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2020 9th IEEE International Conference on Communication Systems and Network Technologies

CSNT 2020

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Effective Framework for Underwater Image Enhancement using Multi-Fusion Technique

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***Abstract*—Underwater environments are totally different from the atmospheric environments as the environments in underwater are often complicated and shortage of light due to its physical properties. Special cameras are used for underwater imaging are mainly used for observing the deep sea ground there exist many problems, the images are under-exposed as the light transportation characteristic of water makes it difficult, the underwater images suffer by various effects and the images look hazy & blurred, they reduce clarity of image. In this paper, we present an efficient algorithm for underwater images enhancement by applying the enhancement technique in the original hazy underwater image and then calculating the white-balance and contrast enhancement technique and then calculate the weight-maps on both techniques and then finally fuse the images by fusion technique.**

Keywords—Underwater image, Image enhancement, Image Dehazing, Light Scattering, Filtering Technique.

I. INTRODUCTION

The processing of underwater images is important for various practical applications in the marine field since the underwater environment has no light and is very complicated when compared with on ground communication. We should consider the basic physics behind the phenomenon of light propagation in the water [1] while dealing with the underwater image processing, the properties of the water medium cause degradation effects in the image that are not present in the regular images taken in air medium [2]. Underwater images identified by their poor visibilities since light cannot reach very deep water and hence the scenes produce poorly contrast, hazy and blur. Illumination attenuation limiting the clear visibility of in water so by 20m in clear water and approximately 5m in marine water [3]. The amount of absorbed light decreases as we move further towards the bottom of the sea, the colors fall one after the other according to their wavelengths, the red color has the longest wavelength, therefore travels the shortest in water and the shortest wavelength is of blue color, therefore journeys the longest in water, making the underwater images look conquered by the blue color, natural colors are missing in the underwater images due to presence of floating particles and properties of water scattering, absorption and diffusion, they are the major sources of distortion of underwater imaging system. The wavelength with water floor have been shown in Fig.1.

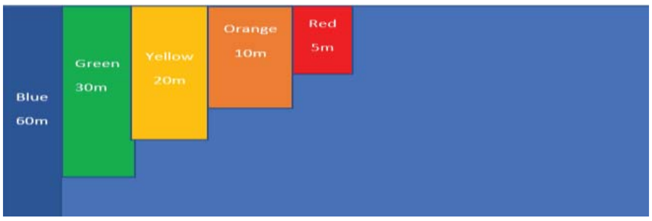

Fig1: Wavelength of Color Reaching in Deep Underwater Floor

This diagram shows that the naturality of colors degrade as we go deep in water and this is due to the difference of wavelengths of different colors because of this some colors fade and can't reach deeper in water red color wavelength is the longest therefore travels the shortest it fades at approx. 5 meters in water, then at about 10 meters the orange color fades after that about 20 meters the yellow color degrades and deep in the water we can see the images have only blue and some green shade. The scattering and absorption phenomenon affects the complete performance of underwater photography. Existence of floating elements called as "marine snow" in water raises the scattering and absorption effects of water. Scattering of light is caused when the light is incident on floating particles and before reaching the camera the light is reflected and deflected multiple times by the objects present in water, because of this the contrast and visibility of images gets lowered and the images look blur and have poor color and poor natural appearance. Color change results in attenuation of varying degrees encountered by traveling of light in water with different wavelengths interpreting ambient marine environment that are conquered by blue color. The light reflected from the objects diffuses toward the camera when we capture the image and a part of the light falls on all these particles that are suspended are present in water [4]. Underwater hazy environments generate serious object detection challenges and make the existing methods difficult to generate suitable results. Forward scattering randomly distracts light on its way from objects present in water to the camera which usually leads to blurring of the characteristics of an image. On the other hand, in backward scattering, some fraction of the light reflected from the water towards the camera position before it reaches the substance in the underwater environment which limits the contrast of the captured images [2]. As a result of this absorption and scattering of the light beam and make the images are out of focus, hazy and blur and the captured images under the water suffer from the difficulties of low visibility, limited contrast, uneven illumination, blur, non-natural color cast, and noise complexity, color diminished [5]. De-hazing is extremely required in computer vision applications, computational photography and detection systems, haze removal can increase the visibility of the scene and adding natural colors in it [6]. For enhancement of images use quality measurement approach to produce a visually more effective and pleasant image and do not depend on any other physical model for image formation.

To demonstrate the effect, take a dataset of original underwater images and then choose one of the hazy underwater image among that which is firstly corrected by gamma correction and then it is filtered by the homomorphic filtering which have been calculated and the result of that create two variations of the single image input that guarantees a natural version of output image, applying

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the white balance to it and removing chromatic societies caused by color of light [7], [10], while the contrast improvement stage produces better visibility, but mostly in the underwater hazy regions [8],[9]. Therefore, through these two operations, the derived inputs taken individually have still little visibility and cannot obtain a clearer version of the input image. Therefore, by efficiently combining the information of the derived inputs, we filter their important characteristics and obtain all the important information, calculating different weight maps combined for Luminance, contrast, saliency, and exposure characteristics of the images white-balanced and contrast enhancement. Then they used the multi fusion algorithm to get an improved resulting image. Color changes due to the exposure process making it difficult to select the images displayed.

II. LITERATURE REVIEW

Enhance the underwater images that are degraded because of the scattering, absorption of the medium [7] single image method for underwater images which calculate the white balance and then two variants of the image made one for which the correction is being calculated and other for which the sharpening is calculated from the resultant image which is white balanced then the weight-maps are being applied and finally multi-fusion technique is applied for getting the final result their approach is able to improve many varieties of images captured under the water with accuracy. Multi-scale Fusion technique calculated for Laplacian pyramid guided by the weight maps [11] Number of pyramids increase with the image size, they introduce multi-scale fusion based on Laplacian decomposition. The underwater environments suffer from dispersion and absorption phenomena that disturb the visualization of the image and propagation of light, degrading the quality of underwater images. A physical model of light propagation method and the use of previous statistical data can restore the image quality achieved in the typical underwater scene. [12] DCP is a statistical prior says that observation of natural underwater images that exhibit mostly dark intensities in a square patch of the image. Enhancing optical images method is done using a weighted guided trigonometric filter and spectral properties of a camera in the water. [13] The improved images are noticed by noise level reduction, a better revelation of dark regions, and enhance contrast so that the very small details and edges are improved. Uses delignating method if there is a presence of the artificial lighting then dual channel prior de-scattering and finally the color correction. This serves a fusion-based strategy that takes two input versions of the original hazy underwater image that are weighted by specific maps to produce accurate and haze-free results. [1] The method calculated in the form of per-pixel and is easy to implement. This method calculated to demonstrate performance, comparative results and even better outputs; it has the advantage of being suitable for real-time application. To improve underwater captured images, consider the principles of fusion, inputs, and measurements of degraded image weight. To overcome the limitations of the submarine environment, the two inputs that characterize the original underwater image frame types with color correction and contrast, aim to increase the visibility of distant objects due to dispersion and absorption phenomenon of the medium. The photosensitive transmission in the hazy scene of underwater on an input image. The diffused light is removed to increase visibility and improve haze-free scene contrasts polished image that accounts the shading of the surface and the transmission function. [14] This allows us to solve ambiguities in the data by looking for a solution in which the resulting shading and transmission functions. Solves an inverse non-linear problem and its performance depends entirely on the quality of the input image.

III. PROPOSED METHODOLOGY

A. Work Flow Diagram

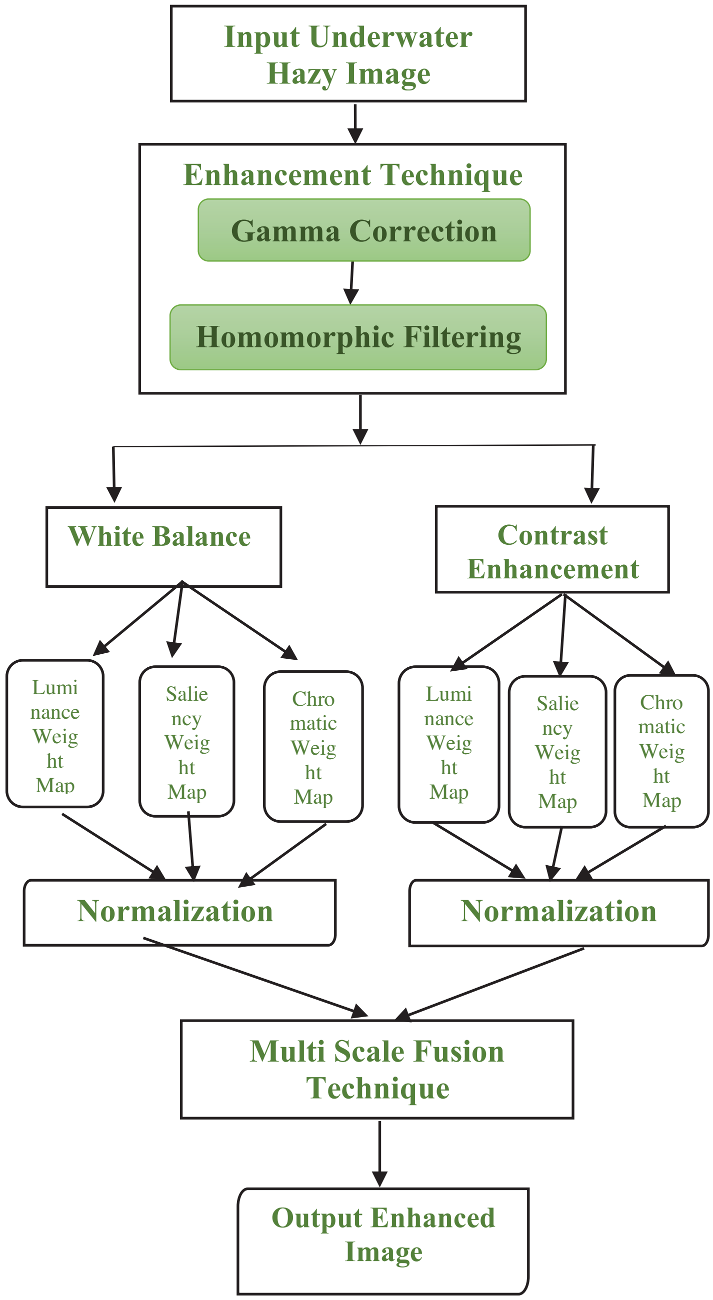


Fig. 2. Workflow of Our Proposed Methodology

B. Proposed Algorithm

- Step1: Take a dataset of all Underwater hazy images.
- Step2: Apply Enhancement techniques on that image.
  Step2(a): Apply Gamma Correction on the input image.
  Step2(b): Apply Homomorphic Filtering on the corrected image.
- Step3: Now create the two versions of the filtered image (input1 and input2).
- Step4: Apply White balance enhancement technique on input1.
- Step5: Apply Contrast enhancement technique on input2.
- Step6: Now calculate the Weight-maps (Luminance, Chromatic, Saliency) on the white balanced and enhanced images.
- Step7: Then Normalize the Weight-maps.
- Step8: Fuse the normalized images by Multiscale Fusion techniques and we will get our resultant enhanced output image.

C. Enhancement Technique

In this technique we will use two sub-technique, first is image correction and second is filtering technique, and by the combination of correction and filtering technique we are performing preprocessing in images.

1) Gamma Correction Technique

In Preprocessing we will first of all apply the gamma correction technique on our input underwater images so that they could get color corrected.

$$G\ (m, n) = [f\ (m, n)]\ \text{^}¥ \tag{1}$$

Where ¥ is the numerical value that is an exponent of the power function, also known as gamma.
Works in Spatial domain. Variation in the values of ¥ varies the enhancement of the images.
It is a non-linear operation that works on the encoding and decoding operations of the luminance images, it helps to display an image correctly on the computer screen. It controls the complete brightness of an image. An image that is not accurately corrected can look either dis-colored out or too dark. We should have a good knowledge of gamma if we are trying to reproduce the colors accurately.
By varying the amount of gamma in an image it can lead to brightness in the image and colors corresponding red to green to blue [15].
Gamma correction is necessary for all digital imaging system. It defines the relationship between pixels numerical value and its luminance. Gamma correction can improve the exposure technique and help in image editing.

¥>1 --------→ Darker image
¥<1 --------→ Brighter image

All the world's photo data contains Gamma Correction. The relationship between the logarithmic data intensity and the resulting film density, it has the slope of the linear range of the curve.

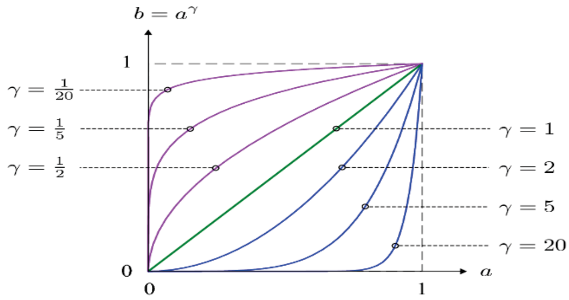


Fig. 3. Gamma correction values graph

2) Homomorphic Filtering Technique

In enhancement we will secondly apply the homomorphic filtering technique on our gamma corrected underwater image. It works in the frequency domain. Light falling on the object is called illumination & light reflecting from an object is called reflectance. Homo-morphic filtering is the process which is used for enhancing the image resulting in improvement of digital images, the image captured under the water is suffering from the poor lightning phenomenon which shows very low illumination in the underwater hazy images. This filtering method is used in several fields that use imaging as their important applications which include biometric, disease detection in plants, medical, recognition of objects, robotic, underwater haze removal and biometrics. Homomorphic filtering mostly used in the frequency domain, use a high pass filter for reducing the consequence of low-frequency components. The homomorphic technique is used to correct the non-uniform lightning and to improve image contrast. It is a frequency filter that corrects uneven illumination and sharpening of the edges at the same time [12].

3) White Balance Technique

White Balance first measure the ambient light and then make changes in the picture, setting white balance incorrectly can ruin a picture, adding all kinds of unwanted color caste and causing picture looks very un-natural, because of most light sources (candle, bulb, flashlight, cloudy, sunlight while rising and sunset). White Balance is the process of eliminating the caste of unrealistic colors caste so that objects will look to have natural colors. White Balance measure of light source color temperature, which refers to the relative warmth of the coolness of white light.
Color Balance is the global adjustment in the intensities of colors and the goal is to render natural colors or neutral colors that include gray balance, white balance, neutral balance [13].
Setting of white balance incorrectly can ruin a picture adding all kinds of color casts makes the picture look very unnatural.
Color Temperature of the white light shows warmth and coolness of the white light. Goal is to render natural colors.
Underwater images depend on how the water absorbs light; we see images that have an unnatural blue, green hue caused by improper white balance. When it comes for attaining accurate and correct colors, there's nothing better than nailing white balance, White balance (WB) is the process for removing unnatural color frames so that objects that appear white are concentrated in white in your picture. White balance in light has a certain "color

temperatures" of a light source, that belongs to the heat or comparative coolness or warmth of white light.

Underwater images depend on the way water absorbs light we see images that have an unnatural blue, green hue caused by improper white balance.

4) Contrast Enhancement Technique

It is used to increase the sensitivity and increase the specificity of the image. The contrast is the difference in the visual quality and the properties that make object different from the others. The properties of visibility that creates the difference in visual qualities making an object distinguishable from other objects and the background Contrast is the difference in visual.

It brings out the information that exists in the low dynamic range of that color image.

The difference in luminance reflected from two adjacent surfaces is contrast.

Contrast is the determination of the difference between the color and brightness of the object with other objects related to it [10].

5) Weight Maps

A derived input alone cannot restore the dehazed image and this imposes the requirement of the map of the assigned weights.

a) Luminance Weight Map:

b) Chromatic Weight Map:

c) Saliency Weight Map:

6) Normalization

Normalization is the process that changes the range of pixels intensity values. Applications including images with low brightness and contrast.

Values adjusted to a convenient frequency. Normalization of weights to have some scale as of these inputs.

7) Multi-Fusion Technique

Multi fusion in the image is the process where the information from multiple image sources are combined and that results in the formation of a single image [6].

Pixel level image fusion refers to the processing of the various combination of the detailed information gathered through different sources for better understanding of the scene

Gaussian and Laplacian Pyramids(reduce, expand):

Pyramid is built by using the multiple copies of the image. Lowest level is of highest resolution and highest level is of the lowest resolution.

The Gaussian calculates the successive images that are weighted using gaussian mean.

The Laplacian calculated as the difference between the original image and the filtered low pass image. The procedure continues to attain a range of band-pass images (each one is the difference between two levels of the Gaussian pyramid). The Laplacian pyramid is a set of band-pass filters.

Bandpass filters and down sampling that results in Laplacian pyramid. Which enhance the details specially at the edges.

The Gaussian and the Laplacian pyramids are used to reduce and expand the images, is very useful in the representation of images, compressed image, composition, optical flow, interpolation. The Pyramid is constructed by using multiple copies of the image. Each level in the pyramid is $1/4^{th}$ of the size of its previous level [30].

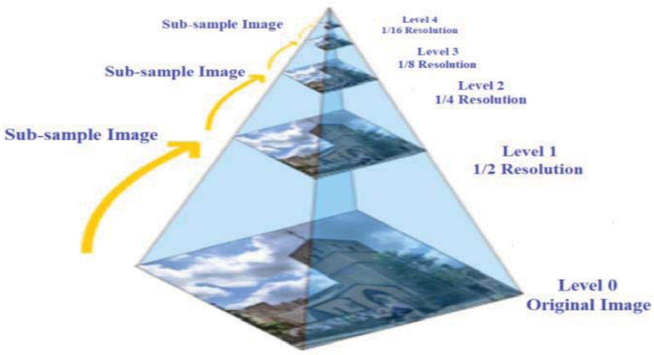


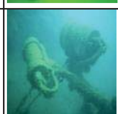
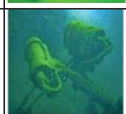
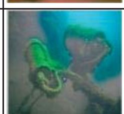
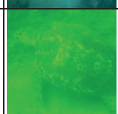
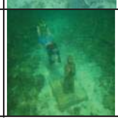
Fig. 4. The filtered image on the top showing Gaussian and Laplacian pyramids

IV. Results and Evaluation

The proposed algorithm/method performance is being evaluated by objective, subjective, comprehensive, and comparative study of various underwater images and the results obtained will tell you about the removal of fog, haze and the natural color balancing capabilities of the proposed method. We have tested the use of our approach for the underwater images. For comparative study purpose, we have selected 12 underwater hazed test images since they are captured under different condition and varied type of water with representing different scene configuration.

In Table1: we have shown the comparative analysis of the various existing underwater dehazing algorithms with the output of our proposed methodology the table displays the original underwater hazy images and then next is the Dark Channel Prior Method and then it is improve the underwater image and finally we have the results of our proposed methodology.

Table 1: Comparison of results for different underwater dehazing approaches

Image Name	Original Underwater Hazy Image	K.He. J. Sun et al (2010)	Ancuti& Ancuti et al (2012)	C. Ancuti et al (2018)	Proposed Method Results
Image 1					
Image 2					
Image 3					
Image 4					
Image 5					

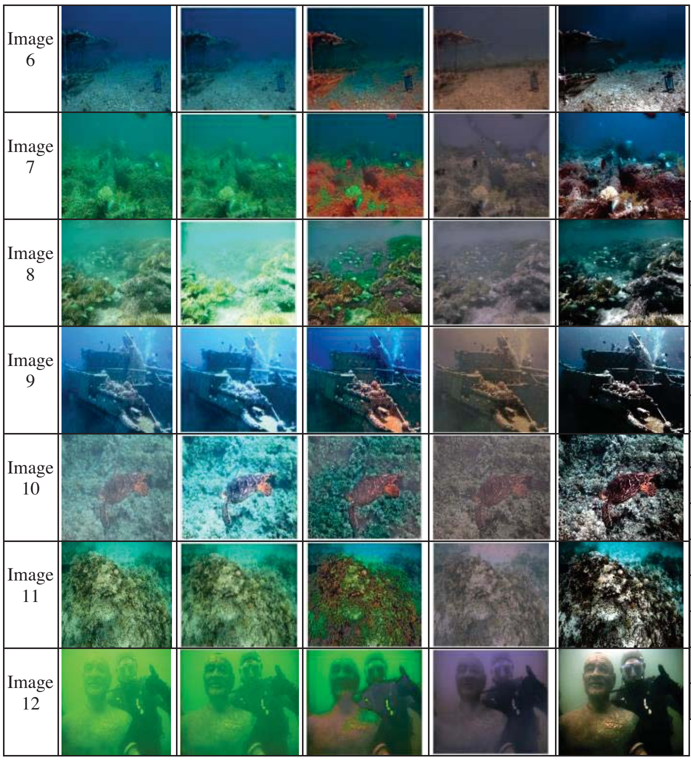


Table 2: Comparison table for MSE (mean square error)

S. No	K.He. J. Sun et. al.	Ancuti& Ancuti et. al.	C. Ancuti et. al.	Proposed Method Results
Image1	0.0141	0.0421	0.0315	0.0090
Image2	0.0321	0.0340	0.0547	0.0061
Image3	0.0060	0.0270	0.0247	0.0099
Image4	0.0390	0.0548	0.0804	0.0113
Image5	0.0134	0.0114	0.0364	0.0015
Image6	0.0075	0.0239	0.0476	0.0077
Image7	0.0059	0.0480	0.0434	0.0097
Image8	0.0863	0.0355	0.0610	0.0140
Image9	0.0277	0.0256	0.0583	0.0133
Image10	0.0593	0.0334	0.0619	0.0124
Image11	0.0368	0.0256	0.0627	0.0126
Image12	0.0300	0.0262	0.0367	0.0039

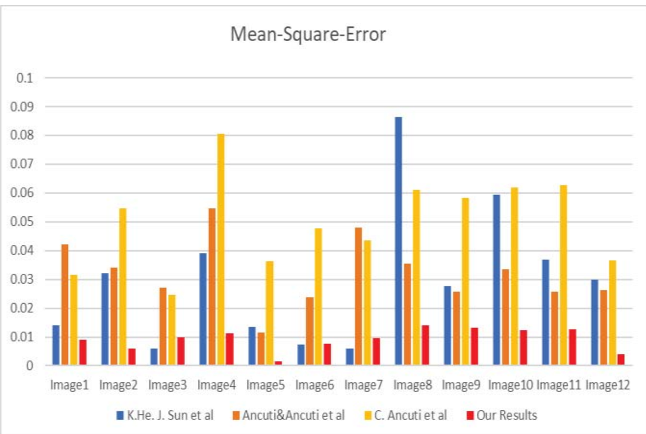


Fig.5 Comparison between the proposed method and existing methods by MSE

From Table.2 Mean-Square-Error value is calculated, lower the values of MSE better are the results, this table shows the comparison between the results of our proposed methodology with existing techniques and hence we see that our results are far better as easily seen by bar graph in Fig 8

Table 3. Comparison table for PSNR values (peak signal to noise Ratio)

S. No	Input Image	K.He. J. Sun et al	Ancuti& Ancuti et al	C. Ancuti et al	Proposed Method Results
Image1	18.35	64.48	61.91	63.18	70.34
Image2	16.90	63.09	62.72	60.77	70.26
Image3	21.76	62.89	63.84	64.22	68.20
Image4	14.46	62.23	60.76	59.10	67.62
Image5	18.74	66.87	67.55	62.55	76.16
Image6	21.23	63.66	64.37	61.38	69.29
Image7	22.27	65.40	61.34	61.78	68.27
Image8	13.98	58.80	62.66	60.30	66.69
Image9	16.63	63.72	64.07	60.50	66.90
Image10	11.83	60.42	62.91	60.24	67.22
Image11	14.36	62.49	64.07	60.18	67.15
Image12	16.04	63.39	63.98	62.51	72.25

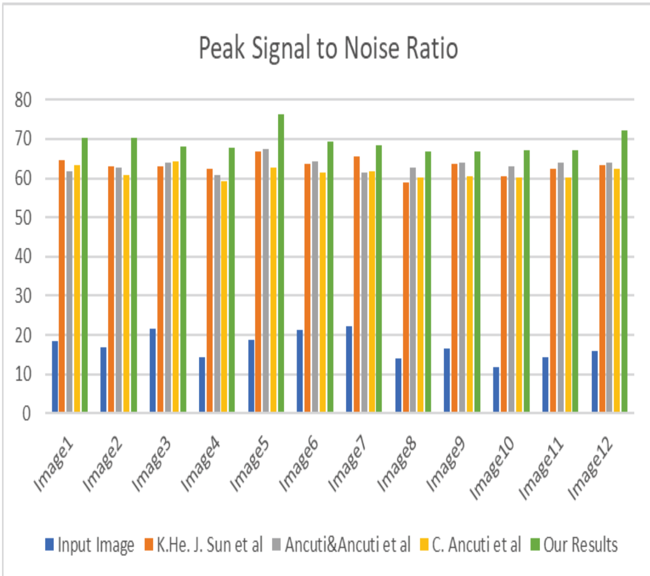


Fig. 6. Comparison between proposed method and existing method by PSNR

In Table.3 Peak Signal to Noise Ratio value is calculated, higher the value of PSNR better are the results, the table shows comparison between the results of our proposed methodology with existing techniques and hence we see that our results are far better as easily seen by bar graph in Fig 5 and Fig 6.

1) Colour Channel Segmentation Assessment:

This parameter is calculated on the input images and the output images all these parameters are calculated by segmenting RGB color channels and if the content of red channel increases then it means that our image is enhanced because red color has a very large wavelength so it cannot reach deep in water so underwater images have absence of red channel those images captured are overpowered by blue and green colors, mentioned below will take input images and enhanced images and compare them to find the output difference.

RGB channels are calculated so that we can find out the color segmentation present in the image balancing of colors are necessary to make an image look natural.

V. Conclusion

In this paper the problem related to find the visibility of long-distance objects in underwater images was investigated, we have examined a few of the enhancement algorithms which have been specifically developed for the underwater pictures, and we will find results from the output image. We have compared the previously developed methods with our proposed method and we have evaluated the performance of all the proposed algorithms in relations to various calculations, this method works on all the underwater images and by using it on single underwater image, the elimination of image haze develops a simpler and more effective technique, proposed method is able to pre-process and refine the image more than the previous methods so we aim for using these results as the base for developing further more progressive underwater image enhancement methods in future.

References

[1.] J. Y. Chiang and Y.-C. Chen, "Underwater image enhancement by wavelength compensation and dehazing," IEEE Trans. Image Process., vol. 21, no. 4, pp. 1756–1769, Apr. 2012.

[2.] R. Fattal, "Dehazing using color-lines," ACM Trans. Graph., vol. 34, Nov. 2014, Art.no. 13.

[3.] S. Paris and F. Durand, "A fast approximation of the bilateral filter using a signal processing approach," Int. J. Comput. Vis., vol. 81, no. 1, pp. 24–52, Jan. 2009.

[4.] H. Lu, Y. Li, L. Zhang, and S. Serikawa, "Contrast enhancement for images in turbid water," J. Opt. Soc. Amer. A, Opt. Image Sci., vol. 32, no. 5, pp. 886–893, May 2015.

[5.] 5. G. Maragatham, S. Md. Roomi, "A review of image contrast enhancement methods and techniques," RJASET February 2015.

[6.] 6. S. Serikawa and H. Lu, "Underwater image dehazing using joint trilateral filter," Computer Elect. Eng., vol. 40, no. 1, pp. 41–50, 2014.

[7.] A. S. Bhadouria, An Effective Framework for Enhancement of Hazed and Low-Illuminated Images, ICSISCET-2019 Springer Conference.

[8.] H. Lu et al., "Underwater image enhancement method using weighted guided trigonometric filtering and artificial light correction," J. Vis. Communication Image Represent., vol. 38, pp. 504–516, Jul. 2016.

[9.] M. Yang and A. Sowmya, "An underwater color image quality evaluation metric," IEEE Trans. Image Process., vol. 24, no. 12, pp. 6062–6071, Dec. 2015.

[10.] S. Emberton, L. Chittka, and A. Cavallaro, "Hierarchical rank-based veiling light estimation for underwater dehazing," in Proc. BMVC, 2015, pp. 125.1–125.12.

[11.] A. S. Bhadouria, Low Light and Non-Uniform Illumination Based Night Image Enhancement Techniques: An Exhaustive Study, IJCSNT-2019.

[12.] O. Ancuti, C. Ancuti, "Color balance and fusion for underwater image enhancement," IEEE Transaction on Image Processing, Vol. 27, NO. 1, January 2018.

[13.] C. O. Ancuti, C. Ancuti, C. De Vleeschouwer, and A. C. Bovik, "Single-scale fusion: An effective approach to merging images," IEEE Trans. Image Process., vol. 26, no. 1, pp. 65–78, Jan. 2017.

[14.] 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, Dec. 2011.

[15.] C. O. Ancuti, C. Ancuti, and P. Bekaert, "Effective single image dehazing by fusion," in Proc. IEEE ICIP, Sep. 2010, pp. 3541–3544.

[16.] R. Achantay, S. Hemamiz, F. Estraday, and S. Susstrunk, "Frequency-tuned salient region detection," in Proc. IEEE CVPR, Jun. 2009, pp. 1597–1604.