

# Visibility Enhancement and Assessment of Undersea Image by ADCP Method

Jasneet Kaur Babool<sup>1</sup>, Satbir Singh<sup>2</sup>, Saurabh Mahajan<sup>3</sup>

<sup>1</sup>M.Tech Research Scholar, Dept. of ECE, GNDU, RC, Gurdaspur, Punjab, India

<sup>2</sup>Assistant Professor, Dept. of ECE, GNDU, RC, Gurdaspur, Punjab, India

<sup>3</sup>Assistant Professor, Dept. of ECE, BECT, Gurdaspur, Punjab, India

---

**Abstract:** Undersea imaging is challenging environmental conditions that complicate image matching and analysis. It is vital to improve these visibility problems since underwater imaging is widely used in scientific research. Underwater vision is plagued by pitiable visibility conditions. By investigating the diversity in light attenuation between in atmosphere and in undersea, we derive a new undersea optical technique to express the creation of an underwater image in the true physical process, and then propose an effective enhancement algorithm ADCP to improve the opinion of undersea images. A new underwater advanced dark channel is derived to estimate the scattering rate. The investigations show that our algorithm can handle underwater images, especially for deep-sea images. We presented a method that can overcome degradation effects occurring in underwater vision. The enormous improvements of scene contrast and color correction were obtained, nearly doubling the undersea visibility range. Our experimental work can be a useful tool in undersea photography, underwater research, and is particularly essential in marine biology research, where close encounters may affect water-creature activities.

objects propagates toward the camera, a portion of the light meets these floating particles. Undersea images are dominated by blue color, because of varying degrees of attenuation for different wavelengths i.e. red, green and blue. This lowers the visibility and contrast. The light attenuation in water is caused mainly by absorption and scattering. According to the selective absorption of water, visible light is absorbed at the longest wavelength first. So red light is much easier to be absorbed than shorter wavelengths such as the blue and green.

Generally, the processing of undersea images focuses exclusively on compensating either light scattering or color change distortion. Techniques targeting on removal of light scattering distortion include exploiting the polarization effects to compensate for visibility degradation [7], using image de-hazing to restore the clarity of the undersea images [8], and combining point spread functions and a modulation transfer function to reduce the blurring effect [9]. Although the aforementioned approaches can enhance scene contrast and increase visibility, distortion caused by the disparity in wavelength attenuation, i.e., color change, remains intact. On the other hand, color-change correction techniques estimate undersea environmental parameters by performing color registration.

Natural light enters from air to an undersea scene point. The light reflected propagates distance to the camera. The radiance perceived by the camera is the sum of two components: the background light formed by multi scattering and the direct transmission of reflected light [3]. Light attenuation, employing histogram equalization in both RGB and HSI color spaces to balance the luminance distributions of color, and dynamically mixing the illumination of an object in a distance-dependent way by using a controllable multicolor light source to compensate color loss [11]. Despite the improved color balance, these methods are ineffective in removing the image blurriness caused by light scattering. A systematic approach is needed to take all the factors concerning light scattering, color change, and possible presence of artificial light source into consideration.

## 1. Introduction

Recognize clear images in underwater environments are an important issue in ocean engineering. The quality of underwater images plays a pivotal role in scientific missions such as gathering of census of population, estimating geological or biological environments, examine the sea life. Taking pictures or images underwater is challenging as undersea environment produce hazy images, which are due to light that is reflected or scattered by water particles and also, color change due to varying degrees of light attenuation for different wavelengths [6]-[7]. Light scattering and color change result in contrast loss and color deviation in images obtained undersea.

Haze is also a source of floating particles such as sand, minerals, rocks, plankton and plants that exist in rivers and oceans [10]. As light reflected from

Image processing techniques enrich the quality of an image from the degraded image. Image fusion is a method of improving the quality of image from given input images [2]. The fusion-based strategy derives from two original hazy image inputs through the use of a white balance and a contrast enhancing procedure. Many development and research is being done in the field areas such as Computer Vision, Automatic object detection, Image processing, parallel and distributed processing, Robotics and remote sensing.

Many authors have presented different methods for efficient single image de-hazing with goal of improved performance. However each of these existing methods is having their limitations. In this paper, we propose a new undersea optical process to describe the formation of undersea images and present an effective undersea image enhancement and assessment method based on ADCP method.

## 2. Literature survey

Literature survey is an essential for understanding and gaining maximum information concerning the specific area of a subject. The images captured in undersea are degraded due to the presence of rocks, creatures in water and also due to camera parameters. Images of scenes captured in water have poor contrasts and colors due to non availability of proper light. This may cause difficulty in detecting the objects in the captured hazy images undersea. Due to haze there is a trouble to many computer vision applications as it diminishes the visibility of the scene. This paper presents a study about different image de-hazing methods to remove the haze from the hazy images captured in real world weather conditions to recover a fast and improved quality of haze free images. There is an improvement in terms of contrast, visible range and color fidelity. All these techniques are widely used in many applications such as outdoor Surveillance, object detection, underwater images, etc.

**Prabhakar C.J et al. (2011)** in this paper, the authors proposed an image based preprocessing technique to enhance the quality of the underwater images. These filters are applied sequentially on degraded underwater images [4]. In the proposed technique, in addition to other three filters, they employ a bilateral filter for smoothing the image. The experimentation is carried out in two stages. In the first stage, various experiments are conducted on captured images and estimated optimal parameters for bilateral filter. In the second stage, the experiments are conducted using estimated optimal parameters, optimal filter bank and optimal wavelet shrinkage function for evaluating the proposed technique. The authors evaluated the technique using quantitative based criteria such as a gradient magnitude histogram and Peak Signal to Noise Ratio

(PSNR) [4]. Further, the results are qualitatively evaluated based on edge detection results. The proposed technique includes four filters such as homomorphism filtering, wavelet de-noising, bilateral filtering and contrast equalization, which are applied sequentially [6]. The main contribution of this paper is inclusion of bilateral filter for smoothing in addition to obtainable other filtering techniques. The proposed preprocessing technique enhances the quality of the degraded underwater images which are suffered from non-uniform illumination, low contrast, noise and diminished colors.

**Yanjuan Shuai et al. (2012)** the image haze removal of dark channel prior, are prone to color distortion phenomenon for some large white bright area in the image and to rectify these problems, the author presents an image haze removal of wiener filtering based on dark channel prior. The algorithm is mainly to estimate the median function in the use of the media filtering method based on the dark channel, to make the media function more accurate and combine with the wiener filtering closer. The wiener filtering method can make image smoother using average filtering, reducing the ringing in the image and it can make a better adjustment of the image contrast after dark colors processing image without losing the details of the image edge. The algorithm used by author can recover the contrast of a large white area fog image and not only compensates for the lack of dark channel prior algorithm, but also expands the application of dark channel prior algorithm and shortens the running time of the image algorithm.

**Soo-Chang Pei et al. (2012)** Removing haze technique is an important and necessary procedure to avoid ill-condition visibility of human eyes. To improve the de-hazing quality, a new haze-removing method is proposed in this paper. Specifically, this method can be properly applied to various dense and distribution haze images without sacrificing color naturalness by using refined Dark Channel Prior (DCP) and adding post processing [20]. Compared with other existing de-hazing methods, the proposed method is superior in de-hazing quality and color naturalness.

**Er. Harpoonamdeep Kaur et al. (2014)** Haze removal techniques denotes to the approaches which are utilized for restoring the perceptibility of the digital picture utilizing some renewal strategies. The degradation may be a result of diverse explanations like relative object-camera motion, misrepresentation of camera miss-focus, twisting due to Polaroid miss-center, relative climatic turbulence and others [13]. This paper has focused on diverse haze clearing strategies. Haze removal has found to be a serious assignment in light of the way that the mist depends on the unidentified scene depth data. The specialists has overlooked the methods to decrease the noise issue which is displayed in the yield pictures of the

current haze evacuation algorithm furthermore, no work has focused on the coordinated effort of the Dark channel prior and the CLAHE [18]. The blueprint and use of the proposed algorithm has been done in MATLAB using image processing toolbox to enhance the results further.

**Dilraj Kaur, et al. (2015)** Visibility restoration refers to various ways that aim to reduce and remove the degradation that have occurred while the digital image has been obtained. The degradation may be due to various factors like relative object-camera motion, blur due to camera mis-focus, relative atmospheric turbulence and others. Underwater image enhancement based algorithms become more useful for many vision applications. The existing methods have neglected the use of ant colony optimization to reduce the noise and uneven illuminate problem. This paper is to evaluate the performance of Ant colony optimization over the available MIX-CLAHE technique and offered a new technique ACO based MIX-CLAHE [17]-[18]. The experimental results implemented in MATLAB indicates that proposed technique offers better results as compare to available methods.

**Ruchika Sharma et al. (2015)** is paper presents a review on the different haze removal techniques. Haze brings trouble to many computer vision/graphics applications as it diminishes the visibility of the scene [14]. Haze is formed due to the two fundamental phenomena that are attenuation and the air light. Attenuation reduces the contrast and air light increases the whiteness in the scene. Haze removal techniques recover the color and contrast of the scene. This paper is to explore the various methods for efficiently removing the haze from digital images. The problem of uneven and over illumination is also an issue for de-hazing methods. New algorithm will integrate the dark channel prior, CLAHE and bilateral filter to improve the results further.

**Magniya Davis. et al. (2016)** in his paper "A Survey on Enhanced Vision of Hazy Images" refers to different methods that have occurred while the digital image was being obtained. The degradation may be due to various factors like relative object-camera motion, blur due to camera mis-focus, relative atmospheric turbulence and others. In this paper they will be discussing about the degradations due to bad weather such as fog, haze, rain and snow in an image [19]. The image quality of outdoor screen in the fog and haze weather condition is usually degraded by the scattering of a light before reaching the camera due to these large quantities of suspended particles in the atmosphere. By the usage of effective haze removal of image the stability and robustness of the visual system can improve.

### 3. Different Methods

#### a. Contrast limited adaptive histogram equalization (CLAHE)

Contrast limited adaptive histogram equalization short form is CLAHE. This method does not need any predicted weather information for the processing of hazed image [17]. Firstly, the image captured by the camera in undersea condition is converted from RGB (red, green and blue) colour space is converted to HSI (hue, saturation and intensity) color space. The images are converted because the human sense colour similarly as HSI represent colour. Secondly intensity component is processed by CLAHE without effecting hue and saturation [18]. This method use histogram equalization to a contextual region. The original histogram is clipped and the clipped pixels are redistributed to each gray-level. In this each pixel intensity is shortened to maxima of user selectable. Finally, the image processed in HSI colour space is converted back to RGB colour space.

#### b. Advanced Dark Channel Prior (ADCP)

Dark channel prior is used for the estimation of atmospheric light in the de haze image to get the more proper result [10]. Advanced Dark-channel prior, an existing scene depth derivation method, is used first to estimate the distances of the scene objects to the camera. The low intensities in the dark channel are mainly due to three factors:

- i. Shadows of objects or substance under water, e.g., the gloom of living thing, plankton, plants, or rocks in seabed images.
- ii. Colorful matter or surfaces, e.g. water plants, red or pale brown sands, and colorful rocks/minerals, deficient in certain color channels.
- iii. Dark stuff or items, e.g. dark creatures, big and small stones.

As the outdoor and undersea images are usually full of shadows and colors etc., the dark channels of these images will be really dark. Due to haze (air light), a haze image is brighter than its image without haze. So that dark channel of haze image will have higher intensity in region with higher haze. So, visually the intensity of dark channel is a rough approximation of the thickness of haze. In Advanced dark channel prior we use pre and post processing steps for getting better results [8]-[9]. In post processing steps soft matting or bilateral filtering is used. Let  $J(x)$  is input image,  $I(x)$  an undersea image, and  $t(x)$  is the transmission of the medium. The attenuation of image due to undersea can be expressed as:

$$I_{att}(x) = J(x)t(x) \quad (1)$$

The effect of haze is air light effect and can be expressed as:

$$I_{airlight}(x) = A(1 - t(x)) \quad (2)$$

Dark channel for an arbitrary image J, expressed as J dark is defined as:

$$J^{dark}(x) = \min_{y \in \Omega(x)} (J^c(y)) \quad (3)$$

In this  $J^c$  is the colors image comprising of RGB components,  $\Omega(x)$  represents a local patch which has its origin at x. The low intensity of dark channels is attributed mainly due to shadows in images, saturated color objects and dark objects in images.

After dark channel prior, we need to estimate transmission  $t(x)$  for proceeding further with the solution. Another assumption needed is that let Atmospheric light A is also known. We normalize (4) by dividing both sides by A:

$$\frac{I^c}{A}(x) = t(x) \frac{J^c}{A}(x) + 1 - t(x) \quad (4)$$

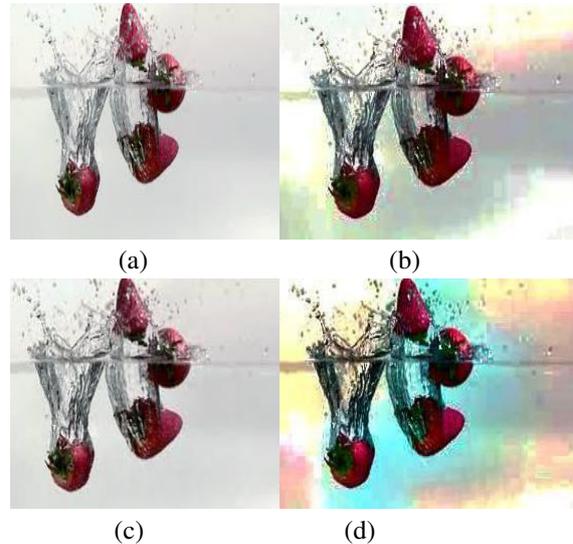
#### 4. Results and Discussions

The algorithm is applied using various performance indices Mean squared error (MSE), peak signal to noise ratio (PSNR), Geometric Accuracy (GA), Standard Deviation (SD) and Contrast Gain (CG). In order to implement the algorithm, design and implementation has been done in MATLAB R2010a version using image processing toolbox. The developed approach is compared against a well-known image de-hazing technique. We are comparing proposed approach using some performance metrics. Result shows that our approach gives better results than the existing technique. As mean square error needs to be reduced therefore the algorithm is showing the better results than the available methods as mean square error is less in every case. The mean square error is reduced in each case. The method is tested on the number of images and in each case shows the better results than the existing method. For example in given table it is clearly shown that the (a),(b),(c),(d) images have very much less MSE values so ADCP method work efficiently.

The underwater input image is represented by image (a) in all cases; (b) is the CLAHE output in all cases; (c) is the Haocheng Wen *et al.* and (d) is the output by ADCP algorithm.

The 1<sup>st</sup> input image (a) is evaluated by the proposed ADCP algorithm and with other existing methods. (Like CLAHE and Haocheng Wen *et al.*). The results shows that the strawberries are producing effect in water due to their natural color for ADCP method

determined this as comparative to other existing methods.



**Figure 4.1: 1<sup>st</sup>:** (a) Strawberry input image (b) CLAHE Result (c) Haocheng Wen *et al.* Result (d) The ADCP Result

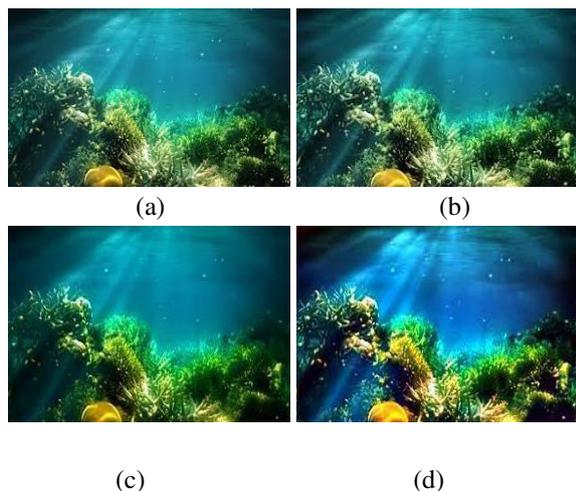
In ADCP output image the Strawberries in water are clearly visible and the brightness of image also retained. The comparison table of diverse parameters using different methods is given below.

**Table 4.1:** Comparison of parameters for 1<sup>st</sup> image using different methods

Parameters	MSE	PSNR	GA	S D	CG
<b>Method</b>					
<b>ADCP</b>	210	17.2176	97.7202	0.0067	16.4895
<b>Haocheng Wen et al</b>	356	15.6730	93.9121	0.0073	13.7167
<b>CLAHE</b>	2375	11.8490	85.3870	0.0088	6.1207

Table 4:1 shows that proposed ADCP method gives better result as compare to the other methods for every parameter. So, it could be concluded from the result of image (d) in figure 4.1 that ADCP method is more effective as compare to other existing methods for same input image (a).

The 2<sup>nd</sup> input image (a) is evaluated by the proposed ADCP algorithm and with other existing methods. The result of input image shows that the grass in water produces natural color for ADCP method as comparative to other existing method.



**Figure 4.2:** 2<sup>nd</sup>: (a) Grass input image (b) CLAHE Result (c) Haocheng Wen *et al.* Result (d) The ADCP Result

In ADCP output image result the grass in water is clearly visible in original color. The comparison table of parameter using different methods is given below.

Parameters	MS	PSNR	GA	S D	CG
Method	E				
ADCP	88	20.5494	88.0582	0.0084	8.8504
Haocheng Wen <i>et al.</i>	435	15.1571	83.7588	0.0093	4.4431
CLAHE	355	15.6830	84.3854	0.0093	5.1871

**Table 4.2:** Comparison of parameters for 2<sup>nd</sup> image using different methods

Table 4.2: shows that proposed ADCP method gives better result as compare to the other methods for every parameter. So, it could be concluded from the result of images (d) in figure 4.2 that ADCP method is more effective as compare to other existing methods for same input image (i.e. 2<sup>nd</sup> Image).

The 3<sup>rd</sup> input image is evaluated by the ADCP proposed algorithm and other existing methods. The results of input image shows that the undersea Resort is having chairs, tables and table lamp produces usual color for ADCP method as comparative to other existing methods.



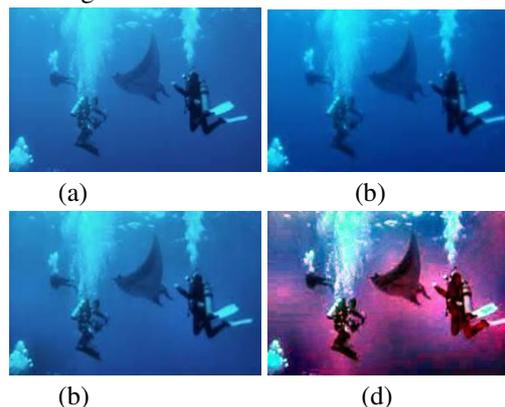
**Figure 4.3:** 3<sup>rd</sup> (a) Resort (b) CLAHE Result (c) Haocheng Wen *et al.* Result (d) The ADCP Result

In ADCP output image result the undersea resort in water is more effectively and clearly visible. The brightness of image is showing usual color of chairs, tables and table lamp of resort. The comparison table of parameter using different methods is given below.

**Table 4.3:** Comparison of parameters for 3<sup>rd</sup> image using different methods

Parameters	MS	PSNR	GA	S D	CG
Method	E				
ADCP	93	20.2838	87.4624	0.0087	8.4413
Haocheng Wen <i>et al.</i>	33	26.1948	99.3605	0.0092	18.8086
CLAHE	375	15.5385	84.8137	0.0096	5.6614

The 4<sup>th</sup> input image is evaluated by the proposed ADCP algorithm and other existing methods. The results of input image are showing that the divers and water is effected by the torch light that the divers are having with them, so the torch effect is also consider in our ADCP method as comparative to other existing methods.



**Figure 4.4:** 4<sup>th</sup> (a) Divers Undersea (b) CLAHE Result (c) Haocheng Wen *et al.* Result (d) The ADCP Result

In ADCP output image result the undersea divers in water is more effectively and clearly visible and the brightness of image also retained. The comparison table of parameter using different methods is given below.

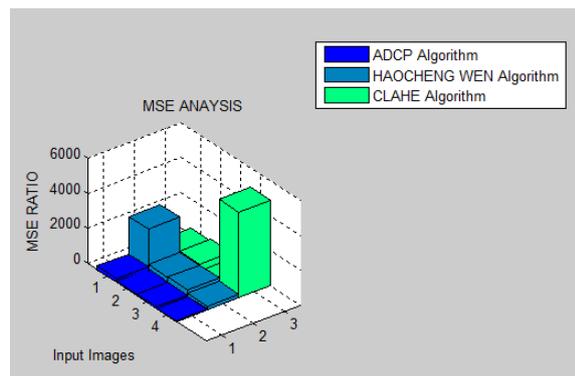
Table 4.4: shows that proposed ADCP method gives better result as compare to the other methods for

every parameter. So, it could be concluded from the result of image (d) in figure 4.4 by advanced dark channel prior (ADCP) method is more effective as compare to other existing method for same image (i.e. 4<sup>th</sup> Image).

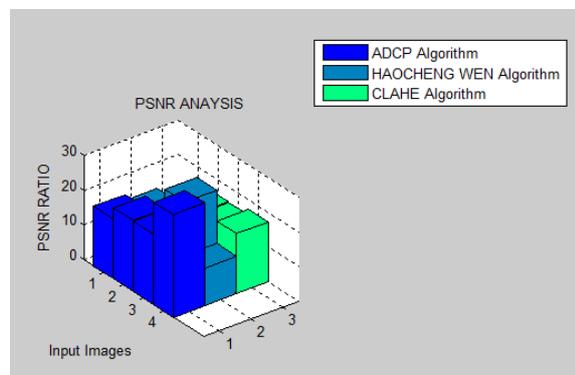
**Table 4.4:** Comparison of parameters for 4<sup>th</sup> image using different methods

Parameters	MS E	PSNR	GA	S D	CG
ADCP	22	29.5563	105.5459	0.0082	23.9564
Haocheng Wen <i>et al.</i>	486	10.8431	80.8971	0.0098	1.1056
CLAHE	205	17.2879	84.0274	0.0091	4.6866

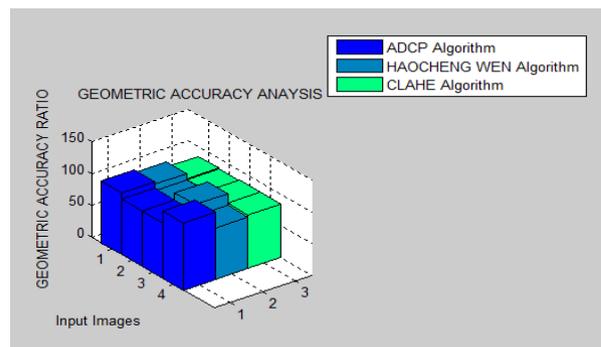
The results are compared using various parameters mean square error (MSE), peak signal to noise ratio (PSNR), standard deviation (SD), geometric accuracy (GA) and contrast gain (CG) to know improvement done by the ADCP algorithm for all the four input images with CLAHE and Haocheng wen *et al.*



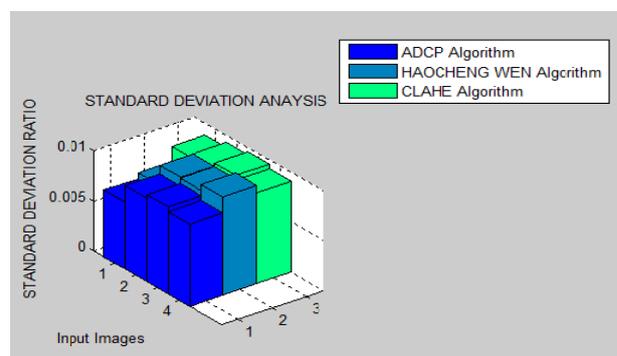
**Figure 4.5:** MSE comparison of images for ADCP, CLAHE and Haocheng wen *et al.* methods



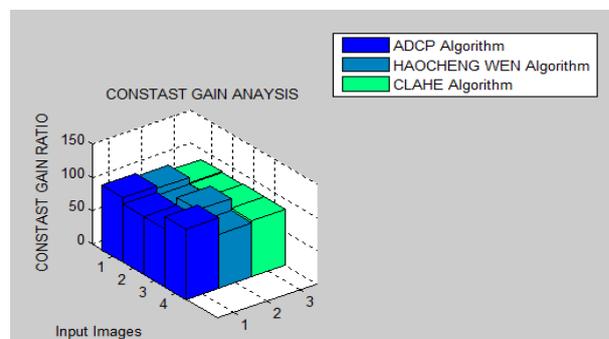
**Figure 4.6:** PSNR comparison of images for ADCP, CLAHE and Haocheng wen *et al.* methods



**Fig 4.7 (a):** GEOMETRIC ACCURACY comparison of images for ADCP, CLAHE and Haocheng wen *et al.* methods



**Figure 4.8:** STANDARD DEVIATION comparison of images for ADCP, CLAHE and Haocheng wen *et al.* methods



**Figure 4.9:** CONSTAST GAIN comparison of images for ADCP, CLAHE and Haocheng wen *et al.* methods

## 5. CONCLUSION

In this paper we report a comprehensive research performed over undersea advanced dark channel prior (ADCP) calculations and regarding their execution. Light underwater or within an ocean is different phenomena than light on earth surface. This is the case of refraction rather than reflection due to two different medium (i.e., one is air & other is water). Undersea is a world that's visibly completely different from our acquainted terrestrial world, and one that marine animals, plants, and microbes area unit tailored to in extraordinary ways that. This

research paper presents the performance evaluation of advanced dark channel prior (ADCP) and its comparison with Haocheng Wen *et al.* and CLAHE. The paper illustrates effectiveness and the power of undersea advanced dark channel prior way of de-hazing cantered on a single degraded image that is changed.

## 6. REFERENCES

- [1] Y. Y. Schechner and N. Karpel, "Recovery of underwater visibility and structure by polarization analysis", *IEEE J. Ocean. Eng.*, vol. 30, no. 3, pp. 570–587, Jul. 2005.
- [2] K. Iqbal, R. Abdul Salam, A. Osman, and A. Zawawi Talib, "Underwater image enhancement using an integrated color model," *Int. J. Computer. Sci.*, vol. 34, no. 2, pp. 2–12, 2007.
- [3] Wang, Yan, and Bo Wu, "Improved single image dehazing using dark channel prior", International Conference on Intelligent Computing and Intelligent Systems (ICIS), Vol. 2 IEEE, 2010.
- [4] Prabhakar C.J, Praveen Kumar P.U., "An Image Based Technique For Enhancement Of Underwater Images," International Journal of Machine Intelligence ISSN: 0975–2927 & E-ISSN: 0975–9166, Volume 3, Issue 4, 2011, pp-217-224.
- [5] H. Yang, P. Chen, C. Huang, Y. Zhuang and Y. Shiau, "Low complexity underwater image enhancement based on dark channel prior," *IBICA*, pp. 17-20, 2011. 756
- [6] He, Kaiming, Jian Sun, and Xiaoou Tang, "Single image Mist removal using dark channel prior", *Pattern Analysis and Machine Intelligence*, *IEEE Transactions on* 33.12, pp. 2341- 235, (2011).
- [7] Shuai, et al, "Image Mist removal of wiener filtering based on dark channel prior", *Computational Intelligence and Security (CIS)*, 2012 Eighth International Conference on, IEEE, 2012.
- [8] Xu, Haoran, et al. "Fast image dehazing using improved dark channel prior", International Conference on Information Science and Technology (ICIST), IEEE, 2012.
- [9] Wang, Jin-Bao, Ning He, Lu-Lu Zhang, and Ke Lu "Single image de-hazing with a physical model and dark channel prior", *Neurocomputing* 149, pp. 718-728, 2015.
- [10] Long Jiso, Zhenwei Shi And Wei Tang "Fast Haze Removal For A Single Remote Sensing Image Using Dark Channel Prior" , "IEEE International Conference On Computer Vision In Remote Sensing" (CVRS), Pp.132-135, 2012
- [11] Kil, Tae Ho, Sang Hwa Lee, and Nam Ik Cho. "A dehazing algorithm using dark channel prior and contrast enhancement.", *Acoustics, Speech and Signal Processing (ICASSP)*, 2013 IEEE International Conference on. IEEE, 2013.
- [12] Huang, Darong, Zhou Fang, Ling Zhao, and Xiaoyan Chu, "An improved image clearness algorithm based on dark channel prior", In *Control Conference (CCC)*, 33rd Chinese, pp. 7350-7355, IEEE, 2014.
- [13] Er. Harpoonamdeep Kaur , Dr. Rajiv Mahajan "Modified haze removal using dark channel prior, gabor filter & clahe on remote sensing images," International Journal of Computer Engineering and Applications, Volume VII, Issue III, September 14.
- [14] Ruchika Sharma, Dr. Vinay Chopra, "A Review on Different Image de-hazing Methods," International Journal of Computer Engineering and Applications, Volume VI, Issue III, June 14 ISSN 2321-3469
- [15] Pranjal Garg, Shailender Gupta, Bharat Bhushan and Prem Chand Vashist, "A Hybrid Defogging Technique Based On Anisotropic Diffusion And IDCP Using Guided Filter", *International Journal of Signal Processing, Image Processing and Pattern Recognition* Vol.8, No.7 (2015).
- [16] Paramjeet Kaur, Nishi, "Single Image Dehazing Using Adaptive Restoration Factor in Dark Channel Prior", *International Journal of Software Engineering and Its Applications*, Vol-9(8), pp. 149-158, 2015.
- [17] Dilraj Kaur, Pooja, "Ant Colony Optimization Based Mixed CLAHE For underwater Haze Removal", *International Conference of Technology, Management and Social Sciences* 2015.
- [18] Dilraj Kaur, Pooja, Varsha Sahni, "Improving Mix-CLAHE with ACO for Clearer Oceanic Images", *International Journal of Advanced Engineering, Management and Science (IJAEMS)* Vol-2, Issue-6, June-2016. ISSN: 2454-1311.
- [19] Magniya Davis, Bineeth Kuriakose, Vince Paul, "A Survey on Enhanced Vision of Hazy Images", *IJCSET*([www.ijcset.net](http://www.ijcset.net)) | January 2016 | Vol 6, Issue 1, 53-56.
- [20] Soo-Chang Pei, Tzu-Yen Lee "Effective Image Haze Removal Using Dark Channel Prior and Post-processing" *IEEE* 978-1-4573-0219-7/12/©2015.