International Journal of Future Generation Communication and Networking
Vol. 13, No. 2s, (2020), pp. 374–381

Underwater Images Haze Removal

Rajat Kumar Singh[1], S.K.Patil[2],Manish Kant Kumar[3],Shivangi Chandra[4]

[1,2,3,4] Dept. of E & TC Engg. Smt. Kashibai Navale College of Engineering, Savitribai Phule Pune University, Pune
[1]manish4801@gmail.com
[2]skpatil_skncoe@sinhgad.edu
[3]str.rajatsingh@gmail.com
[4]shivangichandra796@gmail.com

Abstract

The challenges of capturing underwater images contain problems like aggressive light absorption and disrupting scattering effect in the deep ocean enabling lighting problem. So mainly, we concentrate on the underwater image enhancement through haze removal algorithm by dark channel prior technique. But, it has tendency to darken the image in some situation but shows a good result by reducing haze and noise effect. In order to improve the dehazing result, a histogram equalization technique has been taken. CLAHE on RGB model has been followed in our approach to change the level of contrast and intensity of dehaze image. In the end, a color correction algorithm for visually appreciable result has been used. Our project results expected to show that the proposed algorithm is significantly going to improve quality of underwater images visually as well as quantifiably by enhancing the contrast of the image and reducing noise as well as artifacts in the image.

Keywords-*Dehazing,Dark Channel Prior,CLAHE,Color correction*

I. Introduction

The capability of humans of diving in the deep ocean for a long time is limited to a certain extent due to which the exploration of the sea bed also becomes limited.Exploring into the deep ocean has always been the interest of scientist and geologists,But due to the fact that humans are incapable to dive into the deeper ocean for longer duration,they send UROVs(Underwater remotely operated vehicles).Despite the fact that UROVs have a good quality camera and source of illumination,they are unable to capture good quality images due to the problems like absorption of light and scattering effect in the deep ocean enabling lighting problem. Underwater imaging has many applications, these days and it has become an important field of research because the seas, lakes and rivers contain many valuable resources inside it,also has a huge variety of aquatic organisms to be explored.But, the problem with the underwater is the loss of colors and contrast of the image. Because, as we go deeper , the color and contrast of the underwater image varies according to the depth because of the difference in wavelength of fundamental components of white light. The red or orange light of the sun which has longer wavelengths are absorbed quickly which causes most of underwater images appear blue and/or green in color. Mostly, the refraction and absorbtion by the water are responsible for the change in color. Every color absorbs at a different rate because every color has a different wave length and energy.

ISSN: 2233-7857 IJFGCN

II. LITERATURE SURVEY

Sr.No	NAME OF AUTHOR	ALGORITHMS	FEATURES	LIMITATIONS
1	Y.Schechner, N. Karpe	Contrast Limited Adaptive Histogram Equalization	Effective in comparison with traditional methods	Neglected the techniques to reduce the noise issue
2	J.Y.Chiang, Y. C. Chen	Local dark channel prior	Obtain more accurate result	The problem of the uneven illuminate is also neglected
3	A. Yamashita, M. Fujii, T. Kaneko	Atmospheric scattering model	Achieves good restoration for contrast and color fidelity	Neglected the techniques to reduce the noise issue
4	R. Schettini, S. Corchs	Wiener filtering based on dark channel prior	Shortens the running time	The problem of the uneven illuminate is also neglected
5	K. He, J. Sun, X. Tang	Mixture Contrast Limited Adaptive Histogram Equalization	Improves the visual quality of underwater images	The problem of the uneven illuminate is also neglected
6	P. D., E. Do Nascimento, F. Moraes, S. Botelho, M. Campos,	Dark channel prior	Restore the fogging image effectively and reduce the time	Neglected the techniques to reduce the noise issue
7	C. Y. Cheng, C. C. Sung, H. H. Chang	lowest level channel prior	utilises the exact O(1) bilateral filter for high performance	The problem of the uneven illuminate is also neglected

ISSN: 2233-7857 IJFGCN

8	K. J. Voss	fast bilateral filtering combined with dark colors prior	improve the adaptability and fast execution speed	Neglected the techniques to reduce the noise issue
9	A. Levin, D. Lischinski, Y. Weiss	color image contrast Fog removing algorithm	efficient and reliable choice for fog removing	The problem of the uneven illuminate is also neglected
10	Alka Tripathi, Ms Pragya Gupta, Dr. Vineet Richaria	iterative, adaptive, non-parametric regression method.	denoise the image	The problem of the uneven illuminate is also neglected

Table1:Literature survey for various methods that were carried out to perform haze removal or correction of the underwater images.

III. METHODOLOGY

To develop a system to satisfy our aim, we have used the following algorithms in sequence to obtain the haze free enhanced image.

i)Dark Channel Prior(DCP)
ii)Contrast Limited Adaptive Histogram Enhancement.
iii)Colour Correction.

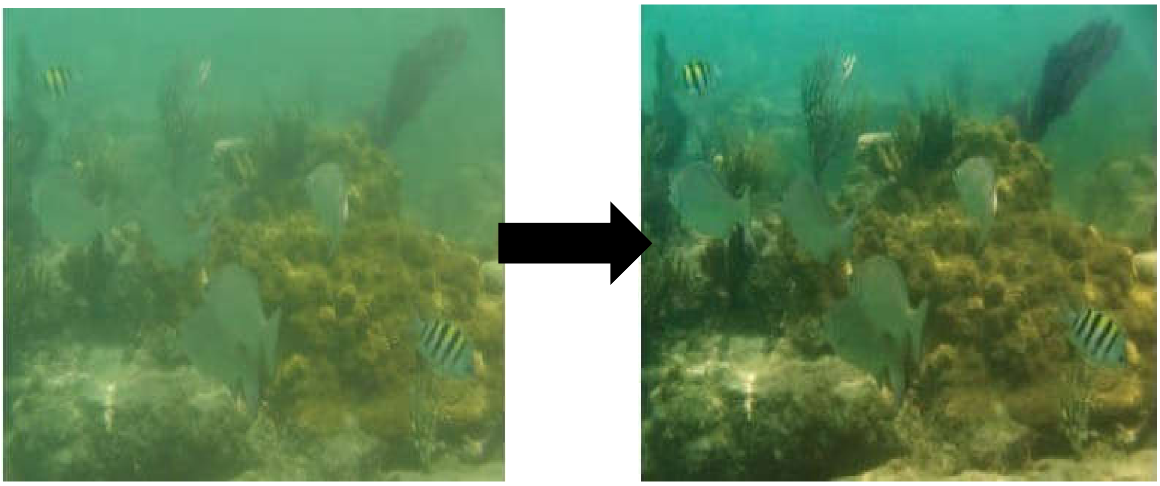
IV. REMOVAL OF HAZE USING DARK CHANNEL PRIOR

Dark channel prior method is usually used to remove haze from underwater image, and produce a natural haze free image. However, we use this method to enhance underwater image. The presence of water particles causes scattering of light which produces haze in the image which can be removed by Dark Channel Prior method.In computer vision applications, a hazy image S (x) can be represented as follows:

$$S(x)=Z(x)t(x)+A\{(1-t(x)\} \qquad (1)$$

In Equation (1), A represents global atmospheric light. S (x) represets haze mixed intensity of the image. Z (x) represents the intensity of the foreground or the intensity of haze-free image, and t (x) represents the percentage of residual energy, when the foreground irradiance passes through the medium, known as the medium transmission. The main aim of the DCP algorithm is the estimation of Z (x); t (x), DCP points that, in the most of the local regions which are present in the background of the image contain some pixels having very low intensity in at least one color (RGB) channel.

ISSN: 2233-7857 IJFGCN



HAZY IMAGE DCP APPLIED IMAGE

Fig.1: Effect of DCP on the original hazy image

V. DEFECTS IN DCP PROCESS

i)Generally in an image, two grounds are there. First is foreground which is the main focus point and second one is the background which is generally irrelevant. DCP technique has major defects in enhancement of the background.
ii) Firstly, if the haze image has small background area with low contrast, Dark Channel Prior will cause a bad result on dark background with very low contrast. This is because the background of image is regarded as scene mixing with thick haze and the DCP method reduces the contrast of the local regions.
iii) Secondly, the direct attenuation has a nonlinearity with the image intensity. So, the attenuation of the image's foreground is underestimated during the DCP process; so the result implemented by DCP has a low contrast compared to the haze free image.
iv) The drawbacks mentioned above have little effect on the haze removal result, but if the hazy image has a larger background area with low contrast, the DCP causes bad results and also reduces the contrast of foreground. To remove this deficiency, we have used adaptive histogram equalization to the DCP result.

VI. ADAPTIVE HISTOGRAM EQUALIZATION

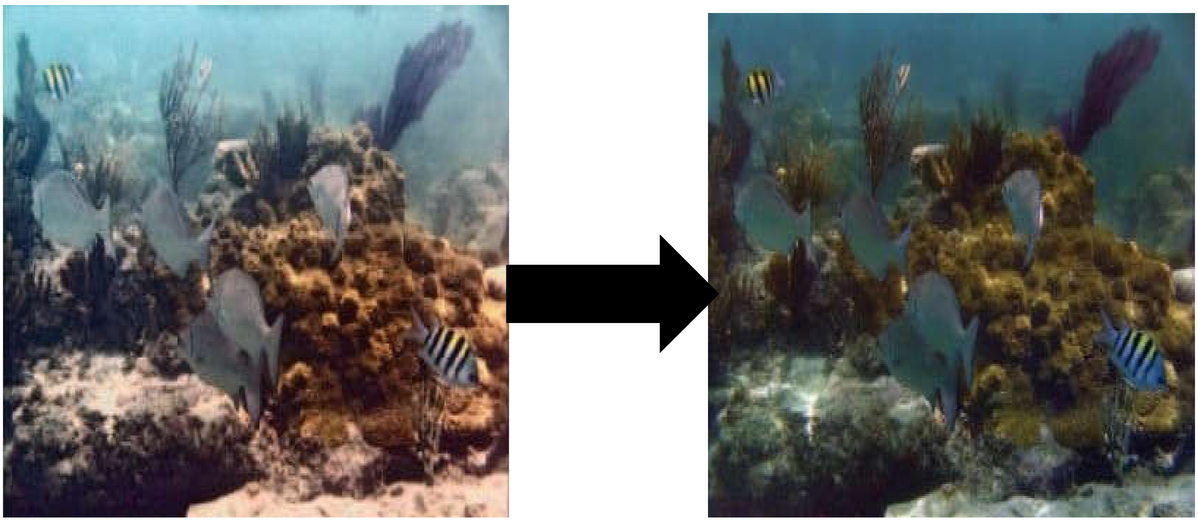
Adaptive histogram equalization (AHE) is a technique used for enhancing the contrast in images. The adaptive histogram 377qualization method computes several histograms, each histogram corresponds to a distinct section of the image. In this way, it improves the local contrast of the image. However, AHE over amplifies the noise in relatively homogeneous regions of an image.
A deviation of Adaptive histogram equalization which is called as contrast limited adaptive histogram equalization (CLAHE) obviates this by limiting the amplication . We have used CLAHE in our algorithm. CLAHE is a generalized version of Adaptive Histogram Equalization where contrast of the image is kept contant. Contrast Limited Adaptive Histogram Equalization color models specifically developed for enhancement of images. Specically, it operates on the tiles of the image. Tiles are nothing but the small regions in the image which is divided according to a particular grid to exploit local spatial coherence in the scene. It enhanced the contrast of each tile. To eliminate the induced articial boundaries, the neighbouring tiles are combined using bilinear interpolation. So the contrast became limited to avoid amplifying any noise especially in homogeneous areas in the image. It was originally developed for enhancement of images having low contrast. It limits the amplication by clipping the

ISSN: 2233-7857 IJFGCN

histogram at a user-dened value called clip limit. The clipping level determines the level of noise that should be smoothed in the histogram and hence the level of the contrast to be enhanced. A contrast limited technique which is known as adaptive histogram clip (AHC) can also be applied. AHC adaptively clips 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:

$$Rayleigh, K = K_{\min} + \left[2\left(\alpha^2\right) \ln\left(\frac{1}{1 - P(f)} \right) \right]^{0.5} \quad \dots (2)$$

where K_{min} is a minimum pixel value, P(f) is a cumulative probability distribution and is a nonnegative real scalar specifying a distribution parameter. In this case, clip limit is set to 0.02 and value in Rayleigh distribution function is set to 0.04.



AHE RESULT CLAHE RESULT

Fig. 2: Effect of CLAHE process on Adaptive histogram equalization applied image

VII. COLOUR CORRECTION

As light crosses a water body, it losses the higher wavelength colours starting with red,orange then yellow then green and so on. Therefore at the end, everything results to look blue.Color correction is the process of adjusting the image to provide good exposure to it.

VIII. RESULTS

The aim is thus achieved and the following requirements which we were aiming are fulfilled:

i)Haze of the underwater image is removed and an hazefree clear image is obtained.
ii)The defects of DCP process are overcome and a good contrast image is image is thus obtained.
iii)Hence the original image which contained haze is corrected and enhanced to get a good quality image.

The histogram of all the processes used in this methodology in sequence is shown below:

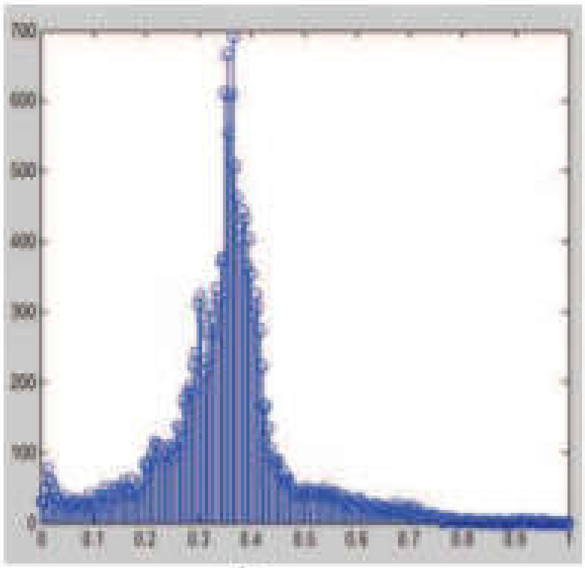


Fig.3 Histogram of original image:

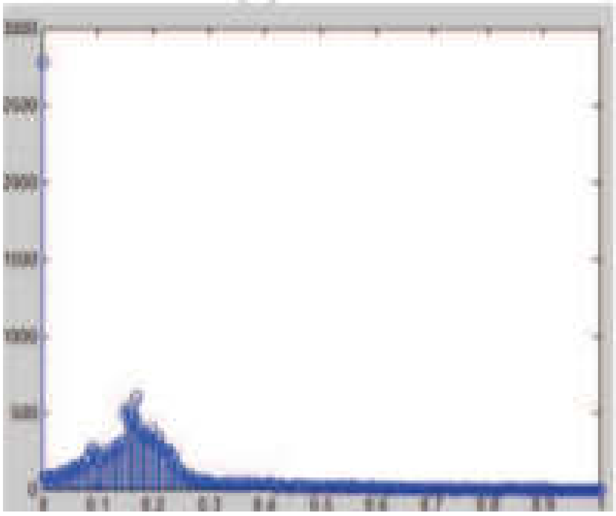


Fig.4 Histogram of dehazed image after the application of DCP:

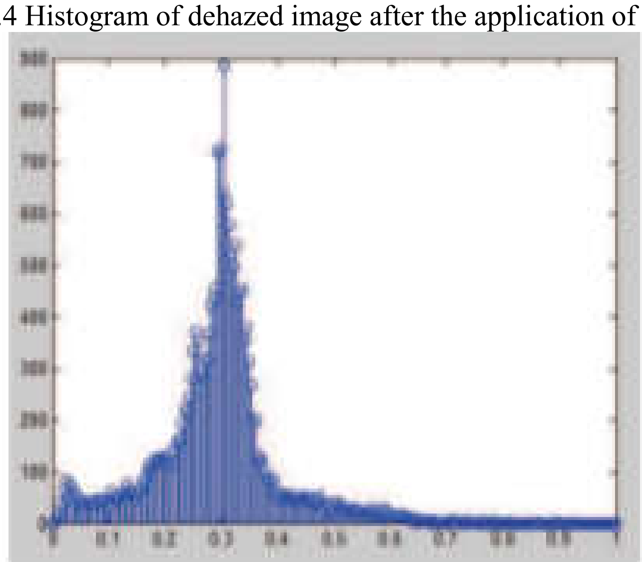


Fig.5 Histogram of enhanced image using CLAHE:

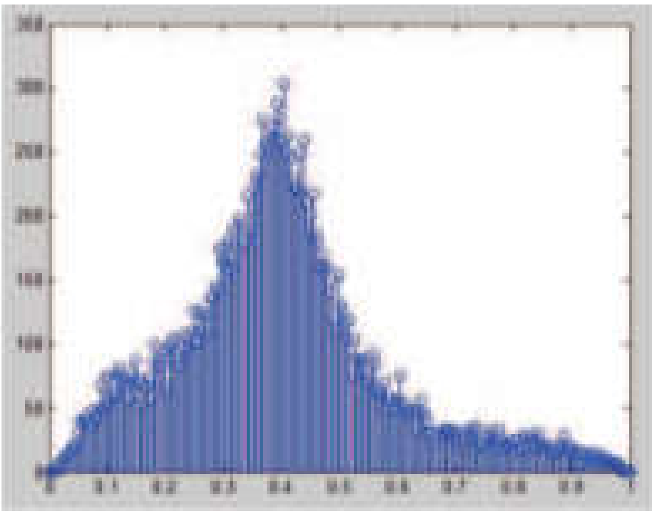


Fig.6 Histogram of the proposed methodology:

IX. CONCLUSION

In our project, we have taken an underwater hazy image. In order to dehaze the image we have used Dark Channel Prior technique but DCP decreases the contrast.Therefore, DCP is followed by a Contrast Limited Adaptive Histogram Equalization which corrects the defects of DCP, After this finally colour correction is applied and Consequently, we get the haze free underwater image.

REFERENCES

[1] T.Łuczy´nski, M. Pfingsthorn, and A. Birk, “The pinax-model for accurate and efficient refraction correction of underwater cameras in flat-pane housings,” Ocean Engineering, vol. 133, pp. 9 – 22, 2017. [Online]. Available: http://www.sciencedirect.com/science/article/pii/ S0029801817300434

[2] J. S. Jaffe, “Computer modeling and the design of optimal underwater imaging systems,” IEEE Journal of Oceanic Engineering, vol. 15, no. 2, pp. 101–111, Apr 1990.

[3] Y. Y. Schechner and N. Karpel, “Recovery of underwater visibility and structure by polarization analysis,” IEEE Journal of Oceanic Engineering, vol. 30, no. 3, pp. 570–587, July 2005.

[4] J. Y. Chiang and Y. C. Chen, “Underwater image enhancement by wavelength compensation and dehazing,” IEEE Transactions on Image Processing, vol. 21, no. 4, pp. 1756–1769, April 2012.

[5] A.Yamashita, M. Fujii, and T. Kaneko, “Color registration of underwater images for underwater sensing with consideration of light attenuation,” in Proceedings 2007 IEEE International Conference on Robotics and Automation, April 2007, pp. 4570–4575.

[6] R. Schettini and S. Corchs, “Underwater Image Processing: State of the Art of Restoration and Image Enhancement Methods,” EURASIP Journal on Advances in Signal Processing, vol. 2010, no. 1, p. 746052, 2010. [Online]. Available: http://dx.doi.org/10.1155/2010/746052

[7] C. Y. Cheng, C. C. Sung, H. H. Chang "Underwater image restoration by red-dark channel prior and point spread function deconvolution". IEEE international on Signal and image processing applications. 2017.

[8] K. J. Voss, "Simple empirical model of the oceanic point spread function".Applied optics 30(18);2647-51 ,1991.

[9] A. Levin, D. Lischinski, Y. Weiss, "A closed-form solution to Alka Tripathi, Ms Pragya Gupta, Dr. Vineet Richaria, “Haze natural image matting".IEEE transaction on pattern analysis and

ISSN: 2233-7857 IJFGCN

Removal and Color Compensation of Underwater Image And machine intelligence ,volume 30;Issue 2,2007.

[10] P. D., E. Do Nascimento, F. Moraes, S. Botelho, M. Campos, "Transmission estimation in underwater single images".IEEE international cionference on computer vision workshops,2013.

[11] S.-L. Wong, Y.-P. Yu, N. A.-J. Ho, and R. Paramesran, “Comparative analysis of underwater image enhancement methods in different color spaces,” in proc. of International Symposium on Intelligent Signal Processing and Communication Systems, pp. 034–038, 2014.

ISSN: 2233-7857 IJFGCN