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A STUDY OF ENHANCEMENT OF UNDERWATER IMAGES USING WHITE BALANCING AND RAYLEIGH-STRETCHING

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ABSTRACT

Underwater environments are one-of-a-kind, and conventional dehazing algorithms need tweaking to account for things like fluctuating water clarity, particle matter, and changing lighting conditions. An essential part of the study is the interaction between dehazing and white balancing as they pertain to underwater imagery. Creating a unified method to deal with the complicated interaction between atmospheric haze and color distortion in underwater landscapes is the real problem. By delving into the interdependencies and finding the sweet spot for applying white balancing and dehazing sequentially or simultaneously, we may improve the outcomes of our investigations into how these processes might work together. Dynamic modifications based on changing undersea circumstances are made possible by the integration of machine learning models and modern computing methodologies, which further strengthens the combined approach's flexibility. The research into dehazing and white balancing to enhance the quality of underwater images goes beyond only technical aspects and covers a wide range of potential uses. Improved underwater photography is a huge help to marine archaeology, environmental monitoring, and marine biological studies. White balancing and dehazing are two of the most important tools for creating accurate representations of coral reefs, marine life, and underwater habitats. Also, businesses like marine tourism may benefit from the technology, as stunning underwater photos are essential for drawing in customers and showcasing the wonders of undersea landscapes.

KEYWORDS: Underwater Images, White Balancing, Rayleigh-Stretching, environmental monitoring.

Reduced contrast, severe blurring, and washed-out colors are the outcomes of absorption and scattering, the two primary challenges in underwater picture capture. Using the RGB color

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model's auto white balancing, gamma correction, and Rayleigh stretching, this study suggests a way to improve the visual quality of underwater photos. The suggested approach relies on a single picture and is very successful without the need for specialized hardware. The uneven color cast that results from the selective absorption of colors with depth may be remedied by using white balancing techniques.

We apply a minimum of 5% histogram stretching to the red channel and a maximum of 95% histogram stretching to the blue channel. The green channel's histogram is distorted in both directions. Histograms of the stretched color channels are mapped to mimic a Rayleigh distribution to correct for the influence of under and over enhancement from the picture. In order to confirm the suggested technique, extensive analysis has been performed.

White Balancing

When colors with shorter wavelengths are absorbed, it causes the R, G, and B channels of the picture to become imbalanced. Beyond 20–25 meters, the impact becomes much more pronounced due to the absorption of most colors and the difficulty in removing distortion. This atmospheric distortion has been eliminated by the suggested method via the use of an automated white noise filter.

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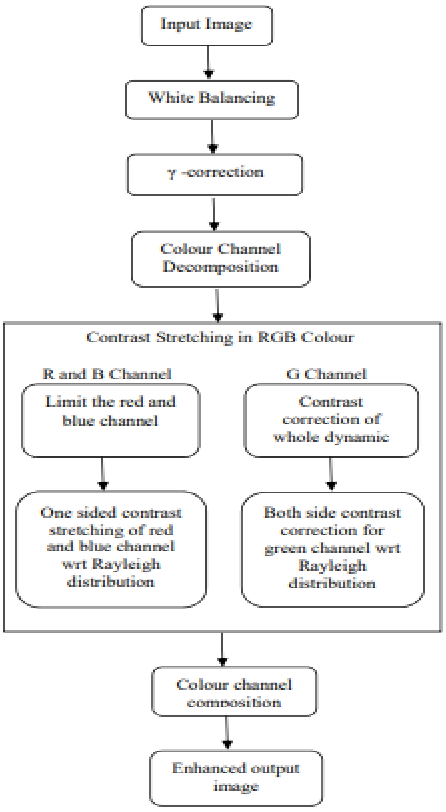

Figure 1 Flow chart for proposed method

In order to minimize distortions induced by the different illuminants present at different depths, white balancing is crucial for underwater photographs. It balances off the undesired color cast. This automatic white-balancing system uses the WPR (White Patch Retinex) method to estimate the amount of light coming into a given area, and then calculates the associated color temperature (CCT). In the white balancing correction step, the parameters for WB (White Balance) correction are determined by the linear transformation model that was employed.

Gamma Correction

To fix the color and contrast issues in the RGB and HSV color models, gamma correction is performed to the white balancing stage's output picture. Equation 1 provides the gamma adjustment.

$$I_{out} = I_{in}^{\gamma}$$

Both Iin and Iout are intensity values that range from 0 to 1, where Iin is the intensity of the location of the input pixels and Iout is the intensity of the output pixels after transformation. This variable's value depends on the specific application. A darker picture is produced when $\gamma > 1$, and a brighter image is produced when $\Omega < 1$. To provide a balanced contrast and color in the underwater picture, the RGB and HSV color models are both set to $\gamma = 1.5$ in this suggested manner. Although all three channels of the RGB color space employ the gamma adjustment, in the HSV model it is only applied to the H (hue) component.

Rayleigh Stretching

Histogram stretching is applied to the gamma-corrected picture. One easy and time-honored method for cleaning up underwater photos is histogram stretching. It has already been claimed that the Rayleigh distribution is the best fit for mapping underwater pictures. Pixels are drawn to trail the aforementioned Rayleigh distribution [95] in the suggested technique in addition to the stretching operation. In order to reduce the impact of the underexposed parts of the picture, we expand the output histogram of the weak color channel, in this case red, from 5% to 100% towards the top limit (255). This 5% is derived from the findings presented in [96], which state that the first 5% of an image's brightness value is black. As a means of reducing the impact of overly boosted regions of the picture, the output histogram of the strong color channel (blue) is pushed all the way down to the low intensity value (0). As stated in [96], the white point is the beginning brightness value inside the final five percent. For the output histogram to include the whole dynamic range, the green intermediate color channel is extended in both directions.

The histogram of the resulting picture takes on a bell form because the histogram stretching approach stated earlier is curved to follow the Rayleigh distribution curve. The main benefit of this bell-shaped curve is that it reduces the output image's least and highest boosted regions by concentrating most of the pixel intensities in the center of the histogram. Histogram stretching has been implemented using Equation 2.

$$P_{out} = (P_{in} - I_{min}) \left[\frac{O_{max} - O_{min}}{I_{max} - I_{min}} \right]$$

Imax, Imin, and Omax, Omin are the maximum and lowest intensities of the input and output pixels, respectively; and Pin and Pout are the intensities of the input and output pixels of the pictures, respectively. The contrast of the underwater picture is increased to a certain degree since the stretching causes the pixel intensities to be uniformly distributed.

In equation 3, we can get the probability distribution function of the Rayleigh distribution, where x is the input pixel and α is the distribution parameter of 0.4 for the system. Since it is suitable for an underwater setting, the value of 0.4 is used for this evaluation of α, as proposed.

$$PDF_{Rayleigh} = \left[\frac{x}{\alpha^2}\right] e^{\frac{x^2}{\alpha^2}}$$

This technique stretches the histogram of the submerged picture. Next, the intensities of the pixels are transformed according to the Rayleigh distribution curve. To get the equation of the Rayleigh stretched histogram, we combine equations 4.2 and 4.3. The above set of equations is shown in equation 4, where the value of α is set to 0.4.

$$F_{str.ray}(x,y) = \frac{\left[(P_{in} - I_{min})\left(\frac{O_{max}-O_{min}}{I_{max}-I_{min}}\right)\right]}{\alpha^2} e^{-\frac{\left[(P_{in}-I_{in})\left(\frac{O_{max}-O_{min}}{I_{max}-I_{min}}\right)\right]^2}{2\alpha^2}}$$

The entropy, NIQE, and UIQM are the three measures of picture quality that are used for quantitative assessment. One way to look at entropy is as a measure of the image's level of detail or the degree to which it's chaotic. A measure for evaluating the quality of naturalness in images is NIQE. Another assessment criterion that is specifically established for underwater picture quality evaluation is UIQM, which stands for underwater image quality measure. The non-reference evaluation parameters are NIQE and UIQM, respectively. All of the outcomes are evaluated using the image processing toolbox of MATLAB 2017a.

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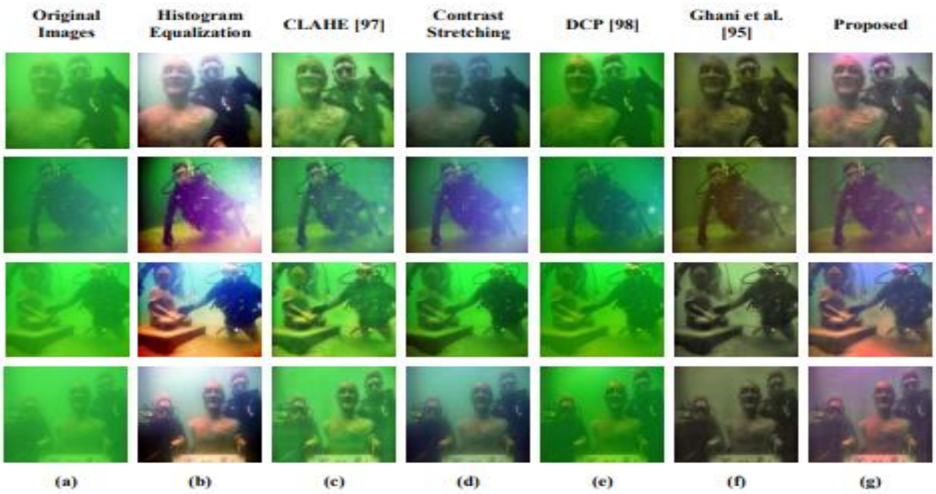

Figure 2 Results of the test images for all five methods from (a)-(g). (a) Original Images, (b) HE Results, (c) CLAHE Results, (d) CS Results, (e) DCP Results, (f) Ghani et al. Results,(f) Proposed Results.

DUAL DOMAIN APPROACH FOR COLOUR ENHANCEMENT OF UNDERWATER IMAGES

In the realm of image and video analysis, underwater picture enhancement is among the most discussed study areas. Researchers in the ocean use ROVs (remotely operated vehicles) and AUVs (autonomous underwater vehicles) to explore submerged oil and gas pipelines, submerged shipwrecks, underwater mines, gorgeous coral reefs, and communications cables. Noise, non-uniform lighting, reduced vision, extreme blurriness, and poor contrast are some of the visual characteristics. The photos are hazy and lack contrast because light attenuates dramatically in water.

When white light propagates farther into the water, it experiences scattering and absorption, both of which contribute to the distortions seen in underwater photographs. These phenomena are brought to light by the presence of water as well as other particles of dirt and dust. Light is distorted in underwater photos due to forward scattering [2], while poor contrast and haziness are the results of back scattering. Light intensity falls with depth due to scattering, and color intensity drops due to absorption at different wavelengths.

Based on classic enhancing methods such as CLAHE, color correction, histogram stretching, etc., many underwater picture restoration and enhancement approaches have been developed.

In low-light situations, these methods cause a loss of color and contrast and only work for underwater scenes that are well-lit. All of these techniques work to make underwater photos less foggy, but not all of them do a great job of enhancing the colors and contrast.

Fading and dull colors are also seen in the result analysis of the method provided in Study 4. In order to address the problems with artificial colors mentioned in the previous study, this study delves into the topic of underwater picture color augmentation using a dual domain technique. Here, we suggest expanding the contrast in the approximation band of discrete wavelet-transformed pictures. The next step is to modify the spatial domain intensity of the various color channels. Processing the picture in HSV (Hue, Saturation, and Value) color space further improves the color quality. In order to outperform previous methods, the suggested DDUIE approach improves upon them by processing the picture in both the frequency and spatial domains, which increases visibility, details, contrast, and colors. Information is well-preserved and colors and contrast are improved in the improved photos.

ENHANCEMENT OF NON-UNIFORMLY ILLUMINATED UNDERWATER IMAGES

These days, no one can avoid using digital photographs. Many academics have been drawn to study picture preprocessing and its applications because of this [18, 22, 103-105]. The vast array of marine life that has so far been mostly undiscovered has marine biologists interested in many different fields, one of which is the improvement of underwater photographs. The attenuation of light in water makes underwater picture capture a tough operation. The two main outcomes of light attenuation—scattering and absorption—are the fading of colors and the reduction of contrast in pictures, respectively. There are a number of suggested improvement approaches that aim to address these concerns and deliver higher visual quality images.

While the underwater photographs processed using the algorithm did show a considerable increase in visual quality, the results were unexpected for a few of the images. This led to a further in-depth examination of the three channels' intensity levels for a new and expanded set of underwater photos. In this study, we extend the approach with more details, a larger dataset, and more thorough analysis of the findings. The goal is to improve the results using the Refined Dual Domain Based Underwater Image Enhancement (RDDUIE) method. The

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RDDUIE technique first adjusts the intensity of various color channels in the spatial domain, and then it stretches the contrast in the approximation band of the discrete wavelet converted picture. The picture is transformed using the HSV color space to further enhance the color quality.

Compared to state-of-the-art approaches, the RDDUIE method performs better, according to the findings. Based on subjective evaluations, the RDDUIE approach reduces non-uniform lighting and the bluish-green effect to a considerable degree. Colors and visual details are improved as a result. Based on the quantitative results, it can be seen that the images have been enhanced efficiently with Underwater Image Quality Measure (UIQM) values of 1-2 and Underwater Colour Image Quality Evaluation (UCIQE) values of 0-1. Additionally, entropy values between 7-8 demonstrate that the proposed method is effective in terms of image details. Its real-time usefulness is enhanced since it enhances underwater photographs' colors and contrast.

CONCLUSION

In this chapter, we provide a dual domain underwater picture enhancing approach that has been refined. When it comes to improving underwater images, the RDDUIE approach uses a mix of frequency and spatial domains. In order to reduce the impact of distortions in the red, green, and blue color channels of the approximation band, RDDUIE uses histogram stretching. In addition, the spatial domain is used to modify the intensities of various color channels, which enhances the visibility and contrast of the picture features. In the HSV color space, a sharpening filter applied to the value channel further improves the image's colors and sharpness. According to the results, using both domains effectively brings the picture details, colors, and sharpness up to a satisfactory level. Quantitative and qualitative analyses show that the RDDUIE approach successfully removes the bluish-green tint from the photos. When compared to other methods, the RDDUIE approach significantly improves the visual quality of underwater photographs. The suggested technique uses a white-balancing algorithm to enhance underwater photographs' color cast and a dehazing strategy to eliminate haze. Additionally, the spatial domain contrast of underwater photographs has been enhanced using a Rayleigh based stretching approach. The different degrees of deterioration experienced by the Red, Green, and Blue channels may be mitigated by extending their histograms to varying degrees. To further enhance the image's features in terms of visibility, colors, and contrast, the spatial domain is used to modify the intensities of various color channels. Testing the suggested strategy on the U45 dataset yielded both quantitative and qualitative results showing that it successfully reduced haziness and minimized blue and greenish tones in underwater photos. When compared to other state-of-the-art methods, the suggested one significantly improves the visual perception of underwater pictures. The efficacy and robustness of the suggested strategy are further shown by a number of application tests.

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