Underwater Low Contrast Color Images Enhancement based on Dynamic Thresholding and Stretching

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Abstract: In the modern era, the underwater images are captures to monitor the internal conditions of water. The underwater images capturing is difficult task because the water medium provides the different challenges like absorption, scattering, diffusion *etc.* To resolve these issues enhancement and color correction plays an important role. In this paper, the underwater images enhancement is done using exposure value, dynamic thresholding and stretching. The benefits of dynamic thresholding and stretching is that the naturalness of the image never loss and incontrollable manners the image stretched. Also, performance analysis of proposed technique is done with existing technique based on Qualitative and Quantitative analysis. The results reflect that the proposed technique have better enhancement and higher entropy as compared to existing technique.

Keywords: Underwater Image Enhancement, Dynamic Thresholding, Exposure Value, Entropy

1. INTRODUCTION

Light plays an important role in photography to generate the satisfactory quality images. The strong and weak light causes have a washed out appearance and poor visibility [1]. The underwater imaging is quite a challenging issue due to scattering, light absorption, reflection [2-3] as shown in fig. 1. These parameters are explain below

- Scattering
The scattering causes the change of the direction of the path. These causes generated not only due to water but also due to tiny particles in the water. There are two types of Scattering
 - Forward Scattering
The Forward scattering causes the blurring of the images.
 - Reverse Scattering
The backward scattering causes the contrast reduces [4].
- Color Absorption
The color wavelengths are absorbed in water deep water. The longest wavelength, with the lowest energy absorbed firstly.

Figure 1 Reasons of distorted Underwater Images [3]

The quality or enhancement of underwater images is done using two ways.

- Image Restoration
The effect of degraded images can be minimized using filtering operations. The overall effectiveness of the process depends on the knowledge of degradation in the image. These techniques required many parameters such a attenuation and diffusion coefficients [5].
- Image Enhancement
The image enhancement techniques improve the visibility by enhancing the image component such as gamma value, color correction *etc* [5]. The image enhancement can be done by two ways
 - Histogram Stretching
In histogram stretching techniques the histograms are stretched over maximum range for enhancement. The techniques are basically used for low contrast image enhancement and stretching technique remaps the histogram bins.
 - Histogram Equalization
The histogram equalization technique equalizes the low contrast or high contrast image by uniform distribution of pixels using probability density function (PDF) and commutative distribution function (CDF).

The paper as follow the Section 2 defines the related work on underwater image enhancement, motivation and contribution. The Section 3 defines the proposed algorithm explanation. The section 4 defines the simulation results on MATLAB and Qualitative and Quantitative analysis is done. In last section V conclusion is done.

2. RELATED WORK

In this section, a review on underwater image enhancement technique is done. Based on survey, defines motivation and our contribution in this paper.

Kuldeep Singh, *et al.* [6], proposed a recursive based histogram equalization technique for image enhancement. In their work, according to exposure value, thresholding sub-histogram created and histogram equalization is applied. The performance analysis of their work is done on the basis of qualitative and quantitative analysis (such as entropy). Also, comparative analysis is done with the existing techniques.

Ahmad Shahrizan Abdul Ghani and Nor Ashidi Mat Isa [7], worked on underwater image enhancement on the basis of histogram stretching. Their techniques have two steps contrast and color correction. In their first step, according to minimum and maximum histogram bins value mid-point found out. The left part of mid-point 5% increase stretching and right part of mid-point 5% decrease stretching. In the second step color correction is done. The performance analysis is done on the basis of MSE, PSNR, Sobel count, MSSIM, EMEE, NIQE.

Ghani, *et al.* [8], proposed a hybrid technique in which contrast and color correction is done. The contrast stretching is done by multiplying the image by a gain factor and mid-point are found out based on maximum and minimum histogram bin. Further, color correction is done by transforming the RGB plane into HSV color space then S and V component enhanced.

Gao, *et al.* [9], discussed that they improving the underwater images by using the restoration and enhancement methods. In the initial stage, image restoration is done by estimating the atmospheric light, refining the transmittance image. After restoration process, the image enhancement is done using deduced histogram equalization method. Their experiment result shows that image quality improves effectively. Xiu Li, *et al.* [10], the underwater images are distorted due to scattering and color wavelength absorbed. They proposed a novel technique based on dark channel prior and luminance adjustment. Their technique resolves these two parameters issues and gives better visualization result.

2.1 Motivation

From the literature survey, the studies of Kuldeep Singh, *et al.* [6] shows that in their technique thresholding value is found out then all pixels are greater than threshold, all set to threshold value. Because of this operation no. of pixels losses of fine details or contained unwanted viewing arte-facts. In the paper, Ahmad Shahrizan Abdul Ghani and Nor Ashidi Mat Isa [7], based on the mid values stretching is done and if the image is under-contrast then mid values lie near 0 and their stretching technique not give enhancement.

2.2 Contribution

In our proposed technique, resolving these two issues. In our technique dynamic threshold is done which never losses fine details. Also, in our technique according to the exposure value stretching maximum limit is set which gives better enhancement as compared to existing techniques.

3. PROPOSED ALGORITHM FOR IMAGE ENHANCEMENT

In this section, the proposed algorithm and there description for image enhancement is given below.

1. Read the RGB image and histograms are plotted.

The underwater images are read for processing and their histograms are plotted for enhancement process.

2. Calculate exposure value by using equation 1.

$$\text{Exposure_value} = \frac{\sum_{k=0}^{L-1} h(k) * k}{L \sum_{k=0}^{L-1} h(k)} \quad (3.1)$$

Where $h(k)$ defines the histograms of the image.

L defines the total number of bins in the image (in gray scale images L value is 255).

The exposure value lies between 0 and 1. If the value less than 0.5 the image have low contrast and if value higher than 0.5 the image have high contrast.

3. Dynamic thresholding of histogram bins

To maintain the naturalness in the image the thresholding process is done. In the existing algorithms proposed by Kuldeep, *et al.* [6], threshold value calculated by using equation 3.2 and the all values above than threshold are fixed to threshold value.

$$T_c = \frac{1}{L} \sum_{k=0}^{L-1} h(k) \quad (3.2)$$

$$h_c(k) = h(k), h(k) < T_c$$

$$h_c(k) = T_c, h(k) > T_c$$

Where T_c is the threshold value calculated from histograms.

$h(k)$ is the original histogram and $h_c(k)$ is the clipped histogram. In the proposed work, the dynamic threshold is done so, the histogram bins never loss a large amount of pixel values. The dynamic threshold is done by using equation 3.3.

$$T_c = \frac{1}{L} \sum_{k=0}^{L-1} h(k) \quad (3.3)$$

$$h_c(k) = h(k), h(k) < T_c$$

$$h_c(k) = \frac{h(k) + T_c}{2}, h(k) > T_c$$

4. Histogram Equalization

The clipped histogram equalization is done for enhancement.

5. Contrast stretching based on the exposure value.

The histogram equalized bins are stretched according to exposure value. The stretching also done variable by using equation 3.5

$$\text{Stretching}_{Function} = \frac{x(i,j) - \text{minimum}}{\text{maximum} - \text{minimum}} X_a \quad (3.5)$$

Where i, j varies from 0 to size of image.

a : in place of 255 the a value is calculated using exposure value.

6. Qualitative and Quantitative Analysis of the proposed algorithm.

The performance analysis of proposed technique is done using qualitative and quantitative analysis. The parameters are calculated are Entropy, MSE, and PSNR.

7. Comparative analysis with existing results.

To show the performance of proposed technique is better than other a comparative analysis is done.

4. RESULTS AND DISCUSSION

The proposed technique is simulated on MATLAB 2013a software. The evaluated images databases taken from existing techniques qualitative analysis and 6 images results are shown here. The proposed technique Qualitative and Quantitative analysis is done and compared with existing technique is done.

The following Parameter is

Entropy: Entropy (Average information content) measures the proportions of the details of the frame and it is usually measured in units as bits.

$$E(p) = -\sum_{i=0}^{G-1} P(i) \log P(i)$$

Where $P(i)$ is probability density function of a given frame at a particular intensity level and G is total number of grey levels in the

frame. An frame having high entropy value is considered to be having high details and better quality.

Table 1 Qualitative and Quantitative Analysis and Comparison with existing techniques.

Original Image	Existing Technique Enhancement Image for Gray Scale Images[6]	Proposed Technique Enhancement Image	Existing Technique Performance Parameters	Proposed Technique Performance Parameters for Color Images
<p>Original Plane</p>	<p>R-ESIHE</p>	<p>Enhanced Image</p>	<p>Original Entropy: 5.05 Enhanced Image Entropy=5.04</p>	<p>Original Entropy: 5.25 Enhanced Image Entropy=6.47</p>
<p>Original Plane</p>	<p>R-ESIHE</p>	<p>Enhanced Image</p>	<p>Original Entropy: 6.26 Enhanced Image Entropy=6.25</p>	<p>Original Entropy: 6.36 Enhanced Image Entropy=6.97</p>
<p>Original Plane</p>	<p>R-ESIHE</p>	<p>Enhanced Image</p>	<p>Original Entropy: 5.87 Enhanced Image Entropy=5.85</p>	<p>Original Entropy: 6.05 Enhanced Image Entropy=6.27</p>
			<p>Original Entropy: 5.05 Enhanced Image Entropy=5.03</p>	<p>Original Entropy: 5.02 Enhanced Image Entropy=6.29</p>

Original Plane	R-ESIHE	Enhanced Image
Original Plane	R-ESIHE	Enhanced Image	Original Entropy: 7.02 Enhanced Image Entropy=6.89	Original Entropy: 7.02 Enhanced Image Entropy=7.11
Original Plane	R-ESIHE	Enhanced Image	Original Entropy: 7.26 Enhanced Image Entropy=7.18	Original Entropy: 7.24 Enhanced Image Entropy=6.62

The table 1 shows that proposed technique have better enhancement as compared to existing algorithm. Also, quantitative analysis shows that the image performance parameter entropy is improved.

5. CONCLUSION

In this paper, the underwater image capturing issues are highlighted that the image quality degraded due to scattering, absorption. To resolve these issues a survey is done and based on survey a dynamic thresholding and stretching technique is proposed. The proposed algorithm is explained with their mathematical equations. The proposed technique qualitative and quantitative analysis is done and compare with existing technique. The results shows that proposed technique have better enhancement and high entropy as compared to existing techniques.

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