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A study on underwater image enhancement using histogram equalization

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Abstract— The Most and important attributes to acquire, extract more information of underwater images are color and contrast. But max of the underwater images are influenced from low illumination due to sea depth and color decrement. This research paper main focused on brief knowledge of many Histogram based equalization techniques for increasing the color and contrast of underwater images. In this paper we will study of Histogram equalization (HE), Adaptive Histogram equalization (AHE) and (CLAHE) techniques. By comparing the experimental research and results the CLAHE technique of histogram give better results.

Index Terms— Underwater Images, Image Enhancement, Histogram Of Color Images

1 INTRODUCTION

Under water image processing is one of the exciting area in Digital image processing which is used in various fields. Such as underwater or marine habitats monitoring. It also make easy inspection of sea- piping in the field of chemical engineering. Underwater imaging is a challenging field due to of the physical properties of underwater environment. This is mainly related to diffraction, diffusion and absorption of light rays.

Underwater images generally lose contrast and influencing from degradation mainly because of poor visibility conditions and affects such as like light absorption, bending, light reflection, and scaterring of light rays. In recent research work under water image processing becomes an aggressive field of the digital image processing. The tools or methods for under water image enhancement are briefly and mainly discussed in the next section. The balance of the as different Histogram equalization techniques, better performance analysis of different techniques of Histogram equalization and experimental results respectively.

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2 HISTOGRAM BASED TECHNIQUES

2.1 Methods And Material

Under water image enhancement by using histogram based techniques is shown below.

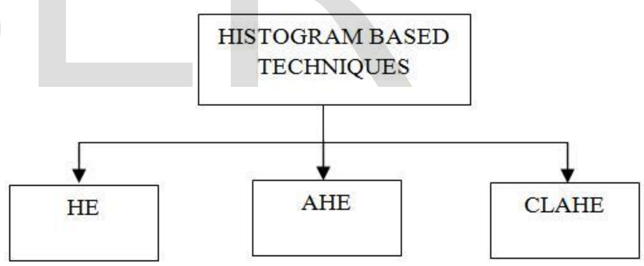

Figure 1. Histogram Based Techniques diagram

A. Histogram Equalization (HE):

Histogram equalization (HE) is a famous image enhancement method and process. HE works by equalizing and stretching the histogram by the intensity range by means of cumulative distribution function (CDF) and probability distribution function (PDF) . HE is used as a simple method in the enhancement process by many scholars.

The histogram is a scale graph which represents the frequency of occurring of data values in the whole data set. It plots the number of pixels for each tonal value in a digital image. Let us consider an image with M total possible intensity levels in an example. Then, the histogram of the digital image in [0, M-1] is defined as a discrete function as below:

P(rk)=nk/n
Where,
rk is the kth intensity level in the interval.
nk is the number of pixels in the image which have intensity level is rk.
n is the total number of pixels in the image.

Histogram equalization (HE) is an image enhancement which enhances the contrast of an image by making spreading the intensity values over the all available dynamic range. This is achieved by using a transformation function T(r), which can be stated by the Cumulative Distribution Function (CDF) of given Probability Density Function (PDF) of the gray levels in an image.

CONTINUOUS CASE: This case is for intensity levels those are continuous quantities normalized to the range [0, 1].
Let, Pr(r) is the probability density functions of the intensity levels.
Then, required transformation of the input levels to get the output level S is:

$$S = T(r) = \int_0^r P_r(w)dw \tag{1}$$

where "w" is dummy variable of integration. Then it could be shown that the probability density function (PDF) of the output levels is uniform,

$$P_s = \begin{cases} 1, for 0 \le s \le 1 \\ 0, otherwise \end{cases} \tag{2}$$

The above mentioned transformation generates a digital image whose intensity levels are equally likely and also, it covers the complete and entire range [0, 1].

This intensity grey level equalization process results in a digital image with greater dynamic range with tendency to receive higher contrast.

DISCRETE CASE: In this case of discrete quantities, we deal with summations (additions) and hence, the equalization transformation of image becomes:

$$S_k = T(r_k) = \sum_{j=1}^{k} P_r(r_j) = \sum_{j=1}^{k} n_j/n \text{, for k =1, 2, 3,…, L} \tag{3}$$

where Sk is the intensity value of output image w.r.t value rk in the input image.

B. Adaptive Histogram Equalization (AHE):

It is quite different from ordinary histogram equalization in the manner that it is not global and it computes and calculates many histograms techniques corresponding to different sections of a digital image. So, it is possible to enhance the contrast of a digital image through AHE.

With AHE, the information content of all intensity ranges of a digital image can be seen simultaneously and there by solving the problem statement of many simple devices which are unable to depict the entire dynamic intensity range. Here, a contextual region is defined for each and every pixel in the image. The contextual region is actually the region centered about that particular pixel. Then, intensity values for this region are basically used to find the histogram equalization mapping function. So, the mapping function there by found is applied to the pixel being processed in region and so finally, the resultant image produced after each pixel in the digital image is mapping near differently.

These results in the local distribution of intensity and final enhancing are depends on local area rather than the full global area of the digital image. This is the main advantage of this histogram technique. But, sometimes, AHE gone to over enhance the noise content that is exist in some homogeneous local block of the digital image by mapping short range of pixels to a wide range.

C. C. Contrast Limited Adaptive Histogram equalization (CLAHE):

The basic and very important difference between Adaptive histogram equalization (AHE) and Contrast limited adaptive histogram equalization(CLAHE) is contrast limiting. The Contrast-LAHE gives clipping limit of histogram to overcome the noise amplification issue. The CLAHE technique divides the image in relative regions and applies histogram equalization process to each and every region. CLAHE has two parameters clip limit (CL) and the block size which are basically control image enhancement quality. By increasing the clipping limit the digital image brightness will be increased. Simultaneously by increasing block size the range becomes larger because of these the image contrast also increases.

The CLAHE method consists the following 7 steps

1. By Dividing the original intensity image in non-overlapping contextual regions. The total number of real image tiles is equals to MxN , and 8x8 is a better value to secure the image chromatic data.
2. By calculating the histogram of each and every contextual region according to gray levels present in the image array.
3. By calculating the CLHE of the contextual region by clipping limit values.
4. Redistribute the remaining pixels until the remaining pixels been all distributed.
5. By enhancing intensity values in each and every region by Rayleigh distribution technique.
6. Reducing abruptly changes.
7. By calculating new gray level assignment of pixels within a submatrix contextual regions by using a
8. Bilinear interpolation method between four different mappings order to eliminate boundary artifacts.

D. Histogram Stretching And Clip-Limit Process:

Under and over contrast basically occurs in an underwater image whereas amount of pixels are cumulatively focused at low and high intensity levels. So, stretching and clip-limit processes are mainly applied to the image histogram respective regions to prevent under and over contrast effects on image. For this reason, the histogram of a particular region from the last step is generated and LUT is built. The clip-limit visual effect process is shown in Fig. 2, in which the spikes in histogram higher than the clip limit will be cut off in equalization. The excessive numbers of pixels are basically equal distributed to all intensity levels, there by increasing the number of the pixels at all intensity levels. In this case, a better normalized value of the clip limit is set at 0.01.

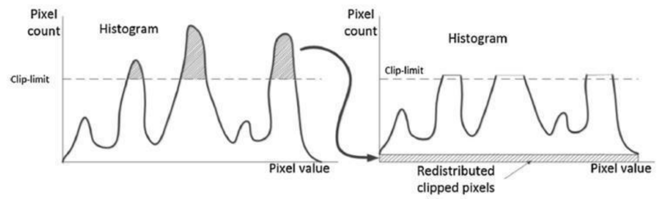

Figure 2. Applying clip limit to the histogram of image.

E. Rayleigh Distribution

The linear stretching of an image is given by

$$P_{out} = (P_{in} - i_{min})\left(\frac{o_{max} - o_{min}}{i_{max} - i_{min}}\right) + o_{min} \quad (4)$$

Rayleigh Distribution is the most basic and appropriate distribution for the underwater imaging. It actually refers to the bell shaped histogram distribution in which maximum pixels are concentrated at the centre of the intensity level. The pixel numbers at the minimum and maximum sides of the Rayleigh distribution is lowest to minimize the pixel amount from having too low or the too high intensity values. Therefore, Rayleigh distribution reduces the pixel number of under and over contrasted areas that may be developed in the resultant image. Fig. 3 shows the RD in which maximum pixels are concentrated around the centre intensity values. The clip limiting process is applied to the image histogram to decrease excessive pixels for dominant intensity levels. Image histogram showing the PDF and CDF is then associated with the Rayleigh Distribution. The PDF and CDF of the RD is given by following Eqs. (5) and (6), respectively

$$PDF_{Rayleigh} = \left(\frac{x}{\alpha^2}\right) e^{\left(\frac{-x^2}{2\alpha^2}\right)}, \quad (5)$$

$$CDF_{Rayleigh} = 1 - e^{\left(\frac{-x^2}{2\alpha^2}\right)}, \quad (6)$$

where x denotes to the input data while a refers the RD parameter. In this study, a value is set at 0.4 . To find the probability density fnction of Rayleigh-stretched distribution, PDFRstretch, Eq. (4) is jointly integrated with Eq. (5) to obtain Eq. (7). The intensity stretching process of the output histogram occupied is from 0 to 255; so, the value of omin may be substituted with 0 to state Eq. (8).

$$PDF_{Rstretch} = \left(\frac{P_{out}}{\alpha^2}\right) \exp\left(\frac{-P_{out}^2}{2\alpha^2}\right) \quad (7)$$

$$PDF_{Rstretch} = \left(\frac{((P_{in} - i_{min})o_{max})}{\alpha^2(i_{max} - i_{min})}\right) \exp\left(\frac{(-(P_{in} - i_{min})o_{max})^2}{2\alpha^2(i_{max} - i_{min})}\right) \quad (8)$$

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Therefore, the cumulative density function of Rayleigh-stretched distribution, CDFRstretch; is given by

$$CDF_{Rstretch} = 1 - \exp\left(\frac{(-(P_{in} - i_{min})o_{max})^2}{2\alpha^2 (i_{max} - i_{min})}\right) \quad (9)$$

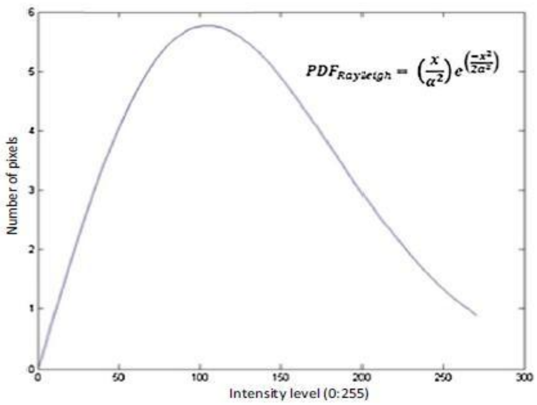

Figure 3. Rayleigh Distribution with most of the pixels concentrated at the middle intensity values.

3 Results And Discussion

The work is done on MATLAB Software with various images. The underwater images are size of 512X512, captured from the internet source. Firstly the different Histogram techniques mentioned in the last section are applied to the images and then the performance of various Histogram based techniques are examined and analyzed.

A. Underwater Image A

UNDERWATER IMAGE A

Result of HE

Result of AHE

Result of CLAHE(CL=0.01)

Result of CLAHE(CL=0.1)

\Result of CLAHE(CL=0.1)

Figure 6. Performance of HE, AHE, CLAHE on Underwater image C

4 CONCLUSION

In this research work Different Histogram techniques are examined on different Under water images. It was clearly analyzed and observed that Contrast limited adaptive histogram equalization (CLAHE) obtained better results compared to Adaptive Histogram equalization (AHE) techniques and Histogram equalization (HE). Hence, Future work focus on observing and extending the algorithms by using more different advanced methods to improve the results.

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