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Underwater Image Enhancement based on Light Attenuation Prior

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RESEARCH ARTICLE

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Abstract— Due to light dispersion and absorption in the underwater medium, images taken underwater often have poor contrast, color distortion, detail blurring, and a blue or greenish tone, all of which negatively impact visibility. Restoration approaches and enhancement methods are the two main categories into which underwater image processing technologies fall. In restoration techniques, the impacts of the underwater environment are thought to be degrading; however, in enhancement, this environment is assumed to be natural and attempts to further improve the visual information. It has been shown that restoration strategies perform better than augmentation programs. These restoration techniques are further divided into three categories: previous knowledge, polarization, and optical imaging. These schemes' main issues include overexposure, red artifacts, difficulties identifying artificial illumination, responding to multi-scatter scenarios, and unnecessary optimization parameters. Many systems fall into these categories in the literature, and the majority of them have one or more of the aforementioned problems. This research will offer a quick and efficient scene depth estimation model based on underwater light attenuation prior for underwater photos. Learning-based supervised linear regression will be used to train the model coefficients. The real scene radiance underwater may be readily recovered by estimating the background light and transmission maps for R-G-B light using the appropriate depth map.

Index Terms— underwater images, restoration, enhancement, r-channel, prior, light attenuation.

1 INTRODUCTION

The process of obtaining scene information in a visual representation is known as image acquisition. Through the transmission of light and the reception of light reflected by the surfaces of the objects in the scene, the capturing device records the scene. The light may scatter or be dimmed due to the matter in the air if there are water molecules or other dust particles in the picture [1][2]. However, if the air is clean, no attenuation nor scattering will occur. The picture will be clear as a result. In the previous instance, the picture will not be clear since the light is not received by the capturing equipment that delivered it. This is an example of taking pictures outside [3][4]. In general, weather conditions may cause some disruption to the external environment. For instance, there will be enormous form chickens in the morning during the winter, making it difficult to take pictures in such conditions. There are difficulties in almost 99% of scenarios in the undersea environment, which is obviously a separate kind of circumstance. Even in cases when the water is clear, taking pictures becomes more challenging as depth rises [5]. The water's characteristics and the influence of light are responsible for all of this. There are two primary types of signal deterioration in the undersea environment, as seen in Fig. 1 [6]. They are light scattering and light attenuation. The phenomenon known as light attenuation occurs when light is absorbed as it travels from the scene's surface to the recording equipment. Therefore, it is not possible to capture a picture when the light signal is weakened. The item in the scene will not be fully shown in the taken photograph. The phenomenon known as "light scattering" occurs when particles in the water cause transmitted or reflected light to disperse. The light will not reach the capturing equipment or the objects of interest due to dispersion. Therefore, the contents of the underwater picture may not be accurately preserved due to these two impacts [7][8].

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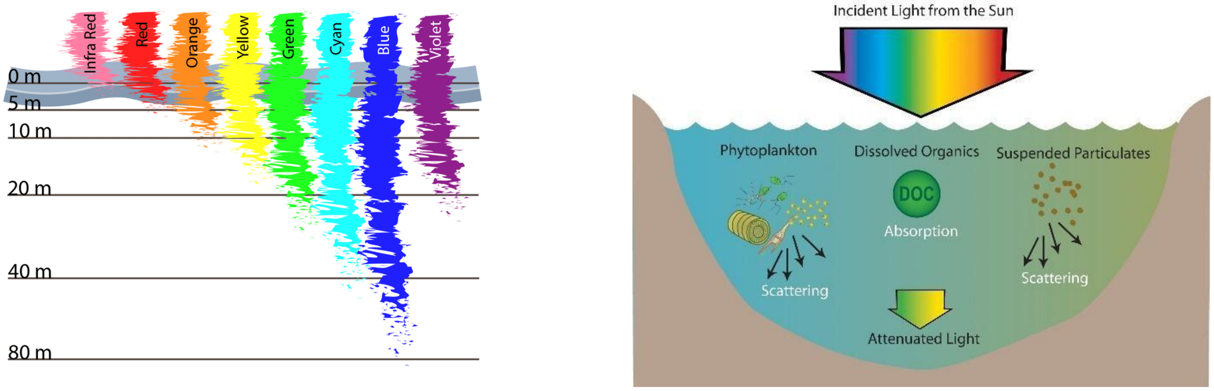

Fig. 1. Underwater environment. (a) Light attenuation (b) Light scattering

2 Light Attenuation Prior

This work proposes a model of depth estimation and picture enhancement based on a light attenuation prior. Let's specify a few concepts that will be utilized to describe the light attrition prior before we define the previous. The first is the g and b channels' maximum values. This might be written as MGB. The R channel comes next. This may be expressed simply as r [9][10].

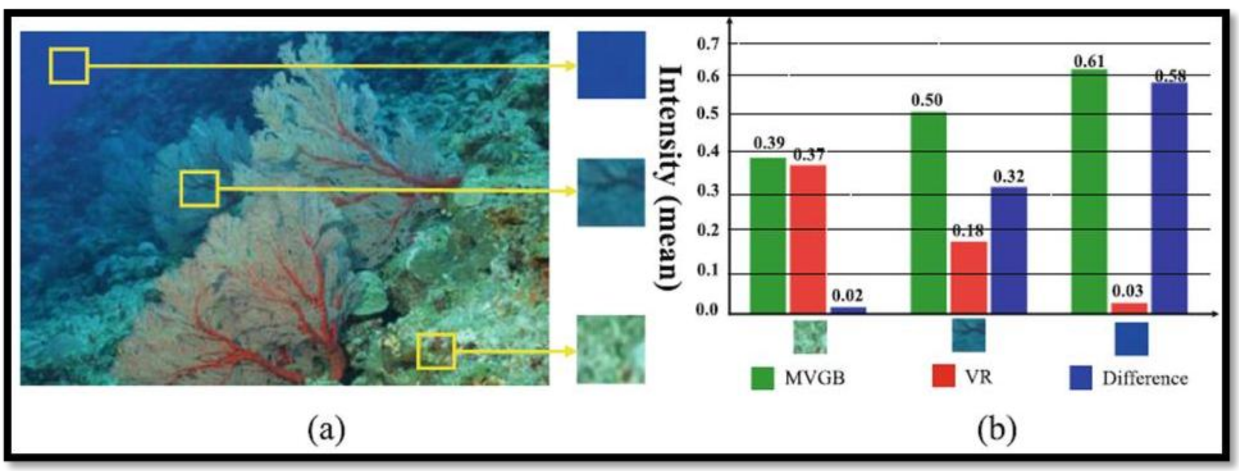

Fig. 2. Model of light attenuation prior

The light attenuation prior is described in Fig. 2. Three points are highlighted in the underwater photo. One is at a shallow depth, another is at a moderate depth, and the last one is deeper. Since the depth is lower at the first point, all color bands may pass through the water, and the red channel will be strong. The green and blue channels will be elevated in addition to the red channel. The highest value of the green and blue channels is 0.39, whereas the value of the red channel is 0.37, as shown in Fig. 2(b). Since the depth is lower, these values make sense. All lights will pass through the water with little to no attenuation or dispersion due to the shallower depth. As a result, the maximum values of the red, blue, and green channels will be almost equal. Additionally, the gap between the maximum value of the green and blue channels and the red channel will be quite small. The image's second point is at a medium depth. The maximum values of the green and blue channels will be somewhat higher than the previous values, and we may anticipate that the red channel will be somewhat attenuated there. The value of the r channel is 0.18, the highest value of the green and blue channels is 0.5, and their difference is 0.32, as shown in Fig. 2(b). Note that from the less depth point to the medium depth point, the gap between the red channel and the maximum values of green and blue grew from 0.02 to 0.32.
The red channel may be attenuated to a maximum degree at the third point, when the depth is quite high, and the maximum value of green and blue will still be larger than the value of the prior example [11][12]. The greatest value of the green and blue channels is 0.61, whereas the value of the red channel is 0.03 in Fig. 2(b). As a result, the difference between the maximum value of the green and blue channels and the red channel was raised to 0.58. It is clear from the research that the depth is closely correlated with the difference between the red channel and the highest value of the green and blue channels. Additionally, the depth may be approximated

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by calculating the color components of a specific pixel and using the aforementioned approach. In order to repair or improve the underwater picture, artificial light and artificial color components may be introduced to the relevant pixels once the depth has been estimated using the light absorption criterion [13][14].

3 Proposed Scheme

Based on the light attenuation prior, the depth is estimated as follows:

$$d(x) = \mu_0 + \mu_1\, m(x) + \mu_2\, v(x)$$

Here, μ_0, μ_1 and μ_2 are the constants to be calculated, m(x) is the maximum value of green and blue channels, v(x) is red channel value. The coefficients μ_0, μ_1 and μ_2 are learned using neural networks and are given below.

$\mu_0 = 0.53314829$,

$\mu_1 = 0.51319827$ and

$\mu_2 = 0.91067194$.

Using the coefficients generated using neural networks, and using the above relation, the depth estimation is possible and accurate results were generated. The depth d(x) is the relative depth map. The relative depth map is not sufficient to find the transmission map. Hence, the relative depth map factored by a scaling factor D_∞ which converts it into realistic distance.

$$d_a(x) = D_\infty \cdot d(x)$$

With the above estimation of actual distance, one can derive the transmission map of the underwater image as:

$$t_\lambda(x) = Nrer(\lambda)^{d_a(x)}$$

4 Simulation Results

In this section, simulation results of proposed scheme are presented. The test images are collected from standard open-source libraries available online.

Input Image Processed Image



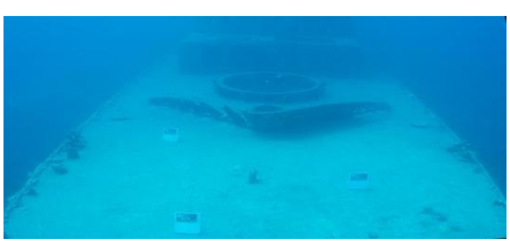


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Fig. 3. Performance of Proposed Scheme on Deep Sea Images

Three categories comprise the dataset. The first is photos taken in the deep water, where certain hues are severely attenuated. In this instance, estimating depth and adding backlight to picture pixels is difficult and requires adjusting depth levels on a logarithmic scale. The suggested scheme's performance is just notional since depth estimation-based approaches are inappropriate in this situation. Images of medium depth and poor substance make up the second group. In order to catch the subtleties of certain features and objects, these photos were taken from a medium height. Figure 4 illustrates how well the suggested technique works with these kinds of photos. The simulation results demonstrate that the suggested strategy increases the image's characteristics and improves its quality. Every item in the picture, including fish and other aquatic life, is part of the setting. Images with medium depth and substantial substance make up the third group. The overall state of the information included in the picture is used to classify the photos with low and high content. There is a lot of information in the photographs in the third category. Additionally, the suggested technique has shown improved performance on these photos. The backdrop is one of the numerous aspects of the high content picture. The contents of the processed picture may power autonomous systems because the suggested technique improved the image.

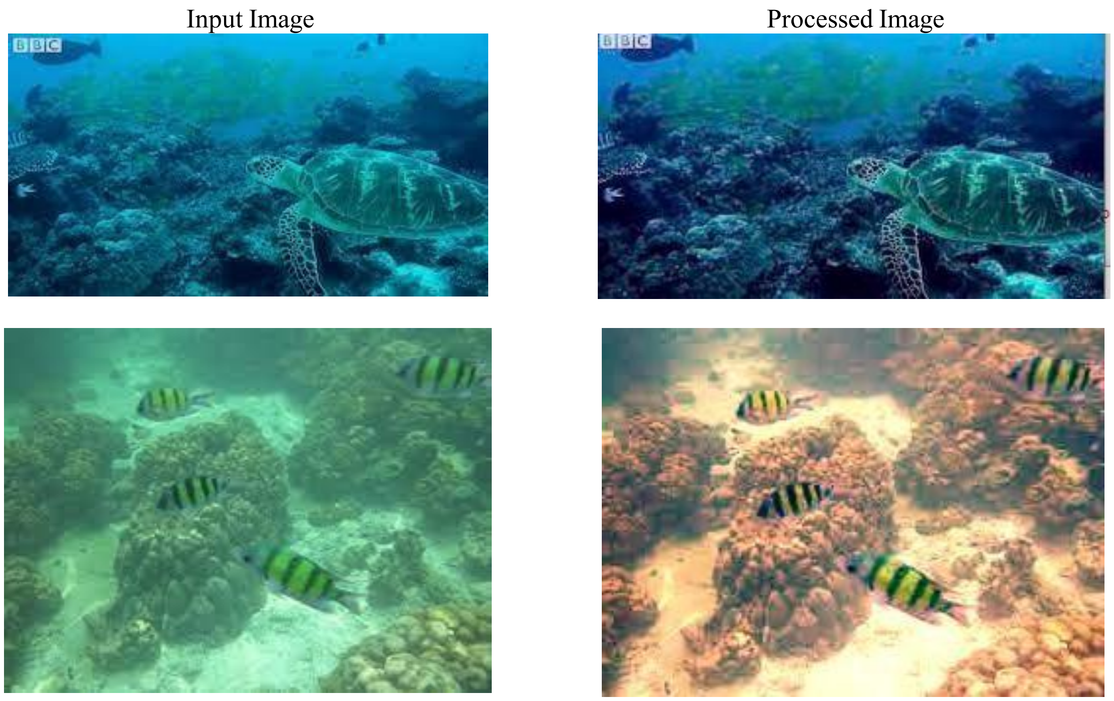
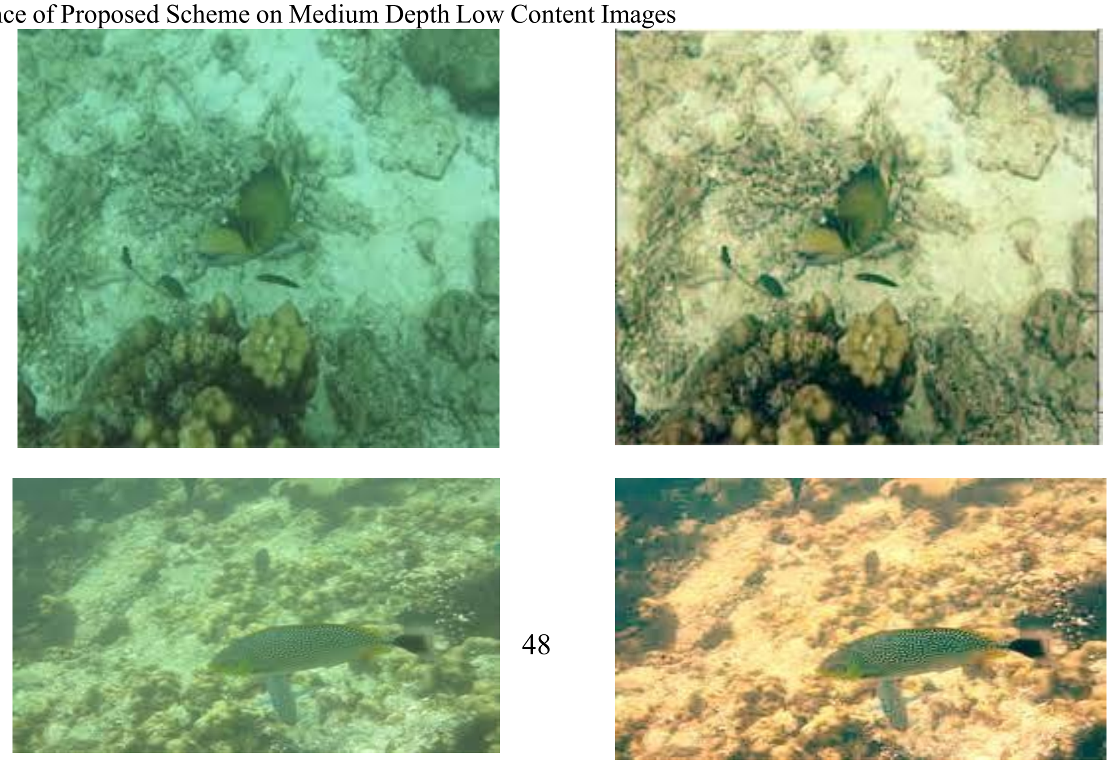


Fig. 4. Performance of Proposed Scheme on Medium Depth Low Content Images



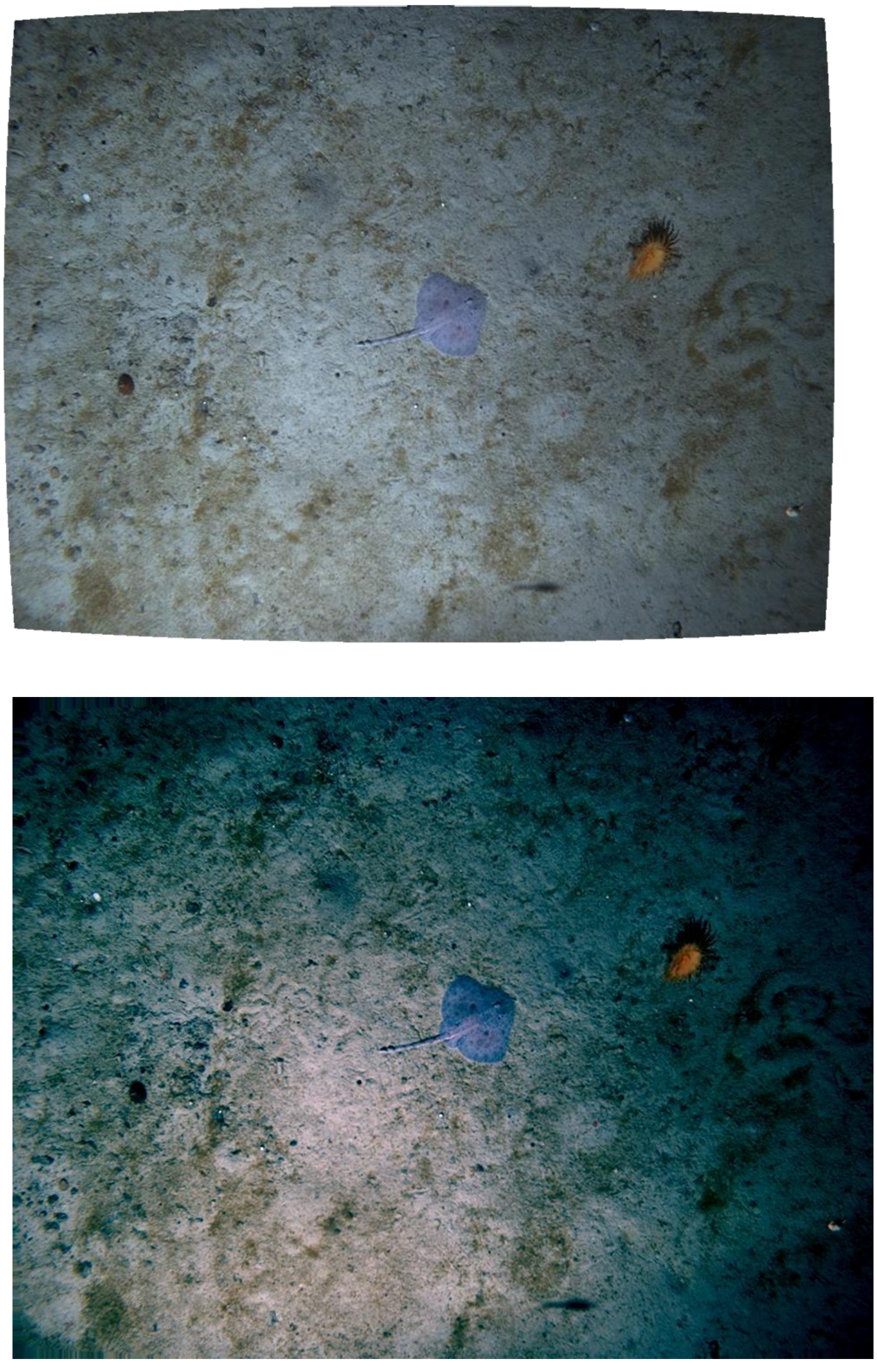


Fig. 5. Performance of Proposed Scheme on Medium Depth High Content Image

5 Conclusions

Numerous natural light effects are present in underwater photos, and a variety of elements affect their quality. The majority of the time, color content is lost in varying amounts, making reversal a difficult operation. Enhancement or restoration may be used to improve the quality of underwater photos. The literature offers several methods for restoring and improving underwater images. While enhancement schemes see the work as enhancing the image's quality or emphasizing certain key elements, restoration methods view the task as restoring lost information. The preceding or light property serves as the foundation for the suggested plan. The depth is defined by the property as a function of the red, green, and blue channels. The RGB channels are restored using a rule that is constructed using the coefficients discovered via deep learning based on the depth information. Several types of underwater photos were used to evaluate the suggested method. The simulation results demonstrate that the suggested strategy performs well at medium and low depths. This is because the red channel will be totally absorbed at a certain depth, making it impossible to determine the precise depth.

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