iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** VII **Month of publication:** July 2022

DOI: https://doi.org/10.22214/ijraset.2022.44014

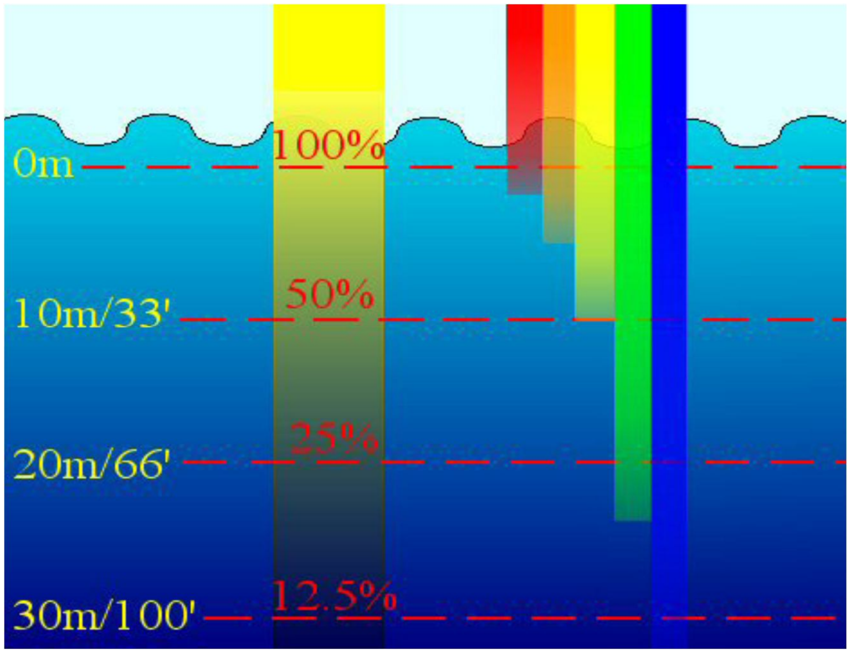
Effective Framework of Underwater Image Enhancement

Anchal Srivastava[1], Dr. Halima Sadia[2]
[1]PG Student Department of CSE Integral University, Lucknow, Uttar Pradesh
[2]Associate Professor Department of CSE Integral University, Lucknow, Uttar Pradesh

Abstract: Underwater photographs are an excellent resource for learning about marine life and analysing the hydrothermal winds that blow across the seafloor. Low contrast, colour distortion, and poor visual appeal are the main obstacles that an underwater image faces. Light disperses and refracts as it progresses from rarer to denser, resulting in a plethora of complexities. The dispersion of light reduces the colour contrast. Water, in addition to dispersion, modifies subsea images due to the presence of subsea animals. We provide a new method for improving underwater fusion photos that accurately restores images underwater. Because the input and a set of processes, such as white balance, gamma correction, sharpening, and weight map manipulation, result in a single image. This research suggests a novel method for recovering and improving underwater photos. We recommended a light canal in front of the underwater environment as the initial step. A clear channel image was analysed and adjusted, environmental light was approximated, and the transmission image was refined in order to reconstruct underwater photos. The simulation was run using the MATLAB software.
Keywords: Underwater Image, enhancement, CLAHE, HE, Entropy, MSE

I. INTRODUCTION

In recent years, an increasing number of academics have concentrated on the enhancement and recovery of underwater pictures. Diffusion and absorption are always responsible for low contrast, fluidity, and colour distortion in underwater photographs. As a result, preserving and improving the underwater image was a challenging task. Figure 1(a) shows some photos taken in the subsea, the quality of which has deteriorated dramatically. High-quality underwater images are required in a variety of industries that use underwater photography to achieve specific specialised goals, such as underwater tracking, 3D recreation of underwater objects, underwater archaeology, underwater biological studies, and marine flooring. Scientists have provided a collection of high-resolution pictures that may be divided into two categories. The first is image restoration, while the second is image enhancement. Image enhancement ignores the physical model and instead focuses on improving image quality using image processing techniques. The image restoration technology is based on a physics model for image generation. This strategy, however, does not work well when it comes to colour distortion. Because of the benefits and drawbacks of both strategies, we combined them in this study and produced satisfactory results. Given that the underwater world is lightless and more difficult to transmit than the surface region, underwater photographs are essential for a wide range of practical applications in the nautical industry. When dealing with an underwater image, the underlying physics of light propagation in water[1] must be investigated; characteristics of the underwater medium cause deteriorating effects in an image that are not present in normal photos collected by air media[2]. When clear visibility in water is reduced, light is reduced by 20 metres in clear water and by roughly 5 metres in marine water[3]. As we travel further into the sea, the amount of light absorbed diminishes, and the colours blur one by one according to their wavelength; red colours have the longest wavelength, while the shorter wavelength in water is blue, giving the underwater photographs a blue and realistic appearance. The wavelength is depicted in Figure 1 in relation to the water's surface. In the deep underground, the colour wavelength Because of the differences in wavelengths of different hues, the natural character of the colours lessens as we go deeper into the water. As a result, the longest red wavelength falls in water for ten metres, after which the colour orange fades, the colour yellow fades, and we only see blue and green images deep in the water. Underwater photography's overall performance is influenced by dispersion and absorption. The presence of floating debris known as "marine snow" in the water exacerbates the effects of water dispersion and absorption. When light strikes, it is dispersed by floating particles, and objects in the water continually reflect and disflect before reaching the camera, reducing contrast and clarity and giving the image a hazy, unnatural appearance. The amount of light in the water with unique wavelengths that interpret the blue colour of the marine environment is reduced when the shade is altered. When the picture and light components are recorded in all the particles suspended in water, the light reflected by the objects diffuses to the camera[4]. Underwater fog makes object detection difficult and prevents current methods from generating adequate results. Further dispersion will cause visual elements to flutter when light from water-based objects is sporadically transferred to the camera. Backward dispersion, on the other hand, occurs when a portion of the light from the water is reflected at the camera's position before reaching the substance beneath the surface.



II. RELATED WORK

Yan Wang (2019): Underwater photographs are essential for ocean research, but they are frequently harmed by water and light absorption. Despite recent advances in picture enhancement and restoration, the usefulness of new technology to increase underwater photography quality has yet to be fully established. We investigate picture enhancement and restoration methods to treat common subsea flaws, such as severe degradation and distortion. To begin, we'll go over the root causes of the decline in underwater imagery quality (IFM). After that, we look at undersea repair approaches, both IFM-free and IFM-based. Then, using both subjective and objective assessments, we conduct a comparative experiment to assess the state-of-the-art IFM-free and IFM technologies, taking into account earlier IFM-based algorithms. Underwater-Image-Enhancement-and-Color-Restoration). We identify the key flaws in present methodologies and make recommendations for future research in this topic based on our work. Our discussion of underwater picture enhancement and restoration provides students with the context they need to comprehend the difficulties and potential of this vital topic.

Yosuke (2019)- Underwater photos are essential to underwater photography, according to Yosuke (2019), since underwater images often have a colourful appearance, low contrasts, and visibility reduced by light absorption and dispersion. In this paper, we provide a new underwater restoration technique based on dark channel generalisation (GDCP). Although there are many other types of underwater photographs, we're concentrating on deep underwater images because present algorithms can't improve them well. GDCP iterations and image fusion are used in the proposed method. In addition, we demonstrate a new ambient light estimate that may be used to a wider range of image formats. Based on experimental findings, the technique advised appears to be effective for several forms of undersea photography, particularly photos of depth.

Miao Yang (2019) - Low contrast, bubble features, colour variations, and inconsistent illumination are just a few of the quality issues that might occur when shooting underwater. Submarine picture restoration and enhancement is a critical challenge for computer vision and image processing. Restoration and enhancement of underwater images has gotten a lot of attention in recent decades. However, no extensive examination of the related successes and breakthroughs, particularly the underwater picture data set, which is a major challenge in the treatment and intelligent use of underwater photographs, has yet been conducted. More than 120 studies on recent breakthroughs in underwater restore and enhancement photography are featured in the exhibition, which includes methodology, data sets, downloadable scripts, and assessment criteria. To gain a thorough understanding of the restoration and improvement of the underwater image, we look at the contributions and limitations of existing technologies. We also provide objective reviews and analyses of typical procedures for five different undersea scenarios, demonstrating their applicability in a variety of subsurface circumstances. Finally, we consider potential issues and open subjects for underwater image restoration and improvement, as well as future research directions.

Guojia Hou; Xin (2020) The improvement and restoration of photographs is one of the most researched topics in the realm of underwater machines. The objective assessment of picture quality is required for optimising underwater technology for improvement and restoration. Most no-reference (NR) metrics, on the other hand, aren't designed to judge the quality of underwater photographs. In most underwater scenarios, full reference (FR) metrics cannot be used to evaluate techniques for improving and restoring the submarine image since reference (ungraded) photographs are not accessible. This study introduces an underwater image synthesis algorithm (UISA) that allows us to generate a synthetic underwater image from an outdoor ground-truth image based on a real underwater image. We created a new massive benchmark using the method, which comprises both real and synthetic underwater photographs taken from the same location (SUID). With outstanding dependability and practicality, our SUID is based on the underwater image building model (IFM) and underwater optical propagation characteristics. Extensive trials and quantitative analysis show that the offered SUID allows a FR evaluation of existing solutions for improving and recovering subsurface pictures.
Changli Li (2020) It's tough to recover colours and improve underwater images due to attenuation and dispersion. The clarity and colour changes in underwater photographs are usually small. The article describes a new colour correction strategy based on the Filter Array (CFA), as well as a method for improving colour underwater images using dense pixels and Retinex's adaptive linear histogram transformation. The RGB values of each digital image taken with a CFA digital camera in the RGB area are dependent on and linked to the interpolation process. As a result, we strive to compensate for the red channel attenuation caused by the green and blue channels in undersea photos. The Retinex model is frequently used to efficiently manage low brightness and smooth images. The McCann Retinex (MR) method estimates light via a pixel spiral path. The simple route selection, on the other hand, does not take into account the image's overall light-dark relationship. To acquire a more precise lighting intensity, we create a system that adds a lot more distributed and dense pixels. A linear histogram transform is a technique that can adapt to any RGB value. Experiments on a large number of underwater photographs show that with our approach, we can achieve acceptable performance metrics with clearer details and a consistent visual impression across all RGB colorspace channels.
Shen *et al.* [23] modi_ed the imaging model by take into account the ampli_ed noise, and then restore the degraded image relying on the correlation between the hazefree image and the transmission map.
He *et al.* [24] in natural terrestrial image dehazing by calculating the amount of spatially homogeneous haze using the local minimum in three channels.

Summary of Recent Image Enhancement Methods

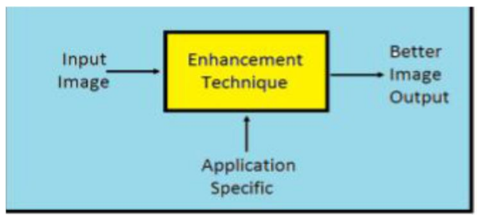
	Methods used	Results
Selva Nidhyanandhan	DSGF method and PCA based Image Fusion method	Improved SSIM for better contrast, improved entropy for high information content and reduced AMBE for better enhancement
Dai	Background light estimation, transmission map calculation, scene radiance estimation and colour balance.	Improved contrast, vivid colour and natural appearance.
Holambe	CLAHE stretching method and wavelet based fusion method	RGB colour space independently to improve contrast of all existing colours in a picture
Sparavigna	GIMP Retinex filter	Better image enhancement by the use of grey tones
Cao	Hyper Column Feature, Dilated convolution and batch normalization	Excellent performance in the smoothness, illumination and the authenticity of the image.
Liang et al.	Colour correction and multi-scale gradient domain detail enhancement considering attenuation level of image	Restored the degraded images taken in adverse weather and special circumstances (hazy, foggy, sandy and etc.)
Mohammed et al.	DNN based De-nosing, Apply CLAHE and white colour balancing.	Pretrained DNN (dnCNN) for image de-noising and achieved better PSNR and SSIM value

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VII July 2022- Available at www.ijraset.com

III. UNDERWATER IMAGE DATASETS

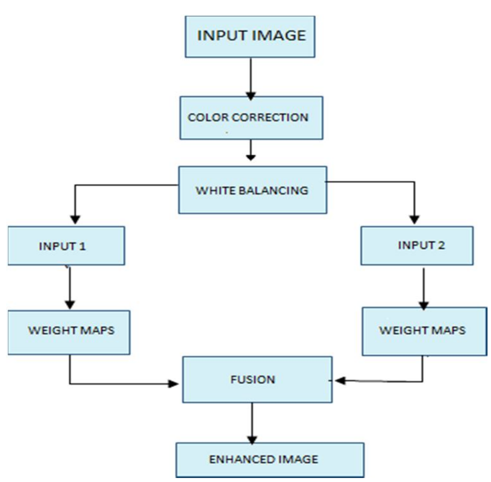
MARIS Autonomous Robotics Dataset; SUN SUN Scene and Object Recovery Dataset[1]. 1100 Undersea map range4; Haze-line Dataset for Raw photos, TIF files, and Camera calibra are only a few of the real-life undersea picture datasets. Current data sets, on the other hand, usually contain boring material, limited scenes, low degradation, and insufficient data. Furthermore, due to various types of water and light conditions, as well as costly and logistical imagery systems, obtaining an underwater picture and a corresponding ground truth picture of the same scene is difficult or impractical, these datasets did not provide relevant soil truth pictures or reference results. In recent years, several methods for underwater picture synthesis have been presented. The deterioration of underwater images has been replicated using milk, chlorophyll, or green tea, and a GAN method 6 has been developed. For the development of subsea pictures, there were three model parameters and an open source image simulation tool[5]. For diverse types of water, a plastic underwater photo dataset with ten subgroups was proposed. However, there is still a separation between synthetic and real-world perspectives. As a result, evaluating state-of-the-art methods and developing effective in-depth teaching models is tough.

IV. PROPOSED METHODOLOGY



This section defines the steps through which the entire work goes. Here tries to overcome the issues faced by underwater images. The proposed methodology is illustratedin Fig 2.

1) *White Balancing:* Color correction is a technique for altering the image's colour intensity. Colors have been neutralised in this image. After that, the white balance is applied. The camera tries to identify the colour temperature in order to remove the cast's undesired color[1]. The restoration colour standard should be kept in mind because white balance is a white colour predictor. The photograph captures the hazy nature of the setting. When we look at the concept of wavelength, we can observe that in the aquatic medium, the wavelength absorbs the light spectrum. Because blue has the shortest wavelength in RGB, it is absorbed last. A blue image of the undersea environment was displayed. The loss rate of the red channel is larger than that of the blue and green channels. Deep-water photographs seem bluish or greenish as a result. As mentioned in the previous section, white balance is an important aspect of underwater image processing. White balance can be achieved using a variety of methods. The grey world method replaces two low-percentage colour components with a high-percentage component at first[3]. The component average is found first in the image. Take, for example, the alpha parameter 1, which is used to alter the colour component. Two separate inputs are produced by the white balanced output. One has been gamma corrected, whereas the other has not. White Balance's main goal is to compensate for the loss of the red channel. The image edge is the focus of unsharp masking. It sharpens the image by removing the blurred version. The application of a Gaussian filter is employed in this case. It is expressed as



2) *Image Fusion*- The main goal of image fusion is to combine many images with higher resolution from different pathways into a single image. The human visual system is represented more accurately and adaptively in these graphics. It adds no new features to the fusion while simultaneously improving the source photos' weak attributes[4]. Different photographs from various sources depict various things.
3) *Image Enhancement*- General improvement concepts aim to improve the image's quality while preserving its information. The advancement has a variety of applications in the military, agriculture, underwater, satellite, and other fields. In the realm of picture enhancement, there are a variety of methods, such as singular decomposition of value. [6]. To improve the fusion image, a novel computer network approach is applied. The image is clear from the start of the fusion process. However, the exact location or entity cannot be determined.

A. Histogram Equalization

Histogram equalization is a method for modifying image intensities and contrast of image in image processing using the image's histogram. Histogram equalization is helpful in pictures with backgrounds and frontal areas that are both bright or both dim. This is a simple and straightforward technique. But it has a disadvantage also that is it also amplifies the background noise present in the image and lead to decrease in the useful signal. So it produces unrealistic effects in the output images. The basic idea lying behind this method is mapping the gray levels depending upon the probability distribution of the input gray levels.

Histogram equalization (HE) is a famous image enhancement method and process. HE works by equalizing and stretching the histogram by the intensity range by means of cumulative distribution function (CDF) and probability distribution function (PDF) . HE is used as a simple method in the enhancement process by many scholars.

The histogram is a scale graph which represents the frequency of occurring of data values in the whole data set. It plots the number of pixels for each tonal value in a digital image. Let us consider an image with M total possible intensity levels in an example. Then, the histogram of the digital image in [0, M-1] is defined as a discrete function as below:

P(rk)=nk/n

Where,

rk is the kth intensity level in the interval.

nk is the number of pixels in the image which have intensity level is rk.

n is the total number of pixels in the image.

Histogram equalization (HE) is an image enhancement which enhances the contrast of an image by making spreading the intensity values over the all available dynamic range. This is achieved by using a transformation function T(r), which can be stated by the Cumulative Distribution Function (CDF) of given Probability Density Function (PDF) of the gray levels in an image.

CONTINUOUS CASE: This case is for intensity levels those are continuous quantities normalized to the range [0, 1].

Let, Pr(r) is the probability density functions of the intensity levels.

Then, required transformation of the input levels to get the output level S is:

$$S = T(r) = \int_0^r P_r(w)dw$$

where “w” is dummy variable of integration. Then it could be shown that the probability density function (PDF) of the output levels is uniform,

$$P_s = \begin{cases} 1, for 0 \le s \le 1 \\ 0, otherwise \end{cases}$$

The above mentioned transformation generates a digital image whose intensity levels are equally likely and also, it covers the complete and entire range [0, 1].

This intensity grey level equalization process results in a digital image with greater dynamic range with tendency to receive higher contrast.

DISCRETE CASE: In this case of discrete quantities, we deal with summations (additions) and hence, the equalization transformation of image becomes:

$$S_k = T(r_k) = \sum_{j=1}^{k} P_r(r_j)$$
$$= \sum_{j=1}^{k} n_j/n \quad \text{, for k = 1, 2, 3,..., L}$$

where Sk is the intensity value of output image w.r.t value rk in the input image.

B. Contrast Limited Adaptive Histogram Equalization (CLAHE)

It is generalization of adaptive histogram equalization. With this technique the image is broken up into tiles. The gray scale is calculated for each of these tiles, based upon its histogram and transform function, which is derived from the interpolation between the manipulated histograms of the neighboring sub-regions. The transformation function is relative to the cumulative distribution function (CDF) of pixel values in the area. CLAHE contrasts from AHE in contrast limiting. CLAHE limits the noise enhancement by cut-out the histogram at a client characterized worth.

The basic and very important difference between Adaptive histogram equalization (AHE) and Contrast limited adaptive.

C. Contrast Limited Adaptive Histogram Equalization

(CLAHE) is contrast limiting. The Contrast-LAHE gives clipping limit of histogram to overcome the noise amplification issue. The CLAHE technique divides the image in relative regions and applies histogram equalization process to each and every region. CLAHE has two parameters clip limit (CL) and the block size which are basically control image enhancement quality. By increasing the clipping limit the digital image brightness will be increased. Simultaneously by increasing block size the range becomes larger because of these the image contrast also increases.

In contrast limited histogram equalization(CLAHE), the histogram is cut at some threshold

and then equalization is applied. Contrast limited adaptive histogram equalization (CLAHE) is an adaptive contrast histogram equalization method , where the contrast of an image is enhanced by applying CLAHE on small data regions called tiles rather than the entire image. Theresulting neighboring tiles are then stitched back seamlessly using bilinear interpolation. The contrast in the homogeneous region can be limited so that noise amplification can be avoided.

The CLAHE method consists the following 7 steps :

1) By Dividing the original intensity image in non-overlapping contextual regions. The total number of real image tiles is equals to MxN , and 8x8 is a better value to secure the image chromatic data.
2) By calculating the histogram of each and every contextual region according to gray levels present in the image array.
3) By calculating the CLHE of the contextual region by clipping limit values.
4) Redistribute the remaining pixels until the remaining pixels been all distributed.
5) By enhancing intensity values in each and every region by Rayleigh distribution technique.
6) Reducing abruptly changes.
7) By calculating new gray level assignment of pixels within a submatrix contextual regions by using a
8) Bilinear interpolation method between four different mappings order to eliminate boundary artifacts.

D. Rayleigh Distribution

Rayleigh Distribution is the most basic and appropriate distribution for the underwater imaging. It actually refers to the bell shaped histogram distribution in which maximum pixels are concentrated at the centre of the intensity level. The pixel numbers at the minimum and maximum sides of the Rayleigh distribution is lowest to minimize the pixel amount from having too low or the too high intensity values. Therefore, Rayleigh distribution reduces the pixel number of under and over contrasted areas that may be developed in the resultant image.

$$CDF_{Rstretch} = 1 - \exp\left(\frac{(-(P_{in} - i_{min})o_{max})^2}{2\alpha^2 (i_{max} - i_{min})}\right) \qquad PDF_{Rstretch} = \left(\frac{P_{out}}{\alpha^2}\right)\exp\left(\frac{-P_{out}^2}{2\alpha^2}\right)$$

V. RESULTS AND DISCUSSION

Original Image	K.He. J. Sun	Ancuti& Ancuti	C. Ancuti	Proposed Method Results

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VII July 2022- Available at www.ijraset.com

Table 1: Comparison table for MSE (mean square error)

	K.He. J. Sun (2020)	Ancuti& Ancuti	C. Ancuti	Proposed Method
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	0.0179	0.0239	0.0476	0.0077
Image 7	0.0379	0.0859	0.0627	0.0052

Table 2: Comparison table for Entropy

	K.He. J. Sun (2020)	Ancuti& Ancuti	C. Ancuti	Proposed Method
Image1	7.5454	7.7031	7.7385	7.8251
Image2	7.2829	6.0340	6.0847	7.5061
Image3	7.0060	7.0954	6.0247	7.1099
Image4	7.1340	5.865	6.0804	7.4113
Image5	6.0133	5.012	7.0364	7.4015
Image 6	6.0379	5.0859	6.0627	7.0052
Image 7	6.0141	5.0119	5.0576	7.0067

Table 1: Comparison table for PSNR

	K.He. J. Sun (2020)	Ancuti& Ancuti	C. Ancuti	Proposed Method
Image1	68.35	64.48	61.91	70.34
Image2	63.09	62.72	60.77	70.26
Image3	62.89	63.84	64.22	68.20
Image4	62.23	60.76	59.10	67.62
Image5	66.87	67.55	62.55	76.16
Image6	63.66	64.37	61.38	69.29
Image 7	65.40	61.34	61.78	68.27

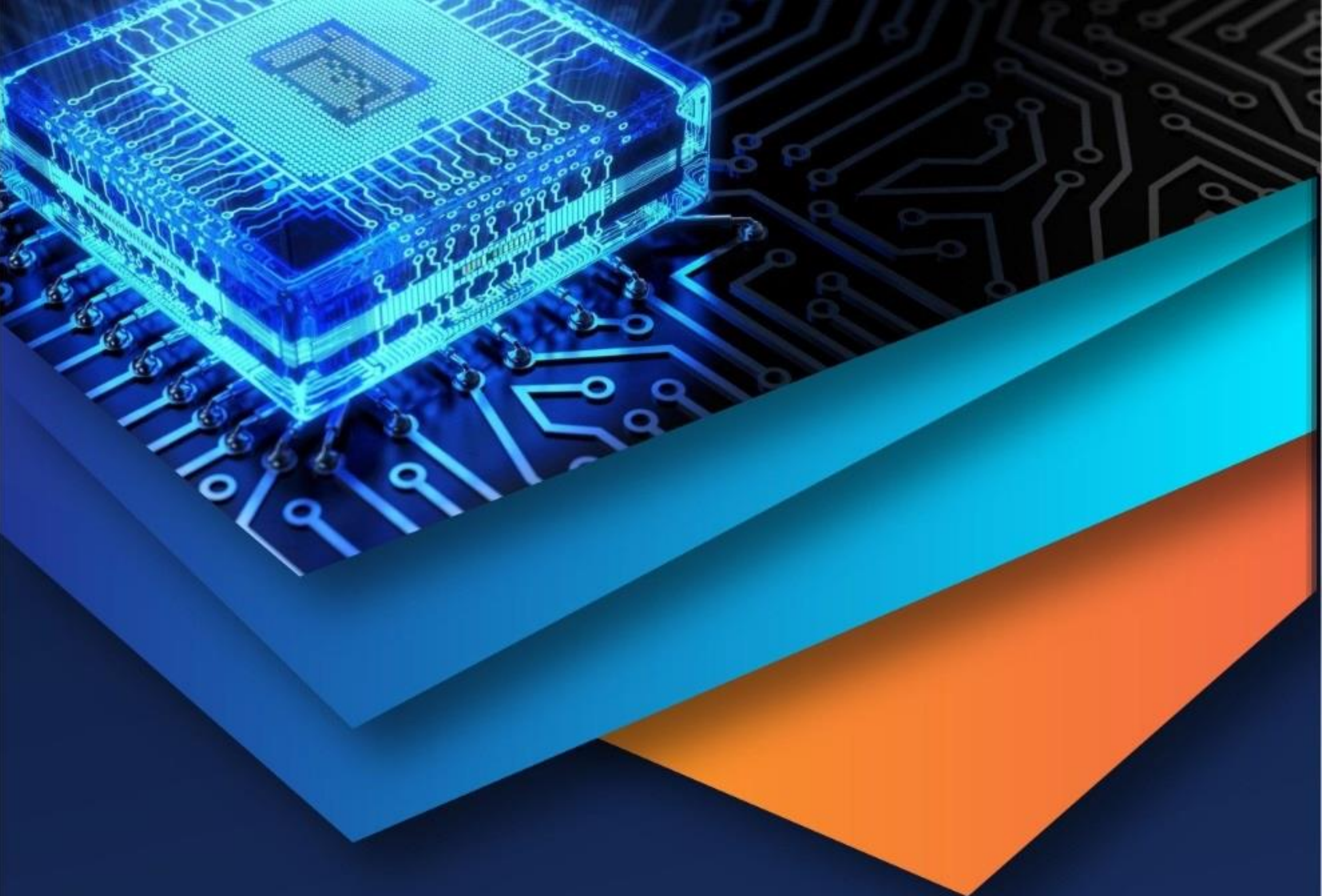
Mean-Square-Error value is calculated, lower the values of MSE better are the results, this table shows the comparison between the results of our proposed methodology with existing techniques.
Peak Signal to Noise Ratio value is calculated, higher the value of PSNR better are the results, the table shows comparison between the results of our proposed methodology with existing techniques

VI. CONCLUSION

In this work, we present an alternate technique for improving the quality of underwater photographs. Deterioration is frequently the result of certain physical events. The first goal is to correct such faults and make the final output as accurate as feasible for viewers. In a variety of difficult subsea applications, we will dramatically improve performance. We've put together a dataset for underwater image enhancement that includes large genuine underwater photographs and related reference images. Our approach achieves outstanding results when painting photos with a relatively higher resolution and a basic texture while balancing processing quality and time constraints. The study of image processing and underwater imaging is becoming more popular. In the production of new things, new approaches and procedures are frequently advocated to improve underwater images and films. Our innovative surface image enhancement technique works on underwater captures, eliminates artificial illumination, and increases image quality.
In future work, we will extend the constructed dataset towards more challenging underwater images and underwater videos. Moreover, we will try to design a range map estimation network. The provided 1100 underwater images with range maps in could be used for the range map estimation network training. With the estimated range maps, we will make full use of such key prior information to further improve the performance of underwater image enhancement network. Besides, inspired by recent work we believe that more physically reasonable underwater image enhancement algorithms will arise. At that time, we will re-organize the selection of the reference images from more reliable results and also further train the volunteers on what the degrading effects of attenuation and backscatter are, and what it looks like when either is improperly corrected. Additionally, the main purpose of constructing the real-world underwater dataset
in this paper is to evaluate the state-of-the-art underwater image enhancement methods and provide paired training data for deep models. Since the full-reference metrics and training a deep model only need a single reference, we do not select multiple references or define the image quality level. However, the image quality level of multiple reference images does help in underwater image enhancement. Thus, we will provide multiple reference images for an underwater image and define the image quality level of their reference images when we re-organize the selection of the reference images.

REFERENCES

[1] Yan Wang;Wei Song;Giancarlo Fortino;Li-Zhe Qi;Wenqiang Zhang;Antonio Liotta An Experimental-Based Review of Image Enhancement and Image Restoration Methods for Underwater ImagingIEEE Access Year: 2019 | Volume: 7 | Journal Article | Publisher: IEEE
[2] Yosuke Ueki;Masaaki Ikehara Underwater Image Enhancement Based on the Iteration of a Generalization of Dark Channel Prior 2019 IEEE Visual Communications and Image Processing (VCIP) Year: 2019 Conference Paper Publisher: IEEE DOI: 10.1109/VCIP47243.2019.8965726
[3] Miao Yang;Jintong Hu;Chongyi Li;Gustavo Rohde;Yixiang Du;Ke Hu An In-Depth Survey of Underwater Image Enhancement and Restoration IEEE Access Year: 2019 Volume: 7 Journal Article Publisher: IEEE Cited by: Papers (12) DOI: 10.1109/ACCESS.2019.2932611
[4] Guojia Hou;Xin Zhao;Zhenkuan Pan;Huan Yang;Lu Tan;Jingming Li Benchmarking Underwater Image Enhancement and Restoration, and Beyond IEEE Access Year: 2020 Volume: 8 Journal Article Publisher: IEEE Cited by: Papers (2) DOI: 10.1109/ACCESS.2020.3006359
[5] Changli Li;Shiqiang Tang;Hon Keung Kwan;Jingwen Yan;Teng Zhou Color Correction Based on CFA and Enhancement Based on Retinex With Dense Pixels for Underwater Images IEEE Access Year: 2020| Volume: 8 Journal Article Publisher: IEEE Cited by: Papers (6) DOI: 10.1109/ACCESS.2020.3019354
[6] Yan Wang;Wei Song;Giancarlo Fortino;Li-Zhe Qi;Wenqiang Zhang;Antonio Liotta
[7] An Experimental-Based Review of Image Enhancement and Image Restoration Methods for Underwater ImagingIEEE Access Year: 2019 | Volume: 7 | Journal Article | Publisher: IEEE
[8] Yosuke Ueki;Masaaki Ikehara Underwater Image Enhancement Based on the Iteration of a Generalization of Dark Channel Prior 2019 IEEE Visual Communications and Image Processing (VCIP) Year: 2019 Conference Paper Publisher: IEEE DOI: 10.1109/VCIP47243.2019.8965726
[9] Miao Yang;Jintong Hu;Chongyi Li;Gustavo Rohde;Yixiang Du;Ke Hu An In-Depth Survey of Underwater Image Enhancement and Restoration IEEE Access Year: 2019 Volume: 7 Journal Article Publisher: IEEE Cited by: Papers (12) DOI: 10.1109/ACCESS.2019.2932611
[10] Guojia Hou;Xin Zhao;Zhenkuan Pan;Huan Yang;Lu Tan;Jingming Li Benchmarking Underwater Image Enhancement and Restoration, and Beyond IEEE Access Year: 2020 Volume: 8 Journal Article Publisher: IEEE Cited by: Papers (2) DOI: 10.1109/ACCESS.2020.3006359
[11] Changli Li;Shiqiang Tang;Hon Keung Kwan;Jingwen Yan;Teng Zhou Color Correction Based on CFA and Enhancement Based on Retinex With Dense Pixels for Underwater Images IEEE Access Year: 2020| Volume: 8 Journal Article Publisher: IEEE Cited by: Papers (6) DOI: 10.1109/ACCESS.2020.3019354



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY