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REVIEW ON VARIOUS UNDERWATER IMAGE QUALITY DEGRADING FACTORS AND METHODS TO OVERCOME DEGRADATION

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Abstract: The images taken under the water are very poor due to the impurities present in the water, Hence the need for enhancement. Images suffers from various connatural distortion in an uncontrolled underwater environment. From haze caused due to suspected particles, to blue cast caused due to the rays from the sunlight, non-uniform illumination caused due to artificial lighting, water bubbles created by turbine in ships, surfers or by moving object. Hence the causes of underwater image distortion can randomly vary due to various reason but the main challenge in obtaining quality images in underwater is due to Color change and the scattering. Scattering is mainly caused by some of the suspended particles present in the water. Therefore the reliability and quality of the image greatly reduced. This in turn decreases the visibility and contrast of the image. This paper gives a review of the various causes of distortion present in images obtained underwater and the algorithms used to overcome the same.

Key Words: *underwater image distortion, Scattering, underwater images, enhancement, dehazing*

I. INTRODUCTION

The images captured in underwater are highly degraded due to the presence of unlike suspension particle like the water droplets or dust particles to the poor lighting or over lighting conditions.
In general an object can be identified with the help of the shape, size, etc. When we travel deeper through water the light beam gets scattered and it gets attenuated so radiance of the image is spoiled exponentially. This is one of the major problem arising in underwater images. Depending upon the wavelength of the color of the objects, the colors get degraded one by one. Hence the visual quality of images decreases a lot in underwater images.

Image enhancement technique uses qualitative and subjective criteria to enhance the degraded images due to scattering or absorption of light from the camera or due to the atmospheric pollution like haze, underwater color cast, etc. The images taken under the water are not clear due to various impurities present in it. The enhanced image can be processed and analyzed for underwater life detection, earth crust shift, submarines, pipeline, and debris of crashed planes or ships. Image processing uses various technologies and method to process the distorted, unclear images to give enhanced output image. Image processing deals with 2D images with the help of a computer. The computer process it pixel by pixel which is also known as picture element There are two main approach in obtaining quality images in an existing image, they are image enhancement and image restoration.

Image enhancement is the process of increasing the image visibility. It includes sharpening of image features such as contrast or edge preservation, etc. The image enhancement process does not change the information of the image which includes grey scale, contrast information, etc. Image enhancement only uses the qualitative approach to create visually enhanced images, while not changing the physical model of the image.

Image restoration is the process of restoring the features of degraded image. It deals with minimizing the effect of image degradation. To obtain better image restoration having a prior knowledge on the object in question can be useful.

Scientist are keen to explore the details underwater, but the research shows various challenges faced in obtaining quality underwater images. This paper describes the various challenges faced in underwater image enhancement technology. The paper is organized as follows. Section 2 deals with the

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various problem faced by underwater images and the techniques used in overcoming the challenges. Section 3 concludes the paper.

II. LITERATURE REVIEW

Back scattering of light is another major problem that faced by the underwater images. The light that travel through the water is reflected not only by the target object but also by the suspended particles that is present in the water. These phenomenon increases the noise present in the underwater images.

Light that travel through the sea water varies greatly depend upon the structure of the sea. When light when travel through the sea water whether it diffuses or it makes some crinkle pattern. Importantly the quality of the water controls the quality of the underwater images.

Haze is the one of the problem that affects the underwater images. Haze in the images is occurred by the dust particles that are suspended in water. The haze particles in water reduces the picture quality.

Contrast of the underwater images are very low due to attenuation of the light that travels through water medium has several problems. Therefore the objects in the images cannot be differentiated from background. Hence Contrast and color is another problem in underwater images.

Color casting is another problem in underwater images. To improve the image quality we use white balancing. Most of the time white balancing is done by color constancy hypothesis.

Most of the time underwater images suffers from scattering and light absorption. Hence one color in the image dominates the entire image. Hence the true color of the image should be retrieved to overcome the problem of lighting.

Due to light scattering and light distortion the light falls on the water get reflected and deflected by the suspended particles in the water. Finally the bluish tone of the underwater images get dominated. Luminance adjustment need to be done to the underwater images to get the high quality images.

The following section of the paper discusses about the various problem and the corresponding solution for the problem.

2.1. Hazing

Underwater images has lots of suspended particles in it. And these suspended particles are called haze particles. When these haze particles suspended in water then the quality of the image reduced. In order to overcome the problem bilateral filter is used. The Bilateral filter [28,29] smoothes the edges of the various objects that present in underwater image. The method is simple , non-iterative and local . This method combines colors or grey levels based on their geometric location or photometric similarity. In general filters operate on three bands of color image but a bilateral filter enforces the perceptual metric in CIE lab color and preserves the image edges and smooth the colors of the image that is tuned to human eye. Bilateral filter is the combination of the domain filter and the range filter. The combined filtering can be explained as the following equation

$$h(x) = k^{-1}(x) \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(\varepsilon)\ (\varepsilon, x) s\big(f(\varepsilon), f(x)\big) d\varepsilon \qquad (1)$$

with the normalization given by

$$k(x) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} c(\varepsilon, x), s\big(f(\varepsilon), f(x)\big) d\varepsilon \qquad (2)$$

Where $c(\varepsilon, x)$ measures the geometric closeness of the neighborhood center x and near by point ε . With the help of bilateral filter the edges of the image is preserved. Bilateral filters are harder to understand and analyze because of the non linear feature.

Bilateral filter used to smooth the image but in order to avoid over smoothing of structures in the images narrow spatial window is used which leads to performing more number of iterations in the process.

Joint Trilateral Filter is proposed to overcome the gradient reversal artifacts occurred in images. JTF is done under the guidance image G where G can be reference image or input image. Let us consider I_p *and* G_p be the intensity of the pixel p of the guided input image and W_k be the kernal window at pixel k. The JTF is given by

$$\text{JTF}(I)_p = \frac{1}{\sum_{q \in w_k} W_{JTF_{pq}}(G)} \sum_{q \in w_k} W_{JTF_{pq}}(G)\, I_q \qquad (3)$$

Besides the trilateral filter smoothes the edges of the structure in the image the joint trilateral filter can remove the overly dark fields of the underwater images by refining the transmission depth map through trilateral filtered source image and estimated transmission depth map.

E. *Hung-Yu Yang et al* in [31] proposed an underwater image enhancement method based on dark channel prior.

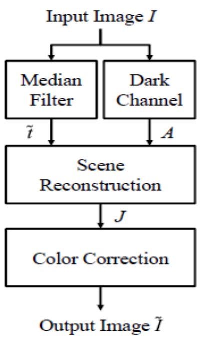

Fig 1 : Flow Chart of dark channel prior method

Here in this method we use median filter directly for the image to get the smoothed transmission $t^{\sim}(x)$. The transmission equation is given by

$$t^{\sim}(x) = 1 - min_c\,(median_{y\,\in\psi(x)}\,\frac{I_c(y)}{A_c}) \qquad (4)$$

A is the atmospheric light . The color adjustment technology is used to achieve the good quality images. To equalize the RGB value the average values of RGB is calculated as follows

$$R_{avg} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} I_r(i,j)}{MXN} \qquad (5)$$

$$G_{avg} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} I_g(i,j)}{MXN} \qquad (6)$$

$$B_{avg} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} I_b(i,j)}{MXN} \qquad (7)$$

Where M and N are the size of the image. I_r, I_g, I_b are the red, green, blue components of the images respectively. In this method median filter is used to observe the input image. Also in order to increase the color quality the color enhancement process also done. Therefore the visual quality of the image increased. But the scheme is lack of transmission map estimation. Since the underwater image, the red hue of the range is absorbed by the particles in large amount. The histogram of DCP is very near to histogram of blue channel. The lack of red in the spectrum causes the incorrect judgment of dark channel prior.

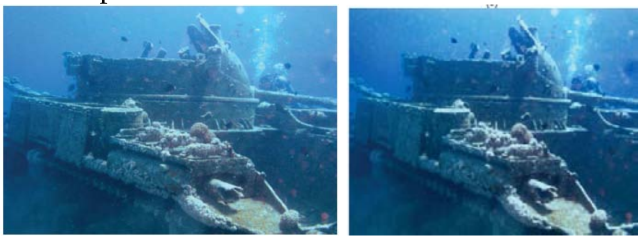

Fig2 :(a) Input image (b) Output Image of DCP

F. P. Drews-Jr et al proposed a method called Underwater dark channel prior [32] . This method is also called as UDCP. Generally blue and the green are the two basic colors of the underwater images which provide the visual information of the objects that present in the underwater. The formal decryption for DCP [32] to create the haze free images is

$$J^{dark}(x) = min_{y\in\Omega(x)}(_{c\in R,G,B}J^c(y)) \quad (8)$$

Here J^c is the scene radiance of each color and $\Omega(x)$ is the local patch centered at x. With the help of this model we can say that J is the haze free image. DCP is fast and very intuitive method. But it is limited for underwater images since it is not

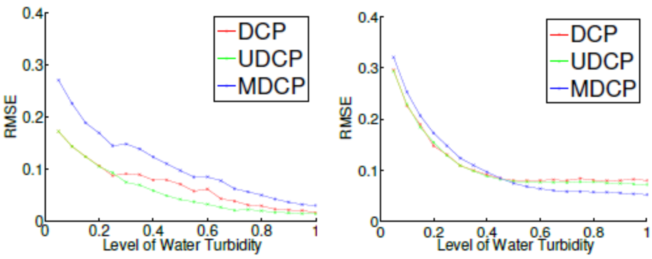

Fig3 : Quantitative evaluation the transmission estimation

always true. The estimation may go wrong due to high absorption rate. Therefore UDCP [32] gives the significant result for underwater images. It produces good result even for the images which get failed in other methods.

G. *Haocheng Wen et al* in [33] proposed algorithm to find the scattering rate, to find the background light in optical model. The model that is used to describe the formation of a haze image is given

$$I(x) = J(x).t(x) + A(1 - t(x)) \quad (9)$$

Where, I is the intensity observed,
J is the scene radiance,
A is the global atmospheric light ,

t is the transmission map.

The background light can be estimated as follows

$$p = \arg min_x (I^{dark(r)}(x) - \max(I^{dark(b)}(x), I^{dark(g)}(x))) \quad (10)$$

Where p=(i,j) is the pixel location.

The scattering rate can be calculated using the following formula

$$t_\alpha^\sim(x) = min_{c\in\{b,g\}}(min_{y\in\Omega(x)}\left(\frac{I^c(y)}{B^c}\right)) \quad (11)$$

$min_{c\in\{b,g\}}(min_{y\in\Omega(x)}\left(\frac{I^c(y)}{B^c}\right))$ is the dark channel image of the normalized underwater image $\left(\frac{I(y)}{B^c}\right)$.

The transmission estimation can be estimated as follows,

$$t_\beta^{\sim b}(x) = t_\beta^{\sim g}(x) = 1 - t_\alpha^\sim(x) \quad (12)$$

This method author employed light attenuation difference based technique to find the background light of underwater image. But in this method author does not focus on color and noise distortion issue.

Fig 5 : (a) Input Image (b) Output Image of scattering Method

Huimin Lu et al in [35, 36] has presented a method to enhance the shallow underwater images with the help of optical images with median filter and wavelength characteristics.

Scattering, color alteration and absorption are the most important deformation issues for underwater image system. When light rays travel through the water it get scattered depending upon the wavelength. Scattering is occurred by suspended particles that causes the degradation of images. The author proposed a new model shallow water that reimburse for the attenuation inconsistency along the propagation path. In this method author ignored the approach to correct the vignette effects under non-uniform illumination circumstance.

The authors Manpreet Kaur Saggu and Satbir Singh in [37] have used Contrast limited adaptive histogram equalization (CLAHE) and Mixture contrast limited adaptive histogram equalization (Mix-CLAHE) methods. The authors have fused CLAHE on RGB and similarly fused CLAHE on HSV color models and have combined both the results and compared it with Mix-CLAHE. The authors claim that Mix-CLAHE has better results compared to CLAHE on RGB fusion and CLAHE on HSV fusion, by using image quality metics like Peak Signal to noise ratio (PSNR), bit error rate (BER), Structural Similarity (SSIM) index to validate their claim.

[10] Xiu Li , et all proposed a novel dark channel prior method for the underwater images. The dark channel J(x) of the underwater image is given by

$$J_{dark}(x) = min_{y\in\Omega(x)}(min_{c\in\{r,g,b\}} J_c(y)) \quad (13)$$

The dark channel is mainly created by colorful objects , dark objects or surfaces and shadows. In this method first normalize the haze images. As the second step take the min operation among the three channels in a local patch on normalized function and the transmission map is estimated as follows

$$t^{\sim}(x) = 1 - min_{y\,\in\Omega(x)}\left(min_c \frac{I^c(y)}{A^c}\right) \quad (14)$$

With this approach the author proposed a new image contrast enhanced image which is de-hazed based on dark channel prior. the experimental result verifies that this method is better than the state of art algorithms.

Fig 7 : (a) Input Image (b) Output Image

[4] John Y. Chiang et all proposed an algorithm to dehaze the image that are taken underwater called wavelength compensation (WCID). In this algorithm the distance between camera and object are estimated using dark channel prior, the haze that present in the image is removed by using dehazing algorithm. Once after the depth of the scene is found, from the residual energy ratios of each wavelength in the image is calculated. Reverse compensation is predicted to restore the distortion from the color cast.

Fig 8: (a) Input Image (b) Output image WCID

WCID algorithm[34] removes the haze from the image effectively and restores the color of the image but accurate estimation of rate of energy attenuation is problematic. Also the value of luminance also difficult to estimate.

2.2.Contrast Correction:

The clarity of the image greatly reduced by scattering and light absorption [8]. Therefore one color greatly dominate the image. Hence we need to correct the contrast of the image to overcome this problem. Author Kashif Iqbal, et al., in [3,25] proposes a method which is done in two folding. As the first step the contrast stretching of RGB algorithm is applied to equalize color of the image. To get the good quality images we have to correct the contrast to equal color values of the RGB components. Let us consider $I_r(i,j), I_g(i,j), I_b(i,j)$ be the red, green, blue components of RGB image of size MXN pixels. The maximum pixel components of R,G,B can be calculated as

$$R_{max} = max_{i,j} \quad I_r(i,j) \quad (15)$$

$$G_{max} = max_{i,j} \quad I_g(i,j) \quad (16)$$

$$B_{max} = max_{i,j} \quad I_b(i,j) \quad (17)$$

Maximum color component is found using the above steps. The average values of the color component is found using the below equations.

$$R_{avg} = \frac{1}{MN}\sum_{i=1}^{M}\sum_{i=1}^{N} I_r(i,j) \qquad (18)$$

$$G_{avg} = \frac{1}{MN}\sum_{i=1}^{M}\sum_{i=1}^{N} I_g(i,j) \qquad (19)$$

$$B_{avg} = \frac{1}{MN}\sum_{i=1}^{M}\sum_{i=1}^{N} I_b(i,j) \qquad (20)$$

The underwater image has predominately blue color . Hence high values are used to increase the other color in the image so that the other colors get balanced in image. With the help of the dominant color we can calculate the gain factors as follows

$$A = \frac{B_{avg}}{R_{avg}} \qquad (21)$$

$$B = \frac{B_{avg}}{G_{avg}} \qquad (22)$$

With the help of contrast correction method red component of the image is increased and blue component of the image is reduced and the contrast of the image is greatly equalized. One of the problem with this method is that the range of pixel values lies between 0-255. And the outlying pixel has high or low value that may affect the quality of the image. And this problem can be overcome with the help of clipping. That is can cut off the pixel values from the both sides of the histogram. Therefore the image can be enhances by clipping the pixel values within the range 0.2% to 99.8%.
ICM [8] and UCM produces highly improved image by enhancing the contrast but it gives images with noise and low quality.
Kashif Iqbal et all. In [3] Proposed a method for contrast correction. In this method normalization is used to find the maximum and the minimum values in the histogram and stretch the values within a range. The problem with this method is single outlying pixel having too low or high value effect the image quality badly.

Authors Ahmad Shahrizan Abdul Ghania, Nor Ashidi Mat Isab, in [9] proposed a new method for contrast stretching. In contrast method the image is applied within certain range. In this method the output image is limited instead of limiting the input image. Normally for the underwater images red and blue color are the lowest and the highest intensity color channels. Therefore the histogram stretching is done for only one side. For the red color channel the minimum stretching point of the output image is set to the minimum intensity level of the original histogram. Mathematically it can be represented as

$$O_{r,min} = \begin{cases} i_{r,min}, & i_{r,min} > 5\% \text{ of } I \\ 5\% \text{ of } I, & Otherwise \end{cases} \qquad (23)$$

Hence the image contrast is increased with the help of applying histogram stretching to the image channel. Whereas the intensity level of output image is limited to 5% of the minimum and maximum limits in the proposed method. In this method histogram modification of integrated HSV and RGB color models are used. The pixel distribution is designed to use Rayleigh distribution. The same technique is used in HSV color model, this model reduces the effect of over enhanced and under enhanced image. And the noise of the input image is reduced significantly. The effect of green and blue illumination in underwater images also reduced significantly. Thus the visibility of the objects in the underwater images get increased.

In [5] Miao Yang has conducted a few experiments to evaluate the quality metrics based on the discriminator environment of underwater images. With the slope of the log-contrast power spectrum we can verify that the patch based mean underwater image quality metric can find the sharpness and blurriness of the underwater images.
In paper [19] the author reveals about various techniques that are used to enhance the underwater image. Image processing on underwater images helps us to identify objects in underwater images. Whereas lot of work has been carried out to improve the image but only limited work has been done in enhancement field. Histogram equalization is one of the well-known image enhancement technique that used to enhance the contrast of the image. Also it is easier and simplest method when compared to all other technique.

Muhammad Suzuri Hitam et all. In [26] has presented a method called mixture Contrast Limited Adaptive Histogram Equalization (CLAHE). This method operates on RGB and HSV color models and give result on Euclidean norm. CLAHE on RGB color model is given by

$$R = \int_{300}^{830} S(\gamma)R(\gamma)\,d\gamma \qquad (24)$$

$$G = \int_{300}^{830} S(\gamma)G(\gamma)\,d\gamma \qquad (25)$$

$$B = \int_{300}^{830} S(\gamma)B(\gamma)\,d\gamma \qquad (26)$$

Where $S(\gamma)$ is the light spectrum, $R(\gamma), G(\gamma), B(\gamma)$ are the sensitivity functions for R, G and B sensors respectively. CLAHE on HSV color model. HSV model takes RGB components in the range of [0 1]. The maximum value of RGB can be calculated as

$$V = \max(R, G, B) \qquad (27)$$

To calculate hue value first we need to calculate R',G',B'.

$$R' = \frac{V - R}{V - \min(R,G,B)} \qquad (28)$$

$$G' = \frac{V - G}{V - \min(R,G,B)} \qquad (29)$$

$$B' = \frac{V - B}{V - \min(R,G,B)} \qquad (30)$$

Hue can be calculated as

$$H = \begin{cases} 5 + B' & R = max\ (R,G,B) and\ G = \min(R,G,B) \\ 1 - G' & R = \max(R,G,B)\ and\ G \neq \min(R,G,B) \\ R' + 1 & G = \max(R,G,B)\ and\ B = min(R,G,B) \\ 3 - B' & G = \max(R,G,B) and\ B \neq \min(R,G,B) \\ 3 + G'B = \max(R,G,B) & \\ 5 - R' & Otherwise \end{cases} \qquad (31)$$

Thus this method enhance underwater image using mixture Contrast Limited Adaptive Histogram Equalization . This method enhances the image with lowest MSE value and highest PSNR values.

Naim and Isa (2012) proposed a method [24] to do the color correction process called pixel distribution shifting color correction (PDSCC) . This method is designed by shifting the pixel value. This is done with the help of moving the pixel values diagonal plane of the 3D RGB color model. 3D rotational method is used due to its simplicity and easy to use. 3D pixel distribution is rotated three times using three different rotation angles. The process of shifting is done on 2D two color channel plane instead of on 3D RGB color model. And the 2D color plane is designed from 3D RGB color model called red green plane, red blue plane and green blue plane. This process could assures illumination pixel distribution to be achromatic. This method corrects the image color and helps to appear the image to be more clear and natural.

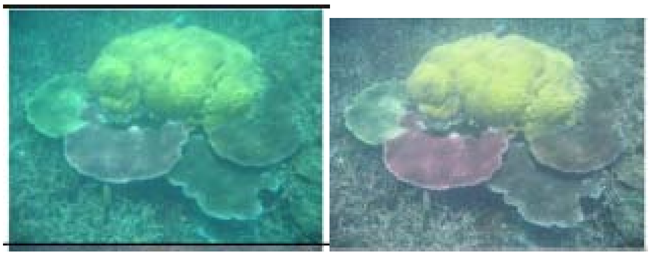

Fig 11 : (a) original image (b) Corrected

The image that we get from PDSCC gives good Mean Square Error and PSNR values. On the other hand contrast of the image is not greatly increased. The blue green pigmentation of the image remains same in this method. To overcome the above problem contrast stretching is used. [8] RGB algorithm is used to equalize the color in the images.

A.Parameshwari and M.V Srinath in [11] has proposed a method to enhance the quality of underwater image in both frequency and spatial domain. They proposed a system in two level they are by noise removal followed by RGB intensity equalization.

This method gives the better resolution of underwater images than the existing system the PSNR values that obtained using this method is as follows,

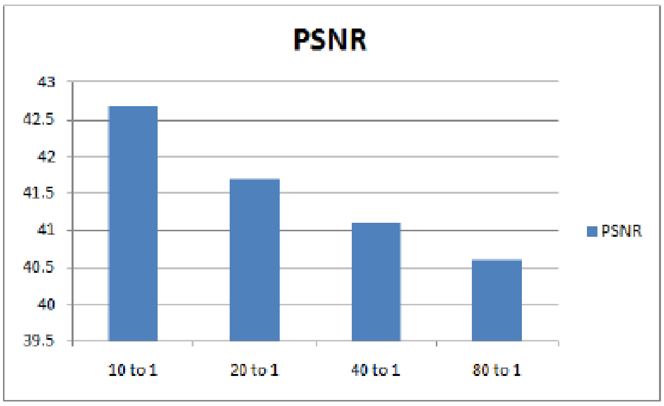

Fig 13 : PSNR values the system

2.3. Color Cast:

Color cast is the tint of one particular color which effects the whole image. The color casting is done by equalizing the color value. The dominant color cast is chosen generally in underwater images blue color is the predominant color to adjust the blue color cast we apply contrast correction method on the minimum side to reduce the blue color cast.

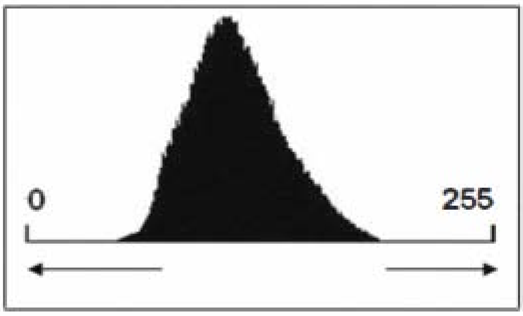

Fig 14 : Contrast correction in

The contrast correction method [3] is given by
(Upper Limit - Lower Limit) / (Maximum - Minimum) and it is changed by (Maximum of Blue - Lower Limit) / (Maximum - Minimum) the lower limit is Zero and the upper limit is maximum of blue color. Contrast correction method plays an important role in image enhancement techniques with the help of this method the blue color cast of the underwater image is decreased to the minimum and the red color cast of the underwater image is increased. Blue and red are the two colors that effect the underwater images which can be highly equalized using this contrast stretching. Therefore the quality of the image gets increased. The system uses two color channels to reduce the color cast. So in order to adjust the image [3]Von Kries proposes a method to balance the image is given by

$$R' = A \times R \quad (32)$$

$$G' = B \times G \quad (33)$$

Where R and G are the exact pixel values in the image and R' and G' are the adjusted pixel values of the image.

[23] White balancing is one of the technique that is used to enhance image quality. [23] Varsha chikane proposed method for white balancing. This can be done in three steps white object purification, white point detection, and white point adjustment.

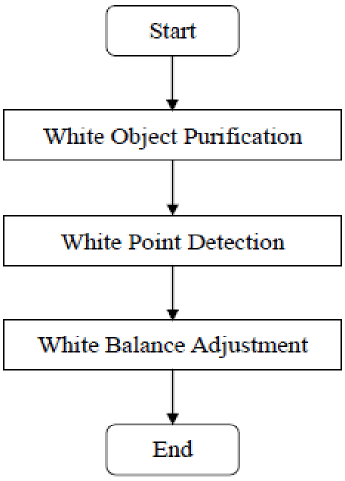

Fig 15 :Flow Chart of the white balancing

White object purification is done by purifying the white object by removing the color cast on the white object. To find the white point detection follow the given flow chart .The white balance is done later. This method works well under all possible conditions. The white object purification step the method finds the white object successfully with any color cast with any source of light.

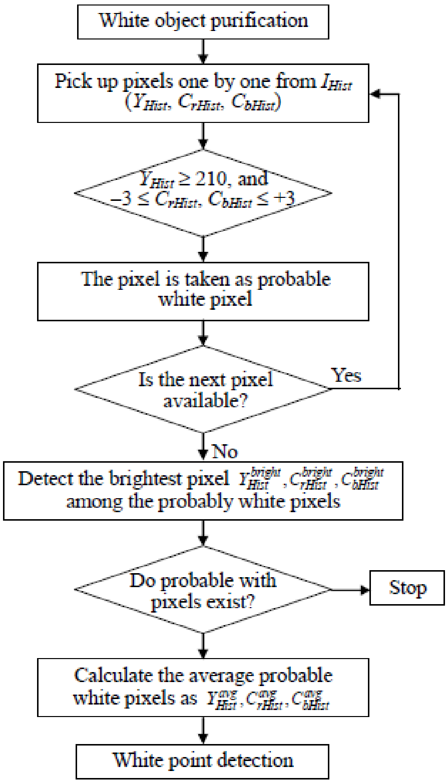

Fig16 : Flow Chart for white point detection

When light falls on water surface gets scattered and distorted. Therefore one color of the image gets scattered through the entire image. In order to increase the true color of the image the slide stretching method [25] is used. As the first step the contrast stretching is done using the RGB algorithm followed by saturation and intensity stretching of HSI which is used to increase the true color the image. Therefore by increasing the true color the pleasant visualization of the image can be obtained. The saturation and the intensity of an element produce a wide range of colors. The contrast stretching is done with the help of the following formula[25] . Each pixel is scaled using the following formula

$$P_o = (P_i - c) \times (b - c) / (d - c) + a \qquad (34)$$

Where

P_o is the normalized pixel value;

P_i is the considered pixel value

a is the minimum pixel value of the desired range

b is the maximum pixel value of the desired range

c is the lowest pixel value currently present in the image.

d is the highest pixel value present in the image.

In this algorithm[25] each pixel is scaled with the same scale value therefore the color of the image is maintained. In the second step the RGB image is converted to HSI image by using saturation and the intensity the true color of the image is increased.

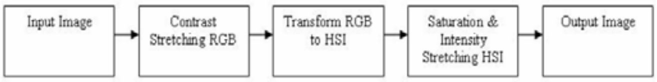

Fig 17 : Steps to increase the true color of the

With the help of the transform function we can stretch intensity and the saturation of the image. The HIS model[25] helps to solve the lighting problem of the image.

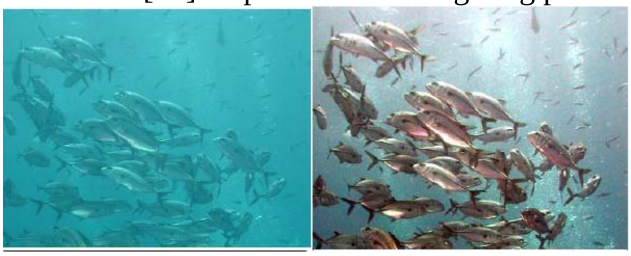

Fig 18 : (a) Original image (b) Image after Enhancement

2.4.Luminance Adjustment:

When light falls on water it gets reflected and deflected by many particles that are suspended on the surface of the water the luminance of the image greatly reduces and the image clarity also affected by this reflection so we need to adjust the luminance of the image . [27]Eustice et al. proposed a method to adjust contrast and luminance of the image called contrast limited adaptive histogram specification (CLAHS) . The basic idea behind the method[27] is to divide the original image into equal contextual regions. Then each divided region is histogram equalized by monotonically non decreasing grey level transform g=T|f| which maps each grey level histogram to ideal grey level distribution. Fourier based method for scale rotation and translation recovery gives robustness against the dissimilar image regions.

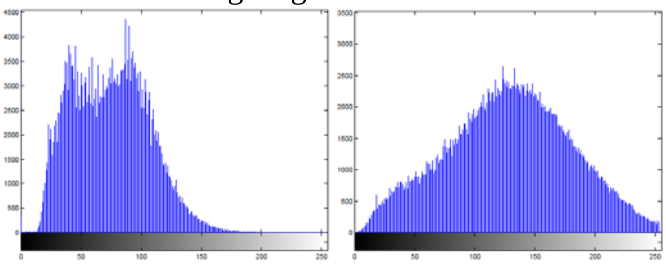

Fig 19 : (a) Histogram before enhancement (b) Histogram after

The main drawback of the method is that it cannot be done automatically since it need few parameters depending upon the image characteristics. This method increases the quality of the image but also reduces the color performance of the image. Also some noise might remain in the image. To overcome this problem once enhancement is done in this method one can apply saturation and intensity stretching using HSI to increase the color quality of the image.

Authors Sonali and Shraddha in [30] have used maximum likelihood Estimation Method in order to remove non-uniform illumination in a color image. In their paper they have each estimated θML for individual R,G,B channels and have proceeded by applying Histogram stretching to each channel with respect to Rayleigh distribution by using estimated value θML. The authors in order to validate their work, have used the average contrast (AC), average information entropy (AIE), and average luminance (AL). The results obtained in the paper are compared with histogram equalization (HE), adaptive histogram equalization (AHE), and homomorphic filter. The results obtained shows that the proposed algorithm gives better results than the existing.

[10] Xiu Li et all utilized the luminance adjustment to equalize the non-uniform illumination to preserve edges and image details. Hence therefore the output image that is obtained using this method has more quality when compared to all other methods.

Rafael Garcia et all presents a method to solve lighting problem in underwater image. Due to absorption and scattering effects of light in water we need artificial source of light. [30] proposes a system that deals with illumination - reflectance model, histogram equalization, homomorphic filtering and subtraction of illumination field. The reflectance of a scene is given by

$$f(x,y)=i(x,y).r(x,y) \quad (35)$$

where f(x,y) is the image captured by camera, r(x,y) is the reflectance function and i(x,y) is the illumination multiplicative. The image captured is smoothened point by point and gives raise to the ideal image

$$r^{\sim}(x,y) = \frac{f(x,y)}{f_s(x,y)}\delta \quad (36)$$

Where δ is the normalization constant of the image luminance.

Similarly we can perform homomorphic filtering followed by subtraction of illumination field to get the enhanced image the subtracted image can be acquired as,

$$r^{\sim}(x,y) = f(x,y) - \emptyset(x,y) + \delta \quad (37)$$

Where δ is the normalization constant which need to be adjusted to get the desired luminance.

[17] Manon et all presented due to lighting conditions and halo effects the light is non-uniformly distributed so in order to void these problem author proposed homomorphic filtering. Lighting effect correction is done with the help of histogram equalization method. It is well known method to equally represent each gray value to make the image histogram flat. Homomorphic filtering is done and parameters qualitatively noticed each time. The filter gives good visual quality and satisfying result respectively.

In [18] authors Sonali Sachin Sankpal and Shraddha Sunil Deshpande , suggested a method for non-uniform illumination correction for underwater images. Author used maximum likelihood estimation of scale parameter to map distribution of image to Rayleigh distribution. The flow of the system is given in the figure. The input image is divided into three channels red, blue, green . By assuming that R, G, B Channel is Rayleigh distributed histogram stretching is done. Histogram stretching is done with respect to the Rayleigh distribution. The histogram stretching corresponding to each color is given by

$$i_{out} = i_{min} + \left[2 * \alpha^2 * In\left(\frac{1}{p_{i(i)}}\right)\right]^{1/2} \quad (38)$$

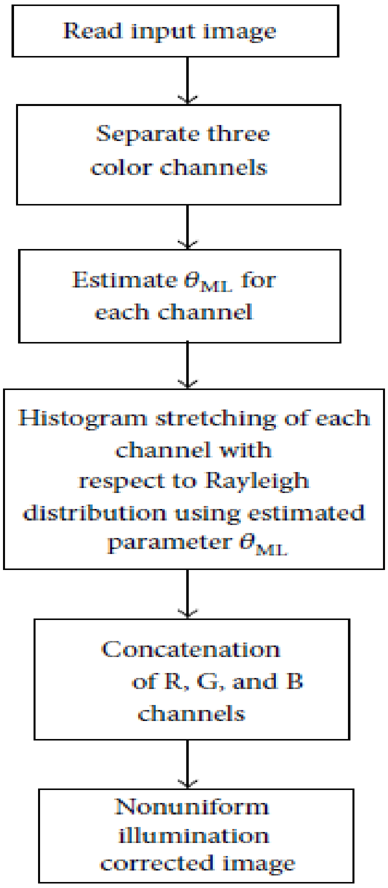

Fig 20 : Flow of the system

This method is used to correct the non-uniform illumination in underwater images which effects the overall contrast of the image. This method shows the enhancement of quality of the image with the help of quality metrics. But there exist a small degradation in average luminance when compared to the traditional methods. Whereas degradation is very small when compared to the quality of the resultant image.

III. CONCLUSION

In this paper we have discussed about various problems that occurs in obtaining quality underwater images .and the methods to overcome the problems are discussed. A detailed review on various methods proposed by various authors, in order to efficiently remove hazing, color cast, contrast correction, true color and luminance adjustment, etc. are elaborated in this paper. The performance of the method are also discussed in the paper , the merits and demerits of the methods are discussed. And other possible methods to overcome the demerits of the same are also discussed in the above sections.

In this paper we discussed about hazing, which is caused by the suspended particles present in the underwater images. Bilateral filters are used in paper [28,29] to preserve the object edges and to remove the haze in the image. But with this methods number of iterations increases. Hence trilateral method and joint trilateral methods are used to dehaze the image which is used to remove the overly dark fields of the underwater images. Dark Channel Prior method is used for dehazing the image in which the median filters are used, so that the image is smoothly dehazed. But the method lacks transmission map estimation. UDCP method is used to overcome DCP method's disadvantage.

Wavelength of the image is not estimated and corrected so we go for WCID method. In WCID method the dehazing is done using DCP algorithm followed by WCID method by which the wavelength is estimated correctly.

Similarly the contrast of the image is not clear in case of underwater images. Kashif Iqbal proposes ICM method to produce images with increased image resolution but it also produces images with high noise. Kashif Iqbal proposes UCM for contrast correction, Normalization is done that is within the histogram value the contrast is stretched. Later the patch based method is used to find the blurriness and sharpness of the image based on the information the contrast of the image is corrected. CLAHE method is used for the contrast correction. This method gives images with lowest MSE and PSNR values. The color of the image that obtained directly from the underwater images are not so clear so the color of the image need to be corrected.

PDSCC method is used in color correction. In this method pixel shifting procedure is used and it gives good MSE and PSNR values. Another method is proposed which is done by RGB algorithm followed by noise removal algorithm.

Color casting is done by white balancing method. This can be done in three steps white object purification, white point detection, and white point adjustment. Light get scattered and distorted when it falls on the underwater images in order to get the true color of the image we follow slide stretching method. With the help of the method light of the image is also rectified so that true color of the image is obtained to get the clear image.

Luminance of the image plays a great role in the clarity of the image to in order to handle luminance of the image CLAHS method is used. This method used HSI of the image to increase the quality of the image. Later proposed a method to the luminance correction in this method homomorphic filtering is used which subtracts the luminance of the image. We have also discussed a collection various algorithms from various authors to adjust the non-uniform lighting including.

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