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Underwater Image Enhancement using Conventional Techniques with Quality Metrics

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Abstract: Image enhancement is a widely used technique to increase the quality of an image. In this process the intensity levels are gradually increased in an image or parts of an image, results a quality image compared with the image captured at image acquisition process. These techniques are helpful to detect the edges or patterns present in the input images, used in different applications such as computer vision, medical imaging, underwater imaging and other multimedia applications to detect the objects or patterns in a given input image. Due to the degradation of color, light absorption and scattering, artificial light, suspended particles in underwater, the acquired images are having low contrast or very dim in color and causes only one color to dominate the entire image. Hence, the identification of the objects in the underwater image becomes tricky. After the image acquisition, preprocessing step is must to increase the quality of the degraded images for image processing and underwater or marine applications. This paper included numerous underwater image enhancement techniques developed in the recent years along with the limitations and challenges in it.

Index Terms: Underwater Image enhancement, Histogram equalization, AHE, CLAHE, Dark Channel Prior

I. INTRODUCTION

Underwater images are hampered by poor contrast, color change, suspended and floating particles. Particularly with cameras mounted on ROV and AUV systems has widespread in civil and military applications [1]. The processing and analysis of underwater images is nontrivial in ocean engineering and many other scientific applications. The quality of underwater images is important in many applications such as inspection of plants, Sea based exploration, search of wrecks up to the exploration of natural sources and geological and biological fields. The broad issue in ocean engineering is acquiring the clear images in underwater environment. Capturing of underwater images is a great challenging task compared to terrestrial images, because of the haze caused by light that is reflected from the surface and is deflected and also diverted by several water particles. Different wave lengths of light cause various degrees of attenuation and the most visible color in the water is blue. Subsequently, with light scattering and deviation of color leads to the contrast loss in the captured images.

Image enhancement is a technique, used to increase the quality of an image by increasing the intensity levels of the image or parts of the image so that the resultant image should be clearer compared to the captured image and hence, used for display or further image analysis.

This process will not increase the intrinsic information of the image. This includes manipulation in the gray level and contrast, removing the noise, sharpening the object regions, filtering, and color correction and so on [2].Several image enhancement techniques such as histogram equalization, filtering with morphological operators, linear contrast adjustment, median filtering are exist. Histogram equalization (HE) is a widely used spatial domain technique used to increase the contrast for a given image using the histograms of it. This method is more appropriate for the images which are having less contrast; otherwise the outcome of this method is worse. When a person takes a photo in foggy climate conditions, the procured picture endures with poor visual quality as a matter of course. The objects that are far from the camera can lose the contrast and once in a while get obscured with their environment. Dark channel prior method can produce a natural haze free image. It is mainly used for removing the haze that exists in the outdoor images. The working principle of DCP is that in the non-sky region of the input image, at least one color channel contains low intensities at some pixels.

Background

Several image processing operations are applied on the images to increase the quality or to extract important features or patterns from the given input image. It is identical to signal processing, in which the input is image and output is also an image or portions of the image. In broad, there are mainly three stages incorporated in any image processing application i.e. image acquisition, process the image, getting the desired output.

The ultimate goal of computer vision or image processing application is to build up a software system or tool that can perform different sorts of processing techniques for the given image. This digital system will take the input as the digital image and process it by various image processing algorithms and produce the required output. In Figure 1, we have shown a simple image processing technique i.e. rotation of an input image with an angle of 180^0. At first, the image is captured by a camera and it will be sent to the Digital Image Processing (DIP) System. The image processing operation applied here is rotation, change the direction of the image with the given input angle. The DIP System includes many stages such as preprocessing, digitization, image enhancement and restoration, image segmentation, feature extraction, image representation and interpretation. Among these stages image enhancement and restoration holds a vital role.

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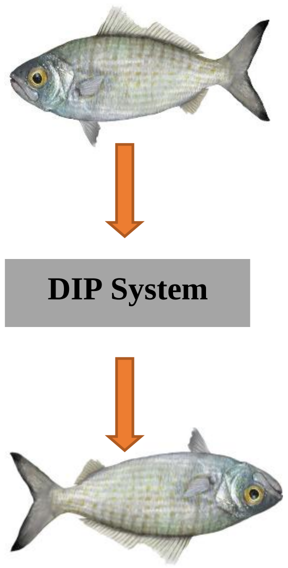


Fig. 1 Conventional DIP Tool

The rest of the paper is sorted out in five sections. Section 2 is the brief study of underwater image enhancement and its applications. Section 3 describes the experimental study of various image enhancement techniques. Section 4 describes the recent work on underwater image enhancement and the quality measures along with the research gaps in the literature. Section 5 concludes the paper.

II. IMAGE ENHANCEMENT

In this section, we presented the outline of image enhancement techniques in DIP System. In short, Enhancement implies that improving the intensity values to get the clear illustration of the image for the viewers or to the subsequent stages of image processing algorithms. It sharpens the features that are present in the image such as contrast, boundaries and edges etc. that makes the graphical appearance of the image to be clear. Image enhancement does not mean that it increase the content of the image. There exists numerous image enhancement techniques, all of these techniques are classified by any one of these two categories i.e. spatial domain and frequency domain. In *Spatial domain enhancement* methods all the operations are performed within the image plane itself and the manipulation of pixel values are directly applied to input pixels. Consider an Image I(x, y), the transformation will be applied directly on I(x, y) itself. This transformation function is shown in equation (1) to get the desired result.

$$O(x, y) = T[I(x, y)] \quad (1)$$

Here, I(x, y) is a two dimensional input image, O(x, y) is the transformed two dimensional image after applying the transformation 'T' on I(x, y). Further, these techniques are classified as point processing methods, i.e. image negatives, log transformations and spatial operations, i.e. smoothing, sharpening etc. Second, *Frequency domain enhancement* methods converts the input image in to frequency domain. All the operations are applied in the frequency domain and converted back to the spatial domain to get the final result. The methods of these category are out of the scope in this paper, and mainly focused on the spatial domain methods.

What happens in underwater?

In the recent years, Underwater Image Processing (UIP) has become an interesting and challenging research area in the field of computer vision. After thought of the fundamental physics of the light propagation in underwater medium, several authors concentrated on the diverse techniques to upgrade the natural quality of the underwater image. A noteworthy issue with the underwater images is *light attenuation*. It constraints the visibility at around 20 meters in the clear water and 5 meters or less in turbid water. Figure 2, shows the solar spectrum filtered through water. Absorption and scattering are the major reasons for light attenuations. Suspended particles present in the water, plaque and other dark segmented regions are the main cause to get the absorption. The general solutions for light attenuation is connecting a light source to the vehicle or to the diver who captures the image in underwater. Unfortunately, manufactured lights have a tendency to enlighten the scene in a non-uniform design produce more light in the center and poor illumination at the surroundings of the image.

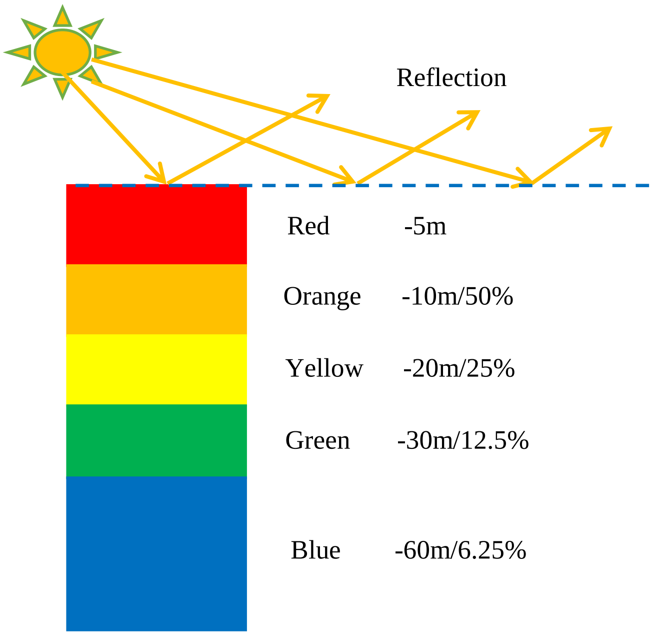


Fig. 2 Solar Spectrum filtered through water

Applications of UIP

Drinking water reservoir and in many other underwater infrastructure installations are usually inspected visually or manually by divers. The problem with this approach is, it is dangerous, costly, time consuming process and does not often enable a full assessment. All of these methods are camera based inspection. Underwater imaging has many applications such as inspection of plants, sea based exploration, search of wrecks up to the exploration of natural sources.

However, capturing the images in underwater brings several technical challenges with the design of camera system, lightings and several image processing methods. Mostly the cameras failed as consequence of less contrast, visibility in underwater due to suspended particles, light scattering, absorption, and light reflection. Therefore it is very important to design a new sophisticated image enhancement and processing techniques. UIP is used in seismic monitoring, detection and tracking of marine objects, 3D mapping system and in other underwater vision applications. It is also used in underwater optical imaging, vision based navigation and mosaicking and other underwater multimedia systems. The main challenges in underwater imaging is that develop novel and efficient restoration methods with high quality and increasing the significance of the image, methods of dynamic lighting and image fusion, full inspection of objects with quality output in underwater are becoming a challenging and interesting to do the research in this area [4].

III. EXPERIMENTAL WORK

In this section, we presented the methods available for enhancing the quality of an image under water.

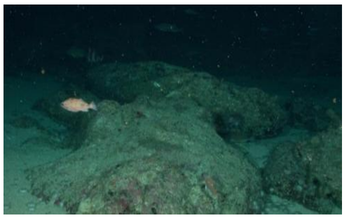
Noise Filtering

Filtering is the process of removing noise exists in the captured image. The noise may occurred in image acquisition process due to different weather, environmental conditions, the hardware problems in the image capturing device yields some pixel values different from the true intensities in the captured image. The variation of these pixels are considered to be noise and there exist several methods to eliminate it. For example noise removal using average filter, linear filter and by using un-sharp masking. Noise removal is the first step in any image processing application. Figure 3, shows the most commonly used noise removal techniques for an underwater image. The results of average filter, Gaussian filter and median filters are shown in Figure 3.b, Figure 3.c and Figure 3.d respectively (for Figure 3.a.). We have taken the kernel size as 3 X3, the results may vary for other kernels with size 9X9 and 15X15.

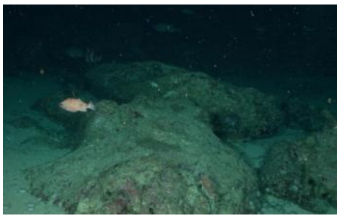
Histogram Sliding

Histogram, the graphical representation of the intensity distribution of an image. Histogram Sliding is the basic method to increase or to manipulate the brightness of an image. The complete histogram is shifted towards to the left position or right position. Due to this sliding of the histogram towards left or right, there will be a significant change observed in the original image. Consider a 4X4 image having 16 pixels (Figure 4.a.), to increase the brightness, say 10 points, then we add 10 to each pixel value in the input image and the resultant image is shown in Figure 4.b. Only the first row and first column pixel values are highlighted. Figure 4.c denotes the variation of pixels at different levels. The green line depicts the input pixels and the line above that are

a. Input image with noise



b. Result of 3X3 average filter



c. Result of 3X3 Gaussian filter

d. Result of 3X3 median filter

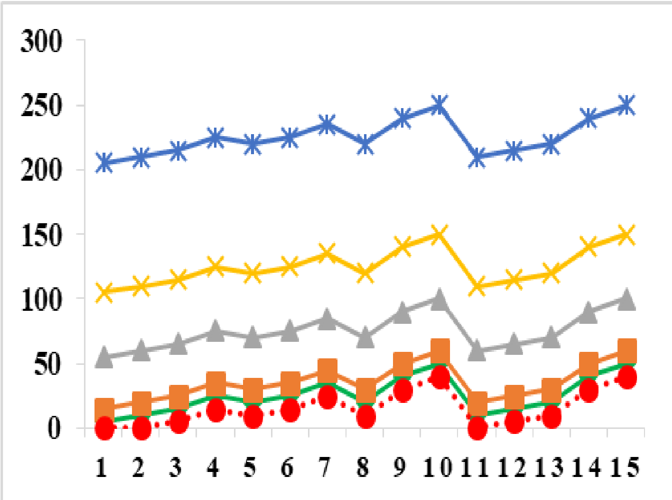
Fig. 3 Noise removal using filters

5	**10**	**15**	**25**
20	25	35	20
40	50	10	15
15	20	40	50

a. Pixels before applying Method

15	**20**	**25**	**35**
30	35	45	30
50	60	20	25
25	30	50	60

b. Pixels after applying the Method



c. Sliding of pixels at different intervals

Fig. 4 Histogram sliding

Histogram sliding of 10, 50,100,200 pixels and the dotted red line denotes the histogram sliding of negative of 10 pixels. In equation (2), for each input pixel f(x, y), a value ‘V’ is to be added to get the output pixel g(x, y). Here, ‘V’ is a constant.

$$g(x, y) = f(x, y) + V \quad (2)$$

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Histogram Stretching

Histogram Stretching is another technique to increase the contrast (difference between the maximum and minimum pixel intensity) of an image and it can be achieved from equation (3).

$$g(x, y) = \frac{f(x,y) - fmin}{fmax - fmin} * 2^{bpp} \quad (3)$$

Here, f (x, y) is the input image, g(x, y) is the output image. For the gray scale image the bpp (bits per pixel) is 8. The problem with histogram stretching is that when the maximum intensity value is 255 and minimum intensity value is 0 for a gray scale image, then there is no change in the contrast. The original image is equal to the resultant image.

Histogram Equalization

Histogram equalization (HE) is a widely used spatial domain technique, in which all the pixel values are normalized to increase the contrast of a given input image [4]. For example, the gray values of an image are equally distributed within a range of 0 to 1. Histogram equalization is also called as histogram flattening. Consider an image which is having low contrast or poor visibility, then the histogram of the input image should be skewed together. It means that all the details of the image are compressed in to one position in the histogram. All the pixels are to be adjusted towards to the other end, so that all the intensity values should be within a specified range. This method works effectively when the picture has low contrast. If we apply this method for high contrast images then the results should be worse [5].

Adaptive Histogram Equalization

The problem with the HE method is, it works on the whole image, but in real time most images contain local regions of low contrast or dark regions. The traditional histogram equalization method will not work efficiently on such types of images [6]. A modification of histogram equalization method called Adaptive Histogram Equalization (AHE) operates on small regions in the image. This means that AHE works by considering only small regions and based on their regional *Cumulative Distributive Function* (CDF) it performs contrast enhancement. Each region contrast is enhanced, so that the histogram of the output region approximately matches with the specified histogram. In [25], the authors used Otsu's thresholding to increase the contrast in the given image.

Contrast Limited Adaptive Histogram Equalization

Contrast Limited Adaptive Histogram Equalization (CLAHE) was initially developed to increase contrast in the medical images [7]. It is a generalized model for Adaptive Histogram Equalization and it differs in its contrast limiting. Based on the clip limit the CLAHE method will clips the histogram. This user defined clip level determines how much noise in the histogram and hence how much the contrast should be enhanced. Another variation of contrast limited technique called *Adaptive Histogram Clip* (AHC) can automatically adjust the clipping level and moderates over-enhancement of background regions of the image. Rayleigh distribution produces a bell-shaped histogram under AHC, the function is given in equation (4).

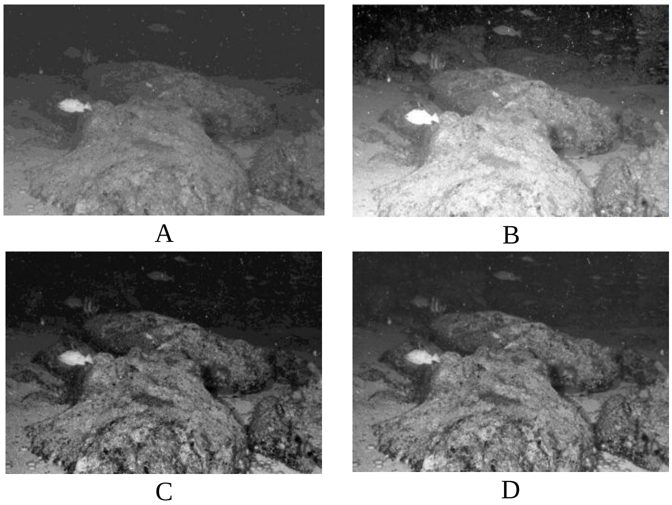

Fig. 5 Results of (a). histogram sliding (b) histogram equalization (c) CLAHE (d) DCP

$$\text{Rayleigh}(h) = h_{min} + 2(\alpha^2)\ln\left(\frac{1}{1-p(f)}\right)^{0.5} \quad (4)$$

Here h_{min} is the minimum pixel value, p (f) is the cumulative probability distribution,'α' denotes non negative real scalar value. The values of clip limit and α values are 0.01 and 0.04 respectively. For the input image given in Figure 3.a, the gray scale results of histogram sliding, histogram equalization, CLAHE and DCP are shown in Figure 5. The value 'V' is taken as '40' for histogram sliding, the clip limit is 2.0 and the grid size is (8, 8) are taken for CLAHE algorithm. The normalized frequency distribution of the resultant images are shown in Figure 6.

Dark Channel Prior

The *Dark Channel Prior* (DCP) method is mainly used for removing the haze that exists in the outdoor images. The working principle of DCP is that in the non-sky region of the input image, at least one color channel contains low intensities at some pixels. For example in RGB color image any of the three color channels such as either red or green or blue intensity values are very less or approximately it is almost near or equal to 0. It means that the minimum intensity in that region should have least value. Consider an example image J, one can define the dark channel intensity value as given in equation (5).

$$J_{dark}(x) = \min_{c \in \{r,g,b\}} \left(\min_{y \in \Omega(x)} (J_c(y))\right) \quad (5)$$

Where J_c represents color channel of **J,** Ω(*x*) represents local patch centered at *x*. In other words we can say that the other parts except the sky region, the intensity values of J_{dark} are very less and tends to be zero, Here J is treated as haze-free outdoor image and dark channel of J is denoted as J_{dark}.

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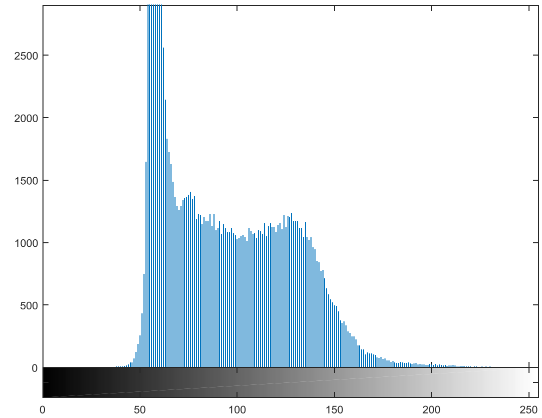
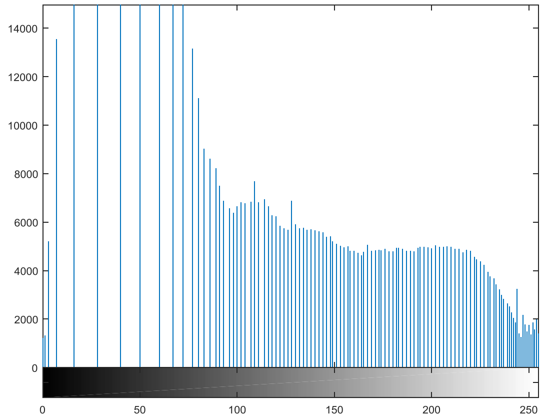
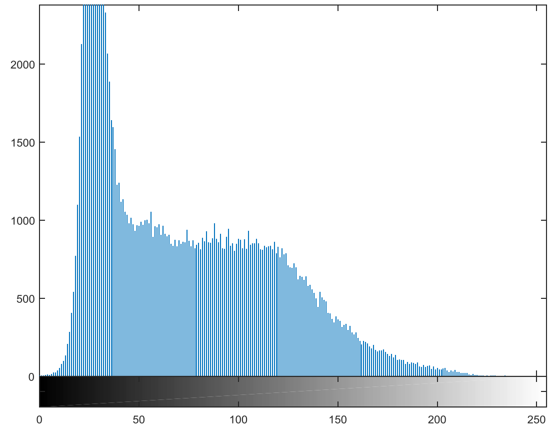


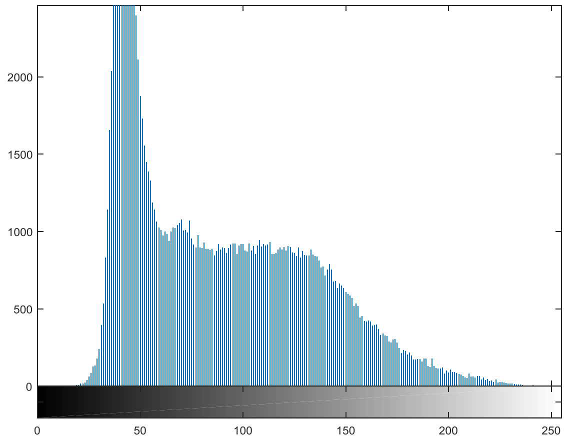
a. Histogram sliding



b. Histogram equalization



c. CLAHE



d. DCP

Fig. 6 Frequency distribution of pixels after applying enhancement methods

IV. RECENT WORKS

Images captured in the hazy or underwater environment will tend to be blur, low contrast and visibility. Removing the haze from these hazy images is a challenging issue in computer vision applications [11]. Many researchers have been proposed methods on dehazing techniques. There exist two kinds of algorithms for dehazing i.e. using single image and the other one is using multiple images. It means that by using the additional information from other images a clear image can be restored [12]. **He et al. [13],** proposed a method called Dark Channel Prior (discussed in section 3.7).

Algorithm 1 : WCID

Step1: Image is collected from the underwater (input image).
Step2: Compute the d(x) by dark channel prior and image matting.
Step3: Once depth map is derived, from the image foreground and back ground areas are segmented.
Step4: The low intensities from both foreground and background are compared for identifying the presence of artificial light occurred at image acquisition.
Step5: If artificial light is detected, remove it. Otherwise go to step 6.
Step6: Compensate the light scattering and color change along the path to camera.
Step7: With residual energy ratio compute the scene depth.
Step8: Apply energy compensation for the three channels to adjust the underwater color to natural color

The working principle of DCP is that in the non-sky region of the input image, at least one color channel contains low intensities at some pixels. Consider an example, in RGB color image any of the three color channels having a value very near to or almost zero. Using this earlier knowledge we can estimate the thickness of the haze directly and produce a high quality image. DCP becomes better only if the extent of the patch is more. If the probability of a patch contains a dark pixels is more, then DCP gets better results. This method is not suitable for some images, i.e. the scene objects are almost same as the atmospheric light and this method is not appropriate for sky regions due to the color of the sky. Almost the color of the sky is similar to atmospheric light.

John Y. Chiang and Ying-Ching Chen [14] proposed an image enhancement technique for underwater images by wavelength compensation and dehazing (WCID). This method includes two concepts such as image dehazing and wavelength compensation. The concept of scene-depth derivation from DCP can be helpful in this method. The working procedure of this method is shown in Algorithm 1.

The earlier strategy of DCP method has accomplished great outcomes in single image dehazing, yet it is invalid for images which having vast regions that are naturally same as that of atmospheric light. To take care of this issue **Yinqi XIONG et.al. [15]** Proposed an improved method of estimating global atmospheric light based on the dense hazy regions is put forward to obtain more accurate result. According to their work, atmospheric light can be calculated more appropriately and transmission map can be calculated more accurately by the replacement mechanism.

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With the help of this mechanism color distortion and halos in invalid regions can be avoided. The resultant images are apparently more clear and natural. **Kim [10] et al. [16],** uses the contrast enhancement to discover the transmission parameter in a local patch. With the help of histogram uniformity and intensity variance they measured the quality of the contrast. The cost function to discover the parameter is consolidated as given in equation (6).

$$G_{const}(t) = G_{unit}(t) - G_{std}(t) \quad (6)$$

Here G_{unit} (t) is cost function for histogram uniformity and G_{std} (t) is standard deviation of local intensity. We can find the transmission parameter once the cost function is reduced. Another method, DCP can restore the color but it ignores the contrast enhancement and it is summarized in Table 1.

Table. 1 Comparison of Kim method with DCP

Method	Color restoration	Contrast enhancement
Kim method	No	Yes
DCP	Yes	No

This method overcomes the problems by combining the methods proposed by Kim et.al and He et.al., by considering the color restoration and contrast enhancement. From this we can derive a cost function as shown in equation (7).

$$G(t) = \alpha . G_{const}(t) + (1-\beta) G_{dark}(t) \quad (7)$$

Here β denotes weight, which is used for color distortion.

Suzuri hitam and afreen awalludin [17] proposed a method specifically designed for underwater images called mixture CLAHE (Contrast Limited Adaptive Histogram Equalization). This strategy works on RGB and HSV models by applying CLAHE and the outcomes are joined together by utilizing Euclidean standard. The proposed strategy improves the visual nature of the underwater pictures by upgrading the contrast and decreasing the noise.

Hongteng Xu [18] proposed a model which combines techniques such as contrast enhancement and white balance techniques together to in a single framework of raised programming of histogram. This technique is adaptable compared to conventional histogram since it doesn't need to obey uniform distribution. In a few circumstances the conventional histogram equalization prompts over upgrading results by unwinding the limitations of uniform distributions. This strategy is favorable because white balance and contrast enhancement techniques are depicted as the changes in terms of histogram. It means that the outcome of this is white balance and it's a linear transform. In the interim, if the transform has a nonlinear tendency then the outcome is nearer to contrast enhancement. In sum the generalized equalization model with reasonable parameters, keeps a harmony between the contrast enhancement and tonal distortion. This strategy can also be utilized as post processing stage in some dehazing algorithms to correct the tonal distortion.

Chunmei Qing et.al, [19] proposed another versatile dehazing structure for improving the quality of images that are captured in underwater. This method incorporates two primary concepts: one is brightness estimation and the second is Locally AHE. The outcomes of this method are more accurate and the quality is good at dark areas in the given image. What's more, enhanced differentiation for the better points of interest and edges are improved fundamentally in the pictures. As indicated by Qing, enhancement is done by the following steps. Firstly, the impacts of absorption in various color channels are adopted with dehazing. Besides, because of the diverse of absorption of light in water, brightness is estimated to recover the original image as the second step. Thirdly, AHE strategy is used to advancement of the natural quality of image. At last, the execution of proposed structure is assessed subjectively as well as objectively. In our previous work, **M. Sudhakar and M. Janaki Meena [24]**, we used Block Based Enhancement Technique to improve the contrast in the input image to get the foreground region, but optimal selection of block size is tricky for different underwater images.

Huimin Lu et al. [20] proposes another model to balance attenuation caused along the path, and proposed a novel method which gives the result automatically and very fast as compared to the existing methods called trigonometric bilateral filtering. The upgraded images are portrayed and decreased noise level, clear visibility of dark regions and the contrast is increased globally and the edges are improved significantly.

1. Similar to the bilateral filter, guided trigonometric filter also performs the edge preserved smoothing, however has better conduct close to the edges.
2. It has a quick and non-approximate consistent time calculation, having the autonomous computational complexity.
3. To enhance the images in underwater αACE is more appropriate.

Min han and chao chen [21], Proposed technique to upgrade the quality of the image based on DCP. Based on this method back ground light is estimated by combining the dark channel prior with the saturation map. Later the transmission maps are estimated for different color channels based on the ratios of attenuation coefficients to recover the underwater image. Here the authors are added saturation map to avoid the wrong estimation of natural light. The transmission maps of each color channel are estimated based on the ratios of attenuation coefficients of diverse wavelengths in underwater. Once this happened still there is little color cast in the restored image. Authors are added a color correction method to balance the color. Finally a dehazed and color corrected image produced with better visibility.

Chongyi Li et.al [22] has proposed a new method based on dehazing and color correction. The first strategy is applied on blue and green color channels and the second strategy is applied on red color channel. In the RGB Color model green and red light having shorter wavelength compared to red channel. Because of this property green and blue light will scatter more than the red light [8]. Henceforth, we accept that red light attenuation is caused from absorption and blue-green color attenuation is caused only because of scattering.

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In the existing technique like Dark Channel Prior restore the image by applying the single equation for three RGB channels. With the help of dehazing algorithm and variation of DCP algorithm first we can recover blue-green color channels and with the gray-world hypothesis we can correct the red color channel. The outcome may look excessively diminish or more bright at some cases. Finally to resolve this adaptive map is constructed. Subjective evaluation of this technique demonstrates noteworthy improvements in the contrast and visibility of the underwater image and qualitative examination gets great outcomes as for as entropy, average gradients and locally neighborhood points.

In the ocean investigation filed, detecting the objects in underwater environment such as marine objects and other anomalies is the fundamental task. This tasks especially those conveyed by AUVs (Autonomous Underwater Vehicles) and ROVs (Remotely Operating Vehicles). In the sea environment the shadows of suspended particles behind the objects will cause some side effect (i.e. poor contrast or dark region) and it will cause the inaccurate results for the analysis in the underwater object detection. There is an essential need to remove such type of noise from the image to provide better results.

Table. 2 Recent works on underwater image analysis

YEAR	AUTHOR	TITLE	APPROACH	RESULT
2016	Ayman Alharbi et.al	Efficient Pipeline Architectures for Underwater Big Data Analytic	Parallel Processing of Digital Image Algorithms in Big data analytics	Parallel Processing of Images.
2016	Shiqi wang et.al	Guided Image Contrast Enhancement Based on Retrieved Images in Cloud	Collecting the images from the cloud guided enhancement will be done.-	Upgrade in the quality.
2015	Chunmei Qing et.al	Underwater Image Enhancement with an adaptive dehazing Framework	Brightness estimation and Locally adaptive Histogram equalization	Image enhancement with dehazing
2015	Karen Panetta et.al	Human-Visual-System-Inspired Underwater Image Quality Measures	UICM UISM UICoM	Efficient Quality measures for underwater images.
2014	Pooja sahu et.al.	A Survey on Underwater Image Enhancement techniques	RGB Color Level stretching	Upgrading the contrast and noise removal
2012	Chiang, J.Y., Ying Ching Chen	Underwater Image Enhancement by wavelength compensation and dehazing	Wave length compensation, dehazing	Dehazing and improvement in quality in deep water
2012	Hung-Yu Yang et.al.	Low Complexity Underwater Image Enhancement Base on Dark Channel Prior	Dark Channel Prior	Decrease in implementation time.

Chang and Lendasse (2016) [23], propose a novel strategy to discover the objects in the water with the assistance of removing the shadows of scanned sonar images. This method

Works in two stages. In the first stage, to divide all the pixels from the underwater image, fuzzy C-mean clustering can be utilized. Furthermore criminisi algorithm in the view of isophotic-driven sampling process is used to remove the shadow by filling the appropriate regions of shadow in the image. Few of the other recent works on underwater image analysis are listed in Table 2.

Quality Metrics

Quality measures are crucial for any digital image processing system. Once, the enhancement technique was applied, for a specific application we can test the quality of an image, whether your algorithm or method getting the better results or not. Hence reliable quality metrics are needed in the advancement of digital processing systems. Image Quality Assessment techniques are broadly categorized in to two types. First one is Subjective method and the other one is objective method. In the subjective method human beings are involved to measure the quality and in the objective method the system automatically measures the quality based on some processing measures. Objective quality measures compute the quality as close to subjective quality metric [8]. Some examples of objective measures such as full-reference (FR), reduced-reference (RF), and no-reference quality measures works with the help of reference image.

Mathematical Measures

A two dimensional signal is taken as the input, the measure is computed as the relation or dissimilarity or distinct similarity between the reference and distorted images. There are various kinds of distance measures such as minkowski metric calculate distance between the two kinds of images. Here assume reference image is treated as ‘X’ and distorted image is treated as ‘Y’. The measure is computed from the equation (8).

$$E\alpha = \frac{1}{N} \sum_{i=1}^{n} |X_i - Y_i|^{\frac{1}{\alpha}} \quad (8)$$

Where $'X_i'$ denotes the sample collected from image 'X', 'Y_i' is the sample collected from image 'Y'. 'N' is total samples, 'α' is considered as the range and it is between α € [1, ∞). Here if we considered the value of 'α' is 2 means that it is denoted as square root of mean square error (MSE) and Peak Signal Noise Ratio (PSNR) can be computed from equation (9) and (10) respectively.

$$E_2 = \frac{1}{N} \sum_{i=1}^{n} |Xi - Yi|^{\frac{1}{2}} = \sqrt{MSE} \quad (9)$$

$$PSNR = 20 \log_{10} \frac{MAX}{\sqrt{MSE}} \quad (10)$$

Here MAX represents the highest grey level, if it is a gray scale image then MAX=255, i.e. for a gray scale image 8 bits per pixel= 2^8 = [0,255]. These metrics are simple and mathematically tractable, but these measures are not correlates well since it doesn't include the characteristics of Human Vision System in their equations [9].

Although we have many image enhancement algorithms and quality measures to evaluate, still there is a challenge to measure the quality of underwater images. Generic objective evaluation measures such as PSNR, MSE are applied to the underwater images also. There are very less objective measures are exist to evaluate the quality for underwater images. Karen Panetta et.al proposed a new underwater image quality measure (UIQM) based on few attribute measures such as color, sharpness and contrast [10].

Underwater Colorfulness measure - Rather than utilizing regular statistical values, one can use asymmetric alpha trimmed statistical values to evaluate the underwater colorfulness. This measure works even there is a change in the parameters and also it gives better results for various kinds of underwater images such as images with more bubbles or containing light rays [32].

Underwater Image sharpness measure - This measure works in two stages. In the first stage apply the Sobel edge detector operator on each color channel in RGB color image. The output of the first stage is multiplied with the given input image for getting the grayscale edge map. It is called Enhancement Measure Estimation (EME).

Underwater Image Contrast Measure (UICoM) - To measure the contrast log (AMEE) measure is applied on the intensity image as shown in equation (11) and Underwater Image Quality Metric (UIQM) is computed from equation (12). Here, c1, c2, c3 parameters are application dependent.

UICoM = log (AMEE) (Intensity) (11)

UIQM= c1* UICM + c2* UISM +c3* UICoM (12)

Gaps in the Literature

The main purpose of using any algorithm for image enhancement is that to increase the quality of the captured image and to sharpen the features in the image to visually more pleasant and less noisy output image. Although Image enhancement has wide applications in computer vision it has been observed that most of the researches are neglected in some key subjects. The following are some research gaps identified:

- Very Less in number of image processing techniques are applied to the underwater images especially to enhance the quality of the underwater image, in particular to detect objects in the underwater.
- The existing methods neglects the noise presented in the output image after processing the image
- Less effort has focused on the integration of approaches like histogram equalization or wavelength decomposition and Dark Channel Prior techniques.
- Very Less research was done in color correction algorithms after enhancing the underwater image.
- The problem with illumination of suspended particles and artificial light is still exists and less work is going on to process the huge amount of underwater images using big data analytics.

V.CONCLUSION

The strategies utilized for the enhancement of underwater images are mostly similar with the enhancement techniques used for medical images, satellite images and other multimedia images except the conditions in the environment in the underwater. These techniques are helpful in various applications such as sea side monitoring and object detection in the underwater environment. There is a significant proportion of research is going in the upgrade of medical and outdoor images and so forth however less work has been done in the zone of underwater pictures as a because of the diverse environment present in the water, i.e. light absorption , scattering, color distortion etc. In this paper, we presented the recent research works on underwater image enhancement techniques, yet every strategy contains some drawback still it is challenging to get the optimal results. Integration of histogram equalization and dark channel prior with color correction technique is considered as a future work.

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