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NEW APPROACH IN COLOR DISTORTION REDUCTION IN UNDERWATER CORAL REEF COLOR IMAGE ENHANCEMENT BASED ON ESTIMATION ABSORPTION USING EXPONENTIAL EQUATION

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ABSTRACT

Indonesia's coral reef shares 18% part of the world's coral reef. It is estimated that Indonesia's coral reef comprises of 51,000 km^2. It is estimated that 7% of coral reef is in very good condition, 33% good, 45% is damaged, and 15% poor. The color of coral reef indicates its health. One difficulty to identify the original color of coral reef is that the color changes when it is taken out of water. Color distortion of an underwater image is caused by light spread and color change. Color spread occurs because some light beam is reflected and refracted by underwater environment, whereas underwater object color change is caused by different light wave when spreading in the water. This research proposes an exponential approach to enhance the appearance of coral reef in underwater image. This approach restores the color constancy of red, green, and blue. The result is measured by using Peak Signal to Noise Ratio, and it gives PSNR value of 20.58. We concluded that exponential approach can enhance underwater coral reef color well.

Keywords: *Coral Reef, Color Image Enhancement, Absorption, Color Constancy, Exponential Equation*

1. INTRODUCTION

Indonesia is the biggest archipelago in the world. It has 81,000 km shoreline and more than 17,508 islands. Its coral reef comprises the width of 51,000 km2, sharing the portion of 51% of Asia's and 18% of the world's coral reef. 7% of coral reef is in very good condition, 33% good, 45% is damaged, and 15% poor [1] [2]. One indicator of coral reef health is the original color of coral reef. The difficulty to identify the original color of coral reef is that the color changes when it is taken out of water.

Generally, underwater image quality is very low because the incoming light in the water influenced underwater particles [3] [4] [5]. Two main causes of underwater image color distortion are light spread and color change . Color spread occurs because some light beam is reflected and refracted by underwater environment. Meanwhile, underwater object color change is caused by different light wave when spreading in the water. Red is absorbed nearly 100% under the water surface, while green and blue are penetrated deeper, thus green and blue dominate [6].

Another method is called Unsupervised Colour Method [7], It is based on color correction in RGB and HSI color models. The result of this method shows that it is more efficient to eliminate bluish color and to enhance reddish color in underwater images.

Another approach is based estimates of absorption of light, polynomial approach can enhance underwater color image, the result of this approach approximates the color a color image on the surface of the water [3] [4] None of their proposed methods can eliminate color distortion that is caused by color spread and color change occurring simultaneously [8]. The color quality of coral reefs very low level of brightness due to environmental influences underwater became one of the problems in this study.

In this paper we propose exponential equation approach to eliminate color distortion for underwater coral reef color image enhancement.

Two stages of the approach used, the first step of this approach is determining the equation of the relation between color intensity on the water surface and that in a certain depth. The second step is determining the function of color intensity absorption below the water surface by using least square method.

2. RELATED WORKS

Pujiono, et.al. [3] [4] proposed a polynomial approach based on the absorption of light to enhance the color of underwater. image. Two steps being taken are the first to determine the relationship between the intensity of the color on the surface of the water with the color at depth below the water surface, the second stage determines the absorption coefficient using least square. The results of this approach can enhance underwater color image as color images on the surface of the water. Implementation of polynomial approach can improve the color of coral reefs as approaching the original color or color on the surface of the water.

Pujiono, et.al [5] proposed exponential approch to enhance color of umderwater image. The results of this approach can enhance underwater color image just as its original color. Evaluated exponential approach measured by using Peak Signal to Noise Ratio yielding an average value of 19.18.

Iqbal K, Salam RA. Osman A, and Talib AZ [6], In the underwater environment the level of clarity of an image degraded by the absorption and scattering of light, this causes a color will dominate the color. In an effort to improve color image underwater the proposed color-based approach in contrast stretching. There are two objective of this approach first contrast stretching algorithm with RGB to match the color contrast in the image; second, saturation and intensity contrast strecting HSI is used to improve the color of the actual and resolve lighting problems.

Iqbal K, Odunayo M, James A, Salam RA and Talib AZ [7] Absorption and scattering of light in the underwater environment causing underwater image has low contrast and the color is not uniform thus affecting the quality of image processing under water. In this paper, the proposed method of unsupervised color correction, wherein the method is based on the color balance, contrast correction RGB color model and contrast correction HSI color model. The results of this approach to efficiently reduce the intensity of blue color, increasing the intensity of red, improve lighting so improve underwater color image

Chong-Yi Li, et al [9], the effects of absorption and scattering caused underwater image degradation, so that the display and analysis of underwater images that do have limitations. The low contrast and color quality underwater images lowering the level of detection accuracy of underwater images and recognition of marine biology. Methods of improving the image of the underwater systematic algorithm using an underwater image dehazing and a contrast enhancement algorithm. Dehazing algorithms in principle to restore visibiltas and underwater color image, while contrast enhancement algorithm based distribution histogram previous work to increase the contrast and brightness of colors underwater. There are two versions of the output generated from the proposed method, the first version in the form of color relatively original and natural as well as in accordance with the display while the version of the output of the two levels of contrast and brightness so high that it can be used to get more detailed information of the image underwater.

Miao Yang and Arcot Sowmya [10], the main purpose of underwater video capture is to evaluate the image quality under water. Currently there is no proposed metrics for evaluating color quality underwater imagery (UCIQE). Absorption and scattering characteristics underwater does not allow the application to directly measure the quality of underwater images of the underwater environment is different. This paper testing subjectively underwater image quality. The statistical distribution of the image pixel under water in the CIELAB color space associated with the subjective evaluation showed sharpness and correlates well with the subjective perception of image quality. The new metric approach UCIQE which is a linear combination of chroma, saturation and contrast for measuring non-uniform color, blur and low contrast. Experiments were performed to describe the performance metrics UCIQE and the ability to measure the results of image enhancement under water. Results of research conducted show there is good correlation metric UCIQE with a subjective mean opinion score.

Yan-Tsung Peng and Pamela C. Cosman [11] distortion of the color and low contrast to the image of the underwater because light is scattered and absorbed by the light propagates in the water. A depth estimation method based on image blur and the absorption of light used in Image Formation Model (IFM) to improve and enhance the image of

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the underwater. The proposed method can estimate more accurate depth underwater scene.

Yan-Tsung Peng, et al. [12] propose new approaches to improve the image of the underwater of the image blur based on depth estimation. The experimental results show that the proposed method can result in increased underwater pictures better in different lighting conditions compared to the repair method based on Image Formation Model (IFM).

Yaomin wang, et al. [13] currently one of the important and fundamental task in underwater research is improving the image of the underwater. Approach the models and the virtual retina image quality assessment (IQA), where in the virtual retina model approach produces a high correlation with the human visual system and then make an adaptive image enhancement strategy. The strategy for improving adaptive image taken with a kind of a no-reference image quality assessment based patch Discrete Cosine Transform (PDCT), which indicates whether the patch images are naturally uniform or not. The proposed approach to achieve great performance, effective and precision for underwater imagery

Guraksin et.al [14] underwater image resolution and contrast is very low due to the absorption and scattering of light underwater, this condition causes one of the colors dominate the color. Underwater image enhancement approach using differential evolution algorithm is able to reduce the effects of scattering and absorption of light in water. Sudhan et.al [15] Dark Channel Prior approaches with Contrast Limited Adaptive Histogram Equalization is used to improve underwater pictures have performance improves contrast and reduces noise underwater pictures.

Chiang, J.Y., and Chen, Y.C. [16], two major sources that cause a decrease in visibiltas and underwater image contrast is light scattering and discoloration. The scattering of light caused by light entering into the water is absorbed and reflected by particles of water while color changes due to the different wavelengths when light propagates in the water. Proposed WCID algorithm, where the algorithm is able to complete the scattering of light and color change and improve the contrast of colors underwater.

Andono, P.N., et al. [17] the quality of underwater image is one of the factors that determine the underwater image registration. Proposed a method of improving the image of the underwater use of adaptive filtering based on CLAHE using Rayleigh distribution. The result of applying this method increases by 41% for image registration using SIFT approach. Adaptive Clahe method can be an alternative solution to improve the performance of image registration underwater compared to manual contrast stretching

Hitam, M.S., Yussof, W.N.J.H.W, Awalludin, E.A., Bachok, Z [18] The low quality of the image underwater due to the physical properties of the water medium. Proposed a new method that is mixture Contrast Limited Adaptive Histogram Equalization specifically developed to enhance underwater color image. This method operates on RGB and HSV color models, and the results of both models are combined using the Euclidean norm. The results showed that the proposed approach can enhance the quality and image contrast underwater..

bt. Shamsuddin et. al. [19] Underwater imagery is a challenge in the world of photography due to the low resolution and a regular digital camera. The problems in underwater image as low level visibilty, low lighting, light scattering and color change. In this study proposed two techniques to perform manual color correction is a technique and automation. Results of manual techniques more precise and effective way to perform color correction of underwater imagery.

Rai, R.K., Gour, P., and Singh B [20], Underwater object is not clearly visible because of the low contrast and light scattering, so the difficulty in performing object segmentation underwater. In this research object segmentation underwater, where underwater image quality improved by using Contrast Limited Adaptive Histogram Equalization and object segmentation is done by using the histogram thresholding. The results of this research is the method CLAHE able to increase the contrast and equalizes the histogram more efficiently. Beohar, R. and Sahu P [9] Difficulties in the analysis of objects underwater because of the image in the underwater environment loses the detail of the object. In this paper used the method Contrast Limited Adaptive Histogram Equalization and 2D median filter to improve the image of the underwater and image segmentation using histogram tresholding for later analysis. The results of this research is the method CLAHE with 2D median filter not only improves the contrast but also equalizes the image histogram more efficiently

SwarnaLakshmi, R. and Loganathan, B [21] Environmental conditions underwater object color is distorted because the incoming light in tedifusi water and partly absorbed by the particles of color under water causing one color dominates the underwater object. The proposed method of feature extraction algorithms and color constancy, where

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the results of this method can improve underwater color image

3. MATERIALS AND METHOD

3.1. Data Acquisition and Location

The data were taken in Karimunjawa islands. It is located in the north of Java island, Indonesia, at 5° 49'- 5° 57' South Latitude and 110° 04' - 110° 40' East Longitude, as shown in Figure 1. Due to the natural diversity in Karimunjawa islands, based on the decree of Forestry Minister of Republic of Indonesia, it becomes natural conservation area [17].

Figure 1: Karimunjawa Island, Central Java, Indonesia

The coral reef images were taken by using Olympus Tough-8010 camera, with 1280X720 pixel resolution a 5 meter depth under the water surface, as shown in Fig. 2. The coral reef objects were taken in the form of videos. The researchers conducted three sessions of video taking, each session took 20-30 minutes to obtain videos with better quality. The videos were next converted into images to process the color enhancement.

Figure. 2: Data Acquisition

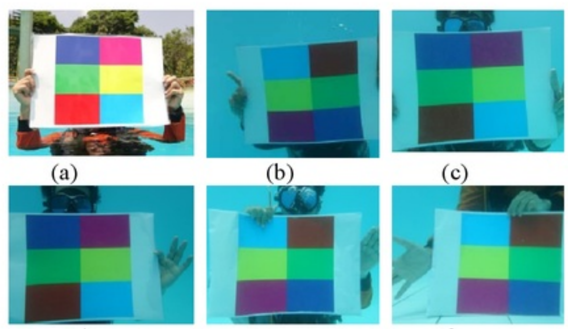
3.2. Exponential Equation

Exponential equation is an approach to determine the constancy of red, green, and blue in underwater image. This approach consists of two steps: first, determining the absorption function of color intensity on the water surface and the color intensity in a certain water depth; second, determining the absorption coefficient by using least square. According to Beer-Lambert law the exponential equation in underwater image color intensity can be stated as follows [5]:

$$I_k = I_p e^{-ck} \quad (1)$$

where I_k, I_p are image color intensity in k depth and image color intensity on the water surface respectively, e^{-ck} is absorption function with c is absorption coefficient and k is depth at k

The image samples consist of six colors on the water surface, in 1 meter, 2 meter, 3 meter, 4 meter, and 5 meter depth below the water surface, Figure. 3.



(a) (b) (c)
(d) (e) (f)

Figure 3. (a). water surface (b). 1 meter depth (c). 2 meter depth (d). 3 meter depth, (e). 4 meter depth (f). 5 meter depth

The images were taken from objects having basic colors of red, green, and blue (Figure 4).

Figure 4 : Basic color : Red, Green and blue

The basic colors were used to determine the value of average intensity of those colors (Table 1).

Table 1: The Value of RGB Color Intensity in each Depth

Depth (m)	Color		
	Red	Green	Blue
0	254.38	226.57	199.08
1	72.04	126.51	116.79

2	47.8	160.39	140.64
3	78.86	162.81	143.51
4	115.91	204.36	180.93
5	83.37	200.73	177.94

By applying logarithm equation and minimizing with least square [5] [8]. in equation (1) and Table 1, the correlation between instensity of color on the water surface and a depth k for red, green, and blue can be obtained as follows:

$$I_{kr} = I_{pr}\, e^{-0.3096k} \quad (2)$$

$$I_{kg} = I_{pg}\, e^{-0.0897k} \quad (3)$$

$$I_{kb} = I_{pb}\, e^{-0.0878k} \quad (4)$$

I_{kr}, I_{kg} and I_{kb} are image color intensities at k depth for red, green, and blue respectively, while I_{pr}, I_{pg} and I_{pb} are color intensities on the water surface for red, green, and blue respectively, k is a depth.

Equation (2), (3), and (4) are exponential approach to enhance the image based on the color constancy of red, green, and blue [5]. Given the intensity of red, green, and blue at k depth, therefore the intensity of red, green and blue on the water surface can be determined. The intensity of red, green, and blue are the basic of an image. If the image color at k depth is identified, by using exponential the image color on the water surface can be determined.

4. EXPERIMENTAL AND RESULT

The coral reef images were taken in Karimunjawa. They are in the form of video file taken by using Olympus Tough-8010 with 1280 x 720 pixel resolution. The video file was then extracted into images. One of these images can be seen in Figure 5.

Figure 5 Image Extraction

The process of enhancing underwater image color quality involved exponential equation approach. It was performed by using fifty Karimunjawa coral reef samples. The result of exponential equation was measured by using Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) method. Table 2 shows the average value of MSE and PSNR for Red, Green and Blue color respectively.

Table 2: The Value of MSE and PSNR

Method	MSE			PSNR		
	Red	Green	Blue	Red	Green	Blue
HE	1342,73	587,05	553,88	17,85	21,12	21,40
CLAHE	992,38	649,76	613,98	18,39	20,14	20,38
Exponential Equation	3550,08	263,41	208,95	12,83	23,93	24,97

Figure 6, Show the average Peak Signal to Noise Ratio (PSNR) of Exponential approach, yielding the average value of Peak Signal to Noise Ratio is 20.58. This value is greater than that using Histogram Equalization (HE) and Contrast Limited Adaptive Histogram Equalization (CLAHE).

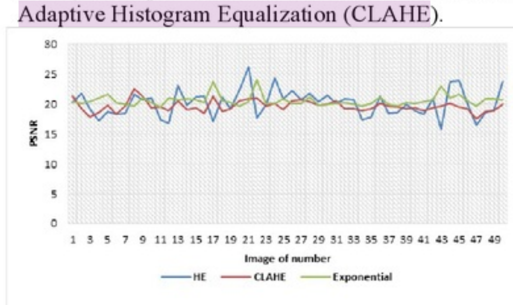


Figure 6 : The average value of PSNR

A histogram graphic of red, green, and blue color channels of the underwater image (Figure 7a) and image colors after exponential equation application (Figure 7b). The brightness enhancement of green and blue color channels after exponential equation application is relatively small compared to that of red color channel. This is because in 5 meter depth below the water surface red is mostly absorbed whereas green and blue are penetrated, and even dominate [18].

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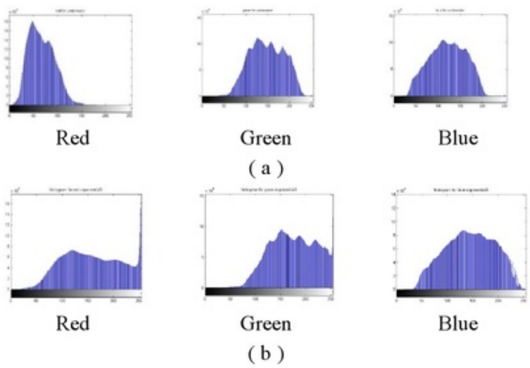

Figure 7 : (a) histogram graphic of underwater image, (b) histogram graphic of image using exponential equation

The results of exponential equation are displayed in Fig. 8. Shows coral reef and fish image in 5 meter depth below the water surface in which yellow dominates. By applying Histogram Equalization (HE) and Contrast Limited Adaptive Histogram Equalization (CLAHE) the coral reef is contrastingly dominated by purplish color, whereas by applying exponential equation the coral reef color appears similar to its color in the water depth with better brightness.

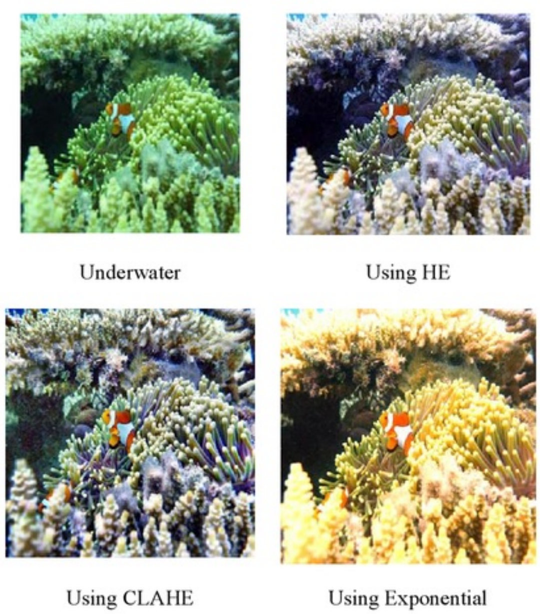

Figure 8 : Coral Reef and Fish Image

Figure 9 shows a stone-like coral reef in 5 meter depth that has low visibility. By applying Histogram Equalization (HE) and Contrast Limited Adaptive Histogram Equalization (CLAHE), the stone-like coral reef object is dominated by purplish color with fair contrast, while exponential approach gives a more natural color and better brightness to the object.

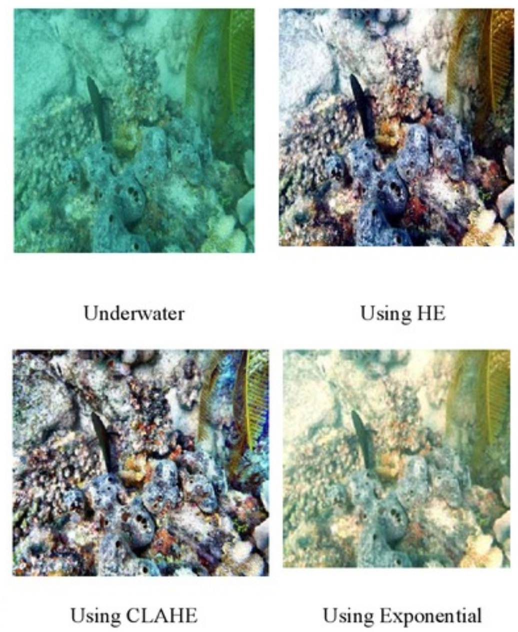

Figure 9: a Stone-like Coral Reef

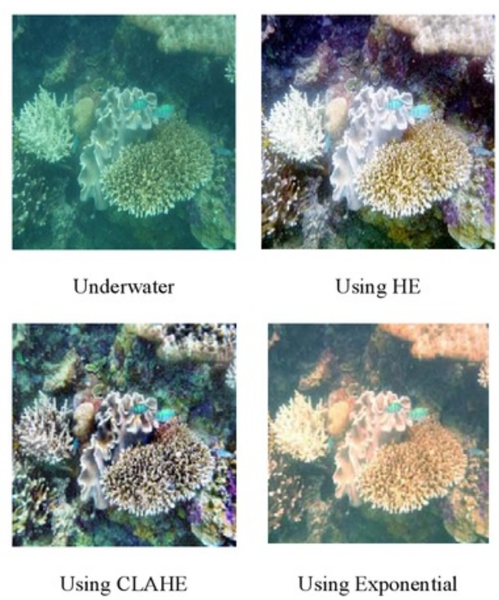

Figure 10 : Coral Reef

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Figure 10 Presents coral reef color with relatively low contrast. By applying Histogram Equalization (HE) and Contrast Limited Adaptive Histogram Equalization (CLAHE) the coral reef is dominated by purplish color that is highly contrasting, and the color is also brighter despite purplish color domination. The exponential equation approach gives a color that is relatively similar to that in 5 meter depth with a fairly good brightness level despite hazy appearance.

5. CONCLUSION

This research proposes an exponential approach to enhance underwater coral reef color. This equation restores the color constancy of basic colors is red, green, and blue color. The first step of this approach is determining the equation of the relation between color intensity on the water surface and that in a certain depth. The second step is determining the function of color intensity absorption below the water surface by using least square method.

The result of exponential equation approach is measured by using Peak Signal to Noise Ratio which results in PSNR value average of 20.58, this value is better than existing methods. It can be concluded that exponential equation approach can enhance the underwater image color better. A further research is necessary to improve coral reef color in more than 5 meter depth by applying other approaches that has better.

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