



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 5, May 2022

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

[ijirset@gmail.com](mailto:ijirset@gmail.com)

[www.ijirset.com](http://www.ijirset.com)



# Undersea Image Noise Removal and Improvement using CLAHE Method by Improving SNR and Image Enhancement Technique

Ausaf Ali Khan<sup>1</sup>, Sudheer Verma<sup>2</sup>

Assistant Professor Department of Electronics and Communication Engineering, TIEIT, Bhopal, M.P, India<sup>1</sup>

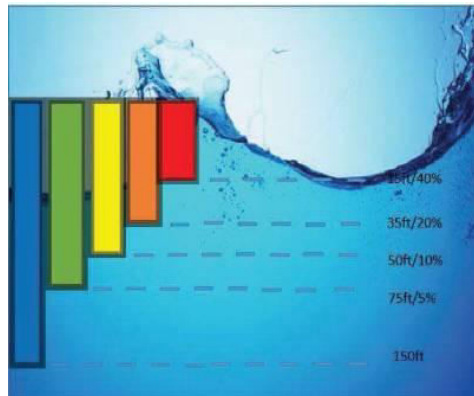
Assistant Professor, Department of Electronics and Communication Engineering, IES University, Bhopal, M.P, India<sup>2</sup>

**ABSTRACT:** The population across the world is increasing on a daily basis. With that also comes the increase in the demand of the resources. Over the years the seas and oceans have been viewed and proved a vital source for our sustenance. From food to transport, from energy to defense operations seas have been providing us with a perfect platform for increasing our quality of life. The full potential of this platform has still not been fully explored. Further we also need to make sure that the already existing methods are done at maximum efficiency and with extreme precaution. This calls for a complete monitoring of the underwater scenery before during and after the large scale usage of such a platform. One of the main challenges during monitoring is posed by light and scattering of light as it travels from air to water which presents us with a bluish background while studying the scenery. Added to this there is a hazy appearance in the visuals and calls for Image Enhancement techniques. In this paper, we use a method called Dark Channel Prior to remove the haze and noise caused by the bluish environment. But, this method has a tendency to darken the image. So we further use Contrast limited adaptive histogram equalization (CLAHE) on the RGB image to improve the contrast and intensity of the image. Finally, a colour correlation technique is carried out for obtaining visually pleasing results. The experimental results provide us a favorable outcome, both subjectively and objectively, and this has helped to be even more effective in monitoring the underwater scenario.

**KEYWORDS** - Haze removal, Dark channel prior, CLAHE, RGB, Image Enhancement

## I. INTRODUCTION

The resources which the seas and oceans contain are enormous. While making use of these resources we must also ensure that there is no damage done to the ecosystem. Various food chains and at various levels of the Food web should not suffer as a result. In order to maintain a balance between the usage of underwater resources and the ecosystem continuous surveillance of the underwater scenario is being done. Here the underwater imaging finds a large scale application. But a problem with underwater images is loss of colour and contrast and a presence of a bluish and a hazy background. The white light from the sun as it travels from air to water (rarer to denser medium) suffers from refraction (The process of bending of light as it travels from medium to another) and absorption. Considering the sun as a white light source and water as prism, it is split into its constituent seven colours (Violet, Indigo, Blue, Green, Yellow, Orange and Red in increasing order of wavelength). All these colours are absorbed by the water. Refraction and absorption by water are responsible for changes in colour and bluish tone in the image [1]. Every colour absorbs at a different rate because every colour has a different wave length and energy level. The factor of depth also plays a part here. As we go deeper and deeper under the seas the colours with larger wavelengths are absorbed more. Colours like red, orange and yellow are absorbed more than blue and green causing a bluish tone to the image. Fig.1 shows an illustration about the absorption by light with depth. Besides common images, underwater images suffer from poor visibility because of the attenuation of the propagated light. The haphazard attenuation of the light underwater causes a foggy and misty appearance of the distant object in the image and the scene is characterized by poor contrast. To improve the quality of such images and scenes, image enhancement needs to be done.



**Fig. 1. Absorption of light by water**

Image enhancement is a technique used to enhance the optical quality of images to ensure better visual quality or better extraction of information from the image. Ancuti et.al. [2] suggests a method to enhance underwater videos and images using fusion principles. Fattal [3] presents a new method to estimate the optical transmission in hazy scenes. Based on this estimation, the scattered light is eliminated to increase scene visibility and recover haze-free scene contrasts.

Hitam et.al. [4] presents a new method called mixture contrast limited adaptive histogram equalization (Mix-CLAHE) colour models where the method is operated on both RGB and HSV colour models. But, the problem with this algorithm is that it over amplifies the objects and noise in the final image. Image dehazing is a process to remove haze or fog effects from the poor quality images. It is an image enhancement technique which is usually used to remove haze. He et.al.[5] propose a simple but effective image dehazing algorithm; Dark Channel Prior(DCP) to remove haze from a single input image. But, the defect in the Dark channel prior is that tends to darken the image and reduces contrast.

In this paper, we propose a new algorithm combining DCP and CLAHE and further a colour correlation technique to produce a more visually pleasing image. We started with DCP to remove the haze in the image, but in doing so we found the image darkened and contrast reduced. Hence we applied CLAHE to enhance contrast and further applied a colour correlation algorithm to obtain a better result.

This paper is divided into eight sections with section I being the Introduction. In section II, we take a look at the existing methods, Section III deals with the gaps in the literature and existing methods. Section IV focuses on the detailed view of CLAHE and DCP, Section V deals with Proposed Algorithm, Section VI involves Simulation and Analysis while section VII is for performance evaluation. Finally in Section VIII, we give the conclusion for this paper

## II. EXISTING IMAGE ENHANCEMENT METHODS

Before going into our proposed algorithm we first look into the already existing algorithms. This section tends to give a brief outlook on the existing methods.

### A. Homomorphic Filtering

This method is used to fix the non-uniform lighting in an image which needs its contrast to be reinforced. It is a frequency filtering technique

$$F(x,y)=I(x,y)*r(x,y) \quad (1)$$

Where  $F(x,y)$  is the function of the image detected,  $I(x,y)$  is the Illumination function and  $r(x,y)$  is the reflectance [6]. Here the image is Fourier Transformed, Multiplied with a filter function and then transformed back into the spatial domain. By multiplying these components filter can reduce non- uniform illumination. It is one of the most used methods as it addresses the non-uniform illumination and sharpens the image.



### B. Anisotropic Filtering

In this method the image components are disentangled to enhance image division. It is used to decrease compositions and diminishes the objects by erasing little edges enhanced by homomorphic filtering. This method also deals with low contrast and non-uniform illumination problem in images [7].

### Wavelet Denoising

This method is used to reduce high frequency noise in images. A wavelet transform is computed from the original image. Noise level at each wavelet is estimated separately and a threshold is defined for zeroing wavelet co-efficient. Other wavelet co-efficient are shunted and an inverse wavelet transform is performed. In Addition to the Fourier transform which tells about the frequency Components (Sines and Cosines) and their amplitudes, the wavelets also tell us where they exist in the time axis. This gives us a better PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error) results compared to Homomorphic and Anisotropic Filtering [6].

### D. Red Channel Method

Colours associated with Short wavelengths which were lost due to absorption are recovered leading to a recovery of lost contrast [7]. It can be considered as a variant to the Dark Channel Prior Method. A Pixel that lies at a maximum depth with respect to the camera is first chosen. It is assumed that degradation of the image depends upon location of pixel. Transmission map of the scene is estimated and then colour correlation is done for visually pleasing results.

### E. Histogram Equalization

It is a method used for modifying the image intensities and image contrast using the histogram of the image. When the obtained image of the underwater scenery has both the background and the frontal areas as both bright or both dark, this method is used to enhance the image. The key in this method is mapping the gray levels with the probability distribution of the available gray levels. One disadvantage in this method can be over amplification of the background noise and decrease in the useful signal.

## III. GAPS IN LITERATURE & EXISTING METHODS

There are many image enhancement algorithms in use right now and many more advanced which are yet to be explored. All the methods have both positive and a negatives to them which makes us look for new solutions. Here in this section we take a look at the differences between the already existing methods and how the proposed algorithm can be looked at as a solution. Given below are some of the gaps that were found after literature review:

- The existing methods have neglected issues relating to noise present in the underwater images .
- The problem of the uneven illumination in underwater conditions is not considered by the most of the researchers.
- Not much effort has been focused on the integrated approach like combining two existing techniques to produce a result better than individual ones.

Therefore, we have proposed a method combining DCP and CLAHE techniques, providing an integrated approach to underwater image processing.

## IV. THEORETICAL REVIEW OF DCP AND CLAHE

In this section we look into the DCP and CLAHE algorithms. First the image is subjected to a haze removal algorithm which is the DCP and is further is enhanced by the CLAHE technique.

**A. Haze removal using Dark Channel Prior (DCP)** This is used to obtain a natural Haze free image and is generally used in the process of Image Enhancement. The haphazard attenuation of light by water particles as we go deeper and deeper into the sea causes a foggy and misty appearance to the image of the scenery.

A hazy image can be characterized by using a function  $S(x)$  which is given by

$$S(x) = Z(x)t(x) + A(1-t(x)) \quad (2)$$

Where  $S(x)$  is the haze containing image,  $Z(x)$  is the haze free image,  $t(x)$  is the transmission map and  $A$  is the global atmospheric light. The transmission map is equal to  $e^{-\beta d}$ , where  $d$  is the scene depth and  $\beta$  is the scattering coefficient. For haze free images scattering coefficient has a value of zero. This results in  $t(x)$  to be equal to 1. This results in the term  $A(1-t(x))$  to zero. Hence the Haze containing image will directly be the Haze free image i.e., Haze for Haze free images is zero. This is the ideal case as in clear sky conditions where the scattering is considered as



zero. But in real scattering is not zero, but still we get haze free images in air because the scattering is negligible in spite of air being a fluid like water. The scattering underwater cannot be treated as a negligible quantity owing to non-uniform attenuation and refractive index of water.

The main aim of DCP is to find the haze free image  $Z(x)$  from the haze containing image  $S(x)$ . There are 4 steps in the dehazing process which include (i) estimation of atmospheric light, (ii) Transmission Map Estimation, (iii) Transmission Map Refinement, (iv) image reconstruction.

He[5] proposes that most of the local regions in the background of the image often have some pixels which have a very low intensity in one of the three channels of the (RGB). It can be denoted as  $(x)$  and it is considered as the dark channel at  $x$ .  $(x)$  can be denoted as

$$Z^{\text{dark}}(x) = \min_{c \in \{R, G, B\}} \{ \min_{y \in \Omega(x)} Z^c(y) \} \quad (3)$$

$$c \in \{R, G, B\} \quad y \in \Omega(x)$$

where  $Z^c$  is one of the channels in  $Z$  and  $\Omega(x)$  is a

square region with center  $x$ . If the square region does not belong to any local regions, then tends to zero. Hence, it is called dark channel.

$S(x)$  is an image whose intensity mixed with atmospheric light. So it is usually brighter than  $Z(x)$ . So the dark channel of  $S(x)$  is brighter than the dark channel of  $Z(x)$ . This fact serves as a useful result in the estimation of  $Z(x)$ . Substituting (3) in (2) we get

$$\min_{c \in \{R, G, B\}} \{ \min_{y \in \Omega(x)} S^c(y) \} = \min_{c \in \{R, G, B\}} \{ \min_{y \in \Omega(x)} Z^c(y) \} t(x) + A^c (1-t(x)) \quad (4)$$

$$c \in \{R, G, B\} \quad y \in \Omega(x) \quad c \in \{R, G, B\} \quad y \in \Omega(x)$$

From this expression we follow the four steps of estimation in DCP. For computing the value of  $A$ , the highest 0.1% of brightest pixels in the dark channel is selected and the colour with the highest intensity value among the selected pixels is selected as the value of  $A$ . Now dividing both LHS and RHS of (4) by  $A^c$ , we get

$$\min_{c \in \{R, G, B\}} \{ \min_{y \in \Omega(x)} S^c(y)/A^c \} = \min_{c \in \{R, G, B\}} \{ \min_{y \in \Omega(x)} Z^c(y)/A^c \} t(x) + (1-t(x)) \quad (5)$$

(5)

Now for Dark channel Prior the Dark Channel for the image without Haze tends to zero[8]. i.e.,

$$\min_{c \in \{R, G, B\}} \{ \min_{y \in \Omega(x)} Z^c(y)/A^c \} = 0 \quad (6)$$

$$c \in \{R, G, B\} \quad y \in \Omega(x)$$

Combining equation (5) and (6) we get,

$$t(x) = 1 - \min_{c \in \{R, G, B\}} \{ \min_{y \in \Omega(x)} S^c(y)/A^c \} \quad (7)$$

$$c \in \{R, G, B\} \quad y \in \Omega(x)$$

He[5] introduces a factor  $w$  to keep a small amount of haze in the image to perceive the depth of the object.

Hence  $t(x)$  can be computed as

$$t(x) = 1 - w \min_{c \in \{R, G, B\}} \{ \min_{y \in \Omega(x)} S^c(y)/A^c \} \quad (8)$$

$$c \in \{R, G, B\} \quad y \in \Omega(x)$$

This is the second step in dehazing using DCP. The next step is refining the transmission map  $t(x)$ . Usually a Soft mapping is done to refine the transmission map. Finally the last step is the reconstruction of the haze free image.

$$Z(x) = [S(x) - A / \max(t(x), t_0)] + A \quad (9)$$

Where  $t_0$  is the threshold value applied to avoid low value of denominator

#### Defects in Dark Channel Prior:

There are major defects in DCP. The first one is with respect to the background. In any image there is a main object and the background. After DCP, where there is a removal of haze, there is very low contrast with the background and sometimes this may also darken the local regions of the image. This is because background may also be mixed with the haze. The term  $Z(x)t(x)$  is called direct attenuation and has a non-linearity with the intensity of the image.



After DCP is performed the resultant image has a lower contrast than  $Z(x)$ . The term  $[1-t(x)]$  represents the thickness of the haze present in the image. For different values of  $A$  under the same attenuation and same thickness of haze also results in an image which is lower in contrast of the Haze free image  $Z(x)$ . These are overcome by performing the CLAHE algorithm.

#### Contrast Limited Adaptive Histogram Equalization (CLAHE):

This method is used to enhance the contrast of images. This is a derivation of the Adaptive histogram equalization (AHE). Here the contrast of the image is kept constant and histogram equalization is done. The image is divided into tiles. Tiles are small regions in the image which are divided in accordance to a particular grid to exploit local spatial coherence. The contrast of each tile is enhanced. This is where the difference between AHE and CLAHE must be noted. In AHE, the different regions are joined together once they are enhanced in contrast without removing the induced boundaries of the tiles which adds to the noise in the background whereas in CLAHE the induced boundaries are removed by interpolation. This is where we limit the contrast and prevent the addition of noise to image especially in homogeneous areas of the image.

The main procedural steps to be noted in this process are (i) Colour Channel Decomposition of the image, (ii) Converting the RGB model into HSV (Hue, saturation, Value) model, (iii) Subjecting the image to CLAHE, (iv) Converting the HSV channel image back to RGB channel, (v) Again subjecting back to the colour channel composition.

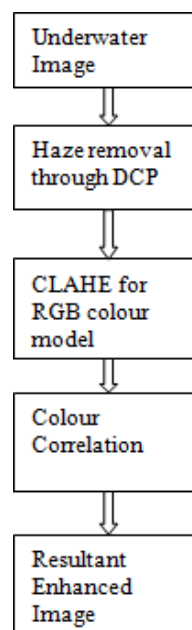
This method can be used to enhance low contrast images. The amplification is limited by clipping of the histogram at a user specified value called clip limit. The clip limit determines the amount of noise to be removed and the level of contrast of the resultant image.

### V. PROPOSED ALGORITHM

In this Section we take a look at the proposed algorithm in order to obtain a more enhanced, more haze free and a visually pleasing image of the underwater scenery.

The process flow is mentioned below for better understanding of working of the method.

The first step as we all know is the obtaining of the Underwater Image. We will find that most images suffer a hazy effect which is based on light conditions and depth of the scenery. So to remove the haze we subject the image to haze removing algorithm called DCP. But, on removal we found that the contrast of the image is reduced and the image is darkened.





In order to overcome the disadvantage of DCP, we subject the image further to CLAHE to enhance the contrast of the image where the image is divided into tiles and contrast is improved for each tile and tiles rejoined by the process of interpolation.

After enhancing the contrast of the image, we further subject the image to colour correlation technique in order to get a more visually pleasing and refined image [9]. The reason for doing this is mainly to get a better image of the object and better refinement of the image.

In Color Correlation technique we compute the Mean Square error(MSE) and mean value in each of the RGB channels of the image say  $Z$ .

We compute the maximum and minimum value in each Channel as Follows

$$Z^c(\max) = Z^c(\text{mean}) + Z^c\mu(\text{var}) \quad (10)$$

$$Z^c(\min) = Z^c(\text{mean}) - Z^c\mu(\text{var}) \quad (11)$$

Where  $C\epsilon(R, G, B)$ ;  $Z^c(\text{mean})$  is the mean value and  $Z^c(\text{var})$  is the mean square error;  $\mu$  is the parameter to control the image dynamic.

The colour Corrected image can be computed as follows

$$Z(\text{cr}) = [Z^c - Z^c(\min) / Z^c(\max) - Z^c(\min)] \times 255 \quad (12)$$

Where  $Z(\text{cr})$  is the colour corrected image which is more refined, a better visually pleasing image, a haze free image and an image with image with better contrast.

## VI. SIMULATION AND ANALYSIS

Simulations for the proposed algorithm is done with the help of MATLAB Image Processing toolbox. In order to make it more visually engaging, we have designed a Graphical User Interface(GUI). This GUI, shown below, helps us to see the image enhancement after each step in the algorithm.

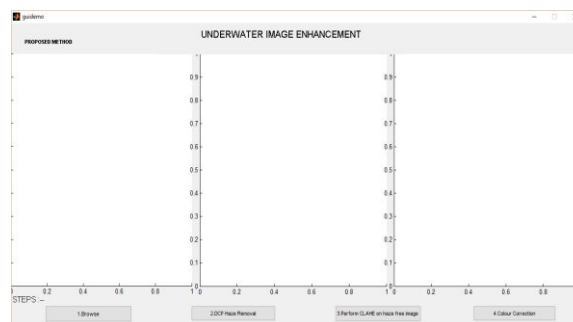


Fig.2. GUI for proposed method

An underwater input image is browsed to the first plot using a push button designed in the GUI shown in Fig.3.

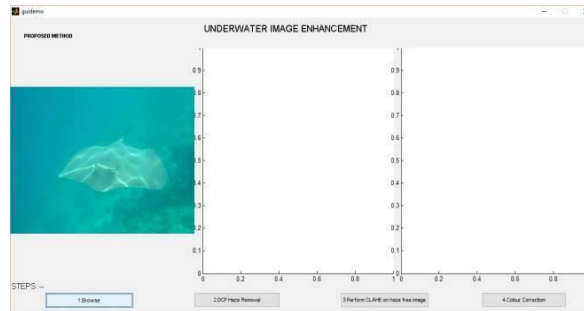


Fig.3. Browsing the input image

Subsequently, the next process of DCP haze removal is done by triggering the second push button as shown in Fig.4. The output of DCP process for the browsed input image in first plot is displayed in the second plot.

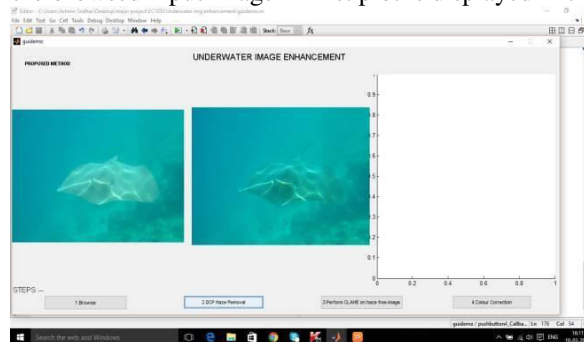


Fig.4. Haze Removal by DCP

Haze free image obtained in this step is subjected to CLAHE in the next step which is displayed in the third plot as shown in Fig.5.

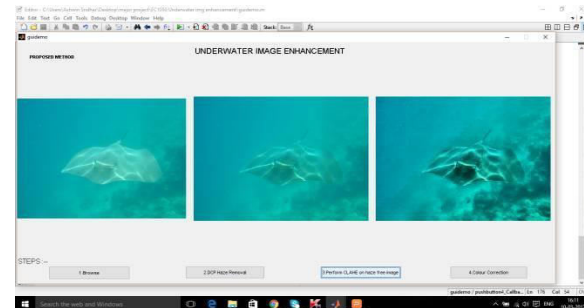


Fig.5. CLAHE is performed on haze free image

Finally, colour correlation is performed on the image in the third plot to get the final output for the proposed method. Fig.6 shows the final enhanced output of the algorithm compared to the original input image.

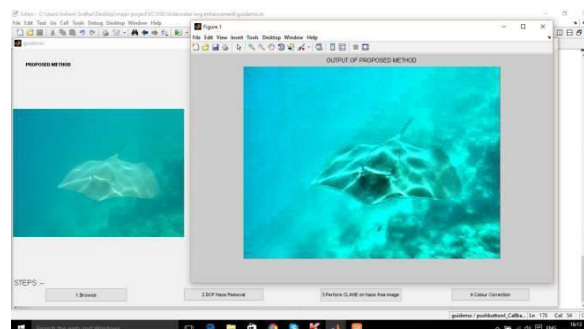


Fig.6. Final result of the proposed method





**VII. PERFORMANCE EVALUATION**

The evaluation of quality of the image can be of two types, Subjective and Objective methods. Subjective methods are widely used for judging perceived quality of an image as it can be said that the human being is the best judge himself. Fig.6. shows that

,subjectively, the output of proposed method has a better quality visually than the original underwater input image. Objectively, there are several parameters through which it can be quantitatively proved which image is better. In this paper, we have considered parameters like Peak Signal to Noise Ratio, Mean Squared Error and Mean Absolute Error.

PSNR is the ratio between the maximum power of a signal and the power of corrupting noise. More the value of PSNR, better will be the quality of the image. PSNR is given in decibels.

- **Mean Squared Error (MSE)**

	Imag e 2	Imag e 3	Imag e 4	Imag e 5	Imag e 6
Proposed	462	242.7	38.3	54	17.3 121.8
CLAHE	595.5	565.9	79.9	74.5	41.9 211.9
DCP	Pr5o6p5osed48	C3L9A.H2E 6	.D2 CP58.6	151	

MSE measures the average of the squares of the errors or deviations. The MSE is a measure of the quality of an estimator and is always non- negative. Values of MSE closer to zero are better.

- **Mean Absolute Error (MAE)**

	Image 2	Image 3	Image 4	Image 5	Image 6
Proposed	11.77	8.8	1.87	3.9	1.78 4.97
CLAHE	11.8	12	3.3	4.6	2.6 6.3
DCP	9.82	9.3	1.9	4.34	1.913 5.43

MAE is a quantity which is used to measure how close the enhanced image is to the original image. Lower the MAE, better the quality of the image.

Therefore, with the help of both subjective and objective parameters, we have obtained positive performance evaluation results for our proposed integrated algorithm for all the input test images.

**VIII. CONCLUSION**

In this paper, we have reviewed the various existing methods to enhance the quality of underwater images. We also looked into the disadvantages which comewith the methods along with gaps in the literature survey which enabled to propose a new integrated approach combining DCP and CLAHE techniques for better quality of images. DCP method is used to remove the haze in the image. But, we also saw that DCP darkens the image and results in image of poor contrast. So, to enhance the contrast of the image, we subjected it to CLAHE and got an image of better contrast. Finally ,we subjected the image to colour correction technique and got a more visually pleasing image.



Objectively, with proper simulation for various images and comparison of various parameters like PSNR, MSE and MAE, we have arrived at results that has favored the integrated approach.

Thus, we can conclude that our proposed integrated algorithm is better suited than the already existing methods in enhancing the quality of underwater images.

#### REFERENCES

1. 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.
2. C. Ancuti, C. O. Ancuti, T. Haber, and P. Bekaert, "Enhancing underwater images and videos by fusion," in *proc. of IEEE Computer Vision and Pattern Recognition*, pp. 81–88, 2012.
3. R. Fattal, "Single image dehazing," *ACM Trans. on Graphics*, vol. 27, no. 3, p. 72, 2008.
4. M. S. Hitam, W. N. J. H. W. Yussof, E. A. Awalludin, and Z. Bachok, "Mixture contrast limited adaptive histogram equalization for underwater image enhancement," in *proc. of IEEE International Conference on Computer Applications Technology*, pp. 1–5, 2013.
5. K. He, J. Sun, and X. Tang, "Single image haze removal using dark channel prior," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 33, no. 12, pp. 2341–2353, 2011.
6. Dr.G.Padmavathi, Dr.P.Subashini, Mr.M.Muthu Kumar and Suresh Kumar Thakur. "Comparison of Filters used for Underwater Image Pre-Processing" *IJCSNS* , 2010.
7. Adrian Galdran, David Pardo, Artzai Picón and Aitor Alvarez-Gila " Automatic Red-Channel underwater image restoration" Elsevier, 2014.
8. T. H. Kil, S. H. Lee, and N. I. Cho, "A dehazing algorithm using dark channel prior and contrast enhancement," in *proc. of IEEE International Conference on Acoustics, Speech and Signal Processing*, pp. 2484–2487, 2013.
9. X. Fu, P. Zhuang, Y. Huang, Y. Liao, X.-P. Zhang, and X. Ding, "A retinex-based enhancing approach for single underwater image," in *proc. of IEEE International Conference on ImageProcessing*, pp. 4572–4576, 2014.



**INNO SPACE**  
SJIF Scientific Journal Impact Factor  
**Impact Factor: 8.118**



**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details