REVIEW OF UNDERWATER IMAGE ENHANCEMENT TECHNIQUES

Sonam Bharal

[1] *Student, Department of Computer Science and Engineering, GNDU Amritsar, Punjab, India*

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Abstract - ***Image enhancement is the process of improving the quality of the input image so that it would be easily understood by viewers in the future. Image enhancement improves the information content of the image and alters the visual impact of the image on the observer. Image enhancement intensifies the features of images. It accentuates the image features like edges, contrast to build display of photographs more useful for examination and study. Image enhancement includes many operations such as contrast stretching, noise clipping, pseudocoloring, noise filtering etc to improve the view of images. Active range of the chosen features of images is amplified by enhancement so that they can be detected simply. Underwater images mainly suffer from the problem of poor color contrast and poor visibility. These problems occurred due to the scattering of light and refraction of light while entering from rarer to denser medium. Scattering causes the blurring of light and reduces the color contrast. These effects of water on underwater images are only not due the nature water but also because of the organisms and other material present in the water. Many techniques and methods are established by researchers to solve the problem of underwater image enhancement. In this paper different underwater image enhancing techniques are reviewed and studied. The overall objective is to explore the shortcomings in earlier techniques.***

Key Words: *Image enhancement, Contrast stretching, CLAHE*

1. INTRODUCTION

Image enhancement is the mechanism to process the input image to make it more appropriate and clearly visible for the required application. Image enhancement improves the information content of the image and alters the visual impact of the image on the observer. Image enhancement intensifies the features of images. It accentuates the image features like edges, contrast to build display of photographs more useful for examination and study. Qualitative objective approach is used in enhancing images to construct a visually impressive picture. Image enhancement includes many operations such as contrast stretching, noise clipping, pseudocoloring, noise filtering etc to improve the view of images. Active range of the chosen features of images is amplified by enhancement so that they can be detected simply.

The existing research shows that underwater images bears poor quality because of nature of light. When light enters the water it got refracted , absorbed and scattered as water is denser medium then air , so the amount of light drops when it enters from air to water and got scattered in different directions. Scattering causes the blurring of light and reduces the color contrast. These effects of water on underwater images are only not due the nature water but also because of the organisms and other material present in the water. Light containing different wavelengths of blue, green and red colors will make a way into water to a changeable degree [2]. Figure 1 shows the picture about the light absorbed by water. With every 10m augmentation in depth the brightness of sunlight is going to fall by half. Almost all red colored light is decrease to 50% from the surface but blue continues to great deep in the ocean because blue color have the shortest wavelength and so it travels the longest distance in the water. That is why most of the underwater images are subjected to blue and green color.

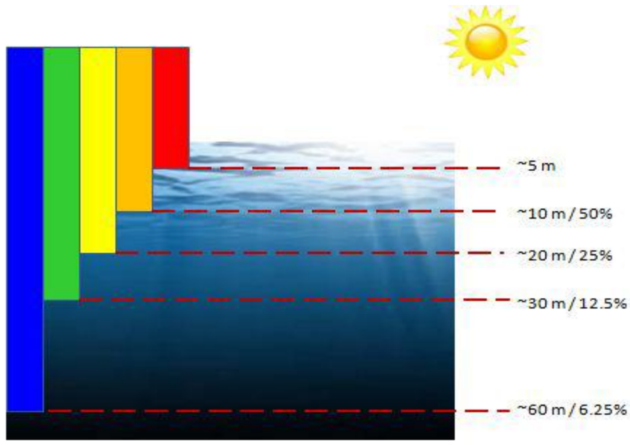

Fig 1

2. LITERATURE SURVEY

Hitam et al. (2013)[2] have discussed a new method specifically developed for enhancing the underwater images called mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) color model. The method operates Contrast Limited Adaptive Histogram Equalization on RGB and HSV color model and Euclidean norm is used to combine both results together. The combined results show less mean square error and high peak signal to noise ratio(PSNR) then other methods of under water image enhancing. It shows that the projected method is capable of classifying coral reefs particularly when visual cues are visible.

Shelda Mohan and T.R. Mahesh, 2013[5] has presented Particle Swarm Optimization (PSO) for tuning the enhancement parameter of Contrast Limited Adaptive Histogram Equalization relied on Local Contrast Modification (LCM). The quality of enhanced image is tested using a criteria based on edge information of the image. The planned method provides finest contrast enhancement though preserving the local data and details of the input mammogram picture.

Sowmyashree et al. 2014[8] have presented a relative study of the different image enhancement methods used for enhancing images of the bodies under the water. It also describes the various properties of water due to which the underwater images images are distorted and degraded.

Setiawan et al. 2013[7] used Contrast Limited Adaptive Histogram Equalization (CLAHE) to enhance color retinal image. In this paper, they proposed new enhancement method using CLAHE in G channel to improve the color retinal image quality. The enhancement process conduct in G channel is suitable to enhance the color retinal image quality. Visual observation is used to judge the enhanced images and compare them with the original ones.

Chang et al. 2014[1] have proposed the mean-variance analysis technique that is engaged in partitioning the grey scale image into four associated images for individual image. The contrast of the palm bone X-ray radiographs is enhanced by newly proposed technique i.e. quad histogram equalization technique. Experimental results using this method illustrate that the proposed algorithm is better than the global histogram equalization (GHE) technique and brightness saving bi-histogram equalization (BBHE) technique.

Khan et al. 2012[3] has proposed Bi- and Multi-histogram equalization methods designed for contrast improvement of digital images. Multi-HE methods are projected so that natural look of image is maintained at the cost of either the brightness or its contrast. Simulation results for a number of trial images shows that the proposed method enhances the contrast even as preserving brightness and natural look of the images.

Senthilkumaran N and Thimmiaraja J 2014[6] have compared different techniques such as Global Histogram Equalization (GHE), Local histogram equalization (LHE), Brightness preserving Dynamic Histogram equalization (BPDHE) and Adaptive Histogram Equalization (AHE) by means of diverse objective quality measures for MRI brain image improvement. Quality measures used for comparison are Weber contrast, Michelson contrast, Contrast and AMBE.

Talha et al. 2013[4] have proposed Balanced Contrast Limited Adaptive Histogram Equalization (BCLAHE) for Adaptive Dynamic Range Compression (ADRC) of real time medical pictures. The proposed method scheme is tested and has given away high-quality results in terms of latency and perceptibility of tiny details. They have concluded that Balanced-CLAHE gives accurate results in improving local information than global histogram equalization.

Erturk et al.2012[9] have presented a new algorithm based on an Empirical Mode Decomposition (EMD) which is used to improve visibility of underwater images. It is indicated that the proposed method provides finer results compared to regular methods such as contrast stretching, histogram equalization. In the given approach, initially EMD is used for decomposing every spectral part of an underwater image into Intrinsic Mode Functions (IMFs). Then by combining the IMFs of spectral channels, enhanced image is constructed with variables weights in order to attain an improved image with enhanced visual features.

Galdran et al. 2014[10]proposed a Red Channel method, where colors associated to short wavelengths are recovered, as expected for underwater images, leading to a recovery of the lost contrast. The Red Channel method can be interpreted as a variant of the Dark Channel method used for images degraded by the atmosphere when exposed to haze. Experimental results are also shown.

Sasi et al. 2013[11] constructed productive color space for enhancing the contrast of myocardial perfusion images. Effects of histogram equalization and contrast limited adaptive histogram equalization are founded by the investigation. The method which gives good contrast improvement outcome is used for the appropriate color space. The color space giving better outcomes is selected experimentally. Exceptionality of this work is that contrast limited adaptive histogram equalization(CLAHE) technique is applicable to the chrominance parts of the cardiac nuclear image. It left the luminance channel unchanged which consequence an improved image as resultant in projected color space.

G.Padmavathi et al. 2010[12] have compared and evaluated three filters performance. These filters are homomorphic filter, anisotropic diffusion and wavelet denoising by average filter. All these filters are helpful in pre-processing of underwater images. Image quality is improved, noise is suppressed, edges in an image are preserved and image is smoothen by the use of these filters. Among the three filters used wavelet denoising by average filter gives required results in terms of Mean Square Error(MSE) and Peak Signal to Noise Ratio(PSNR).

Singh et al. [13] have done analysis of different underwater image enhancement techniques. The comparison between performance of contrast limited adaptive histogram equalization method, contrast stretching, and histogram equalization method is done. Mean square error(MSE) and signal to noise ratio (SNR) are used as parameters for comparing the performance of above methods. The methods were examined on different type of underwater images.

Chiang et al. 2012[15]have proposed a fresh efficient approach based on dehazing algorithm, used to enhance underwater images. This algorithm is used to compensate the attenuation inconsistency along the transmission course and to acquire the possible effect of presence of an artificial source of light into consideration. The haze occurrence and deviation in wavelength attenuation along the propagation path underwater to camera are corrected after compensating the influence of artificial light. The performance was evaluated both objectively and subjectively, of the proposed algorithm for wavelength compensation and image dehazing(WCID) by using ground-truth color patches.

Garcia et al. 2002[16] have analyzed and compared already available techniques for dealing with the problems of underwater images. These techniques mainly deal with nonuniform illumination, lowcontrast in underwater images. The analyzed methodologies consist the review of the homomorphic filtering, illumination-reflectance model, local histogram equalization and subtraction of the illumination field. Many illustrations on real data have been carried out to compare and contrast the dissimilar methods.

Iqbal et al. 2007[14] have projected an approach which is based on slide stretching. This approach has dual objectives. First objective is to balance the color contrast of images by applying the contrast stretching of RGB color model. Second objective is to amplify the true color and resolve the problem of illumination by the use of saturation and intensity stretching of HSI color space. For enhancing the underwater images an interactive software has been proposed.

3. DIFFERENT TECHNIQUES FOR UNDERWATER IMAGE ENHANCEMENT

1. Contrast stretching- Contrast stretching is a straightforward image enhancement method that is used to improve, enhance the image contrast by `stretching' the series of intensity values. **A** measure of image's dynamic range or the "broaden" of image's histogram **is the contrast of an image.** Whole range of intensity values present within the image, or in a easier way, the minimum pixel value subtracted from the maximum pixel value is called dynamic range of image. It differs from the more complicated histogram equalization in a way that it can only concern a linear scaling function to the image pixel values.

2. Empirical Mode Decomposition- EMD is a versatile and based on the local moment period function of the figures[9]. So, it is suitable to help nonlinear along with non-stationary data so that it is an incredibly adept opportunity for real-life software. The EMD method is exceptionally direct, and the fundamental procedure is to carry out sifter operations on the new data arrangements until the final data series are stationary, and subsequently disintegrate the whole signal into many Intrinsic Mode Functions (IMFs) and a residue. EMD is connected to the Red, Green, Blue channels independently. The original image is break up into several intrinsic mode functions by EMD process and a final residue.

3. Homomorphic filtering
The homomorphic filtering is utilized to fix non-uniform lighting to reinforce contrast from the impression. This is a frequency filtering technique. It is the most utilized system on the grounds that it redresses non-uniform lighting and sharpens the picture.

$$F(x, y) = I(x, y)*r(x, y)$$

Where F(x, y) is the function of image detected by device, I(x, y) the illumination function and r(x, y) the reflectance function[12]. By multiplying these components filter can reduce the non uniform illumination present in the image.

4. Anisotropic filtering
Anisotropic filtering disentangles picture components to enhance picture division. This channel smoothes the picture in homogeneous range however conserve edges and upgrades them. It is utilized to smooth compositions and diminishes relics by erasing little edges enhanced by homomorphic filtering.

5. Wavelet denoising by average filter
Wavelet denoising is used to stifle the noise i.e the Gaussian noise are normally present in the camera pictures and other kind of instrument pictures. While moving the pictures Gaussian noise can be included. This wavelet denoising gives great results contrasted with other denoising routines because, unlike other methods, it does not assume that the coefficients are independent. Undoubtedly wavelet coefficients in normal pictures have enormous conditions. Besides the reckoning time is short.

6. Red channel method
In this method, colors associated to short wavelengths are recovered, as expected for underwater images, leading to a recovery of the lost contrast[10]. The first thing in this method to estimate is the color of the water. Pick a pixel that lies at the maximum depth with respect to the camera. It is assumed that degradation of image depend upon location of pixel. After estimating the waterlight transmission of the scene is estimated. Then Color correction is done.

7. Histogram equalization

Histogram equalization is a method for modifying image intensities and contrast of image in image processing using the image's histogram. Histogram equalization is helpful in pictures with backgrounds and frontal areas that are both bright or both dim. This is a simple and straightforward technique. But it has a disadvantage also that is it also amplifies the background noise present in the image and lead to decrease in the useful signal. So it produces unrealistic effects in the output images. The basic idea lying behind this method is mapping the gray levels depending upon the probability distribution of the input gray levels.

8. Contrast Limited Adaptive Histogram Equalization (CLAHE)

It is generalization of adaptive histogram equalization. With this technique the image is broken up into tiles. The gray scale is calculated for each of these tiles, based upon its histogram and transform function, which is derived from the interpolation between the manipulated histograms of the neighboring sub-regions. The transformation function is relative to the cumulative distribution function (CDF) of pixel values in the area. CLAHE contrasts from AHE in contrast limiting. CLAHE limits the noise enhancement by cut-out the histogram at a client characterized worth.

A. CLAHE on RGB color model

RGB color is an additive color model which which depicts hues regarding the measure of red (R), green (G) and blue (B) present. It depicts what sort of light needs to be transmitted to create a given hues present in the image. CLAHE can be applicable to all the three parts ie. red, green and blue separately. The effect of full-color RGB can be acquired by combining the individual components of model.

B. CLAHE on HSV color model

HSV color model defines colors in terms of the Hue (H), Saturation (S), and Value (V). HSV color model is cylindrical-coordinate illustration of points in an RGB color model. Hue is the characteristic of a visual sensation as indicated by which a territory seems to be related to one of the color seen. The hue and saturation level don't have any kind of effect when value is at max or min intensity level. CLAHE is applied on V and S components[2].

9. Integrated color model

The integrated color model is principally established on color harmonizing by contrast improvement is RGB color space and color adjustment in HSI model[14]. In integrated color model first step is to diminish the color cast by the equalization of all the color values present. In the second step an improvement is applied to the contrast amendment to broaden the histogram values of the red color. Second step is again done for green and blue colors. In the last step of the model, the saturation and intensity components of the HSI color model is applicable for contrast adjustment to enhance the true color and for dealing with the issue of uneven illumination.

4. GAPS IN LITERATURE

Nowadays image enhancement algorithms are very much popular, helpful and valuable for many image based applications. It has been originated that the majority of the current examination have mistreated various points. Below mentioned are the different research gaps accomplished from the literature survey:-

1. The presented strategies have ignored the methods to lessen the noise issue, which is available in the resultant pictures of the current image improvement procedures.
2. Much effort has not paid attention on L*A*B color space using CLAHE based enhancement.
3. The issue of the uneven light illumination is likewise disregarded by the vast majority of the scientists.

5. CONCLUSIONS

In this paper different underwater image enhancement techniques are reviewed and studied. All the reviewed methods enhance the underwater images to great extent. The issue of the uneven light illumination is likewise disregarded by the vast majority of the scientists. But no method paid attention on L*A*B color space using CLAHE for enhancing the underwater images. The presented strategies have ignored the methods to lessen the noise issue, which is available in the resultant pictures of the current image improvement procedures. In future work, we will apply CLAHE on L*A*B color space and compare the results on different color spaces.

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