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Dark Channel and Laplace Based Under Water Image Restoration

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***Abstract*- As the digital world is increasing day by day so number of digital image processing issues are cover by different researchers. Out of those this work focus on under water noise removal which is also known as visibility restoration refers to different methods that aim to reduce or remove the degradation that have occurred while the digital image was being obtained. This paper has utilized the Laplace base distortion detection with dark channel technique for image restoration. Combination of both these techniques helps in identifying the actual color values present in the original image scene. Experiment is done on many images of different environment or category. Results shows that LEDCR (Laplace Edge Based Dark channel Restoration) is better as compare to CBF CBF in [8].**

***Keywords*- Digital Image Processing, Image Enhancement, Information Extraction, visibility restoration.**

I. INTRODUCTION

For an underwater image, the radiance of the scene point attenuates exponentially with the propagating distance, according to Beer–Lambert law. The light attenuation in water is caused mainly by absorption and scattering. From red to violet, the wavelength becomes shorter gradually. According to the selective absorption of water, visible light is absorbed at the longest wavelength first. So red light is much easier to be absorbed than shorter wavelengths such as the blue and green. On the other hand, based on Rayleigh scattering theory, scattering intensity is inversely proportional to the fourth power of wavelength, so that shorter wavelengths of violet and blue light will scatter much more than the longer wavelengths of yellow and especially red light.

We can conclude that water absorbs the longer wavelength of red and scatters the blue and violet when visible light disseminates in it. The wavelength of green light is between the wavelength of red and blue light, but much closer to the latter. Thus, we can also assume that the attenuation of green light only results from scattering. All of the above constitutes the theoretical basis of our work.

It should be noted that for an outdoor haze image, the major factor resulting in light attenuation is scattering due to suspended particles [1]. Clearly, there are significant difference between underwater images and outdoor haze images in physical process. Recently, several techniques have been proposed to handle single underwater image [5, 7, 8]. In [7, 8], the authors directly applied the dark channel prior [4] in underwater conditions. However, as we will specify in Section III, the traditional dark channel prior is not applicable for underwater images. Carlevaris-Bianco et al. [5] proposed a prior that exploits the strong difference in attenuation between the three image color channels to estimate the depth of the scene and then used the depth map to reduce the effect of water. In [3], Fattal presented a method for single image dehazing, but he also provided results for underwater images. Among these methods, the authors all built their underwater image enhancement work on the atmospheric scattering model. However, due to the distinction between atmosphere and water, it is not appropriate to use the atmospheric scattering model for underwater images.

Light scattering is a form of scattering in which light is the form of propagating energy which is scattered. When camera light incident on objects then it get reflected and deflected number of times by particles present in the water before reaching the camera [6], this phenomenon is known as a light scattering. This light scattering results in a poor visibility and low contrast in the underwater image .Light scattering depends on the frequency or wavelength of the light being scattered. Forward scattering generally leads to blur of the image and results into the low contrast of image.

The second cause for underwater image distortion is color change. Color change is due to varying degrees of attenuation for different wavelengths .Blue color has shortest wavelength so it travels longest distance in the water. This is the reason behind why underwater images are dominated by blue color .And red color has highest wavelength, so it travels a very short distance in water. Suspended particles (sand, plankton, minerals) are responsible for hazy underwater image. As light reflected from objects towards camera, a portion of light meets these suspended particles, this will in turn absorb and scatters light bea. [3]. A number of underwater image processing techniques used to remove light scattering and color change effect. Generally most of the processing techniques focus on removing either light scattering effect or color change effect. The only technique called WCID will handle these problems simultaneously [6].

II. RELATED WORK

Shelda Mohan and T.R. Mahesh, 2013[5] has presented Particle Swarm Optimization (PSO) for tuning the enhancement parameter of Contrast Limited Adaptive Histogram Equalization relied on Local Contrast Modification (LCM). The quality of enhanced image is tested using a criteria based on edge information of the image. The planned method provides finest contrast enhancement though preserving the local data and details of the input mammogram picture.

Sowmya shree et al. 2014[8] have presented a relative study of the different image enhancement methods used for enhancing images of the bodies under the water. It also describes the various properties of water due to which the underwater images images are distorted and degraded.

Setiawan et al. 2013[7] used Contrast Limited Adaptive Histogram Equalization (CLAHE) to enhance color retinal image. In this paper, they proposed new enhancement method using CLAHE in G channel to improve the color retinal image quality. The enhancement process conduct in G channel is suitable to enhance the color retinal image quality. Visual observation is used to judge the enhanced images and compare them with the original ones.

Chang et al. 2014[1] have proposed the mean-variance analysis technique that is engaged in partitioning the grey scale image into four associated images for individual image. The contrast of the palm bone X-ray radiographs is enhanced by newly proposed technique i.e. quad histogram equalization technique. Experimental results using this method illustrate that the proposed algorithm is better than the global histogram equalization (GHE) technique and brightness saving bi-histogram equalization (BBHE) technique.

In [6] proposed perceptual models that can be able to forecast the value of distorted images with as little prior information of the images or their deformation as possible. The new IQA model, which is known as Natural Image Quality Evaluator is based on the production of a “quality aware” collection of statistical features based on a simple and successful space area natural scene statistic model.

In [7] proposed novel widespread guided image filtering method with the suggestion image generated by signal sub-space projection technique. It accepts complicated parallel study through Monte Carlo imitation to choose the dimensions of signal subspace in the patch-based noisy images. The noise free image is reconstructed from the noisy image expected onto the significant images by component analysis. Test images are utilized to decide the relationship between the most favorable parameter value and noise divergence that maximizes the output peak signal-to-noise ratio.

In [8] has presented a new method called mixture CLAHE color models that specifically developed for underwater image enhancement. The process performs CLAHE method on RGB and HSV color models. The projected technique has considerably enhanced the visual superiority of underwater digital images by enhancing illuminate, as well as dropping noise and artifacts.

III. PROPOSED METHODOLOGY

This paper focus on the digital hazy image restoration. Here image store the edge region of the image then applies Laplace distribution for pixel value restoration. Here whole work is explained in fig. 2. Proposed work is trm as LEDCR (Laplace Edge Based Dark channel Restoration).

1. Pre-Processing

Here as the image is the collection of pixels where each pixel is representing a number that is reflecting a number over there now for each number depend on the format it has its range. So read a image means making a matrix of the same dimension of the image then fill the matrix correspond to the pixel value of the image at the cell in the matrix.

2. Edge Detection

In order to find the edges in the image convert it into gray format then apply the canny algorithm. This is the method to convert an gray scale image into binary image. For this analysis of each pixel is done.16X16 Block As work is done on color image so embedding is done on the red matrix of the image, so whole operation of embedding is done this red matrix. Whole red, green, blue matrix is divide into 16X16 blocks for restoration of image.

3. Laplace Distribution

Lap lacian destitution help to find are non-directional changes because they enhance linear features in any direction in an image. They do not look at the gradient itself, but at the changes in gradient. In their simplest form, they can be seen as the result of taking the second derivative. In this step μ is mean of the block or region

S of image I having three color channel c {red, green, blue}.

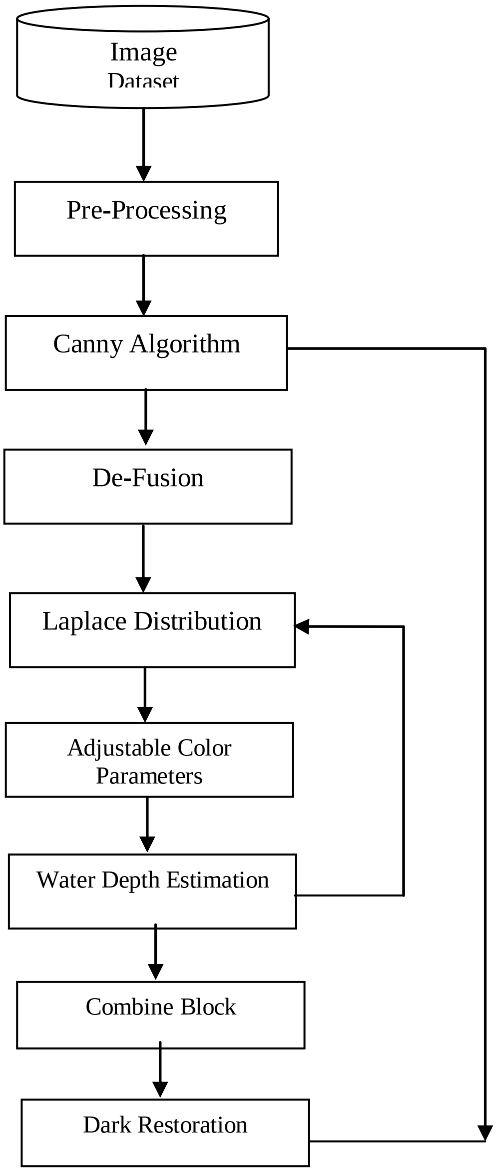

Fig.1 Block diagram of proposed Restoration Image Work.

So first σ is estimate which act as the scaling parameter of the lap lace distribution.

$$\sigma = \frac{1}{\alpha}\sum_{L\in S}\left|I^c(L) - \mu\right|$$

$$P(\Delta^c(L)\,|\,S) = \frac{1}{\alpha}\sum_{L\in S}\frac{1}{2\sigma}e^{\frac{(I^M(L)-I^c(L))-\mu}{\sigma}}$$

4. Water Depth Estimation

In this step color adjustment parameter is calculate with the help of Laplace distribution values of each block. Here color adjustment parameter is the ratio of the color chromatic parameter to the maximum value of the color chromatic parameter of each channel of the image.

$$a^c = \frac{\upsilon^c}{\max I^c}$$

Here υ^c is the color chromatic parameter obtain by the ratio of the maximum laplace distribution value of the color region to the laplace distribution of the block.

Finally color adjustment in the haze image is done by change in pixel value

$$J^c(x) = \frac{\alpha^c(I^c(x) - A^c)}{\max(t(x), t_o)} + \alpha^c A^c$$

Here A^c is atmospheric light adjustment parameter in the block so for each block it is evaluate by

$$A^c = \min(\max(S))$$

$$t(x) = \min\left(\frac{I^c}{A^c}\right)$$

5. Dark Restoration - Here edge obtain from initial image is combine in the new edge position obtain after applying lap lace and haze thickness steps.

6. Dark channel prior- In [2] Dark channel technique is developed in order to calculate the atmospheric light in the image. So it is emerged as a common technique in non sky part of the image because few color channels has very less intensity in the few pixels. Here in dark color channel low intensity is present because of the below three components:

- Surface Colourful objects such as grass, trees, etc.
- Shadow of tree, building, pillers, etc.
- Any high intensity object surface such as black stone, trunk, etc.

So most of outdoor image is full of above three points which include colorful object, few shadows and dark channels which fill image with noise. In presence of fog in environment image get brighter than actual image without fog. So it can be conclude that dark channel of the image have high intensity of image in region with higher haze. So in order to find the light intensity an approx value is find by estimating the thickness of the haze.

In case of shady channel prior this technique use pre and post processing steps in order to improve results. In post processing stepladder technique use flexible matting or two-sided filtering etc. This can be understand as if J(x) is input image, I(x) is under water image, t(x) is the transmission of the environment. The reduction of image because of presence of fog can be calculate by: Here A^c is atmospheric light adjustment parameter in the block so for each block it is evaluate by

$$A^c = \min(\max S) ----------(1)$$

$$t(x) = \min\left(\frac{I^c}{A^c}\right) ----------(2)$$

In above equation (2) S is the region in the block of image having channel. C represent color band Red, Green, Blue, etc. the effect of fog is Air light effect and it is calculate as:

$$\text{Air Light}(x) = A(1 - t(x))\text{--------------}(3)$$

In this Jc is color image comprising of RGB components, represents a local patch which has its origin at x. The low intensity of dark channels is attributed mainly due to shadows in images, saturated color objects and dark objects in images.

After dark channel prior, one need to estimate transmission t(x) for proceeding further with the solution. Another assumption needed is that let Atmospheric light A is also known. This normalize (4) by dividing both sides by A:

$$J^c(x) = \frac{(I^c(x) - A^c(1 - t(x)))}{\max(t(x), t_o)} ----(4)$$

IV. EXPERIMENT AND RESULT

In this section, first introduce experimental settings, and then present the experimental results that validate the effectiveness of the approach. The experiments actually contain two parts. This work is compare with other CBF in [8] which have utilize the laplace and haze thickness estimation only.

1. Evaluation Parameter

1.1 Visible edge restoration parameter- The *e* metric represents the rate of visible edge restoration in the haze-free image and is given by

$$e = \frac{V_r - V_o}{V_o} --- (5)$$

where *Vr* and *Vo* represent the total number of visible edges within the restored under water image and the incoming under water image, respectively.

1.2 Contrast restoration- *r* metric is used to express the quality of contrast restoration within the haze-free image. As
such, the .*r* metric is formulated as follows:

$$r = \exp\left[\frac{1}{V_r}\sum_{p_i \in \wp_i} \log(r_i)\right] ----(6)$$

where *Pi* is the corresponding element within the set ℘*r*, and *ri* is the rate of gradients between the restored under water image and the incoming under water image. Note that ℘*r* consists of the visible edges in the restored under water image.

1.3 Over or Under Exposed Metric- Moreover, the σ metric represents the number of pixels that might be either overexposed as white or underexposed as black in the restored image. The σ metric is calculated as follows:

$$\sigma = \frac{V_s}{\dim_x \dim_y}$$

where *Vs* represents the total of both overexposed and underexposed pixels in the restored image, and dim*x* dim*y* represents the size of the incoming image.

2. Data Sets

In order to conduct the experiment an artificial dataset which is a collection of images from different category are utilize. The TURBID, is an open image dataset that has been generated to contribute with the underwater research area. TURBID consists in a collection of five different subsets of degraded images with its respective ground-truth. The subset Milk and DeepBlue has 20 images each and the subset Chlorophyll has 42 images.

3. Results

Table 1 Comparison of LEDCR and CBF on visible edge restoration parameter.

Images		Visible Edge Restoration	
		LEDCR	CBF
1.	Deep Sea	0.677149	2.1478
2.	Milk	1.81068	3.92459
3.	Chlorophyll	0.570313	1.91146

In Table 1 It is obtained that LEDCR is better as compare to previous as edge restoration value of LEDCR is higher as compare to previous. So inclusion of edge feature in haze removal has increase the performance of the work.

Table 2 Comparison of LEDCR and CBF on visible edge restoration parameter.

Images		Contrast Restoration Image	
		LEDCR	CBF
1.	Deep Sea	5.2608	1.56222
2.	Milk	7.06553	2.28161
3.	Chlorophyll	42.5612	2.23584

In table 2 It is obtained that LEDCR is better as compare to previous as contrast restoration image value of LEDCR is higher as compare to previous. So inclusion of edge feature in haze removal has increase the performance of the work.

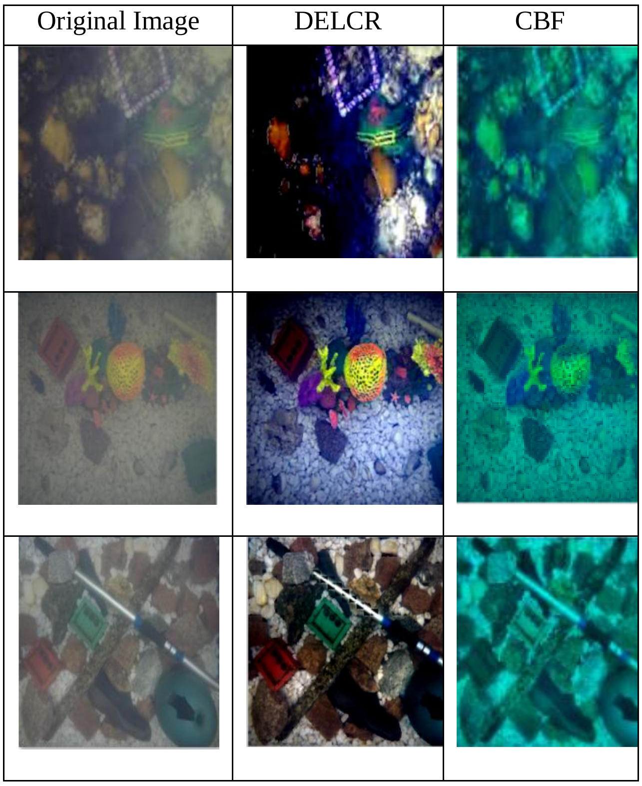

Fig.2 Milk and Deep Blue has 20 images each and the subset Chlorophyll has 42 images.

Table 3 Comparison of LEDCR and CBF on visible edge restoration parameter.

Images		Over or Under Exposed Metric	
		LEDCR	CBF
1.	Deep Sea	2.51239	1.45273
2.	Milk		
3.	Chlorophyll	2.04129	1.43985

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In table 3 It is obtained that LEDCR is better as compare to previous as Over or Under Exposed Metric of Restoration image value of LEDCR is higher as compare to previous. So inclusion of edge feature in haze removal has increase the performance of the work.

V. CONCLUSIONS

A new combination of Laplace and edge feature is done in this work where post dark channel restoration increase image quality in different scene. The algorithm removes spatially varying water level based on the water depth estimation. As experiment is done on images of different environment and it is obtained that LEDCR is better on all the evaluation parameters of de-hazing images. In Future improvements of the method will deal with possible corner, and histogram effects caused by the image processing.

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