, the effectiveness is considerably restrained [2]. Late investigations of Hou’s group
demonstrated that the knowledge of in-water optical properties and their relationship to the image
development can be exploited in order to restore the imagery to the best possible level based on Wells’
small angle approximation (SAA) [3]. They used imagery-derived modulation transfer function (MTF)
technique as an estimation of image debasement, which was utilized in a robotized restoration framework
for underwater imagery enhancement. Moreover, many types of point spread function (PSF) models were
compared and validated by the same group, and a simplified semi logical type of PSF was proposed and
executed in submerged imaging reclamation applications [4].

It is well known that underwater image processing contrasts broadly from visual image processing,
essentially because of three noteworthy underwater channel disabilities, i.e. assimilation, scattering and
refraction [7], [8], [9], [10], [11]. These variables, in charge of presentation of commotion, shading cast,
low differentiation and lower shine, inspire the improvement of appropriate calculations to invalidate these
impacts with no manual supervision. Comparative is the issue of shading blurring, whereby hues like red
and yellow practically vanish with expanding profundities [12], which is the explanation behind mastery of
either the blue or the green shading. As light goes in water, a quick exponential loss of light power happens
relying upon the shading range wavelength [5].

1.1. Issues in Underwater Image Enhancement

1.1.1. Light Attenuation by Water

As appeared in the visual delineation of reducing under water shading in Figure 1, red shading is consumed
by the water at the profundity of 5 m, trailed by orange, yellow, green, and blue [6]. Underwater images
ordinarily seem green-blue in light of the fact that these shading parts are last consumed. The phenomenon
of shading retention causes the caught underwater images to have low shading and differentiation
performance.
Differentiation upgrade method is generally utilized for underwater image handling to enhance the contrast performance. The advancement of the contrast enhancement strategy for underwater image has pulled in impressive consideration lately.

1.1.2. Light Attenuation by Seawater

When passing through a medium composed of molecules and particles, the light interacts with the constituent matter of this medium. When the light reaches a particle, a part of its energy is absorbed and the remaining energy is scattered all around the particles. Thus, considering a given observation direction, some light is lost by scattering into other directions. The attenuation is characterized by the spectral attenuation coefficient $c_\lambda$ which depends on the wavelength. The quantity of light $L_\lambda(P)$ traveling through an optical path from a point $P_0$ (objects) to a point $P$ (observer) without suffering the influence of attenuation is defined by the Beer-Lambert law [17], with $d$ the length of the path between $P$ and $P_0$:

$$L_\lambda(P) = L_\lambda(P_0) e^{-c_\lambda d}$$

1.1.3. Hazing and Bluish Effects

Capturing images underwater is challenging, for the most part because of haze caused by light that is reflected from a surface and is diverted and scattered by water particles, and color change because of fluctuating degrees of light weakening for various wavelengths [18]–[20]. Light disseminating and shading change result interestingly misfortune and shading deviation in images gained underwater.

Haze is caused by suspended particles for example, sand, minerals, and microscopic fish that exist in lakes, seas, and waterways. As light reflected from objects spreads toward the camera, a bit of the light meets these suspended particles, his thus ingests and diffuses the light pillar, as represented in Fig. 2. Without blackbody radiation [21], the multiscattering procedure along the course of spread further scatters the bar into homogeneous foundation light.
The light reflected propagates distance $d(x)$ to the camera. The radiance perceived by the camera is the summation of two modules: the background light formed by multi-scattering and the direct transmission of reflected light.

Traditionally, the preparing of underwater images concentrates exclusively on remunerating either light dispersing or color change twisting. Systems focusing on expulsion of light dispersing mutilation incorporate misusing the polarization impacts to adjust for perceivability corruption [22], utilizing image dehazing to reestablish the clearness of the underwater images [23], and joining point spread f capacities and a tweak exchange capacity to decrease the obscuring impact [24]. Despite the fact that the previously mentioned methodologies can improve scene complexity and increment perceivability, mutilation caused by the divergence in wavelength lessening, i.e., color change, remains intact. Then again, color-change revision strategies gauge underwater natural parameters by performing color enrollment with thought of light attenuation [25], employing histogram equalization in both RGB and HSI color spaces to adjust the luminance appropriations of color [26], and progressively blending the brightening of an object in a separation subordinate manner by utilizing a controllable multicolor light source to remunerate shading misfortune [27].

1.4.4 Change of Color

The reason for underwater image bending is color change. Color change is because of shifting degrees of constriction for various wavelengths. This is the explanation for why underwater images are overwhelmed by blue color [34].

Fig. 2 Natural lights enter from air to an underwater scene point.
1.4.5 Wavelength of colors

Red color has highest wavelength, so it travels a very short distance in water. Suspended particles (sand, microscopic fish, minerals) are in charge of the hazy underwater image. As light reflected from objects towards the camera, a bit of light meets these suspended particles, this will thus assimilate and disperses light [33].

2. IMAGE ENHANCEMENT TECHNIQUES

The image handling can be tended to from two unique perspectives: as an image restoration technique or as an image upgrade strategy. The image restoration plans to recoup a corrupted image utilizing a model of the debasement and of the first image development; it is basically a backwards issue. These techniques are thorough yet they require many model parameters (like lessening and dispersion coefficients that describe the water turbidity) which are just barely known in tables and can be to a great degree variable. Image improvement utilizes subjective criteria to deliver an all the more outwardly satisfying image and they don’t depend on any physical model for the image development. These sorts of methodologies are generally less complex and speedier than deconvolution techniques [35].

2.1 Spatial Domain

The term Spatial Domain alludes to image plane itself. It is the approximation of pixels creating an image. The image handling strategies in this classification are performed on the image plane itself and they depend on the immediate control of pixels in an image. For the most part, Spatial Domain pixels are more effective computationally and require less handling assets to execute. The two key classes of Spatial Processing are:

- Intensity Transformations
- Spatial Filtering

The spatial domain procedures can be signified by the expression:
\[ g(x,y) = T[f(x,y)] \]
where \( f(x,y) \) is the input image, \( g(x,y) \) is the output image, and \( T \) is an operator on \( f \) defined over a neighborhood of point \( (x,y) \). The administrator can apply to a solitary image or to an arrangement of images, for example, playing out the pixel-by-pixel entirety of a grouping of images for commotion diminishment [35].

2.1.1. Point Processing

It is the procedure of contrast enhancement. It is the procedure to deliver an image of higher contrast than the first by obscuring a specific level. Enhancement at any point in an image depends only on grey level at that point techniques [35].

2.1.2 Histogram Equalization

Histogram equalization is one of the most important parts for an image processing. This technique can be used on a whole image or just on a part of an image [35].
2.1.3 Bit-Plane Slicing

Pixels are digital numbers composed of bits. For example, power of each pixel in a 256-level gray-scale image is made out of 8-bits (i.e., one byte). Rather than featuring intensity-level ranges, we could feature the commitment showed up by particular bits. An 8-bit image may be considered as being made out of eight 1-bit planes, with plane 1 containing the lowest-order bit of all pixels in the image and plane 8 all the most noteworthy request bits.

![Bit-plane portrayal of an 8-bit image](image)

Fig. 3 Bit-plane portrayal of an 8-bit image

Decomposing an image into its bit planes is helpful for examining the relative significance of each piece in an image, a procedure that guides in deciding amleness of the quantity of bits used to quantize the image. Additionally, this sort of deterioration is helpful in image compression [35].

2.1.4 Intensity-Level slicing

Highlighting a particular range of intensities in an image is of intrigue. Applications incorporate upgrading elements, for example, masses of water in satellite symbolism and improving blemishes in X-beam images. The procedure, frequently called intensity-level slicing, can be actualized in a many ways however most are the varieties of two essential subjects. One approach is to show in one esteem (say, white) every one of the qualities in the scope of intrigue and in another (say, dark) all different intensities. This change delivers a binary image. The second approach in view of the change lights up (or obscures) the coveted scope of intensities yet leaves all other intensity levels in the image unaltered [35].

![Intensity-level slicing](image)

Fig. 4 Intensity-level slicing
2.2. Frequency Domain

In frequency domain method the image is first move into frequency domain. It implies the Fourier Transform of the image is processed first. We register the fourier transform of the image to be improved, increase of the image to be enhanced upgraded duplicate the outcome by a filter (as opposed to convolve in the spatial space) and take the reverse change to deliver the upgraded image. These upgrade operations are performed keeping in mind the end goal to alter the image brightness, contrast or the distribution of the grey levels. As an outcome the pixels value (intensities) of the transformation function connected on the input values. Image enhancement just means, changing an image F into image G using T (where T is the transformation function). The estimations of pixels in image F and G are indicated by r and s, separately.

As stated, the pixel values r and s are connected by the expression S=T(r) Where T is a change that maps a pixel value r into a pixel value [35].

3. ENHANCEMENT TECHNIQUES FOR UNDERWATER IMAGES

3.1 CLASSIFICATION OF TECHNIQUES

3.1.1. Image based approaches

Image based approaches excavate the properties of images to enhance the degraded images. For example, CosminAncuti et al [29] utilized combination to upgrade the degraded images.

3.1.2. Model based approaches

Model based approaches upgrade underwater images as indicated by the debased physical model. On the premise of underwater image optical properties, John Y.Chiang et al [30] proposed a wavelength remuneration and image dehazing (WCID) calculation to reestablish the images. In these methods, Dark Channel Prior (DCP) [31] is widely used because of the similar scene between fog and underwater environment. However, underwater images processed by DCP show low brightness, which reduces the visibility and veils many details of images.

3.2. TECHNIQUES FOR ENHANCEMENT

3.2.1. CLAHE technique on RGB and HSV color models

Combination of two output of CLAHE is applied onto two color models of RGB and HSV. The primary objective is to diminish critical commotion acquainted by CLAHE all together with facilitate a resulting procedure of underwater images.

Contrast Limited Adaptive Histogram Equalization (CLAHE) was initially created for upgrade of low-differentiate medicinal images [28]. It is a speculation of Adaptive Histogram Equalization (AHE). CLAHE
varies from standard AHE in its complexity constraining. CLAHE limits the enhancement by clipping the histogram at client characterized esteem called clip limit.

3.2.2. CLAHE on RGB color model

RGB color model portrays colors as far as the measure of red (R), green (G) and blue (B) display. Utilizes added substance color mixing, since it portrays what sort of light should be radiated to create a given color. Light is added to create form from out of the darkness. The value of R, G, and B components is the aggregate of the individual sensitivity functions and the approaching light:

\[
R = \int_{0.3}^{0.8} S(\gamma)R(\gamma) d\gamma \\
G = \int_{0.3}^{0.8} S(\gamma)G(\gamma) d\gamma \\
B = \int_{0.3}^{0.8} S(\gamma)B(\gamma) d\gamma
\]

where \( S(\gamma) \) is the light spectrum, \( R(\gamma), G(\gamma), B(\gamma) \) are the sensitivity functions for the R, G and B sensors respectively.

3.2.3. CLAHE on HSV color model

HSV color model depicts colors as far as the Hue (H), Saturation (S), and Value (V). The model was created by A.R. Smith in 1978. The dominant description for black and white is the term, value. The hue and saturation level don't have any kind of effect when value is at max or min intensity level.

4. IMAGE ENHANCEMENT ALGORITHMS

Yafei Wang et al. (2017) presented an efficient fusion-based underwater image enhancement approach using wavelet decomposition [13].

Ritu Singh et al. (2016) implemented fusion technique based on single hazy image to strengthen the feature of degraded underwater images [14].

Amjad Khan et al. (2016) enhanced the hazy underwater images in term of color and contrast using wavelet-based fusion approach. The quantitative analysis shows the quality of the image is also maintained [15].

Achmad Basuki et al. (2016) proposed a method that uses the adjusted value to stretch the left and right boundary of image histogram based on its distribution [16].

Atsushi Yamashita et al. (2007) proposes a color registration method of underwater images. The proposed method estimates parameters essential to color registration, by using more than two images [25].
5. CONCLUSION AND FUTURE SCOPE

In this paper, a review on underwater image enhancement is presented covering basic enhancement techniques, issues and challenges and existing techniques for underwater image enhancement. It is a challenge to capture an underwater image because of haze. Haze is occurred by the dispersion of light. Dispersion of light refers to reflection after deflection and dispersed by water particles. Due to varying degrees of light attenuation for different wavelengths color has been changed. Haze occurred due to particles like sand, minerals and many more in underwater. The underwater images have color distortion and dominated by bluish tint. Numerous techniques are applied on evacuation of light scattering, to reestablish the clearness of the underwater images, image dehazing has been utilized an adjustment exchange function to diminish the blurring effect. Underwater natural parameters have been assessed by Color-change redress procedures by performing color enlistment with thought of light weakening, utilizing histogram equalization in both RGB and HSI color spaces to adjust the luminance conveyances of color, and progressively blending the brightening of an object in a separation subordinate manner by utilizing a controllable multicolor light source to repay color misfortune.

This study reveals the need for further research to be carried out to come up with novel underwater image enhancement algorithm which could address the problems of haziness, blurring, attenuation effects, visibility degradation, color distortion and bluish tint dominance in underwater images.

REFERENCES


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