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Light Attenuation Prior based Underwater Image Enhancement

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Abstract—Images captured underwater usually suffer from color distortion, detail blurring, low contrast, and a bluish or greenish tone due to light scattering and absorption in the underwater medium, which in turn affects the visibility adversely. Underwater image processing schemes are broadly categorized into two groups, restoration methods and enhancement methods. The approach of restoration methods is to assume the effects of underwater environment as degradation but in enhancement, this environment is assumed to be natural and tries to enhance the visual information to next extent. Restoration schemes are proved to give better performance than enhancement schemes. These restoration schemes are further classified as optical imaging methods, polarization methods and prior knowledge methods. The key problems faced by these schemes are excessive optimization parameters, difficulty of recognizing artificial lighting, adapting to multi-scatter scenario, red artifacts and over exposure. A large number of schemes are proposed in the literature under these categories and most of them suffer from one or more of the above-mentioned issues. In this paper, a rapid and effective scene depth estimation model will be proposed based on underwater light attenuation prior for underwater images and train the model coefficients with learning-based supervised linear regression. With the correct depth map, the background light and transmission maps for R-G-B light are easily estimated to recover the true scene radiance under the water.

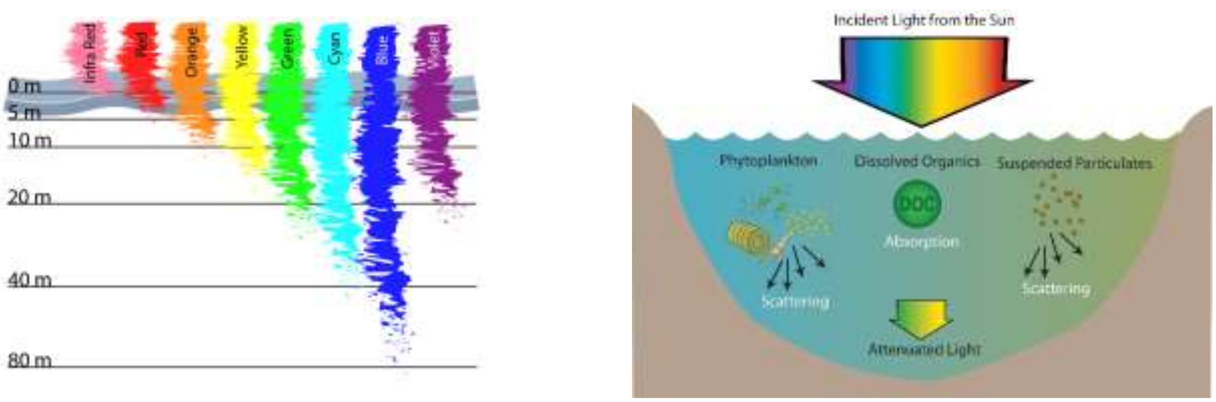
Index Terms— underwater images, restoration, enhancement, r-channel, prior, light attenuation.

1 Introduction

Image acquisition is a process of acquiring a scene information in a pictorial representation. The scene of the situation is captured by the capturing device by transmitting the light and receiving the light reflected by the surface of objects in the scene. If the air in the scene has some water molecules or any other dust particles, the light may scatter or gets attenuated because of the matter present in the air [1][2]. On the other hand, if the air is clear the light will not get attenuated as well as it will not get scattered. Hence the image will be clear. In the earlier case because the light is not received by the capturing device which it transmitted; the image will not be clear. This is a case of outdoor image capturing [3][4].

The outdoor environment is generally susceptible to some disturbance because of weather conditions. As an example, during winter in the morning hours there will be huge form hens capturing an image in that weather condition is not an easy task. The underwater environment is clearly a different class of situation where there is a difficulty in more than 99% of situations. Even if the water is clear as depth increases the capturing of image is a very difficult task [5]. All this is attributed to the water property and light effects.

As shown in Fig. 1, the underwater environment suffers from two main categories of signal degradation [6]. They are light attenuation and light scattering. The light attenuation is the phenomena by which the light signal gets absorbed while it is travelling from either the capturing device or the surface of the scene. So, when the light signal gets attenuated the capturing of image is not feasible. The captured image will not contain the complete details of the object that is present in the scene. Light scattering is the phenomena by which the transmitted light or reflected light gets spread because of the particles present in the water. Because of scattering the light will not reach the objects of interest or the capturing device. So, because of these two effects the contents of underwater scene or not properly captured [7][8].



(a) (b)

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

2 LIGHT ATTENUATION PRIOR

In this paper, a light attenuation prior is proposed based on which a model of depth estimation and image enhancement is proposed. Before defining the prior, let's define few terms which will be used in defining the light attrition prior. The first one is the maximum value of g channel and b channel. This maybe written as MGB. The next one is r channel. This is written simply as r [9][10].

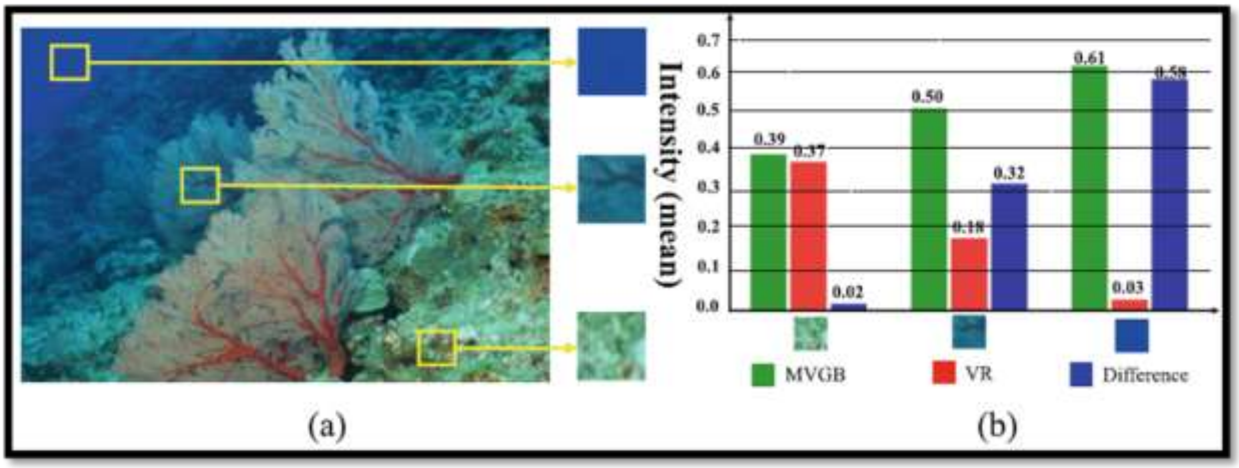


Fig. 2. Model of light attenuation prior

In Fig. 2, the light attenuation prior is characterized. In the underwater image, three points are noted. One is at a low depth, another one at medium depth and the last one is deeper. At the first point, as the depth is less, all colour bands penetrate through the water and the strength of red channel will be high. In addition to red channel, green and blue channels will also be high. In Fig. 2(b), it is shown that the maximum value of green and blue channel is 0.39 and the value of red channel is 0.37. These values are reasonable as the depth is less. Because of less depth all lights will travel inside of the water without any significant attenuation or scattering. Hence the maximum value of green and blue and red channel value will be more or less same. And when we find the difference between red channel and maximum value of green and blue channel, this difference will be very less.

The second point in the image is at medium depth. There we can expect red channel to be attenuated by some extent and maximum value of green and blue channel will be little higher than the earlier values. In Fig. 2(b), it is shown that the value of r channel is 0.18 and the value of maximum of green and blue channels is 0.5 and their difference is 0.32. It is to note that the difference between red channel and maximum value of green and blue was increased from 0.02 to 0.32 from less depth point to medium depth point.

If we consider the third point, where the depth is very high, one can estimate that the red channel maybe attenuated to a maximum extent and the maximum value of green and blue will be still higher than the value of previous case [11][12]. In Fig. 2(b), it is shown that the value of red channel is 0.03 and the maximum value of green and blue channel is 0.61. Hence the difference between the red channel and maximum value of green and blue channel was increased to 0.58.

Based on the analysis presented, it can be understood that the difference between the red channel and maximum value of green and blue channel corresponds directly to the depth. And also, if the colour components of a particular pixel are calculated and apply the above analysis, the depth may be estimated. After estimating the depth, based on the absorption criteria of light, the artificial light and artificial colour components may be added to the corresponding pixels to restore or enhance the underwater image [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.

$$d_a(x) = D_\infty \, . \, d(x)$$

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

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

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.

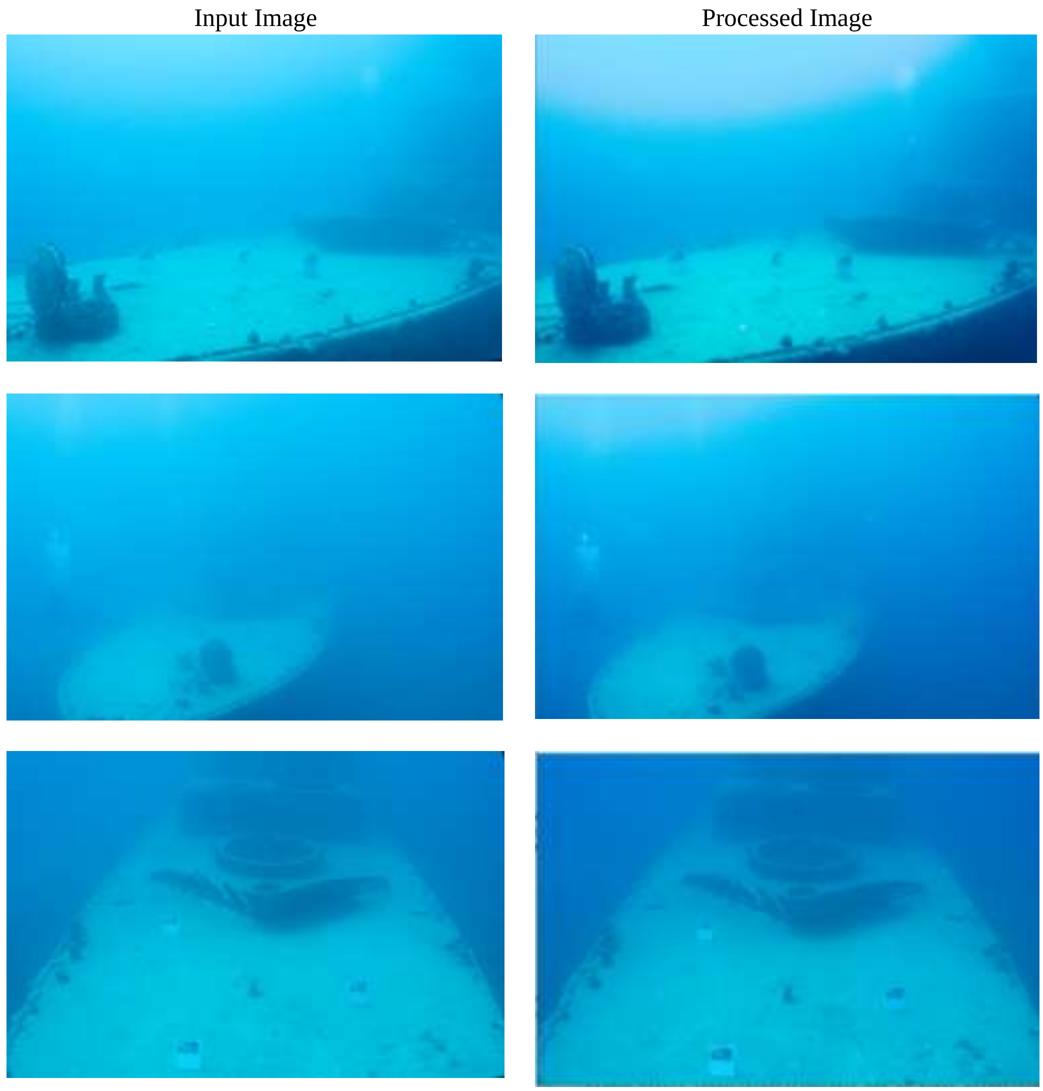


Fig. 3. Performance of Proposed Scheme on Deep Sea Images

The dataset is divided into three categories. The first one is deep sea images, where the attenuation of certain colors is extremely high. In this case, the estimation of depth and applying backlight to pixels of image is challenging and need adaption of levels of depth in logarithmic scale. Depth estimation-based schemes are not suitable for this case and hence, the performance of the proposed scheme is just nominal. The second category of images is that of medium depth low content images. These images are captured at medium height and the image focused to capture the details of specific features and objects. The performance of the proposed scheme on this kind of images is shown in Fig. 4. The simulation results prove that the proposed scheme improves the quality of the and enhances the features of the image. All the objects of the image contained in the scene, like, stones, rocks, fish and other creatures in the water. The third category of images is that of medium depth high content images. The images with low and high content are categorized based on the general condition of information contained in the image.

The third category of images contain much information in the image. The proposed scheme has shown better performance on these images too. The high content image will have many features including background. As, the proposed scheme enhanced the image, the contents of the processed image can drive autonomous systems.

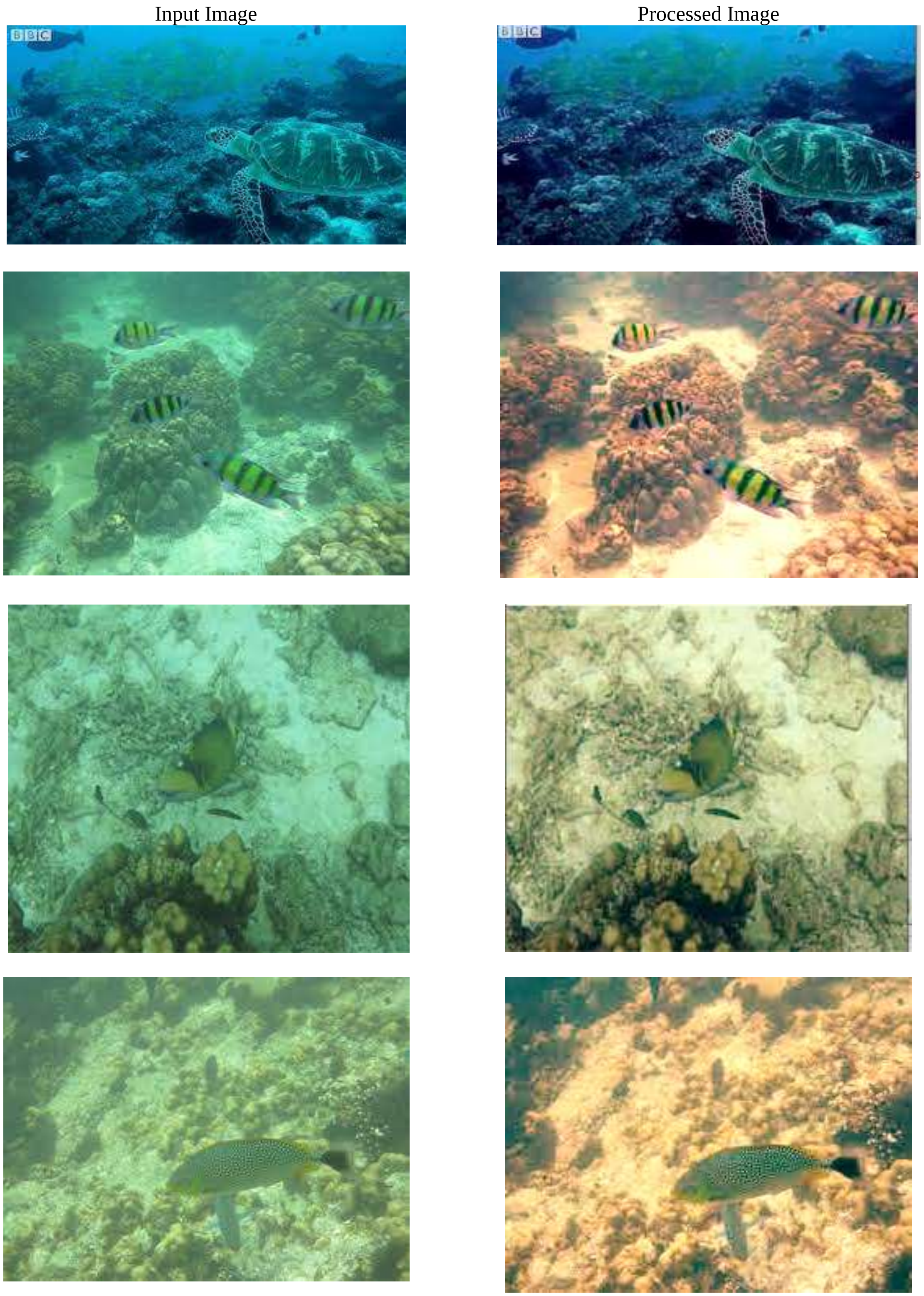


Fig. 4. Performance of Proposed Scheme on Medium Depth Low Content Images

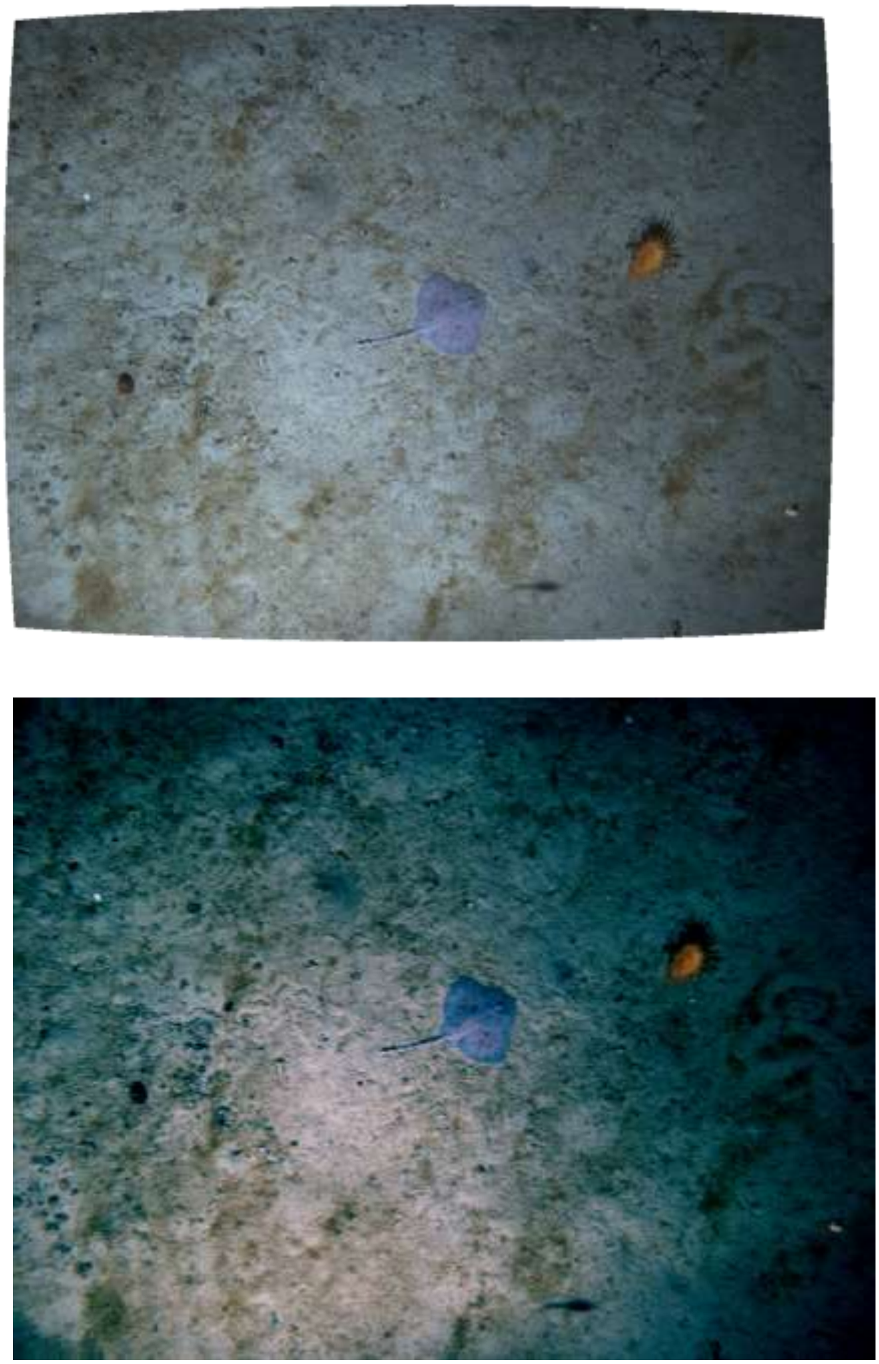


Fig. 5. Performance of Proposed Scheme on Medium Depth High Content Image

5 CONCLUSIONS

Underwater images undergo many natural light effects and the quality depends on many factors. In most cases, color contents loss in different quantity which realizes a challenging task of reversal. Improving the quality of underwater images may be treated as restoration or enhancement. Many underwater image restoration and enhancement schemes are proposed in the literature. Restoration schemes treat the task as recovering lost information and enhancement schemes treat the task as improving the quality or highlighting some important features contained in the image. The proposed scheme is based on a prior or light property. The property defines the depth as a function of red, green and blue channels. Based on the depth information the RGB channels are restored based on a rule defined using the coefficients found using a deep learning. The proposed scheme was tested on different kinds of underwater images. The simulation results proves that the performance of proposed scheme is high when the depth is medium and low. This is because, after a certain depth, the red channel will be completely absorbed and hence give no clue of specific depth.

REFERENCES

[1] Zhao, X., Jin, T., Qu, S.: Deriving inherent optical properties from background color and underwater image enhancement. Ocean Eng. 94, 163–172 (2015)

[2] Huang, D., Wang, Y., Song, W., Sequeira, J., Mavromatis, S.: Shallow-water image enhancement using relative global histogram stretching based on adaptive parameter acquisition. In: Schoeffmann, K., et al. (eds.) MMM 2018. LNCS, vol. 10704, pp. 453–465. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-73603-7_37

[3] He, K.M., Sun, J., Tang, X.O.: Single image haze removal using dark channel prior. IEEE Trans. Pattern Anal. Mach. Intell. 33(12), 2341–2353 (2011)

[4] Galdran, A., Pardo, D., Picón, A., Alvarez-Gila, A.: Automatic Red-Channel underwater image restoration. J. Vis. Commun. Image Represent. 26, 132–145 (2015)

[5] Wang, J.B., He, N., Zhang, L.L., Lu, K.: Single image dehazing with a physical model and dark channel prior. Neurocomputing 149, 718–724 (2015)

[6] Peng, Y.T., Cosman, P.C.: Underwater image restoration based on image blurriness and light absorption. IEEE Trans. Image Process. 26(4), 1579–1594 (2017)

[7] Chiang, J.Y., Chen, Y.C.: Underwater image enhancement by wavelength compensation and dehazing. IEEE Trans. Image Process. 21(4), 1756–1769 (2012)

[8] Drews, P., Nascimento, E., Moraes, F., Botelho, S., Campos, M.: Transmission Estimation in Underwater Single Images. In: Proceedings of IEEE ICCVW 2013, pp. 825–830 (2013)

[9] Wen, H.C., Tian, Y.H., Huang, T.J., Guo, W.: Single underwater image enhancement with a new optical model. In: Proceedings of IEEE ISCAS 2013, pp. 753–756 (2013)

[10] Li, C.Y., Quo, J.C., Pang, Y.W., Chen, S.J., Wang, J.: Single underwater image restoration by blue-green channels dehazing and red channel correction. In: ICASSP 2016, pp. 1731–1735 (2016)

[11] Liu, X.P., Zhong, G.Q., Cong, L., Dong, J.Y.: Underwater image colour constancy based on DSNMF. IET. Image Process. 11(1), 38–43 (2017)

[12] Ding, X.Y., Wang, Y.F., Zhang, J., Fu, X.P.: Underwater image dehaze using scene depth estimation with adaptive color correction. In: OCEAN 2017, pp. 1–5 (2017)

[13] Zhu, Q.S., Mai, J.M., Shao, L.: A fast single image haze removal algorithm using color attenuation prior. IEEE Trans. Image Process. 24(11), 3522–3533 (2015)

[14] He, K.M., Sun, J., Tang, X.O.: Guided image filtering. IEEE Trans. Pattern Anal. Mach. Intell. 35(6), 1397–1409 (2013)