© 2017 IJSRST | Volume 3 | Issue 6 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Implementation of Underwater Image Enhancement Technique

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ABSTRACT

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. 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. Active range of the chosen features of images is amplified by enhancement so that they can be detected simply. Many techniques and methods are established by researchers to solve the problem of underwater image enhancement. In this work we have tried to implement the contrast stretching and the CLAHE image enhancement techniques on underwater images in MATLAB and compared the result on the basis of specific parameters.

Keywords: Text Underwater Image, Image Enhancement Method, Contrast Stretching, CLAHE

I. INTRODUCTION

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. 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. 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. Active range of the chosen features of images is amplified by enhancement so that they can be detected simply. Different methods are developed for enhancing the underwater images like mixture contrast limited adaptive histogram equalization (CLAHE) color model, Bi and multi histogram equalization method, balanced contrast limited adaptive histogram equalization (BCLAHE) etc.

Contrast limited adaptive histogram Equalization on RGB and HSV color model and Euclidean norm is used to combine both results together. Bi- and multi-histogram equalization methods designed for contrast improvement of digital images. BCLAHE is used in improving local information than global histogram equalization performed.

II. LITERATURE SURVEY

Iqbal, K.; Odetayo, M.; James, A.; Salam, R.A.; Talib, A.Z.H. in their work titled" Enhancing the low quality images using Unsupervised Color Correction Method" proposed an Unsupervised Colour Correction Method (UCM) for underwater image quality enhancement. UCM is based on color matching, contrast improvement of RGB color model and contrast improvement of HSI color model. Firstly, the color cast is concentrated by equalizing the color values. Secondly, an improvement to a contrast alteration method is useful to increase the Red color by stretching red color histogram towards the utmost; similarly the Blue color is concentrated by stretching the blue histogram to the minimum. Thirdly, the Saturation and Intensity parts of the HSI color model have been useful for contrast correction to enlarge the true color using Saturation and to address the illumination problem through Intensity.

Shamsuddin, N.; bt. Wan Ahmad, W.F.; Baharudin, B.B.; Kushairi, M.; Rajuddin, M.; bt. Mohd**,** F**.** in their work titled **"** Significance level of image enhancement techniques for underwater images" have worked on problems in underwater images such as partial range visibility, lowcontrast, non-identical lighting, blurring, intense artifacts, colordiminish and noise. They specifically worked on the color diminished images.Both automatic and manual level methods have been used to record the mean values of the stretched histogram.

Hitam, M.S.; Yussof, W.N.J.H.W.; Awalludin, E.A.; Bachok, Z. in their work titled " Mixture contrast limited adaptive histogram equalization for underwater image enhancement." have presented a new technique called hybrid Contrast Limited Adaptive Histogram Equalization (CLAHE) color spaces that specifically developed for underwater image improvement. The technique operates CLAHE on RGB and HSV color spaces and both results are joint together using Euclidean rule. Tentative results show that the future approach considerably improves the visual quality of underwater images by enhancing contrast, as well as dropping noise and artifacts.

III. RELATED TECHNIQUES

3.1 Homomorphic Filtering

Homomorphic blocking is often a frequency filtering approach. These technique all of us used by correcting not for uniform miniature. It truly is promotes the particular comparison from the photograph. Homomorphic filtering provides improvement over some other tactics as it corrects not consistent easy as well as hones the advantage at the same time . Homomorphic filtering utilizes two variables called while light gene along with coefficient of reflection issue. Brightness gene symbolizes very low frequencies inside Fourier convert on the impression along with coefficient of reflection component presents substantial wavelengths. Through increasing number these factors abject wavelengths usually are suppressed [5] distinct this brightness as well as coefficient of reflection elements through the logarithm of the impression. The particular logarithm switches your multiplicative in a great component a single. Large go selection is actually placed on the actual Fourier change Cipher your opposite Fourier convert to come back from the special area and then go ahead and take advocator to obtain the blocked picture .

3.2 Histogram Equalization

Histogram is defined as the statistical probability distribution of each gray level in a digital image (Balvant Singh, Ravi Shankar Mishra, Puran Gour, 2011Histogram equalization is a technique inside impression control of contrast modification while using the images histogram. This process normally enhances the global contrast of countless photos, particularly your useful data on the impression data is represented by near compare values. A great impression offers similar quantity of pixels to all it's dull quantities. This method are known as as Histogram Equalization (He / she).That flattens along with stretches the particular dynamic selection of the whole image histogram as well as ends in boiler suit distinction enhancement. The process pays to inwards photographs having rear-coffee grounds in addition to forward-good grounds which can be each vibrant or maybe equally dark. Histogram Equalization may be generally used when the graphic most of us requires development however; it may substantially change the lighting of your stimulation effigy as well as lead to injury in many purposes in which perfection ongoing availability is necessary

3.3 Bilateral Filtering

Bilaterally symmetrical filtration is a borders-preserving along with sound lowering removing separate out. Bilaterally symmetric blocking smoothness the photographs while keeping edges, through a not-along blend of neighbourhood picture ideals. Taking that approach main bilaterally symmetrical blocking would be to liquidate the number of the effigy what exactly classic filter systems waste the knowledge domain, This kind of weight will be based upon Gaussian submission technique. This particular preserve astute perimeters by simply systematically looping via each image element as well as in accordance weights to the nearby pixels accordingly .The usual notion root isobilateral filtering is always to waste kids associated with an target precisely what conventional filter systems waste it's knowledge domain . Ii pixels we can come close to each other that is certainly, occupied close by spatial location or we could follow a lot like one other. Isobilateral selection is a simple, not-iterative system intended for sharpness keeping smoothing. (Prabhakar C.J., Praveen Kumar P.U., and 9 December 2011).

3.4 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.

3.5 Red Channel Method

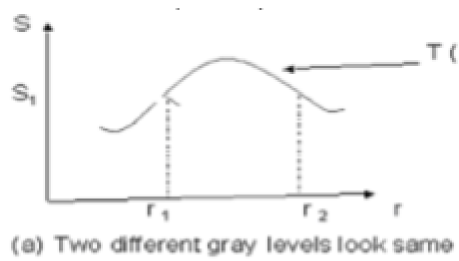
In this method, colors associated to short wavelengths are recovered, as expected for underwater images, leading to a recovery of the lost contrast [10]. The first thing in this method to estimate is the color of the water. Pick a pixel that lies at the maximum depth with respect to the camera. It is 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.

3.6 Contrast Stretching

In local contrast measure is proposed in this project for enhancement. Contrast is stretched between the limit of lower threshold and upper threshold. It is an intensity based contrast enhancement method as Io (x,y) = f (I (x,y)) , where the original image is I (x,y),the output image is Io (x,y) after contrast enhancement, and f is the transformation function .The contrast stretching is a method to make brighter portion more brighter and darker portion more darker. The transformation function T (r) is given as :

$$S = \begin{cases} l * r & 0 < r < a \\ m * (r - a) + v & a < r < b \\ n * (r - b) + w & b < r < L - 1 \end{cases}$$

-----(2)



Original grey level r

Fig. 1 Contrast transformation function

The transformation function is given here, Where l, m, n are the Slopes of the three regions shown in Fig.1. It is clear that l & n are less than one. The S is the modified gray levels and r is the original gray levels. Where a and b are the limit of lower and upper threshold. The identity transformation is shown by doted line. The slope of blue lines is taken 0.5 and the slope of the red line is taken as 1 or greater than 1. so making the brighter portion more brighter and darker portion more darker.

The contrast stretching algorithm is used to enhance the contrast of the image. This is carried out by stretching the range of the colour values to make use of all possible values. The contrast stetching algorithm uses the linear scaling function to the pixel values. Each pixel is scaled using the following function:

$$P_o = (Pi - c) \times (b - c) / (d - c) + a \text{-----(1)}$$

"Where
- P_o is the normalized pixel value;
- Pi is the considered pixel value;
- a is the minimum value of the desired range;
- b is the maximum value of the desired range;
- c is the lowest pixel value currently present in the image;
- d is the highest pixel value currently present in the image”

. Firstly, we use contrast stretching of RGB algorithm to equalize the colour contrast in the images. Secondly, we apply the saturation and intensity stretching of HSI to increase the true colour and solve the problem of lighting. The proposed approach is shown in Figure 3.

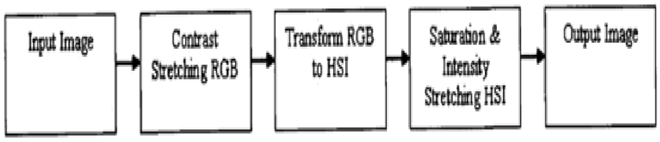


Figure 2. Methodology for underwater image enhancement method

When the contrast stretching algorithm is applied to colour images, each channel is stretched using the same scaling to maintain the correct colour ratio. The first step is to balance the red and green channel to be slightly the same to the blue channel. This is done by stretching the histogram into both sides to get well-spread histogram. In the second step we transform the RGB image into HSI, using the saturation and intensity transfer function to increase the true colour and brightness of underwater images. Using the transform function we have been able to stretch the saturation and intensity values of HSI colour model. Using the saturation parameters we can get the true colour of underwater images. Brightness of the colour is also considered to be important for underwater images. The HSI model also helps to solve the lighting problem using Intensity parameters.

The HSI model provides a wider colour range by controlling the colour elements of the image. The Saturation (S) and Intensity (I) are the element that generates the wider colour range. In a situation when we have the blue colour element in the image it is controlled by the 'S' and 'I' value in order to create the range from pale blue to deep blue, for instance. Using this technique, we can control the contrast ratio in underwater images either by decreasing or increasing the value. This is carried out by employing a histogram of the digital values for an image and redistributing the stretching value over the image variation of the maximum range of the possible values [14]. Furthermore linear stretching from 'S' value can provide stronger values to each range by looking at the less output values. Here a percentage of the saturating image can be controlled in order to perform better visual displays [15].

3.7 Contrast Limited Adaptive Histogram Equalization

Contrast Limited Adaptive Histogram Equalization (CLAHE) is a generalization of Adaptive Histogram Equalization (AHE). CLAHE was originally developed for enhancement of low-contrast medical images [7]. CLAHE differs from ordinary AHE in its contrast limiting. CLAHE limits the amplification by clipping the histogram at a user-defined value called clip limit. The clipping level determines how much noise in the histogram should be smoothed and hence how much the contrast should be enhanced. A histogram clip (AHC) can also be applied. AHC automatically adjusts clipping level and moderates over-enhancement of background regions of images. One of the AHC that normally used is Rayleigh distribution which produces a bell-shaped histogram. The function is given by

$$\text{Rayleigh } g = g_{min} + \left[2(\alpha^2)\ln\left(\frac{1}{1-P(f)}\right)\right]^{0.5} \quad \text{---(4)}$$

where gmin is a minimum pixel value, P(f) is a cumulative probability distribution and is a nonnegative real scalar specifying a distribution parameter. In this study, clip limit is set to 0:01 and value in Rayleigh distribution function is set to 0:04.

CLAHE on RGB color model:

RGB color space describes colors in terms of the amount of red (R), green (G) and blue (B) present. It uses additive color mixing, because it describes what kind of light needs to be emitted to produce a given color. Light is added to create form from out of the darkness. The value of R, G, and B components is the sum of the respective sensitivity functions and the incoming light:

$$R = \int_{300}^{830} S(\gamma)R(\gamma)d\gamma$$
$$G = \int_{300}^{830} S(\gamma)G(\gamma)d\gamma$$
$$B = \int_{300}^{830} S(\gamma)B(\gamma)d\gamma$$
--(3)

where S(γ) is the light spectrum, R(γ), G(γ), B(γ) are the sensitivity functions for the R, G and B sensors respectively. In RGB color space, CLAHE can be applied on all the three components individually. The result of full-color RGB can be obtained by combining the individual components.

CLAHE on HSV color model:

HSV color space describes colors in terms of the Hue (H), Saturation (S), and Value (V). The model was created by A.R. Smith in 1978. The dominant description for black and white is the term, value. The hue and saturation level do not make a difference when value is at max or min intensity level. The HSV model takes RGB components to be in the range [0; 1]. The value V is computed by taking the maximum value of RGB or can be described formally by:

$$V = \max(R, G, B)$$

$$S = \frac{V - \min(R,G,B)}{V}$$
--------(5)

The saturation S is controlled by how widely separated the RGB values are. When the values are close together, the color will be close to gray. When they are far apart, the color will be more intense to pure. Finally, hue H, which determines whether the color is red, blue, green, yellow and so on, is the most complex to compute. Red is at 0°, green is at 120°, and blue is at 240°. The maximum RGB color controls the starting point, and the difference of the colors determines how far we move from it, up to 60° away (halfway to the next primary color). To calculate the hue, we must calculate R', G', and B':

$$R' = \frac{V - R}{V - \min(R, G, B)}$$
---(6)

$$G' = \frac{V - G}{V - \min(R, G, B)}$$
----(7)

$$B' = \frac{V - B}{V - \min(R, G, B)}$$
-----(8)

If $S = 0$ then hue is undefined, otherwise

$$H = \begin{cases} 5 + B' & R = \max(R,G,B) \text{ and } G = \min(R,G,B) \\ 1 - G' & R = \max(R,G,B) \text{ and } G \neq \min(R,G,B) \\ R' + 1 & G = \max(R,G,B) \text{ and } B = \min(R,G,B) \\ 3 - B' & G = \max(R,G,B) \text{ and } B \neq \min(R,G,B) \\ 3 + G' & B = \max(R,G,B) \\ 5 - R' & \text{otherwise} \end{cases}$$
--(9)

Since there is a hue discontinuity around 360°, arithmetic operations is difficult to perform in all components of HSV. Therefore, CLAHE can only be applied on V and S components.

IV. METHODOLOGY

In this work we have presented Contrast Stretching and Contrast Limited Adaptive Histogram Equalization (CLAHE) techniques related to underwater image enhancement techniques

4.1) Contrast Stretching

Contrast stretching (often called normalization) is a simple image enhancement technique that attempts to improve the contrast in an image by `stretching' the range of intensity values it contains to span a desired range of values, e.g. the the full range of pixel values that the image type concerned allows. It differs from the more sophisticated histogram equalization in that it can only apply a linear scaling function to the image pixel values. As a result the `enhancement' is less harsh. (Most implementations accept a graylevel image as input and produce another graylevel image as output.)Before the stretching can be performed it is necessary to specify the upper and lower pixel value limits over which the image is to be normalized. Often these limits will just be the minimum and maximum pixel values that the image type concerned allows. For example for 8-bit graylevel images the lower and upper limits might be 0 and 255. Call the lower and the upper limits a and b respectively.

The simplest sort of normalization then scans the image to find the lowest and highest pixel values currently present in the image. Call these c and d. Then each pixel P is scaled using the following function:

$$P_{out} = (P_{in} - c)\left(\frac{b - a}{d - c}\right) + a$$
----(10)

values below 0 are set to 0 and values about 255 are set to 255.

The problem with this is that a single outlying pixel with either a very high or very low value can severely affect the value of *c* or *d* and this could lead to very unrepresentative scaling. Therefore a more robust approach is to first take a histogram of the image, and then select *c* and *d* at, say, the 5th and 95th percentile in the histogram (that is, 5% of the pixel in the histogram will have values lower than *c*, and 5% of the pixels will have values higher than *d*). This prevents outliers affecting the scaling so much.

Another common technique for dealing with outliers is to use the intensity histogram to find the most popular intensity level in an image (*i.e.* the histogram peak) and then define a *cutoff fraction* which is the minimum fraction of this peak magnitude below which data will be ignored. The intensity histogram is then scanned upward from 0 until the first intensity value with contents above the cutoff fraction. This defines *c*. Similarly, the intensity histogram is then scanned downward from 255 until the first intensity value with contents above the cutoff fraction. This defines *d*.

Some implementations also work with color images. In this case all the channels will be stretched using the same offset and scaling in order to preserve the correct color ratios.

4.2) **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.

V. EXPERIMENTAL RESULTS

An input image is taken and is subjected to pre processing and is filtered and then initially the contrast stretching technique is employed and then CLAHE technique is employed on the Input Image and both techniques are compared.

5.1 Contrast Stretching

Fig 5.1 The original Image

Fig5.2 The RGB contrast enhanced image

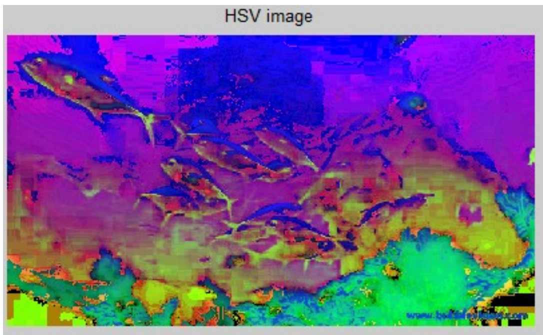


Fig 5.3 The HSV contrast enhanced image

Fig 5.4 The output image with RGB and HSV intensity enhancement

Figure 5.1 to 5.4 shows the results achieved on using the Contrast stretching technique.

5.2 CLAHE Technique

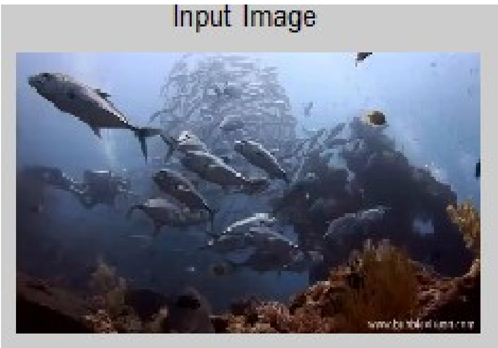


Fig 5.5 The original Image

Fig 5.6 The filtered image

Fig 5.7 The RGB CLAHE image

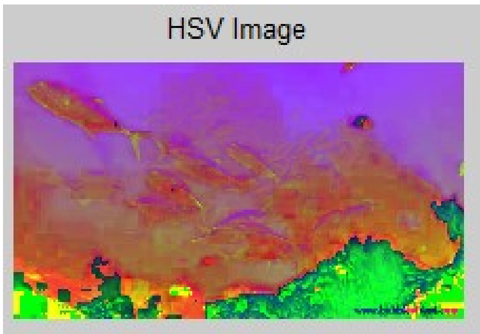


Fig 5.8 The HSV image

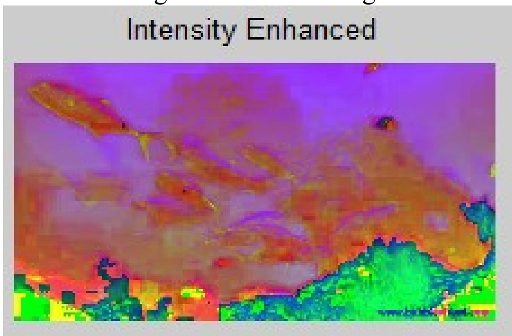


Fig 9 The intensity enhanced image

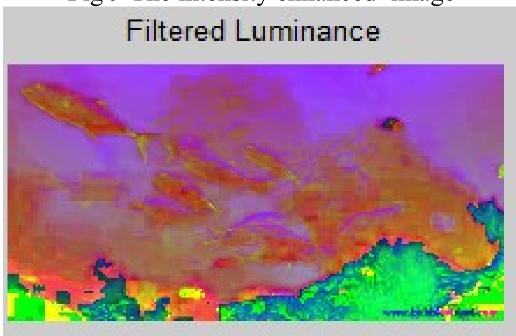


Fig 10 The filtered luminance image

Fig 11 The output image after HSV CLAHE

Figure 5 – 10 show the result achieved on using the CLAHE technique

5.3 Comparative Result

Method\ Parameter	PSNR	MSE
Contrast stretching	15.81	1.7064
CLAHE	19.7828	683.60

We observe that contrast stretching technique shows a PSNR OF 15.81 which is lower then PSNR of 19.728 for the CLAHE technique similarly the Mean square error for contrast stretching is 1.7064 where as for the CLAHE technique is 683.60 and hence we can make a conclusion that CLAHE is better as compared to contrast stretching technique in terms of the PSNR whereas the contrast stretching technique is better as compared to CLAHE in terms of MSE.

VI. CONCLUSION

We have implemented Contrast Stretching and CLAHE image enhancement techniques and on the basis of the results obtained we conclude that CLAHE is better as compared to contrast stretching technique in terms of the PSNR as it has a higher PSNR as compared to the contrast Stretching Technique.Similarly we can also make a statement that Contrast Stretching technique is better as compared to CLAHE technique as it has a lower MSE as compared to CLAHE

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