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Underwater Digital Images Enhanced by L*A*B* Color Space and CLAHE on Gradient based Smoothing

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Abstract

*The underwater digital images generally suffer from blur, low contrast, non uniform lighting and diminished color. This preprocessing technique based on image to improve the quality of underwater digital images. The mixed Contrast Limited Adaptive Histogram Equalization (CLAHE) has neglected the utilization of L*A*B* color image space to improve the image in an effective way. Also the uneven illumination problem is ignored by many researchers. To conquer the problems of uneven illumination in the resultant image of the CLAHE image output has been further removed by utilizing the smoothing process of image gradient. The main objective is to enhance the accuracy of the underwater digital image enhancement techniques. Various types of digital images will be considered for experimental point of view to estimate the efficiency of the image enhancement methods or techniques. Also, various types of image top-quality metrics have been utilized in order to check the significant improvement of the recommended technique over the offered techniques. The significant improvements have shown in the comparative analysis of the proposed algorithm over the available mixed CLAHE*

Keywords: *L*A*B*- L for lightness and a and b for the color opponents green-red and blue-yellow.,CLACHE- contrast limited adaptive histogram equalization-,PSNR-Peak Signal noise ratio,MSE-Mean Square Error,NAE-Normalized Absolute Error*

1. Introduction

Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing „better‟ input for other automated image processing techniques. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Moreover, observer-specific factors, such as the human visual system and the observer‟s experience, will introduce a great deal of subjectivity into the choice of image enhancement methods. There exist many techniques that can enhance a digital image without spoiling it. The enhancement methods can broadly be divided into the following two categories:

1. Spatial Domain Methods
2. Frequency Domain Methods

In spatial domain techniques, it directly deals with the image pixels. The pixel values are manipulated to achieve desired enhancement. In frequency domain methods, the image is first transferred into frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the inverse Fourier transform is performed to get the

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resultant image. These enhancement operations are performed in order to modify the image brightness, contrast or the distribution of the grey levels. As a consequence the pixel value of the output image will be modified according to the transformation function applied on the input values. Image enhancement in the frequency domain is straightforward. It simply compute the Fourier transform of the image to be enhanced, multiply the result by a filter, rather than convolve in the spatial domain, and take the inverse transform to produce the enhanced image. The idea of blurring an image by reducing its high frequency components or sharpening an image by increasing the magnitude of its high frequency components is intuitively easy to understand.

Image de-noising is a common procedure in digital image processing aiming at the removal of noise, which may corrupt an image during its acquisition or transmission, while retaining its quality. This procedure is traditionally performed in the spatial or frequency domain by filtering. The aim of image enhancement is to reconstruct the true image from the corrupted image. The process of image acquisition frequently leads to degradation and the quality of the digitized image becomes inferior to the original image. Filtering is a technique for enhancing the image. Linear filter is the filtering in which the value of an output pixel is a linear combination of neighborhood values, which can produce blur in the image.

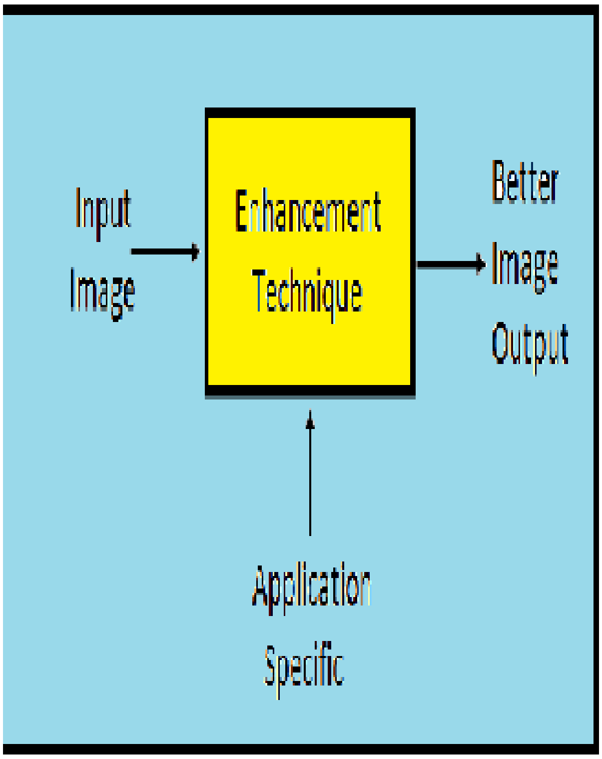

Figure 1. Image Enhancement Working Procedures

Pixel is the smallest element of an image. Each pixel correspond to any one value. In an 8 bit gray scale image, the value of the pixel between 0 and 255. The value of a pixel at any point correspond to the intensity of the light photons striking at the point. Each pixel store a value proportional to the light intensity at that particular location. A pixel is also known as PEL.

1.1. Quality Analysis

1.1.1. L*A*B* Color Space

The LAB color space describes mathematically perceivable colors in the three dimensional L for lightness and a and b for the color opponents green-red and blue-yellow. The terminology “LAB” originates from the hunter 1948 color space. Now a days “LAB” is frequently misused abbreviation for CIE L*a*b* 1976 color space (also CIELAB). The LAB color space exceeds the gamuts of the RGB and CMYK color models (for example, prophetic RGB (Red, Green,Blue)includes about 90% all perceivable colors). One of the most important attributes of the LAB model is device independence. This means that the colors are defined independent of their nature of creation or the devise they are displayed on. The LAB color space is used when graphics for print have to be converted from RGB to CMYK, as the LAB gamut includes both the RGB and CMYK gamut. Also it is used as an interchange format between different devices independency.

Advantages

Unlike the RGB and CMYK color models, LAB color is designed to approximate human vision. It aspires to perceptual uniformity, and their component closely matches human perception of lightness, although it does not take the Helmholtz-kohrausch effect into account. Thus, it can be used to make accurate color balance correction by modifying outputs curves in a and b components, or to adjust the lightness contrast using the L components. In RGB or CMYK spaces, which model the output of physical devices rather than human visual perception, this transformation can be done only with the help of appropriate blend modes in the editing application.

1.2. Clahe Technique

CLAHE stands for contrast limited adaptive histogram equalization. CLAHE is a computer image processing technique used to improve contrast in images. It differs from ordinary histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to distinct section of the image, and uses them to redistribute the lightness values of the image. It is therefore suitable for improving the local contrast and enhancing the definition of edges in each region of an image. However, AHE (Adaptive Histogram Equalization)has a tendency to over amplify noise in relatively homogeneous regions of an image. A variant of adaptive histogram equalization called contrast limited adaptive histogram equalization (CLAHE) prevents this by limiting the amplification.

1.3. Properties of CLAHE

The size of the neighborhood region is a parameter of the method. It constitutes a characteristics length scale: contrast at smaller scales in enhanced, while contrast at larger scales is reduced.

Due to the nature of histogram equalization, the result value of a pixel under this proportional to its rank among the pixels in its neighborhood. This allows an efficient implementation on specialist hardware that can compare the center pixel with all other pixels in the neighborhood.

When the image region containing a pixels neighborhood is fairly homogeneous, its histogram will be strongly peaked, and the transformation function will map a narrow range of pixels values to the while range of the result image. This causes to over amplify small amount of noise in largely homogeneous regions of the image.

1.4. The steps of CLAHE Method are

Step 1: The original picture should be separated into sub-pictures which are continuous and non-overlapping. The dimension of every sub-picture is M×N.

Step 2: The histograms of the sub-pictures are evaluated.

Step 3: The histograms of the sub-pictures are clipped. The CLAHE algorithm partitions the image into contextual regions apply the histogram equalization to everyone. Then uses the grey values therefore makes hidden popular features of the image more visible.

1. 2. Quantitative Analysis

1.2.1. Mean Square Error

The MSE represents the average of the squares "errors" between our actual image and our noisy image. The error is the amount by which the values of the original image differ from the degraded image**.**

Formula for the MSE:

SquareErrorImage = (double (input)-double (noise)).^2;

MSE = sum(sum(SquareErrorImage))/(256*256);

1.2.2. Peak Signal to Noise Ratio

The ratio between the maximum possible power of a value of a signal and the power of distorting noise that affects the quality of its representation. Because many signals have a very wide dynamic range, ratio between the largest and smallest possible values of a changeable quantity.

The PSNR usually expressed in terms of the logarithmic decibel scale.

Formula for the PSNR:

PSNR = 10*log10 (256^2/MSE);

1.2.3. Normalized Absolute Error

Higher value of NAE signifies that image has poor quality.

Formula for the NAE :

NAE = sum(sum(abs(SquaredErrorImage))) / sum(sum(b));

1.3. Literature Survey

1.3.1. Mixture Contrast Limited Adaptive Histogram Equalization for Underwater Image Enhancement

Muhammad Suzuri Hitam, and *et al.*(2013)[1] had introduced that due to poor visibility of underwater images that is caused by physical properties of the water medium, there was need to improve the quality of an underwater image. They also presented mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) color models that specifically developed for underwater image enhancement. The method operates CLAHE on RGB and HSV color models and both results were combined together using Euclidean norm. They had taken underwater images from Redang Island and Bidong Island in Terengganu, Malaysia. Authors found that this approach improved the visual quality of underwater images by enhancing contrast, as well as reducing noise and artifacts. They declared that this algorithm produced the lowest MSE and the highest PSNR values. Histograms are properly equalized independently by utilizing refined histogram equalization that generates flatter histograms.

1.3.2. The (Histogram Equalization) Based Brightness Preservation Techniques often Produce Undesirable Artifacts

Chen Hee *et al.* [5] have shown that various HE (Histogram Equalization) based brightness preservation techniques often produce undesirable artifacts. So, they presented two techniques to overcome the downsides in which the previous approach divides the image histogram based on the parameter median, and iteratively partition into the upper and lower sub histograms, in order to generate all-in-all 4 sub-histograms. The partitioning points in the upper and lower sub-histograms are generally assigned to a brand new DR (Dynamic Range) and then the process of clipping is carried out to each image sub-histogram.

1.3.3. Comparative Analysis of Different Enhancement Methods for Underwater Images

Shiwam Thakarel *et al.* [6] have presented comparative analysis of different enhancement methods for such type of underwater images. They recognized that underwater pictures suffers from low resolution and contrast due to the conditions of poor visibility, hence the identification of an object become the regular task. The processing of the captured underwater image is necessary as it affects the underwater images quality and these types of images results in serious problems when the comparison is done on the images which are captured from a clean and clearer environment. They also have recognized that that lot of noise occurs because of the natural light absorption, low contrast, non-uniform lighting, poor visibility conditions, and little variations in color, and effect of blurring in the underwater pictures. So they stated that there is a need to prevent these underwater images by utilizing various filtering methods

1.3.4. The Underwater Image Enhancement Techniques to Improve Underwater Image

Pooja Sahu *et al.* [3] have presented the underwater image enhancement techniques to improve underwater image. They also discovered that the underwater image processing is essential as these image cause some severe problems for example excessive noise which results in low contrast, non-uniform lighting, poor visibility conditions and little variations in color, blur effect and pepper noise in the underwater images when contrasting to clearer environment images. They employed median filter for the improvement of underwater images. It helps to judge the level of depth map and enhance the image quality by wiping out noise particles. Another technique which utilized for the enhancement of underwater images is RGB CLS (Color Level Stretching).

1.3.5. The Main Sources for Underwater Image Distortion are Change in Color and Light Scattering

Sowmyashree S *et al.* [4] have introduced that the main sources for underwater image distortion are change in color, light scattering. So, underwater images experience low contrast, limited range visibility, blurring, noise and color variation. So they depicted the comparative study of the several image enhancement methods for the enhancement of submerged images.

2. Existing System

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 rare to denser medium. In proposed method, CLAHE is applied on LAB color space to improve the underwater images and it is founded that results are improved as compared to previous work done by other researchers. In results part comparison is done between base paper and proposed method to show the improvement based upon parameters such as MSE, PSNR, Average error and Bit error rate.

Disadvantage

- The Mixed Contrast Limited Adaptive Histogram Equalization (CLAHE) has neglected the utilization of L*A*B color image space to improve the image in an effective way.
- Also the uneven illumination of the problem is ignored by this paper.

3. Propsed System

3.1. Processed Work

This paper proposed a preprocessing technique based on image to improve the quality of underwater digital images. The mixed Contrast Limited Adaptive Histogram Equalization (CLAHE) has actually neglected the utilization of L*A*B color image space to improve the image in an effective way. Also the uneven illumination problem is also ignored by many researchers. To conquer the problems of on hand technique a brand new L*A*B color image space as well as CLAHE based digital image enhancement technique is proposed in this paper. To conquer the problem of uneven illumination in the resultant image of the CLAHE image output has been further removed by utilizing the smoothing process of image gradient. The main objective of the planned algorithm is to enhance the accuracy of the underwater digital image enhancement methods/techniques. Various types of digital images will be considered for experimental point of view to estimate the efficiency of the image enhancement methods or techniques. Also, various types of image top-quality metrics have been utilized in order to check the significant improvement of the recommended technique over the offered techniques. The significant improvements have shown in the comparative analysis of the proposed algorithm over the available mixed CLAHE.

3.1.1. System Architecture

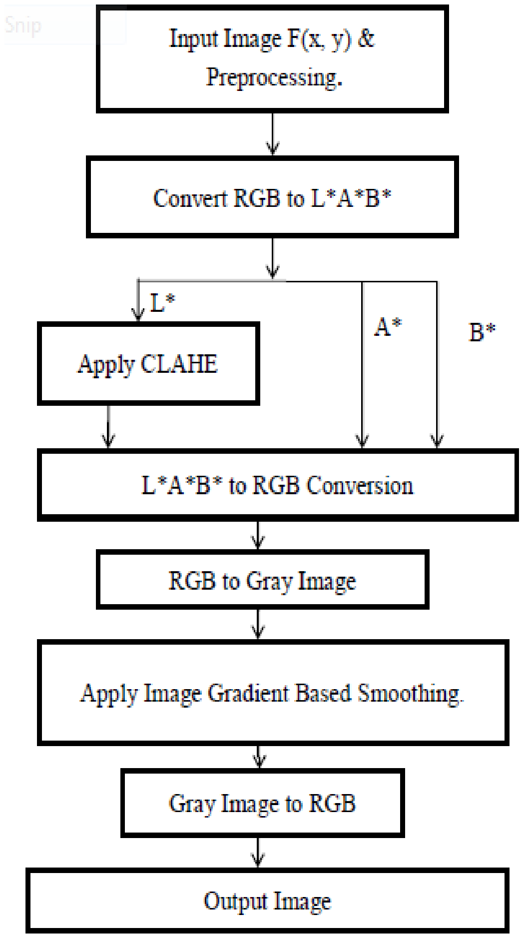

Figure 2. Proposed System

3.2. Modules Description for the Project

- PREPROCESSING OF INPUT IMAGE
- CONVERT RGB IMAGE TO L*A*B* IMAGE
- EXTRACTION OF CLAHE
- CONVERT L*A*B* IMAGE TO RGB IMAGE
- IMPLEMENT GRADIENT BASED SMOOTHING

3.2.1. L*A*B* Color Space

The LAB color space describes mathematically perceivable colors in the three dimensional L for lightness and a and b for the color opponents green-red and blue-yellow. The terminology "LAB" originates from the hunter 1948 color space. Now a days "LAB" is frequently misused s abbreviation for CIE L*a*b* 1976 color space (also CIELAB). The LAB color space exceeds the gamut"s of the RGB and CMYK color models (for example, prophetic RGB includes about 90% all perceivable colors).One of the most important attributes of the LAB model is device independence. This means that the colors are defined independent of their nature of nature of creation or the devise they are displayed on. The LAB color space is used when graphics for print have to be converted from RGB to CMYK, as the LAB gamut includes both the RGB and CMYK gamut. Also it is used as an interchange format between different devices independency.

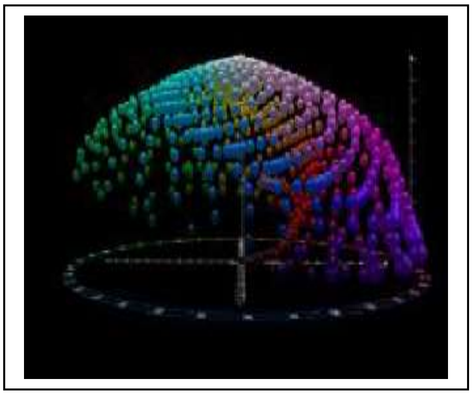

Figure 4. Lab Top View

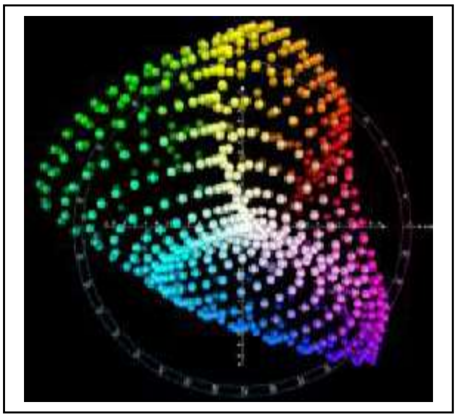

Figure 5. Lab Front View

3.2.2. CLACHE Technique

CLAHE stands for contrast limited adaptive histogram equalization. CLAHE is a computer image processing technique used to improve contrast in images. It differs from ordinary histogram equalization in the respect that the adoptive method computes several histograms, each corresponding to indistinct section of the image, and uses them to redistribute the lightness values of the image. it is therefore suitable for improving the local contrast and enhancing the definition of edges in each region of an image. However, AHE has a tendency to over amplify noise inrelatively homogeneous regions of an image. A variant of adaptive histogram equalization called contrast limited adaptive histogram equalization (CLAHE) prevents this by limiting the amplification. Ordinary histogram equalization uses the same transformation derived from the image histogram to transform all pixels.

Figure 6. CLAHE Image

3.2.3. Gradient Based Smoothing

The gradient based smoothing is an edge detection operator that uses a multi stage algorithm to detect a wide range of edges in images. It was developed by john Canny in 1986. Canny also produced a computational theory of edges detection why the technique works. Canny edge detection is a technique to extract useful structural information from different vision objects and dramatically reduce the amount of data to be processed. It has been widely applied in various computer vision systems. Canny has found that the requirements for the application edge detection on diverse vision systems are relatively similar. Thus, an edge detection solution to address these requirements can be implemented in a wide range of situations.

Figure 7. GBS Image

3.3. Implementation

3.3.1. Algorithm

Step 1: Preprocessing of input image

Step 2: Conversion of RGB image to L*A*B* color space

Step 3: Extract CLAHE

Step 4: Conversion of L*A*B* color space to RGB image

Step 5: Convert RGB image to Gray image

Step 6: Implement gradient based smoothing

Step 7: Convert Gray image to RGB image

Step 8: Get the Output image

4. Result and Screen Shots

Figure 8. Original Image

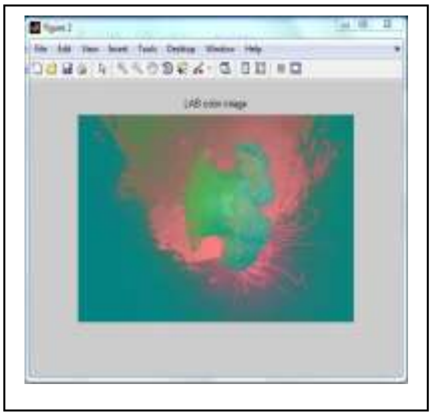

Figure 9. L*A*B* Color Image

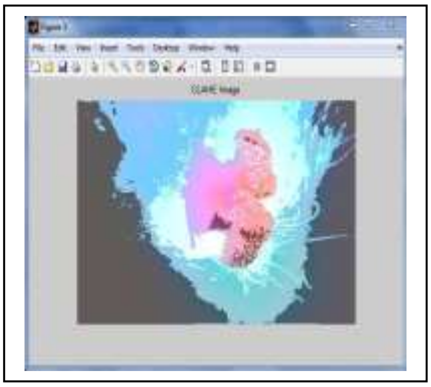

Figure 10. CLAHE Image

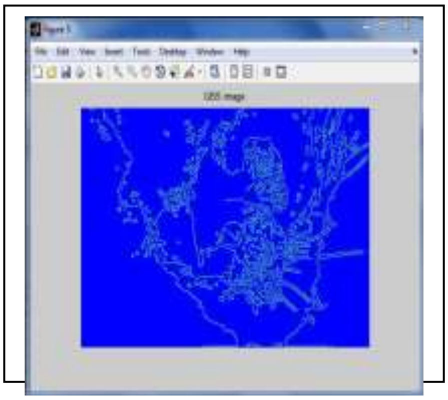

Figure 11. Gradient Based Smoothing Image

Figure 12. Sub Plotted Images

Figure 13. Comparison of Original Image and Enhanced Image

5. Image

Figure 14. Original Image

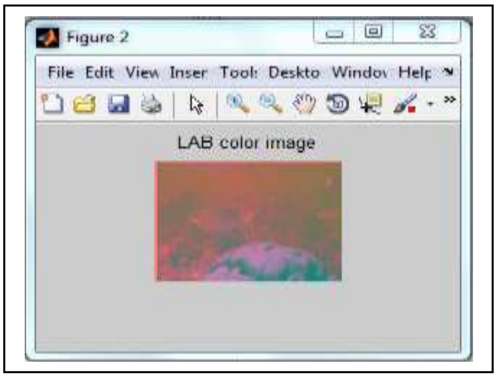

Figure 1 5. L*A*B* Color Image

Figure 16. CLAHE Image

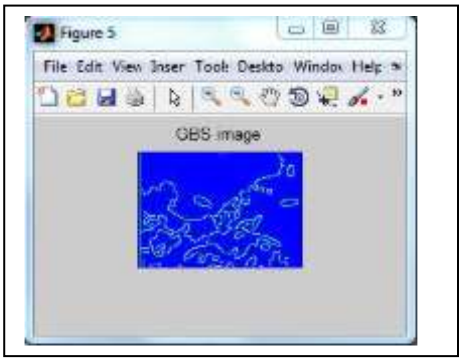

Figure 17. Gradient Based Smoothing Image

Figure 18. Sub Plotted Images

Figure 19. Comparison of Original Image and Enhanced Image

6. Image

Figure 20. Original Image

Figure 21. L*A*B* Color Image

Figure 22. Clahe Image

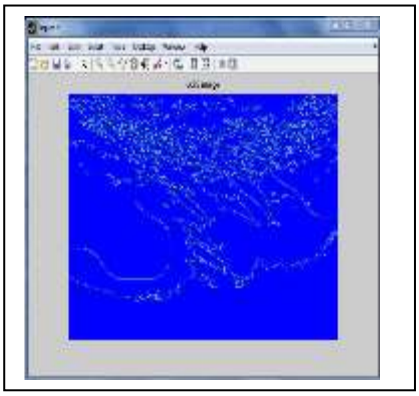

Figure 23. Gradient Base Smoothing Image

Figure 24. Sub Plotted Images

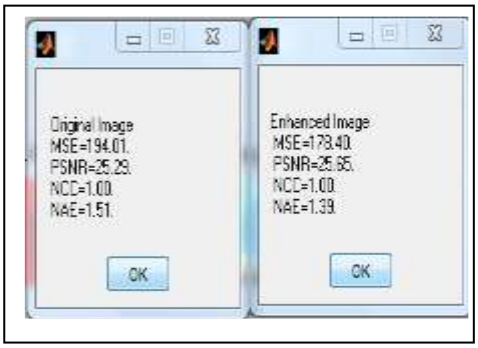

Figure 25. Comparison of Original Image and Enhanced Image

7. MSE, PSNR, NAE Values

Table 1. MSE Values for Original Image and Resultant Image

Input image	Origin al image	Enhanced image
img	177.48	176.58
img	192.17	180.65
Img	190.19	173.12
img	188.67	142.54
img	193.90	183.05

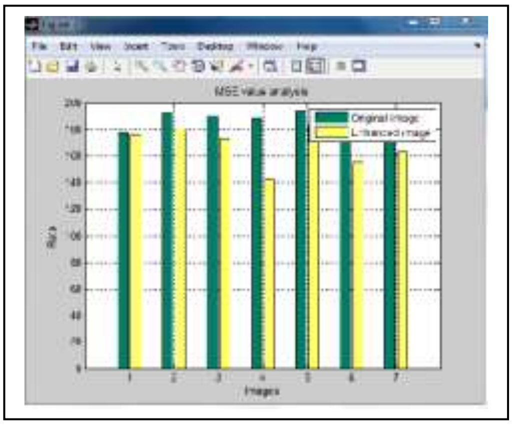

Figure 26. Mse Values for Original Image and Resultant Image

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PSNR Values for Original Image and Resultant Image

Table 2. PSNR Values for Original

Input image	Original Image	Resultant Image
Img	25.67	25.70
Img	25.33	25.60
Img	25.37	25.78
Img	25.41	26.63
Img	25.29	25.54

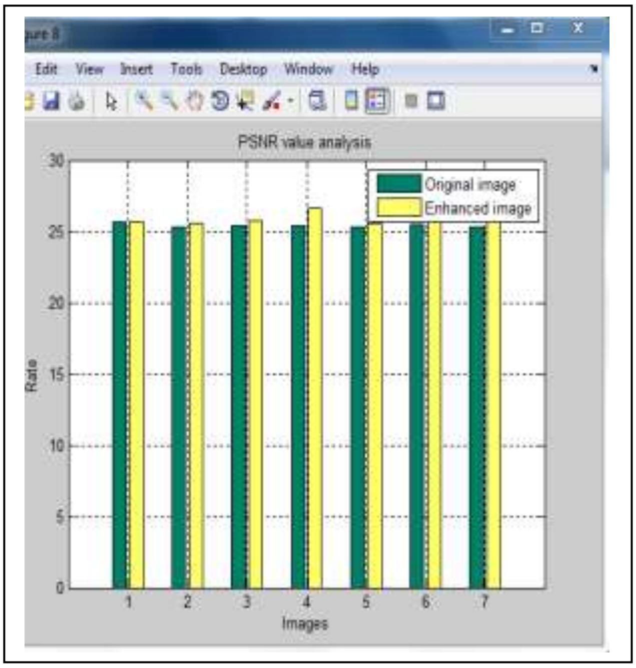

Figure 27. PSNR Value Image and Resultant Image

7.3. NAE Values for Clahe Image and Resultant Image

Table 3. NAE Values

Input image	Original image	Resultant image
Img	2.51	2.49
Img	1.50	1.41
Img	2.69	2.45
Img	1.44	1.09
Img	1.49	1.41

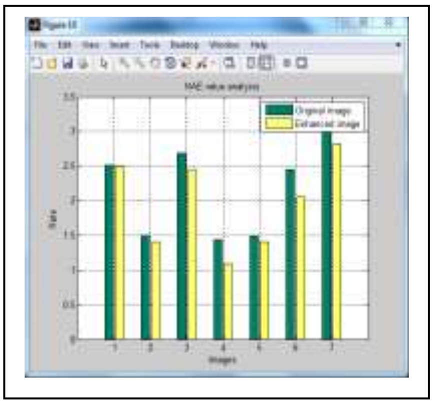

Figure 28. NAE Values for Clahe and Resultant Image Image

8. Conclusion

To resolve the various problems of existing methods a new image enhancement technique based on CLAHE and L*A*B color space is presented in this research paper. To overcome the problem of the uneven illumination in the CLAHE output image has been removed by utilizing the image enhancement gradient based smoothing. The key idea of the proposed technique is to enhance the accuracy of the different underwater image enhancement methods. We have highlighted various measures in this regard like MSE, PSNR, RMSE, NAE, NCC, MD and AD. A comparative study is also performed in this research work. So, in future a new algorithm can be proposed based on the use of joint trilateral filter in order to overcome the various limitations of the prior techniques. This can be done with the help of improved dark channel. This dark channel will make use of decision making which is totally based on the concept of fuzzy logic. The ability of fuzzy decision making can identify different alternative for similar scene and from those alternatives, the best one will be chosen for final output. In order to develop numerous alternatives intended for fuzzy set theory, AHE (adaptive histogram equalization) plus dark channel with different various restoration levels will be utilized.

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