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A Review of Enhancement Techniques for Underwater Images

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Abstract: ***Integration of underwater imaging using artificial intelligence has become an emerging field for researcher now-a-days. Underwater Image processing has wide variety of applications, such as underwater target tracking, marine life surveillance, underwater detection and underwater autonomous navigation. Underwater captured images usually have a problems of unwanted color-cast, color distortion, low contrast, detail blurring and haziness, which in turn degrade the image quality, loss of important details and poor visibility etc. To overcome these issues many enhancement techniques are proposed to improve the underwater image quality (highlight important detail and visibility). This paper proposes a reason for the underwater image degradation and literature survey of various enhancement techniques for underwater images. Furthermore, the comparison for various image enhancement techniques is elaborated and finally, an enhancement technique for underwater images is summarized and the suggestions for future research are given.***
Keywords: Underwater scene, underwater image degradation, underwater image enhancement.

I. INTRODUCTION

In present scenario, underwater imaging has various applications such as target tracking in under water, research in marine biology, environmental protection, optical imaging and navigation etc. The enhanced version of underwater images are mostly have an application in underwater optical imaging [1-3] The reason behind the underwater degradation images such as absorption, scattering effect. Due to scattering in under water image fogging and detail blurring has been occurred and because of absorption, it leads color distortion and reduction in contrast and brightness of underwater image. Color cast which is present in underwater image because of red light is absorbed first due to longest wavelength in approx. 10-15 ft. and then orange and yellow but the blue light has shortest wavelength, present in deep of sea water. To overcome this short coming various enhancement techniques have been proposed [4]. The traditional techniques which are used for enhancement of such degradation are histogram equalization , white balancing and gamma correction Dehazing is a complex task for removal of haze

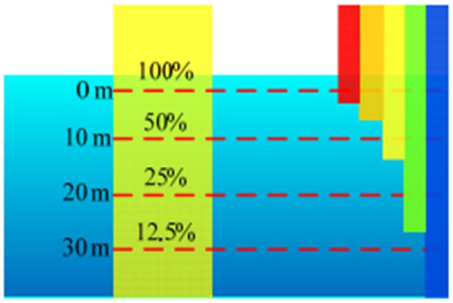

Fig1. Absorption of light water from [26]

present in under water image to improve the quality of images [7]. To remove the classical dark channel prior a combination of automatic white balance and improved background light estimation algorithms has been used for under water image restoration[8]. Dynamic histogram equalization is employed for contrast enhancement of low contrast image without losing any information [9]. For bluish and greenish tone present in underwater image, a hybridized concept of color correction and fusion techniques are used [10].

Section II of this review paper briefly describes underwater image enhancement techniques. Section III explained about literature survey, section IV described the comparative analysis of different techniques, later with the help of different aspects we conclude this review paper in section V.

II. UNDERWATER IMAGE ENHANCEMENT

Underwater image enhancement is a process of computer algorithms which processed on degraded images to improve the image quality, high contrast, richer detail information suitable for the human interpretability and machine as well.

For image enhancement, there are some methods such as Frequency domain based method, spatial domain based method, Color constancy based method and Fusion based method [4].

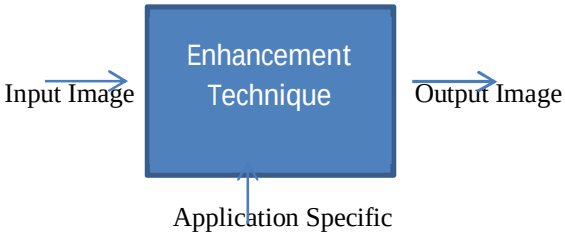

Fig2. Basic block diagram of image enhancement [27]

For image enhancement, there are some methods such as Frequency domain based method, spatial domain based method, Color constancy based method and Fusion based method [1].

In frequency domain based methods are mostly used for removing of noise but can't achieve better results in terms of contrast and color correction , it includes of wavelet transform[20] , low pass filter, high pass filter, homo-morphic filter and quaternion[1]

1) *Wavelet Transform:* Wavelet transform decomposes the image into wavelets and the obtained image is of unequal amount or different scales of information.
2) *Low-pass Filter:* Low-pass filtering is a noise removal technique by suppressing high frequency information.
3) *High-pass Filter:* High-pass filtering is a detail preservation technique by suppressing the low frequency information.
4) *Homo-morphic Filter:* Homo-morphic filter is a combination of reflection component r(x,y) and illumination component i(x,y).The expression for homo-morphic filter as follows:

$$f(x,y) = i(x,y)r(x,y) \qquad (1)$$

Where r(x,y) is a high frequency component and i(x,y) is a low frequency component and then the logarithm is applied in equation (1) are as:

$$z(x,y) = \ln\big(r(x,y)\big) + \ln(i(x,y)) \qquad (2)$$

In spatial domain, the contrast and detail information of an underwater image can be enhanced [9].

Some contrast enhancement techniques are:

a) *Adaptive Histogram Equalization (AHE)***:** It is a contrast enhancement technique which separately enhances the contrast of each RGB channel then performs histogram equalization on the intensity values of the image [10].
b) *Gamma Correction:* Gamma correction is a process of bringing out the nature look and preserves the mean brightness of images [11].
c) *Contrast Limited Adaptive Histogram Equalization (CLAHE):* CLAHE solves the problem of Histogram equalization of ignoring the local features of an image and also the over-enhancement in some portion of an image of adaptive histogram equalization. Before applying the histogram equalization, CLAHE first saves the details of original image and adding these details to Histogram equalization process.

Since retinex and white balance for color correction enhancement are used in color constancy based method [12, 13].

Some color correction techniques are:

i) *White Balancing:* White balancing is a technique that needs to remove the undesirable color cast because of medium attenuation properties. It is basically for compensating the red color loss [12].
ii) *Retinex Method:* Retinex is an application that follows the theory of color correction to achieve the image with better clarity and color-fidelity [4]. It is highly complex and requires more computational time for enhancement. It is basically applied in image defogging and image enhancement.

Fusion methods are generally used for detail enhancement, color correction, color balance and contrast stretching etc. [12].

III. LITERATURE SURVEY

In this literature survey, various image enhancement techniques have been proposed. In underwater image, haze can be reduced through dark channel. Wavelength compensation is used to minimize the color variations in underwater image [5]. Underwater image has low contrast, haziness and greenish or bluish shades because of absorption and scattering effect when light propagated in underwater [6, 7]. Zuan et al. [8] introduced a method based on automatic white balance and improved background light estimation to overcome the shortcoming of classical dark channel prior algorithms for underwater image restoration. Ancuti et al. [12] proposed underwater image enhancement using fusion and color balance techniques, firstly obtained white balance version of original degraded image and then this white balanced image is manipulated through gamma correction and sharpening then fusion of both the results and finally get enhanced version of underwater image Iqbal et al.[14] introduced a slide stretching method, firstly the contrast of an image is equalized by contrast stretching method after that true color is increased by using intensity and saturation stretching. Hitam et al. [15] introduced a method based on Mixture CLAHE which is applied on HSV and RGB color space and then Euclidean norms is employed and fusion of HSV and RGB color space version. Ahmad et al. [16] introduced a method based on Rayleigh-stretched CLAHE for dual image, which ameliorate the detail information and contrast of an image. Garg et al. [17] proposed a blending method of percentile and CLAHE which ameliorate the clarity, visual and brightness of underwater image. Amjad et al. [18] proposed fusion method based on wavelet decomposition of underwater image. Ritu et al. [19] recommended a fusion technique for haze removal of underwater images to improve the color and contrast of an image. Jianhua et al. [20] proposed Lp-norm decomposition method for single under water image enhancement. The original image is manipulated by using histogram normalized version of color balanced and adaptive histogram equalization of local contrast version then weight map extraction would be done after that the result of histogram normalized version and adaptive histogram version is convolved with weight map and finally get enhanced image. Nissan et al. [21] proposed hybrid methods such as white balance using gray world algorithms, gamma correction and discrete wavelet based fusion, and here gamma value is taken as 0.5 to ameliorate the contrast, quality and brightness of an image.

IV. COMPARATIVE ANALYSIS OF DIFFERENT TECHNIQUES

Table1. Comparative study of different techniques

Year	Author	Approaches	Results
2007	K. Iqbal, S. R. Abdul, M. Osman, and A. Z. Talib [14]	Slide stretching	Equalizes the color contrast and provide lesser computational complexity.
2013	M. S. Hitam, E. A. Awalludin, W. N. J. H. W. Yussof, Bachok[15]	Mixture contrast limited adaptive histogram equalization(CLAHE)	Enhanced the image quality of underwater image.
2015	A. Ghmad, A. Shahrizan, M. Isa, and N. Ashidi[16]	Rayleigh stretched CLAHE method for dual image	Noise suppression and enhance the contrast of an image.
2016	Khan Amjad, Syed Saad Azhar Ali [19]	Fusion based on wavelet decomposition	Haziness of undersea capture image is enhanced in terms of contrast and color correction.
2017	Singh, R., & Biswas, M.[18]	Fusion technique based on haze removal of underwater images	Get final enhanced clear image depicted high entropy, PSNR values.
2018	Li, Changli, and Xuan Zhang.[8]	Automatic white balance and improved background light estimation	Color distortion and influence of white object is reduced and get clear final enhanced image.
2018	C. O. Ancuti, C. Ancuti[12]	Fusion , color balance and white balance	Preserved edges and important feature of underwater image.
2018	D. Garg, N. K. Garg, and M.[17]	Combination of percentile and CLAHE methodology	Enhanced the global contrast of underwater images.
2019	Wang, J., Wang, H., Gao, G., Lu, H., & Zhang, Z.[20]	L_p norm decomposition	Enhanced image possess highly accurate details, better contrast and excellent brightness range.
2019	Krishnapriya T S, Nissan Kunju[21]	Hybridized technique of white balancing using gray world algorithms and discrete wavelet based fusion	Provide better results in the compensation of bluish and greenish color cast.

V. CONCLUSION

In this review paper, we are generally introduces research advancement in area of underwater image enhancement. This paper mainly points out the reasons for degradation of underwater images for shortcoming of these issues various image enhancement techniques are employed. Through these enhancement techniques, the final enhanced images are better in terms of image quality, contrast, and uniform dynamic brightness range, edge and corner preservation etc.

From the above enhancement techniques, the approach that is used in Jianhua et al. outperforms the better results as compare to other in terms of contrast enhancement and color correction and the complexity of this paper is excellent as compare to other paper. So, the enhanced final clear images are widely used for the researcher in study of marine life, target tracking, autonomous navigation, archaeology, under water environment protection etc.

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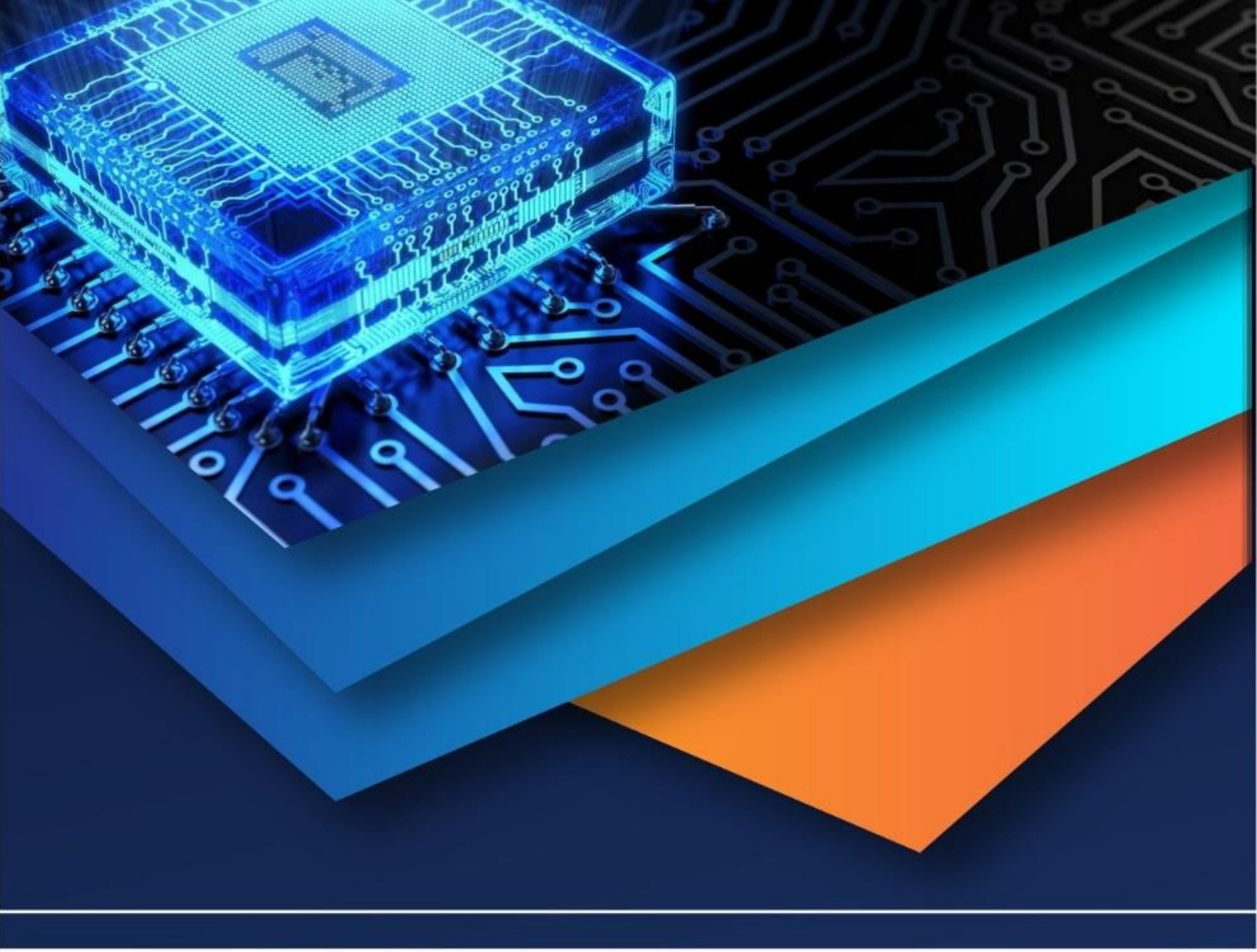

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