Improved Underwater Image Enhancement using L*A*B on CLAHE and Gradient based Smoothing

Anuradha
Dept. of Computer Science & Engg.
CEC,Landran Mohali, Punjab, India

Harsimranjeet Kaur
Asst.Prof.
Dept. of Computer Science & Engg.
CEC,Landran Mohali, Punjab, India

ABSTRACT
The underwater images usually suffer from non-uniform lighting, low contrast, blur and diminished color. This paper proposed an image based preprocessing technique to enhance the quality of underwater images. The mixed CLAHE has neglected the use of L*A*B color space to enhance the image in efficient manner. Also the problem of the uneven illuminate is also neglected by the most of the researchers. To overcome the problems of existing technique a new L*A*B color space and CLAHE based image enhancement algorithm is proposed in this research work. To overcome the issue of the uneven illuminate issue in the output image of the CLAHE output has been further removed using the use of image gradient based smoothing. The main scope of the proposed algorithm is to improve the accuracy of the underwater image enhancement techniques. Different type of the images will be taken for experimental purposes to estimate the effectiveness of the image enhancement techniques. Different kind of image quality metrics has been used to find the significant improvement of the proposed technique over the available techniques. The comparative analysis has shown the significant improvement of the proposed technique over the mixed CLAHE.

Keywords
Underwater Preprocessing Image, L*A*B Color Space CLAHE, Image Gradient based Smoothing.

1. INTRODUCTION
Almost no analysis has been performed on underwater pictures. The quantity of light is reduced once we go deeper to the water and hence colors disappear 1 by 1 depending on the wavelength. Red colorization disappears at the depth of 3 m approximately. The orange color is lost at the depth of 5km. At the depth of 10 m the majority of the yellow goes off and finally the green and purple disappear at further depth. Since the blue color has got the shortest wavelength it travels the longest in water. The underwater images are therefore dominated by blue-green color. Underwater images impose several problems due mainly to light absorption, light scattering, light reflection and denser medium. These problems result in poor visibility of the underwater images. Absorption removes the light energy and scattering changes the direction of light path. These effects aren't only as a result of water but in addition as a result of other components such as for example dissolved organic matter or small floating particles. You can find mainly two forms of scattering such as forward scattering and backward scattering. Forward scattering causes blurring of the image features and backward scattering reduces the contrast of the image.

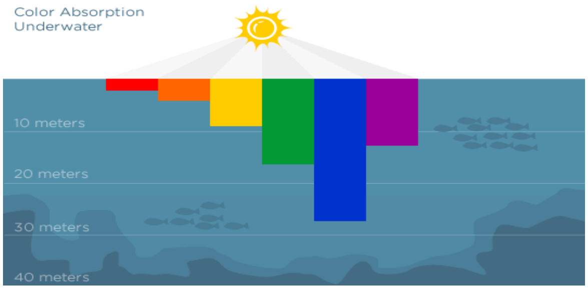


Figure 1: How Color Changes with Depth in Underwater

This paper proposes a new method L*A*B color space. The main goal is to enhance the image quality and smoothing the underwater image. This paper is presents like this: Part two present convert RGB to L*A*B And the next part, we show proposed methodlogies.In the fourth part, compares the quality of the results from different methods. In the last, conclusion the proposed work.

2. LITERATURE REVIEW
Chen Hee Ooi et al. (2010) [6] have described that numerous histogram equalization (HE)-based brightness preserving methods tend to produce unwanted artifacts. Thus, they introduced two methods to overcome the drawbacks in which former method divides the histogram based on the median, and iteratively divides into the lower and upper sub-histograms, to produce a totally four sub-histograms. The separating points in the lower and upper sub-histograms are assigned to a new dynamic range and clipping process is implemented to each sub-histogram. They introduced that later method is the extension of the bi-histogram equalization plateau limit (BHEPL) that segments the histogram of input image based on its mean value and then, clipping process is implemented to each sub-histogram based on their median value. **Nyaml khagva Sengee et al.(2010)[7]** have found that one widely accepted contrast enhancement method is global histogram equalization (GHE), which achieves comparatively better performance on almost all types of image but sometimes causes excessive visual deterioration. So they introduced a new method which is extension of bi-histogram equalization called Bi-Histogram Equalization with Neighborhood Metric (BHENM) which consists of two stages. They declared that in first stage, large histogram container causes washout artifacts, are split into sub-bins using neighborhood metrics; the exact same intensities of the first image are arranged by neighboring information. In the 2nd stage, histogram of the first image is separated into two sub-histograms on the basis of the mean of the histogram of the first image; the sub-histograms are equalized independently using refined histogram equalization, which produces flatter histograms. They showed in results that

BHENM simultaneously preserved the brightness and enhanced the local contrast of the original image.**Zohaib Hammed et al. (2011) [8]** have found that the performance of an edge detection algorithm can be affected by serious noise & intensity in homogeneities. So they introduced a method aiming at detecting edge of image with varieties of gradient signal degradation which comprised two steps: adaptive histogram equalization and gradient modulation filtering process to improve the signal contrast in a discriminative manner. They revealed that this approach is applicable and effective to detect edges of poor images. **Yeong-Kang Lai, Yu-Fan Lai et al. (2011)[9]** have found that thin-film transistor liquid crystal display (TFT LCD) is widely used in handheld mobile devices but it consumes 20%–45% of total system power due to different applications. They also found that by controlling the backlight current to reduce the brightness and the contrast of LCDs can reduce the overall power consumption but this may cause significant changes in visual perception. So that they introduced new method to be able to reduce the energy consumption and get rid of the visual changes, the problem becomes. They introduced two new algorithms predicated on content analysis: the newest backlight-dimming algorithm (NBDA) and the newest image enhancement algorithm (NIEA). They observed that these algorithms can simultaneously reduce power consumption by 47% and increase the image enhancement ratio by 6.8% and also the structural-similarity index metric (SSIM) can be used to gauge image quality.**Seung-Won Jung et al.(2014)[11]** have introduced a new global contrast enhancement algorithm using the histograms of color and depth images. they have implemented this technique on the basis of the histogram-modification framework, the color and depth image histograms are first partitioned into subintervals using the Gaussian mixture model and the positions partitioning the color histogram are then adjusted such that spatially neighboring pixels with the similar intensity and depth values can be grouped into the same sub-interval. They declared that by estimating the mapping curve of the contrast enhancement for each sub-interval, the global image contrast can be improved without over-enhancing the local image contrast. **Gurvir Singh, et al. (2013)[12]** have found that in image enhancement various enhancement schemes have been used for enhancing which includes gray scale manipulation, filtering and Histogram Equalization (HE). They declared that existing techniques produce images with do not look as natural as the input ones and HE tends to introduce some annoying artifacts and unnatural enhancement. So to overcome these drawbacks, they introduced that different existing defined brightness preserving techniques are used to check their performance measurement. They have done comparison on the basis of subjective and objective parameters. And they also found that subjective parameters are visual quality and computation time and objective parameters are Peak signal to- noise ratio (PSNR), Contrast and Error. **Shiwam S. Thakare1 et al.(2014)[13]** have described comparative analysis of various enhancement techniques for such underwater images. They found that underwater image suffers from low contrast and resolution due to poor visibility conditions, hence an object identification become typical task and the processing of underwater image captured is necessary because the quality of underwater images affect and these images leads some serious problems when compared to images from a clearer environment. They have found that a lot of noise occurs due to low contrast, poor visibility conditions, absorption of natural light, non uniform lighting and little color variations, and blur effect in the underwater images. so they declared that there is need to cure these underwater images by using different filtering techniques.**John Y. Chiang et al. (2012) [14]** have found that Light scattering and color change are two major sources of distortion for underwater photography and no existing underwater processing techniques can handle light scattering and color change distortions suffered by underwater images, and the possible presence of artificial lighting simultaneously. So they introduced that a novel systematic approach to enhance underwater images by a dehazing algorithm, to compensate the attenuation discrepancy along the propagation path, and to take the influence of the possible presence of an artifical light source into consideration.They declared that performance of this algorithm for wavelength compensation and image dehazing (WCID) is evaluated both objectively and subjectively by utilizing ground-truth color patches and video downloaded from the Youtube website. They have shown in results that images with significantly enhanced visibility and superior color fidelity are obtained by the WCID. **Pooja Sahu et al. (2014)[17]** Have introduced the techniques to enhance underwater image enhancement techniques. In addition they discovered that the processing of underwater image captured is essential because the caliber of underwater images affect and these image leads some serious problems like a large amount of noise occurs as a result of low contrast, poor visibility conditions (absorption of natural light), non uniform lighting and little color variations, pepper noise and blur effect in the underwater images when comparing to images from the clearer environment. They've observed that because of these reasons quantity of methods are existing to cure these underwater images using different filtering. They introduced that enhancement of underwater images one is image enhancement using median filter which enhances the image and help estimate the depth map and improve quality by eliminating noise particles with assistance from different techniques, and another is RGB Color Level Stretching have used.**Balvant Singh et al.(2011)[18]** have described the performance of contrast limited adaptive histogram equalization method is compared with contrast stretching, and histogram equalization method. For comparing the performance, they have applied mean square error and SNR as parameters. They applied this method on various type of underwater image environment for testing. They found that underwater image suffers from low contrast and resolution due to poor visibility conditions, so object identification under water is difficult task. So they presented comparative analysis of various contrast enhancement techniques for such underwater images.**Sowmyashree M S et al. (2014) [17]** have found that the major sources for distortion of underwater images are light scattering and color change and water has high refractive index when compared to air. Hence, underwater images suffer from limited range visibility, low contrast, blurring, color diminished and noise. So they presented a comparative study of the various image enhancement techniques used for enhancing underwater image.**Cosmin Ancuti et al. (2012) [18]** have described a book strategy to improve underwater videos and images and built on the fusion principles, this strategy derives the inputs and the weight measures only from the degraded version of the image. to overcome the limitations of the underwater medium, they defined two inputs that represent color corrected and contrast enhanced versions of the first underwater image, but in addition four weight maps that aim to improve the visibility of the distant objects degraded as a result of medium scattering and absorption. They declared that this can be a single image approach that does not require specialized hardware or information about the underwater conditions or scene structure. Additionally they declared that fusion framework also supports temporal coherence between adjacent frames by performing a fruitful edge preserving noise reduction strategy and the enhanced images and videos are characterized by reduced noise level, better exposedness of the dark regions, improved global contrast while the best possible details and edges are enhanced significantly.**Pulung Nurtantio ANDONO (2013) [20]** have introduced that Success of scale-invariant feature transform (SIFT) image registration is bound when attempted on camera footage taken under water and largely as a result of poor image quality inherent to imaging in aquatic environments. To overcome this shortcoming, they have introduced a fresh approach to pre-processing of true-color imagery taken under water on the basis of the Contrast Limited Adaptive Histogram image Equalization (CLAHE) algorithm in that the distribution function of the pixel intensity values of an underwater recorded image is dominated by Rayleigh scattering, and that the noise may be removed as a function hereof. They declared that if applying the CLAHE image enhancement method registration success of SIFT increased by 41% in comparison to reference method (a straightforward contrast stretching enhancement).**Muhammad Suzuri Hitam et al. (2013) [13]** have found of improving the quality of an underwater image has received considerable attention due to poor visibility of the image which is caused by physical properties of the water medium. This paper presents a new method called 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 are combined together using Euclidean norm. Experimental results show that the proposed approach significantly improves the visual quality of underwater images by enhancing contrast, as well as reducing noise and artifacts.

3. PROPOSED ALGORITHM

The detailed algorithm for the proposed approach is given below:

Step 1: Input preprocessing image: Firstly, there is a given input image. We take underwater input images imposes several problems due mainly to light absorption, light scattering, light reflection and denser medium. These problems result in poor visibility of the underwater images. The quantity of light is reduced once we go deeper to the water and hence colors disappear 1 by 1 depending on the wavelength. Then we find the image size by using this equation-

[p c d]=size F(x,y)……..(1)

Where p represent rows, c represent columns and d represent dimensions. F(x,y) is an input image.

Step 2: Convert RGB to L*a*b- Apply RGB to L*A*B to convert given image in L*A*B color space plane. Converts the color values in input image to the color space specified in the color transformation structure makecform. The color transformation structure specifies various parameters of the transformation. That is why RGB image produced not much good result, so we apply lab for new enhancement it produced better result than lab.

Lab_image=applycform(input_image,makecform('srgb2lab')) ;…………………………(2)

Steps 3: Extract the L component i.e. light only.

(a) Apply CLAHE on L.

Labclahe_opadapthisteq(lab_image(:, :, 1),'NumTiles', . . .

[8,8],'Cliplimit',0.005);

Lab_op=cat(3,LABCLAHE_op,lab_image(: ,: , 2), lab_image(: , : , 3)) ;………(3)

Step 4: Apply L*A*B 2RGBto convert given image in RGB plane.

Final_image=applycform(lab_op,makecform('lab2srgb'));… …………………….(4)

Step 5: Apply image gradients based smoothing-Then apply image gradients based smoothing to remove the problem of uneven illuminate. Image gradients may be used to extract information from images. Gradient images are created from the original image. After gradient images have been computed, pixels with large gradient values become possible edge pixels. The pixels with the largest gradient values in the direction of the gradient become edge pixels, and edges may be traced in the direction perpendicular to the gradient direction. It is applied to get accurate edges for hue component.

Apply gradient %GBS on RGB color space

New(: , : ,1) =GBS (final image (: ,: ,1)) ;

New(: , : ,2) =GBS (final image (: ,: ,2)) ;

New(: , : ,3) =GBS (final image (: ,: ,3)) ; …………………………………….. (5)

Step 6: Final image which has been visibly stronger than the input image and the output of the available CLAHE results

4. EXPERIMENTAL RESULTS

The quality of the improved image was judged both in subjective ways from visual appeal and presence of unwanted color artifacts as well as by using objective statistical measures. The various types of image taken for experiment result. The mean square error(MSE),root mean square error(RMSE)peak signal noise ratio(PSNR)normalized cross-correlation(NCC),maximum difference(MD),average difference(AD),normalized absolute error(NAE).The Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Root Mean Square Error and Normalized Absolute Error are the four metrics used to compare the quality of the enhanced underwater images. The MSE represents the cumulative squared error between the Enhanced image and the original image, whereas PSNR represents a measure of the peak error. As root mean square error needs to be reduced therefore the proposed algorithm is showing the better results than the available methods as root mean square error is less in every case. And last one is normalized absolute Normalized Absolute Error needs to be reduced therefore the proposed algorithm is showing the better results than the available methods as Normalized Absolute Error is less in every case.

The MSE is calculated using the following equation:

$$\text{MSE} = \frac{\sum M,N[I_1(m,n) - I_2(m,n)]^2}{M*N} \qquad (6)$$

Where I_1 and I_2 denotes the original image and improved image respectively. The size of input image must be same and are denotes by M*N. To compute the PSNR we can use the MSE .The MSE is calculated using the following equation:

$$\text{PSNR} = 20log10\left(\frac{2^B - 1}{\sqrt{(MSE)}}\right) \qquad (7)$$

Where β presented the bit per sample. In this work, β=8 because color images that range from 0-255 are used for experiment.The RMSE is calculated using the following equation:

$$RMSE=\sqrt{\frac{\sum_{M,N}[I_1(m,n)-I_2(m,n)]^2}{M*N}} \quad (8)$$

Normalized Absolute Error (NAE): The large value of normalized absolute error means that image is poor quality. NAE is defined as follows:

$$NAE=\frac{\sum_{i=1}^{N}\sum_{j=1}^{M}Abs(E(i,j))}{\sum_{i=1}^{N}\sum_{j=1}^{M}(I(I,J))} \quad (9)$$

Here, M & N row & column, Abs is absolute error.

To compute the MNormalized Cross Correlation (NCC) is calculated using the following equation: MNormalized cross correlation is used to find out similarities between input image and registered image is given by the following equation:

$$NCC=\frac{\sum_{i=1}^{N}\sum_{j=1}^{M}I(i,j)*O(i,j)}{\sum_{i=1}^{N}\sum_{j=1}^{M}I(i,j)*I(i,j)} \quad (10)$$

Maximum Difference (MD):

MD measure difference between any two pixels such that the larger pixel appears after the smallest pixel. The large value of maximum difference means that image is poor in quality.

$$MD=\max(E) \quad (11)$$

Where *E is error.*

Average Difference (AD):

The Average difference corresponds to pixel which has a value which is less than the pixel in original image and the Average minimum difference corresponds to pixel which has a value which is more than the pixel in original image. The average difference is defined as a value of the difference between maximum and minimum. It needs to be minimized.

$$AD=\sum_{i=1}^{N}\sum_{j=1}^{M}\frac{E(i,j)}{M*N} \quad (12)$$

Where, M&N-Row & Column & E=I (I, j)-O (I, j)

The values of MSE, RMSE, PSNR, NAE, MNCC, MD and AD are shown in Table 1, Table 2, Table 3, Table 4, Table 5, Table 6 and Table 7 respectively. It is clear that the CLAHE L*A*B model not only produced better results but also enhanced the image quality .The MSE value of proposed techniques is decreased almost in every case as compared to CLAHE-Mix.The quality of the improved images which is judged by the RMSE value has shown that CLAHE L*A*B is low in every test. and The result of PSNR value has shown that CLAHE L*A*B is highest for all test images. The large value of Maximum Difference means that image is poor in quality. Average Difference needs to be minimized. The large value of normalized absolute error means that image is poor quality. As MNCC needs to be close to 1, therefore proposed algorithm is showing better results than the available methods as MNCC is close to 1 in every case.

Figure 2: Comparison of methods . Upper left: original underwater image. Upper Right: Mix CLAHE image. Bottom left: L*A*B CLAHE image. Bottom Right: New Enhancement image

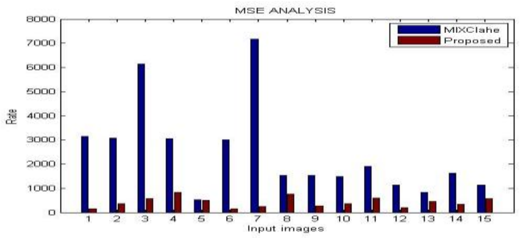
Figure 3: Comparison of methods on 14. Upper left: original underwater image. Upper Right: Mix CLAHE image. Bottom left: L*A*B CLAHE image. Bottom Right: New Enhancement image

Table 1: Comparison of MSE

Image	Mix CLAHE	Proposed
1.jpg	3139.90	163.35
2.jpg	3087.70	365.26
3.jpg	6148.32	574.03
4.jpg	3064.30	819.13
5.jpg	514.77	491.80
6.jpg	3003.50	152.01
7.jpg	7162.14	236.07
8.jpg	1522.15	762.13
9.jpg	1523.17	259.26
10.jpg	1474.59	367.90
11.jpg	1909.48	601.26
12.jpg	1130.26	195.91
13.jpg	837.71	454.44
14.jpg	1631.23	337.63
15.jpg	1139.79	565.16

Graph 1 has shown the quantized analysis of the mean square error of different images using enhancement by Mix clahe transform (Blue Color), enhancement by LAB COLOR space transform (Red color) by Proposed Approach.

It is very clear from the plot that there is decrease in MSE value of images with the use of proposed method over other methods. This decrease represents improvement in the objective quality of the image.



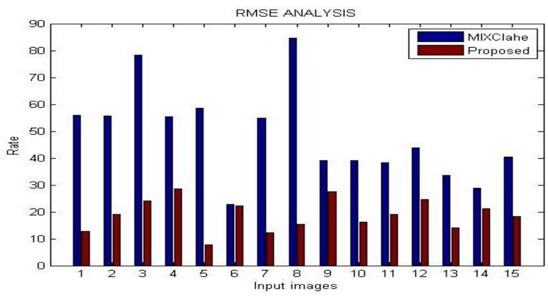
Graph 1 MSE of Existing & Proposed Approach for different images

Table 2: Comparison of RMSE

Images	Mix CLAHE	Proposed
1.jpg	56.03	12.78
2.jpg	55.56	19.11
3.jpg	78.41	23.95
4.jpg	55.35	28.62
5.jpg	58.50	7.81
6.jpg	22.68	22.17
7.jpg	54.80	12.32
8.jpg	84.62	15.36
9.jpg	39.01	27.60
10.jpg	39.02	16.10
11.jpg	38.40	19.18
12.jpg	43.69	24.52
13.jpg	33.61	13.99
14.jpg	28.94	21.31
15.jpg	40.38	18.37

Graph 2 has shown the quantized analysis of the root mean square error of different images using enhancement by Mix clahe transform (Blue Color), enhancement by LAB COLOR space transform (Red color) by Proposed Approach.

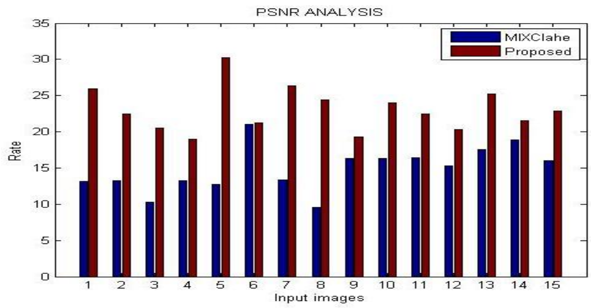
It is very clear from the plot that there is decrease in RMSE value of images with the use of proposed method over other methods. This decrease represents improvement in the objective quality of the image.



Graph 2 RMSE of mix CLAHE & Proposed Approach for different images

Table 3: Comparison of PSNR

Images	Mix CLAHE	Proposed
1.jpg	13.16	25.99
2.jpg	13.23	22.50
3.jpg	10.24	20.54
4.jpg	13.26	18.99
5.jpg	12.78	30.26
6.jpg	21.01	21.21
7.jpg	13.35	26.31
8.jpg	9.58	24.40
9.jpg	16.30	19.31
10.jpg	16.30	23.99
11.jpg	16.44	22.47
12.jpg	15.32	20.34
13.jpg	17.59	25.21
14.jpg	18.89	21.55
15.jpg	16.00	22.84



Graph 3 PSNR of mix CLAHE & Proposed Approach for different images

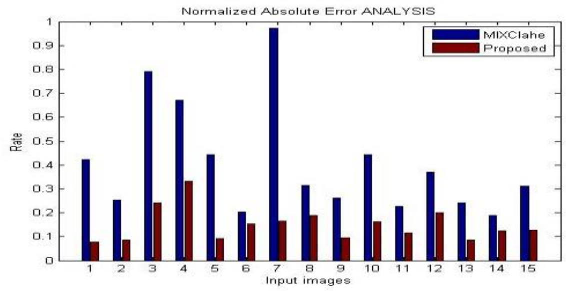
Graph 3 has shown the quantized analysis of the peak signal to noise ratio of different images using enhancement by Mix clahe transform (Blue color), Enhancement by LAB color space transform (Red Color) Proposed Approach.

It is very clear from the plot that there is increase in PSNR value of images with the use of proposed method over other methods. This increase represents improvement in the objective quality of the image.

Table 4 Comparison of NAE

Images	Mix CLAHE	Proposed
1.jpg	0.4236	0.0786
2.jpg	0.2519	0.0855
3.jpg	0.7905	0.2423
4.jpg	0.6715	0.3307
5.jpg	0.4431	0.0920
6.jpg	0.2032	0.1539

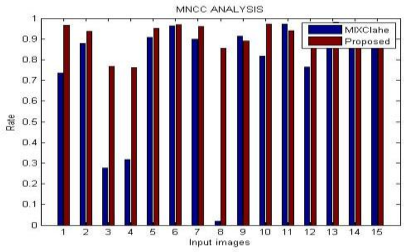
7.jpg	0.9718	0.1645
8.jpg	0.3135	0.1884
9.jpg	0.2609	0.0939
10.jpg	0.4435	0.1620
11.jpg	0.2277	0.1156
12.jpg	0.3709	0.1995
13.jpg	0.2412	0.0877
14.jpg	0.1894	0.1235
15.jpg	0.3124	0.1260



Graph 4 Normalized Absolute Error of mix CLAHE & Proposed Approach for different images

Table 5 Comparison of MNCC

Images	Mix CLAHE	Proposed
1.jpg	0.7351	1.0335
2.jpg	1.1214	1.062
3.jpg	0.2761	0.7664
4.jpg	0.318	0.7606
5.jpg	0.9072	0.9524
6.jpg	0.9629	1.031
7.jpg	0.9005	0.9606
8.jpg	0.018	0.854
9.jpg	1.0856	0.89
10.jpg	0.8158	1.0269
11.jpg	1.028	1.0596
12.jpg	0.7643	0.879
13.jpg	0.9643	1.0201
14.jpg	0.9659	1.038
15.jpg	0.8819	1.1217

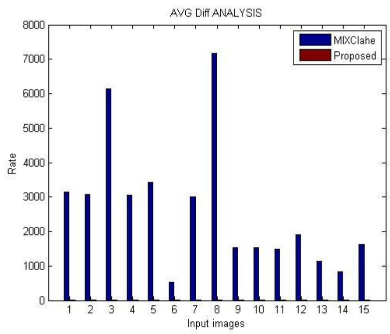


Graph 5 MNormalized Cross-Correlation of mix CLAHE & Proposed Approach for different images

Graph 5 has shown the quantized analysis of the MNormalized Cross-Correlation of different images using enhancement by Mix clahe transform (Blue color), Enhancement by LAB color space transform (Red Color) Proposed Approach.As MNCC needs to be close to 1, therefore proposed algorithm is showing better results than the available methods as MNCC is close to 1 in every case. This increase represents improvement in the objective quality of the image.

Table 6 Comparison Average Difference

Images	Mix CLAHE	Proposed
1.jpg	3139.90	163.35
2.jpg	3087.70	365.26
3.jpg	6148.32	574.03
4.jpg	3064.30	819.13
5.jpg	3423.18	61,14
6.jpg	514.77	491.80
7.jpg	3003.50	152.01
8.jpg	7162.14	236.07
9.jpg	1522.15	762.13
10.jpg	1523.17	259.26
11.jpg	1474.59	367.90
12.jpg	1909.48	601.26
13.jpg	1130.26	195.91
14.jpg	837.71	454.44
15.jpg	1631.23	337.63

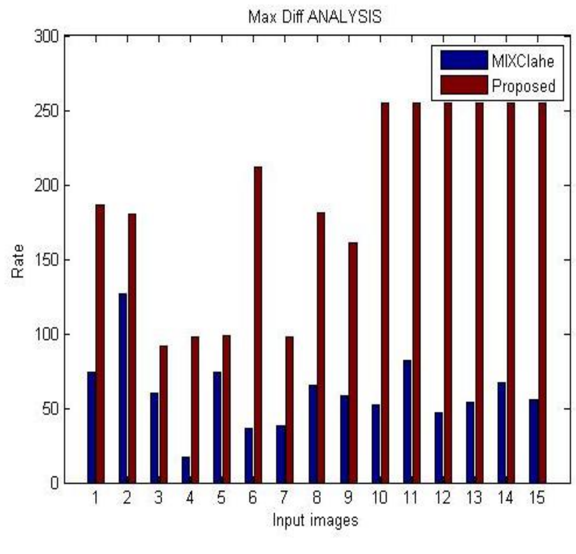


Graph 6 Average difference of mix CLAHE & Proposed Approach for different images

Graph 6 has shown the quantized analysis of the Average difference of different images using enhancement by Mix clahe transform (Blue color), Enhancement by LAB color space transform (Red Color) Proposed Approach.As average difference is less in every case. This increase represents improvement in the objective quality of the image.

Table 7: Comparison of Maximum Difference

Images	Mix CLAHE	Proposed
1.jpg	74	186
2.jpg	127	180
3.jpg	60	92
4.jpg	17	98
5.jpg	74	99
6.jpg	36	212
7.jpg	38	98
8.jpg	65	181
9.jpg	58	161
10.jpg	52	255
11.jpg	82	255
12.jpg	47	255
13.jpg	54	255
14.jpg	67	255
15.jpg	56	255



Graph 7 Maximum difference of mix CLAHE & Proposed Approach for different images

Graph 7 has shown the quantized analysis of the Maximum difference of different images using enhancement by Mix clahe transform (Blue color), Enhancement by LAB color space transform (Red Color) Proposed Approach.As Maximum difference is maximum in every case. This increase represents improvement in the objective quality of the image.

5. CONCLUSION AND FUTURE WORK

To overcome the problems of existing technique a new L*A*B color space and CLAHE based image enhancement algorithm is proposed in this research work. To overcome the issue of the uneven illuminate issue in the output image of the CLAHE output has been further removed using the use of image gradient based smoothing. The main scope of the proposed algorithm is to improve the accuracy of the underwater image enhancement techniques. It produced lowest MSE, highest PSNR,RMSE is less in every case, NAE is reduced in every case .So in near future a new joint trilateral filter along with the improved dark channel prior to overcome the limitations of the earlier techniques. Improved dark channel will use fuzzy based decision making to restore the underwater image produced by t he optical model and dark channel prior. Fuzzy decision making has the ability to find different alternative for same scene and among those alternatives, best one will be selected for final output. To develop multiple alternatives for fuzzy set theory, adaptive histogram equalization and dark channel prior with various restoration levels will be used.

6. ACKNOWLEDGMENTS

The author would like to thanks to institue for providing help for underwater.

7. REFERENCES

[1] Joung-Youn Kim, Lee-Sup Kim, and Seung-Ho Hwang, “An Advanced Contrast Enhancement Using Partially Overlapped Sub-Block Histogram Equalization”, VOL. 11, NO. 4, APRIL 2001.

[2] Chao Wang and Zhongfu Ye, “Brightness Preserving Histogram Equalization with Maximum Entropy: A Variational Perspective”, Vol. 51, No. 4, NOVEMBER 2005.

[3] Mary Kim and Min Gyo Chung, “Recursively Separated and Weighted Histogram Equalization for Brightness Preservation and Contrast Enhancement”, Volume:54 , August 2008.

[4] Yisu Zhao, Nicolas D. Georganas, Emil M. Petriu, “Applying Contrast-limited Adaptive Histogram Equalization and Integral Projection for Facial Feature Enhancement and Detection”, 3-6 May 2010.

[5] Zhen Jia, Hongcheng Wang, Rodrigo Caballero, Ziyou Xiong, Jianwei Zhao and Alan Finn, “REAL-TIME CONTENT ADAPTIVE CONTRAST ENHANCEMENT FOR SEE-THROUGH FOG AND RAIN”, 14-19 March, 2010 IEEE International Conference.

[6] Chen Hee Ooi and Nor Ashidi Mat Isa, “Adaptive Contrast Enhancement Methods with Brightness Preserving”, Volume 56, Issue 4, November 2010.

[7] Nyamlkhagva Sengee, Altansukh Sengee, and Heung-Kook Choi, “Image Contrast Enhancement using Bi-Histogram Equalization with Neighborhood Metrics”, Volume 56, Issue 4, November 2010.

[8] Zohaib Hameed and Chunyan Wang, “Edge Detection Using Histogram Equalization And Multi-Filtering Process”, 2011 IEEE International Symposium, 15-18 May 2011.

[9] Yeong-Kang Lai, Yu-Fan Lai, “Content-Based LCD Backlight Power Reduction with Image Contrast

Enhancement Using Histogram Analysis", 2011 IEEE International Conference, 9-12 January.

[10] Seung-Won Jung, "Image Contrast Enhancement Using Color and Depth Histograms" , VOL. 21, NO. 4, APRIL 2014.

[11] Gurvir Singh[1], Mandeep Singh[2], "Histogram Eualization Techniques for Image Enhancement using Fuzzy Logic", Volume-3, Issue-6, December-2013.

[12] Eunsung Lee, SangjinKim, Wonseok Kang, Doochun Seo, and JoonkiPaik, "Contrast Enhancement Using Dominant Brightness Level Analysis and Adaptive Intensity Transformation for Remote Sensing Images", VOL.10, NO.1, JANUARY2013.

[13] Muhammad Suzuri Hitam, Wan Nural Jawahir Hj Wan Yussof, Ezmahamrul Afreen Awalludin, Zainuddin Bachok, "Mixture Contrast Limited Adaptive Histogram Equalization for Underwater Image Enhancement", 2013.

[14] John Y. Chiang and Ying-Ching Chen, "Underwater Image Enhancement by Wavelength Compensation and Dehazing", Vol. 21, No. 4, APRIL 2012.

[15] Prabakar and Praveen Kumar, "AN IMAGE BASED TECHNIQUE FOR ENHANCEMENT OF UNDERWATER IMAGES", Volume 3, Issue 4, 2011.

[16] Shiwam S. Thakare1, Amit Sahu, "Comparative Analysis of Various Underwater Image Enhancement Techniques", *Vol. 3, Issue. 4, April 2014.*

[17] Pooja Sahu,Neelesh Gupta and neetu Sharma, " A Survey on Underwater Image Enhancement Techniques", Volume 87 – No.13, February 2014.

[18] Balvant Singh , Ravi Shankar Mishra , Puran Gour , "Analysis of Contrast enhancement Techniques For Underwater Image", Volume 1 , Issue 2, 2011

[19] Dr.g.padmavathi, dr.p.subashini, mr.m.muthu kumar and suresh kumar thakur, comparison of filters used for underwater image pre-processing", 2010.

[20] Pulung nurtantio, "Underwater image enhancement using adaptive filtering for enhanced sift-based image matching, 2013 .

[21] Iqbal, K.; Odetayo, M.; James, A.; Salam, R.A.; Talib, A.Z.H., "Enhancing the low quality images using Unsupervised Colour Correction Method," Systems Man and Cybernetics (SMC), 2010 IEEE International Conference on , vol., no., pp.1703,1709, 10-13 Oct. 2010.

[22] Jinbo Chen; Zhenbang Gong; Hengyu Li; Shaorong Xie, "A detection method based on sonar image for underwater pipeline tracker," Mechanic Automation and Control Engineering (MACE), 2011 Second International Conference on , vol., no., pp.3766,3769, 15-17 July 2011.

[23] Hung-Yu Yang; Pei-Yin Chen; Chien-Chuan Huang; Ya-Zhu Zhuang; Yeu-Horng Shiau, "Low Complexity Underwater Image Enhancement Based on Dark Channel Prior," Innovations in Bio-inspired Computing and Applications (IBICA), 2011 Second International Conference on , vol., no., pp.17,20, 16-18 Dec. 2011.

[24] bt. Shamsuddin, N.; bt. Wan Ahmad, W.F.; Baharudin, B.B.; Kushairi, M.; Rajuddin, M.; bt. Mohd, F., "Significance level of image enhancement techniques for underwater images," Computer & Information Science (ICCIS), 2012 International Conference on , vol.1, no., pp.490,494, 12-14 June 2012.

[25] Hitam, M.S.; Yussof, W.N.J.H.W.; Awalludin, E.A.; Bachok, Z., "Mixture contrast limited adaptive histogram equalization for underwater image enhancement," Computer Applications Technology (ICCAT), 2013 International Conference on , vol., no., pp.1,5, 20-22 Jan. 2013.

[26] Muhammad Suzuri Hitam and Ezmahamrul Afreen Awalludin, "Mixture Contrast Limited Adaptive Histogram Equalization for Underwater Image Enhancement", 2013.