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Underwater Image Enhancement using Image Processing Techniques: A Review

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***Abstract*—**While capturing underwater image there are lot of imposed due to low light, light variation, poor visibility. Photography is about light, but since water has an a lot more prominent density than air — around 800 times more noteworthy — not all orientation of light travel similarly well inside it. This implies as we go down into deep water, we lose the shades of the range one by one. This is the reason submerged photographs lose all the red and orange hues even at a genuinely shallow profundity and appear to be increasingly more blue as we go deep in water, henceforth captured image need enhancement. It's a vital research area. We proposed an effective technique so that we can improve the images which are captured underwater and degraded because of the medium scattering and absorption. Our technique is a single image approach that does not require specialized hardware or knowledge about the underwater conditions or scene structure. It is build on the blending of two images that are directly derived from a color compensated and white-balanced version of the original degraded image. The two images to fusion, as well as their associated weight maps, are defined to promote the transfer of edges and color contrast to the output image. To avoid that sharp weight map transitions builds artifacts in the low frequency components of the reconstructed image, we also conform a multi scale fusion strategy. Our extensive qualitative and quantitative analysis reveals that our enhanced images and videos are characterized by better exposedness of the dark regions, enhanced global contrast, and edges sharpness. Our validation also shows that our algorithm is reasonably independent of the camera settings, and enhance the accuracy of several image processing applications, such as image processing and key-point matching.

***Keywords*—** Image Enhancement, De-blurring, Color Correction, Histogram Stretching, Gamma correction.

I. INTRODUCTION

The primary objective of image enhancement is to process a assigned image so that the consequence is more appropriate than the original image for a specific application. It accentuates or sharpens image characteristics for instance edges, boundaries, or contrast to create a graphic display more helpful for display and analysis. Image enhancement can be simply described in fig.-1 block diagram.

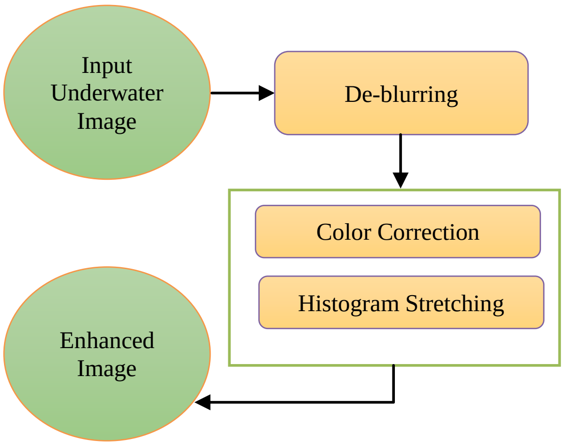


Figure :-1 Image Enhancement Steps

The enhancement doesn't inflate the inherent information content of the data, but it increases the dynamic range of the chosen features so that they can be detected easily.Two methods of cultivating image quality is by image restoration and image enhancement.

Image restoration: It dealt with filtering the input under water image to minimize the effect of dreadful conditions. The efficiency of image restoration be determined by on the degree and the accuracy of the knowledge of dreadful conditions process. Image restoration varies from image enhancement. Image restoration is centered on further extraction of input image features. The image restoration intentions to recover a tainted image using a model of the degradation. These methods needs various model parameters like attenuation and diffusion coefficients that characterize the water turbidity.

Image enhancement: Image enhancement recuperate the visibility of one aspect or component of an image. It mentions to improving of image features such as boundaries, or contrast to make a graphic display. This is mostly valuable for display & examination. This procedure will not upsurge the intrinsic information content in the data. This comprises gray level & contrast influence, noise lessening, sharpening, filtering, interpolation and magnification, pseudo coloring etc.. Image enhancement uses qualitative subjective approach to produce a additional visually pleasing image. It do not trust on any physical model for the image development. These methods are typically pretentious and quicker than de-convolution methods. The prevailing research shows that underwater images increase new fangled challenges and enact significant problems due to light captivation and trickle effects of the light and inherent structureless. environment. Travel around, accepting and examining underwater activities of images are acquisition of importance for the last few years. Scientists are keen to explore the bizzare underwater world. Anyhow, this field is still lacking in image processing analysis techniques and methods that could be used Researchers have tried to employ various different enhancement techniques.

Color correction is the most essential step for image enhancement as depth increases in water colors snoozes one by one contingent on their wavelength Firstly, red color vanishes at the depth of 3 m roughly. At the depth of 5 m, the orange color is vanished. Mostly the yellow goes off at the depth of 10 m and ultimately the green and purple disappear at further depth. The blue color proceeds the longest in the water because of its shortest wavelength. The underwater images are hence dominated by blue-green color. Also the light source variations causes the color perception. As a result, a strong and non-uniform color cast will characterize the particular underwater images. In this paper we will discuss different methods of image enhancement.

In the next section of the paper we will elaborate some literature, in section III we will discuss about how we have proposed the method, in section IV we will discuss how we motivated towards this research and problem in underwater image enhancement and also we give experimental evaluation of different existing image enhancement techniques, at last we will conclude our study.

II. LITERATURE SURVEY

Md. J. Islam et. al. introduced a conditional generative adversarial network-based model for underwater image enhancement concurrently. To administer the adversarial training, we developed an objective function that estimates the perceptual image quality supports its global content, color, and native style details. As well as, author presented EUVP, a large-scale dataset of a paired and an unpaired pile of underwater images (of poor and good quality) which are captured via seven distinct cameras over several visibility conditions throughout oceanic explorations and human-robot collaborative evaluation..Author concluded that proposed model can be used to improve real-time perception performances of visually-guided underwater robots [1].

C. O. Ancuti et. al. introduces an efficient technique to reinforce the pictures captured underwater and degraded thanks to the medium scattering and absorption. this method may be a single image approach that doesn't require specialized hardware or knowledge about the underwater conditions or scene structure. It works on the merging of two images that are directly derived from a color compensated and white-balanced version of the original degraded image. The two images to fusion, also as their associated weight maps, are defined to market the transfer of edges and color contrast to the output image. To avoid the load map transitions create artifacts within the low frequency components of the reconstructed image, we also adapt a multi-scale fusion strategy [2].

L. Neumann et. al. said that Underwater image processing has to face the problem of loss of color and contrast that occurs when images are acquired at a certain depth and range. The longer wavelengths of light such as red or orange are speedly absorbed by the water, while the shorter ones have higher scattering. Thereby, at larger distance, the scene colors appear bluish-greenish, as well as blurry. The loss of color increases not only vertically through the water column, but also horizontally, so that the subjects further away from the camera appear colorless and indistinguishable, suffering from lack of visible details. Author presents a fast enhancement method for color correction of underwater images. The method is formed on the gray-world assumption involved in the Ruderman-opponent color space and is capable to cope with non-uniformly illuminated scenes. Vital images are exploited by the proposed approach to perform fast color correction, take into consideration locally changing luminance and chrominance. Because of the low-complexity cost this approach is suitable for real-time applications to make certain realistic colors of the entity, more visible characteristics and enhanced visual quality [3].

M. D. Kodak et. al. discussed advances in the field of underwater optical imaging . A review of research and technical innovations is introduced. Various recent applications of novel systems are shown as examples, and trends in emerging underwater imaging research and inventions are shortly summarized by author [4].

G.L.Foresti et. al. proposed visual inspection of sea bottom structures by an autonomous underwater vehicle. It uses three-dimensional model of the environment and of an extended kalman filter allows the guidance and the control of the vehicle in real time. This paper describes a vision-based system for inspection of underwater structures by an autonomous vehicle.[5].

A. Olmos et. al. presented a system to Detect man-made objects in unconstrained subsea videos. They uses Quality Metric and Bayesian Classifier. This model describes an automatic vision system capable of detecting a variety of man-made objects in underwater imaging conditions[6].

M. Mangeruga et. al. state that images attained in an underwater environment are usually affected by colour cast and experience from poor visibility and insufficiency of contrast. In the report, there are various enhancement algorithms which improve distant aspects of the underwater imagery. In each review, when presenting a fresh algorithm or method, typically compares the preferred technique with some alternatives exists in the current state of the art. There are no such studies on the reliability of benchmarking approaches, as the comparisons are established on different subjective and objective metrics. Author has analyzed improved images by means of three different approaches: objective metrics often adopted in the related literature, a panel of experts in the underwater field, and an evaluation based on the results of 3D reconstructions [7].

R. Protasiuk et. al. proposed approach combines both local and global information through an easy yet powerful affine transform model. Local and global information are carried through local color mapping and color covariance mapping between an input and a couple of reference source, respectively. Various experiments on the degraded underwater images explains that the proposed method performs favourably to all or any or the other methods including ones that are tailored to correcting underwater images by explicit noise modelling [8].

Table 1

S.No.	Author/Publication Year	Title	Approach Used	Description
1.	Md Jahidul Islam et. al. / 2019	Fast Underwater Image Enhancement for Improved Visual Perception/ arXiv	Conditional generative adversarial network-based model	Proposed model can be used as an image processing pipeline by visually-guided underwater robots in real-time applications
2.	Codruta O. Ancuti et. al./ /2018 IEEE	Color Balance and Fusion for Underwater Image Enhancement	Combining white balancing and image fusion	Blending of two images that are directly derived from a colorcompensated and white-balanced version of the original degraded image.
3.	László Neumann et. al./ 2017	Fast Underwater Color Correction Using Integral IMAGES / arXiv	Ruderman-opponent color space	Presents a fast enhancement method for color correction of underwater images. The method is based on the gray-world assumption applied in the Ruderman-opponent color space
4.	M. D. Kodak F.R.Dalgleish, M.F.Caimi and Y.Y. Schechner. / 2008	A focus on recent developments and trends in underwater imaging.	Image formation and Image processing methods and Extended range imaging techniques.	This proposed approach focuses on the recent advancements in hardware, software and algorithmic methods to overcome the absorpt and scattered nature of sea water.
5.	G.L.Foresti/ 2001	Visual inspection of sea bottom structures by an autonomous underwater vehicle.	It uses three-dimensional model of the environment and of an extended kalman filter allows the guidance and the control of the vehicle in real time.	This paper describes a vision-based system for inspection of underwater structures by an autonomous vehicle.
6.	A.Olmos and E.Trucco/ 2002	Detecting man-made objects in unconstrained subsea videos.	Quality Metric and Bayesian Classifier	This model describes an automatic vision system capable of detecting a variety of man-made objects in underwater imaging conditions.
7.	B.A.Levedahl and L.Silverberg/ 2009	Control of underwater vehicles in full unsteady flow.	Reduced-order model, Coupled Fluid Vehicle Model and Fluid compensation control.	This model describes the full unsteady flow and measures the hydro-dynamic loads directly and also shows how a rational balance between canceling the hydrodynamic load.
8.	J.P.Tarel, N.Hautiere, L.Caraffa, A.Cord, H.Halmaoui and B.Gruyer/2012	Vision enhancement in homogeneous and heterogeneous fog.	Colour and contrast enhancement and Enhancement based on Koschmieder's law.	This model proposes the rating visibility enhancement algorithms which is based on the addition of various generated fog on synthetic and camera images.
9.	D.-M.He and G.G.L.Seet/2004	Divergent-beam LiDAR imaging in turbid water.	Under Water LiDAR Imaging (UWLI) principle and system.	Describes the divergent-beam UWLI system to range-gate on the targets which are required to capture and to range-gate out the targets which are not required.
10.	Y.Y.Schechner and Y.Averbuch/2007	Regularized image recovery in scattering media.	Restoration using adaptive regularization.	This study demonstrates the approach in atmospheric and underwater experiments based on an automatic method for determining the medium transmittance.
11.	J.Y.Chiang and Y.-C.Chen/ 2012	Underwater image enhancement by wavelength	Wavelength Compensation and Image Dehazing	The propound WCID algorithm handles light scattering and colour change distortions caused by underwater images concurrently.

		compensation and dehazing.	(WCID) Algorithm	
12.	P.Drews-Jr., E.Nascimento, F.Moraes, S.Botelho, M.Campos and R.Grande-Brazil/ 2013	Transmission estimation in underwater single images.	Underwater Dark Channel Prior (UDCP).	UDCP examines that blue and green colour channels are the underwater visual information source which allow a remarkable improvement over DCP.
13.	A.Galdran, D.Pardo, A.Picon and A.Alvarez-Gila/ 2015	Automatic red-channel underwater image restoration.	Red Channel Underwater Image Restoration	This method is an extension of Dark Channel Method which adapts the way images are degraded and it handles visibility loss and colour corruption.
14.	S.Emberton, L.Chittka and A.Cavallaro/ 2015	Hierarchical rank-based veiling light estimation for underwater dehazing.	Region-based approach, Superpixel segmentation and clustering and Transmission estimation	This method considers scene features thus it avoids estimation of veiling lights from regions that contain objects also it includes transmission estimation which handles over saturations and the production artefacts.
15.	H.Lu, Y.Li, L.Zhang, and S.Serikawa/ 2015	Contrast enhancement for images in turbid water.	Descattering and colour correction	This model proposes a Physical UDCP. For the estimation of ambient light a robust colour line-based ambient light estimator is used also a weighted guided domain filter used to compensate for the transmission.
16.	H.Lu, Y.Li, S.Nakashima, H.Kim and S. Serikawa/ 2017	Underwater image super-resolution by descattering and fusion.	High turbidity underwater image SR algorithm and Convex fusion	The SR method proposed to recover the distorted images in turbid water and also it removes noise or artefacts in high resolved scattered images.
17.	C.Ancuti, C.O.Ancuti, T.Haber and P.Bekaert/ 2012	Enhancing underwater images and videos by fusion	Multi-Scale fusion principle	The fusion technique takes the degraded image and performs white balance to remove the colour cast. This image is further enhanced by suppressing the unwanted noise. The second input is taken from this image to render the details in all intensity range and fusion is done by both these inputs.
18.	S.Bazeille, I.Quidu, L.Jaulin and J.P.Malkasse/ 2006	Automatic underwater image preprocessing	Parameter-free algorithm	The underwater preprocessing algorithm is automatic and requires no parameter adjustments and no prior knowledge of the acquisition conditions because its functions calculate their parameters else uses pre-adjusted default values.
19.	F.Petit, A.S.Capelle-Laize, P.Carre/ 2009	Underwater image enhancement by attenuation inversion with quaternions	Quaternions colour correction, colour contraction and underwater image colour enhancement	This model focues on light attenuation inversion after processing a colour space contraction through quaternions. This imporves contrast and colour dynamic on underwater images via turning water pixels to grey or low saturation colours while objects remain completely coloured.
20.	M.Chambah, D.Semani, A.Renouf, P.Courtellemont, and A.Rizzi/ 2003	Underwater colour constancy : Enhancement of automatic live fish recognition	Automatic Colour Equalization (ACE) algorithms	The ACE algorithm merges the Grey World and White Patch equalization method to consider the spatial distribution of colour information. The segmentation is used for correct recognition of fish which uses background substraction.
21.	F.Bonin, A.Burguera and G.Oliver/ 2011	Imaging systems for advanced underwater vehicles	Different illumination techniques	This study suggest the best way to enhance the image quality while not increasing the AUV cost or power consumption, is to hold the light source and the camera apart from each other

III. METHODOLOGY

Architecture of Proposed Scheme

The architecture of the proposed scheme is illustrated in Fig.

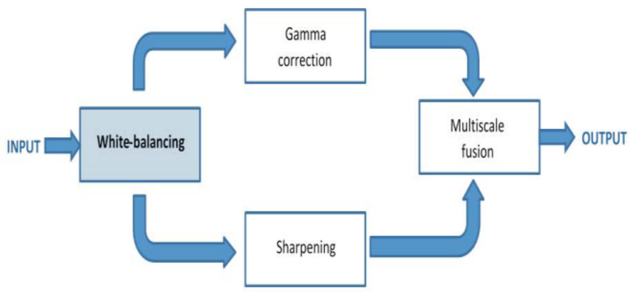


Figure 2 :- Architecture of proposed scheme

This approach adopts a two step strategy, combining white balancing and image fusion, to improve underwater images without resorting to the explicit inversion of the optical model.

In this approach white balancing focuses at compensating the color cast caused by the selective absorption of colors with the depth, while image fusion is considered to improves the edges and attributes or details of the scene, to mitigate the loss of contrast resulting from back-scattering.

IV. RESULTS AND DISCUSSION

There are some problem in underwater image processing:

1. The exhibited methodologies have overlooked the techniques to diminish the noise issue, which is accessible in the resultant photos of the present picture improvement strategies.
2. Sharpening of image not done.

For discussing different methods of image enhancement, we have implemented different techniques using Matlab 2018. We have taken different underwater images and the we used some different approaches to evaluate our proposed method so that the comparison could be performed. The different approaches are Contrast-Limited Adaptive Histogram Equalization, Image enhancement by adjusting image intensity value or color space, Image enhancement by enhancing contrast using histogram equalization and Gamma correction.

Figure 3 :- shows the different underwater images as input

(I) Contrast-limited adaptive histogram equalization (CLAHE):

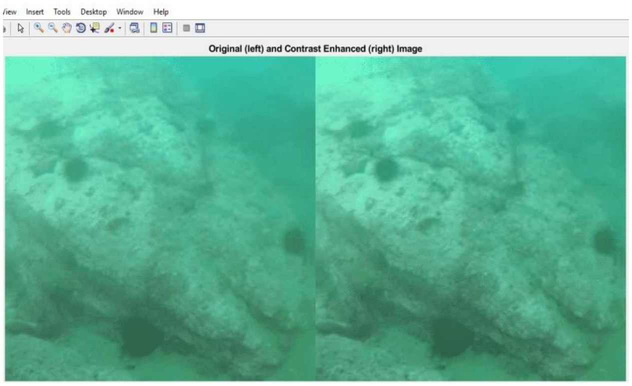


Figure 4 :- Original image vs Enhanced Image (CLAHE)

(II) Image enhancement by adjusting image intensity value or color space. Figure 4 depicts the same. It saturates the bottom 1% and the top 1% of all pixel values. This operation increases the contrast of the output image

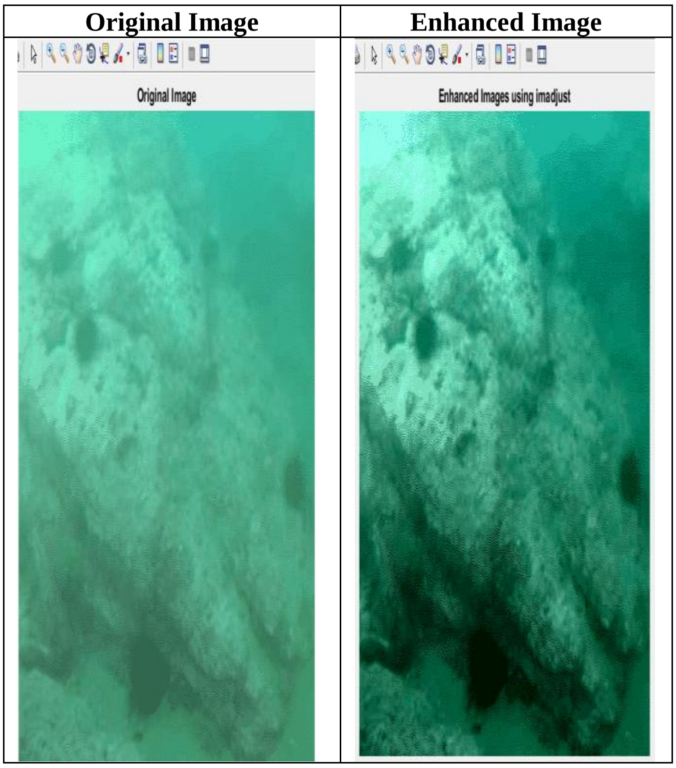


Figure 5 :- Original image vs Enhanced Image w.r.t. (II)

(III) Image Enhancement by enhancing contrast using histogram equalization figure 5 depicts the same.

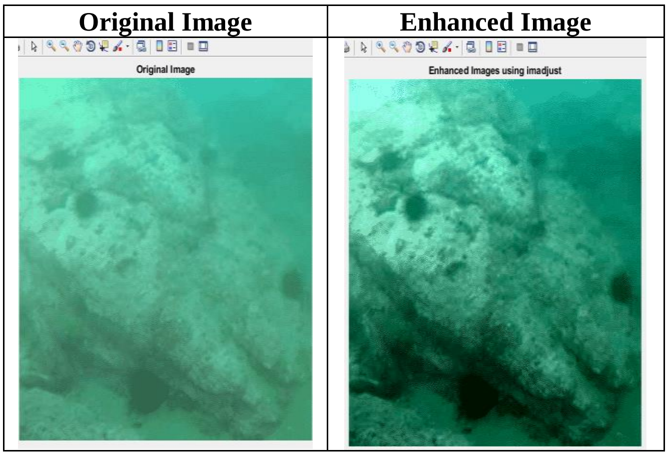


Figure 5 - Original image vs Enhanced Image w.r.t. (III)

(IV) Gamma Correction: By changing intensity value fig.6 depicts the comparison of original image vs image with gamma value 1,2,3.

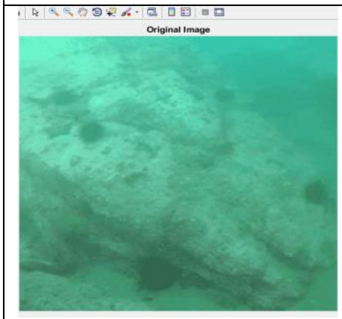
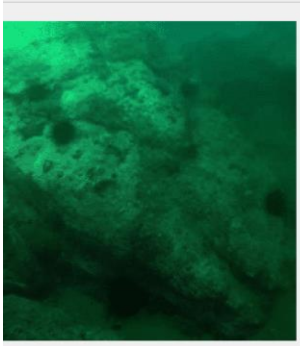
Original Image	Gamma value=1
	
Gamma value=2	**Gamma value=3**
	

Figure 6 - Original image vs Enhanced Image w.r.t. (IV)

V. CONCLUSION

In this paper we reviewed some conventional techniques of image enhancement like CLAHE,adjusting image intensity value, gamma correction etc. Image enhancement recovers the visibility of one aspect or component of an image. Current camera systems often fail as a result of deprived visibility underwater rising from light scattering, light refraction, absorption, and uncontrolled particles in underwater. As well the right conception of components and their arrangement, henceforth vital to make an elegant image enhancement and processing. For the utilization of camera systems within the underwater area. In this paper we concluded that de-noising is required for under water image enhancement which will significantly improve the value of PSNR.

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