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Literature Review: Reconstruction of Under Water Image

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ABSTRACT:
Image Reconstruction and enhancement is the process of improving the quality of the input image so that it would be easily understood by viewers in the future. Image enhancement improves the information content of the image and alters the visual impact of the image on the observer. Image enhancement intensifies the features of images. It accentuates the image features like edges, contrast to build display of photographs more useful for examination and study. An Underwater image pre-processing is absolutely necessary due to the quality of images captured under water. When capture such images, quality of images degrade due to many factors like ripples in water, lack of availability of light,organic matter dissolved in water etc and also such images are captured from a very small distance , so the images must be pre processed before applying any kind of operation on these images.

Keywords: Image enhancement, Underwater image preprocessing, Quality improvemen

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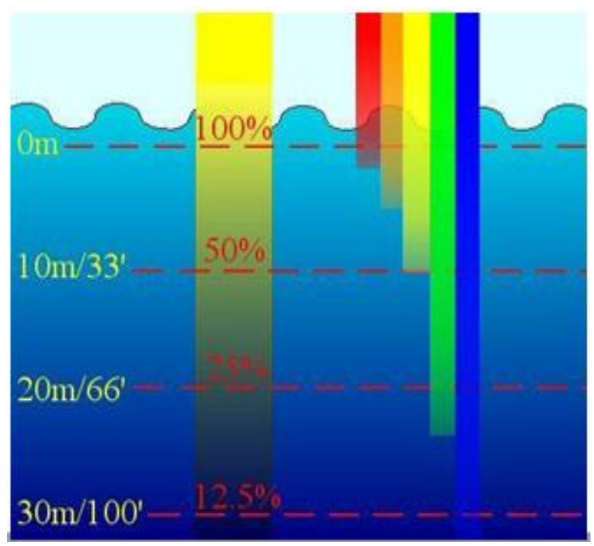
I. INTRODUCTION

Image enhancement is the mechanism to process the input image to make it more appropriate and clearly visible for the required application. Image enhancement improves the information content of the image and alters the visual impact of the image on the observer. Image enhancement intensifies the features of images. It accentuates the image features like edges, contrast to build display of photographs more useful for examination and study. Qualitative objective approach is used in enhancing images to construct a visually impressive picture. Image enhancement includes many operations such as contrast stretching, noise clipping, pseudocoloring, noise filtering etc to improve the view of images. Active range of the chosen features of images is amplified by enhancement so that they can be detected simply. The existing research shows that underwater images bears poor quality because of nature of light. When light enters the water it got refracted , absorbed and scattered as water is denser medium then air , so the amount of light drops when it enters from air to water and got scattered in different directions. Scattering causes the blurring of light and reduces the color contrast. These effects of water on underwater images are only not due the nature water but also because of the organisms and other material present in the water. Light containing different wavelengths of blue, green and red colors will make a way into water to a changeable degree [1]. Figure 1 shows the picture about the light absorbed by water. With every 10m augmentation in depth the brightness of sunlight is going to fall by half. Almost all red colored light is decrease to 50% from the surface but blue continues to great deep in the ocean because blue color have the shortest wavelength and so it travels the longest distance in the water. That is why most of the underwater images are subjected to blue and green color.

Figure: 1: The light absorbed by water



Underwater image enhancement techniques provide a way to improve the object identification in underwater environment. Underwater sea images needs to be preprocessed due to lower quality of sea water images. When such images are captured, quality degrades due to many factors like ripples in water, lack of availability of light and organic matter dissolved in water etc.Due to these factors such images needs to be captured from a very small distance , so the quality of underwater images suffers.Thats why these kind of images must processed before applying any kind of operation on these images. To denoise an image without affecting the image quality and edges in an image, edge preserving filters are used [2]. When an underwater image is captured, pre-processing is necessarily done to correct and adjust the image for further study and processing. Pre-Processing is an important step in image processing technique.

Recently, many researchers have developed pre processing techniques for underwater images using image enhancement methods. Prabhakar C.J. et. al. [3] studied an image based preprocessing technique to enhance the quality of the underwater images. The technique comprises a combination of four filters such as homomorphic filtering,wavelet denoising, bilateral filtering and contrast equalization. These filters are applied sequentially on degraded underwater images. The literature survey reveals that image based preprocessing algorithms uses standard filter techniques with various combinations. For smoothing the image, the image based preprocessing algorithms uses the anisotropic filter. The main drawback of the anisotropic filter is that iterative in nature and computation time is high compared to bilateral filter. In addition to other three filters,we employ a bilateral filter for smoothing the image. The technique using quantitative based criteria such as a gradient magnitude histogram and Peak Signal to Noise Ratio (PSNR). Further, the results has been qualitatively evaluated based on edge detection results.

G.Padmavathi et. al. [2] studied that the under water images suffering from quality degradation due to transmission of limited range of light, low contrast and blurred image due to quality of light and diminishing color. When an underwater image is captured, pre-processing is necessarily done to correct and adjust the image for further study and processing. The filters used normally improve the image quality, suppress the noise, preserves the edges in an image, enhance and smoothen the image. Therefore three famous filters namely, homomorphic filter,anisotropic diffusion and wavelet denoising by average filter used for under water image pre-processing. The speckle reduction by anisotropic filter improves the image quality, suppressed the noise, preserves the edges in an image, enhance and smoothen the image .The mean square error value which must be low for an image and peak signal to noise ratio which must be high in an image .Though the wavelet filter shows high and low for PSNR and MSE. Isabelle Quidu et. al. [4] proposed that underwater images suffer from limited range, non uniform lighting, low contrast, diminished colors, important blur. Moreover many parameters can modify the optical properties of the water and underwater images show large temporal and spatial variations. So, it is necessary to pre-process those images before using usual image processing methods. The various filter composed homomorphic filtering to reduce illumination problems and to enhance the contrast, wavelet denoising and anisotropic filtering to cancel out the noise and enhance edges, contrast adjustment and color compensation to suppress the predominant color.

II. EXISTING METHODS FOR UNDERWATER IMAGE ENHANCEMENT:

1. Contrast stretching

Contrast stretching is a straightforward image enhancement method that is used to improve, enhance the image contrast by `stretching' the series of intensity values. A measure of image’s dynamic range or the "broaden" of image’s histogram is the contrast of an image. Whole range of intensity values present within the image, or in a easier way, the minimum pixel value subtracted from the maximum pixel value is called dynamic range of image. It differs from the more complicated histogram equalization in a way that it can only concern a linear scaling function to the image pixel values.

2. Empirical Mode Decomposition

EMD is a versatile and based on the local moment period function. So, it is suitable to help nonlinear along with non-stationary data so that it is an incredibly adept opportunity for real-life software. The EMD method is exceptionally direct, and the fundamental procedure is to carry out sifter operations on the new data arrangements until the final data series are stationary, and subsequently disintegrate the whole signal into many Intrinsic Mode Functions (IMFs) and a residue. EMD is connected to the Red, Green, Blue channels independently. The original image is break up into several intrinsic mode functions by EMD process and a final residue.

3. Homomorphic filtering

The homomorphic filtering is utilized to fix non-uniform lighting to reinforce contrast from the impression. This is a frequency filtering technique. It is the most utilized system on the grounds that it redresses non-uniform lighting and sharpens the picture. Where F(x, y) is the function of image detected by device, I(x, y) the illumination function and r(x, y) the reflectance function. By multiplying these components filter can reduce the non uniform illumination present in the image.

4. Anisotropic filtering

Anisotropic filtering disentangles picture components to enhance picture division. This channel smoothes the picture in homogeneous range however conserve edges and upgrades them. It is utilized to smooth compositions and diminishes relics by erasing little edges enhanced by homomorphic filtering.

5. Wavelet denoising by average filter

Wavelet denoising is used to stifle the noise i.e the Gaussian noise are normally present in the camera pictures and other kind of instrument pictures. While moving the pictures Gaussian noise can be included. This wavelet denoising gives great results contrasted with other denoising routines because, unlike other methods, it does not assume that the coefficients are independent. Undoubtedly wavelet coefficients in normal pictures have enormous conditions. Besides the reckoning time is short.

6. Red channel method

In this method, colors associated to short wavelengths are recovered, as expected for underwater images, leading to a recovery of the lost contrast. The first thing in this method to estimate is the color of the water. Pick a pixel that lies at the maximum depth with respect to the camera. It is assumed that degradation of image depend upon location of pixel. After estimating the waterlight transmission of the scene is estimated. Then Color correction is done.

7. Histogram equalization

Histogram equalization is a method for modifying image intensities and contrast of image in image processing using the image's histogram. Histogram equalization is helpful in pictures with backgrounds and frontal areas that are both bright or both dim. This is a simple and straightforward technique. But it has a disadvantage also that is it also amplifies the background noise present in the image and lead to decrease in the useful signal. So it produces unrealistic effects in the output images. The basic idea lying behind this method is mapping the gray levels depending upon the probability distribution of the input gray levels.

8. Contrast Limited Adaptive Histogram Equalization (CLAHE)

It is generalization of adaptive histogram equalization. With this technique the image is broken up into tiles. The gray scale is calculated for each of these tiles, based upon its histogram and transform function, which is derived from the interpolation between the manipulated histograms of the neighboring sub-regions. The transformation function is relative to the cumulative distribution function (CDF) of pixel values in the area. CLAHE contrasts from AHE in contrast limiting. CLAHE limits the noise enhancement by cut-out the histogram at a client characterized worth.

A. CLAHE on RGB color model RGB color is an additive color model which which depicts hues regarding the measure of red (R), green (G) and blue (B) present. It depicts what sort of light needs to be transmitted to create a given hues present in the image. CLAHE can be applicable to all the three parts ie. red, green and blue separately. The effect of full-color RGB can be acquired by combining the individual components of model.

B. CLAHE on HSV color model HSV color model defines colors in terms of the Hue (H), Saturation
(S), and Value (V). HSV color model is cylindricalcoordinate illustration of points in an RGB color model. Hue is the characteristic of a visual sensation as indicated by which a territory seems to be related to one of the color seen. The hue and saturation level don't have any kind of effect when value is at max or min intensity level. CLAHE is applied on V and S components.

c. .MIX – CLAHE It is based on CLAHE. The visibility of the underground image is improved by this method. It produces the maximum PSNR and the minimum MSE values. Thus, this method is able to classify the coral reefs. absorption of light by water is illustrated in this image. By 10 meter increase in depth the brightness of sunlight will decrease to half. All blue light continues to greater depth whereas all red is reduced by 50% from the surface. This is because the most underwater images are conquered by green-blue coloration. CLAHE-RGB is result of first normalizing applied on CLAHE-MIX. The results of Mix-CLACHE working on image and CLACHE techniques result applied on HSV and RGB color models. As the figure illustrates the it gives the human sense of color when applied RGB color model. A much better and logical approach can be the spread of color values uniformly, leaving the colors themselves (e.g., hues) unchanged. The CLAHE-HSV result shows that the overall color is more rational in comparison to CLAHE-RGB. But, the overall image looks unnatural and is much brighter. Also, there is enhancement of noise in smooth regions is identified which is unavoidable. In order to reduce the the brightness and unwanted artifacts in CLAHE HSV and CLAHE RGB images. New approach was introduced which is the output of mix result of both HSV and RGB images. This method of mixing both images is known as CLACHE-MIX. The method aimed to enhance the contrast of the image while preserving the natural look of underwater image.

III. INTEGRATED COLOR MODEL

The integrated color model is principally established on color harmonizing by contrast improvement is RGB color space and color adjustment in HSI model. In integrated color model first step is to diminish the color cast by the equalization of all the color values present. In the second step an improvement is applied to the contrast amendment to broaden the histogram values of the red color. Second step is again done for green and blue colors. In the last step of the model, the saturation and intensity components of the HSI color model is applicable for contrast adjustment to enhance the true color and for dealing with the issue of uneven illumination.

IV. HOMOMORPHIC FILTERING

The homomorphic filtering is used to correct non-uniform illumination to enhance contrast in the image. It is a frequency filtering method. Compared to other filtering techniques, it corrects non-uniform lighting and sharpens the image.

In the Illumination-reflectance model, where image is defined as a intensity illumination and the reflectance function as follows

$F(x, y) = i(x , y) \times r(x, y)$------Eq.1

Where F(x,y) is the image sensed by instrument, i(x,y) the illumination and r(x,y) the reflectance function. On contrary, reflectance is associated with high frequency components. By multiplying these components a highpass filter can be suppress the low frequencies, i.e the non uniform illumination in the image can suppressed. The algorithm is described as follows:

1.) The illumination and reflectance components by taking the logarithm of the image give (Eq.2). G(x,y)=ln ـي)ٹ ,ٻ=(ln(i(x, y)×r(x, y)) = ln (i(x, y))+ ln (r(x, y)) -- -----
Eq.2

2.) Computation of the Fourier transform of the log image gives (Eq.3)

$G (wx, wy) = I (wx, wy) + R(wx, wy)$ -----------Eq.3

3.) High-pass filtering. The filter applied to the Fourier transform decreases the contribution of low frequencies (illumination) and also amplifies the contribution of mid and high frequencies (reflectance), sharpening the edges of the objects in the image given in (Eq.5)

$S(wx, wy)=H(wx, wy) \times I(wx, wy) + H(wx, wy) \times R(wx, wy)$ --------Eq.4

With,

$H (wx, wy) = (rH - rL)\times (1 - \exp (- (w2x+ w2 y2 /2w)))$
$+ rL$ ------ Eq.5

where rH = 2.5 and rL = 0.5 are the maximum and minimum coefficients homomorphic filtering factors these two are selected empirically.

4.) Computation of the inverse Fourier transforms is taken to reconstruct the original image. The resultant filtered image is obtained.

V. ANISOTROPIC FILTERING

Anisotropic filtering simplifies image features to improve image segmentation. This filter smoothes the image in homogeneous area but preserves edges and enhances them. It is used to smooth textures and reduce artifacts by deleting small edges amplified by homomorphic filtering. The previous step of denoising is very important to obtain good results with anisotropic filtering. It is the association of wavelet denoising and anisotropic filtering which gives such results. Anisotropic algorithm is usually used as long as result is not satisfactory.Perona and Malik anisotropic diffusion is the edge sensitive extension of the average filter. Anisotropic diffusion can be applied to radar and medical ultrasound images, underwater images.

VI. WAVELET FILTERING

Wavelet filter is also used to suppress the noise i.e the Gaussian noise are naturally present in the camera images and other type of instrument images. While transferring the images Gaussian noise can be added.This wavelet denoising gives very good results compared to other denoising methods because, unlike other methods, it does not assume that the coefficients are independent. Thresholding is a simple non-linear technique, which operates on one wavelet coefficient at a time. In its most basic form, each coefficient is thresholded by comparing against threshold, if the coefficient is smaller than threshold, set to zero; otherwise it is kept or modified. Replacing the small noisy coefficients by zero and inverse wavelet transform on the result may lead to reconstruction with the essential signal characteristics and with the less noise. A simple denoising algorithm that uses the wavelet transform consist of the following three steps,

(1)Calculate the wavelet transform of the noisy signal
(2)Modify the noisy detail wavelet coefficients according to some rule
(3)Compute the inverse transform using the modified coefficients.

13. Improved PDE-based algorithm:

Based on experiments, mathematical derivation and proof, we select the PWL algorithm since it is a generalization of the various contrast stretching approaches. Thus, based on findings from this work [26] and previous study [24] [25], we combine the local and global operations in cascaded form such as;

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and introduce additional control parameters to further regularize and regulate the various processes within the new PDE [34]. The improved PDE-based approaches are discussed in this section and utilize additional components for processing specific images.

Proposed method:
Bispectrum technique:

In this section, we give a brief review on the main technique of our algorithm. Assume that I(u, v) is the Fourier transform of a 2-D signal i(x, y) (for example, an image), which is also expressed as the magnitude-and-phase form:

$$I(u, v) = |I(u, v)| exp\{j\varphi i(u, v)\} \quad (1)$$

From Eq(1), a signal can be recovered given that the magnitude and the phase in the Fourier domain are known. In this paper, the bispectrum technique is used to recover the signal phase.

The bispectrum has two main properties: (1) the phase information of a signal can be preserved and (2) the bispectrum of a Gaussian signal is zero. This enables us to recover th correct phase of a signal using the bispectrum technique.

The bispectrum is the Fourier form of the triple correlation of a signal. The bispectrum of a 2-D signal is given by

$$B(u1, u2; v1, v2) = I(u1, u2)I(v1, v2)I*(u1 + v1, u2 + v2)$$

$$= I(u1, u2)I(v1, v2)I(-(u1 + v1), -(u2 + v2)) \quad (2)$$

where $B(u1, u2; v1, v2)$ denotes the bispectrum, and $*$ indicates the complex conjugate. Note that the bispectrum of a 2-D signal is four dimensional.

Since the normal of the water surface is a Gaussian distribution, the phase distortion of a submerged object is also considered as Gaussian distributed. This allows us to use the properties of Gaussian random process and overcome the phase corruption by averaging the bispectrum of the ensemble of the raw images [6]. So that we build the relationship between the object phase spectrum $\varphi O(u, v)$ and the phase of the mean bispectrum $\varphi B(u1, u2; v1, v2)$ by

$$\varphi o(u1 + v1, u2 + v2) = \varphi o(u1, u2) + \varphi o(v1, v2) - \varphi B(u1, u2; v1, v2) \quad (3)$$

From Eq.(3), one can estimate the phases at higher frequencies using the phases at lower frequencies and the mean bispectrum phases given that the phases at (±1, 0) and (0,±1) are known (the phase at (0, 0) is zero)[5, 6, 7].

VII. CONCLUSION

In this paper different underwater image enhancement techniques are reviewed and studied. All the reviewed methods enhance the underwater images to great extent. The issue of the uneven light illumination is likewise disregarded by the vast majority of the scientists. But no method paid attention on L*A*B color space using CLAHE for enhancing the underwater images. The presented strategies have ignored the methods to lessen the noise issue, which is available in the resultant pictures of the current image improvement procedures. In future work, we will apply CLAHE on L*A*B color space and compare the results on different color spaces.

We propose an original idea to reconstruct a submerged object distorted by moving water surface. We assume the normals of the water surface are Gaussian distributed. The bispectrum technique is employed to recover the phase of the true object. Although experiments show that our approach is promising, there exist some limits. One limit is that our algorithm needs a large computer memory and heavy computation because that the bispectrum of an image is four dimensional. Another limit is the recursive phase recovery method with only a subset of the phase information of the averaged bispectrum being used. This may reduce the resolution of the output. To overcome such limits is the next step in our research.

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