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A Review Underwater Optical Image Quality Enhancement based on Guided Filter

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Abstract: In underwater location, accuracy of images are degenerated by light absorption and scattering. Underwater image enhancement is use for colour control in the underwater image. There are discussing two method of underwater image. Firstly, the contrast stretching of RGB algorithm is applied to equalize the colour contrast and brightness in images. Secondly, the saturation, hue and intensity of underwater image to increase of real colour and solve to the problem of lighting moves in underwater. Generally Mat lab software are use for underwater image enhancement. A novel method to enhance underwater optical images by dehazing. Scattering and attenuation are two major problems of distortion for underwater imaging. Scattering is caused by large depended particles, like fog or turbid water which contains sufficient particles, plankton etc. attenuation according to the varying degrees of attenuation encountered by light traveling in the water with different wavelengths to the according different underwater colour image. The underwater image enhancements techniques are use for reduced noised level, haze, fog, better possibility of the dark regions, increase global contrast and edges preserving smooth. The quality and visibility of underwater images is damage than atmosphere image and images usually appear foggy and hazy.

Keywords: Underwater optical Image; Underwater visibility enhancement; Guided filter.

I. INTRODUCTION

Underwater Images are firstly importance in underwater for applications sea life and biological environment. Some of its major application areas are water animals and water plants, sense new fish species etc. The detection system should have underwater camera. Nowadays sonar is used to sense underwater technologies. The most importance of Underwater Image Processing Object Detection system is to recognize objects, which are in the form of images, without any human intervention. This is done by selecting boundary information and reducing noise and haze. [1]

The purpose of image processing is to use data contained in the image to enable the system to understand, interpret and recognize the processed information available from the underwater image pattern. Image enhancement can be utilized to different areas like space image, underwater image s and atmosphere image. Nowadays underwater image enhancement use for underwater image pattern to monitor marine species, underwater mountains & plants, to receive this purpose it is absolutely necessary to use the clear images. Enhancement of underwater images necessary modeling and estimation of the water absorption and scattering characteristics to remove noise and different types haze. A more difficulty in processing underwater images comes from light attenuation. Light attenuation limits the visibility distance, normally twenty meters in clear water and five meters or less in turbid water. The light attenuation process is produce by the absorption (which reduce light energy) and scattering (which vary the direction of light path). Absorption and scattering effects are due to haze presence in water and to other components such as dissolved organic matter or small observable floating particles. First, the rapid attenuation of light requires attaching a light source to the vehicle providing the necessary lighting. Unfortunately, artificial lights proportional to illuminate the scene in a non-uniform fashion producing a bright spot in the center of the image and poorly illuminated area surrounding. Then the distance between the camera and the scene usually induced prominent blue or green colour (the wavelength corresponding to the red colour disappears in only few meters). Then, the floating particles highly variable in kind and concentration, increase absorption and scattering effects. At last the variable of the underwater vehicle affects once again image contrast. It is found that image enhancement is one of the most important issues in low-level image processing. In some algorithm basically, enhancement methods were classified into two classes: global and local methods. [2]

A. Light propagate in underwater:

With respect to light reflection, Church [3] describes that the reflection of the light varies generally depending on the structure of the water surface. Another main concern is related to the water that bends the light either to make crinkle patterns or to diffuse it as shown in Figure (1.1). Most importantly, the quality of the water controls and influences the filtering properties of the water such as sprinkle of the dust in water [5]. According to Anthoni [4] the reflected amount of light is partly polarized horizontally and partly enters the water vertically. An important characteristic of the vertical polarization is that it makes the object minor shining and therefore helps to capture deep colors which may not be possible to capture otherwise. For an ideal transmission medium they received light is influenced mainly by the

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properties of the target objects and the camera lens characteristics. This is not the case underwater. First, the amount of light available under water, depends on several factors. The interaction between the sun light and the sea surface is affected by the time of the day (which influences the light incidence angle), and by the shape of the interface between air and water. The diving location also directly impacts the available light, due to a location-specific color cast: deeper seas and oceans induce green and blue casts; tropical waters appear cyan, while protected reefs are characterized by high visibility. In addition to the variable amount of light available under water, the density of particles that the light has to go through is several hundreds of times denser in seawater than in normal Atmosphere. [7]

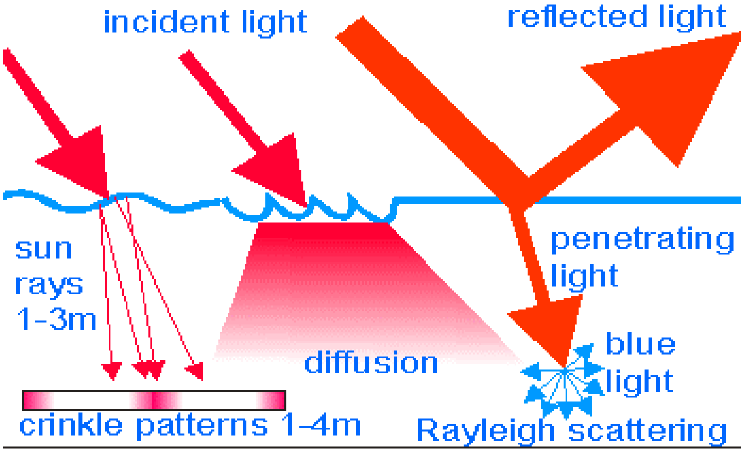

Figure (1.1) Water surface effects [4]

Another problem discuss the underwater images is related to the density of the water in the sea which is considered 800 times denser than air. Therefore, when light traveling from the air to the water, it is partly reflected back and at the same time partly enters the water [4]. The amount of light that enters the water also starts reducing as we start going deeper in the sea [6]. Similarly, the water molecules also absorb certain amount of light [5]. As a result, the underwater images are getting darker and darker with the depth . Not only the amount of light is reduced when we go deeper but also colours drop off one by one depending on the wavelength of the colours. For example, first of all red colour disappears at the depth of 3m. Secondly, orange colour starts disappearing while we go further. At the depth of 5m, the orange colour is lost. Thirdly most of the yellow goes off at the depth of 10m and finally the green and purple disappear at further depth [5]. This is shown diagrammatically in Figure 2. As a matter of fact, the blue colour travels the longest in the water due to its shortest wavelength. This is what makes the underwater images having been dominated only by blue colour. In addition to excessive amount of blue colour, the blur images contain low brightness and low contrast.

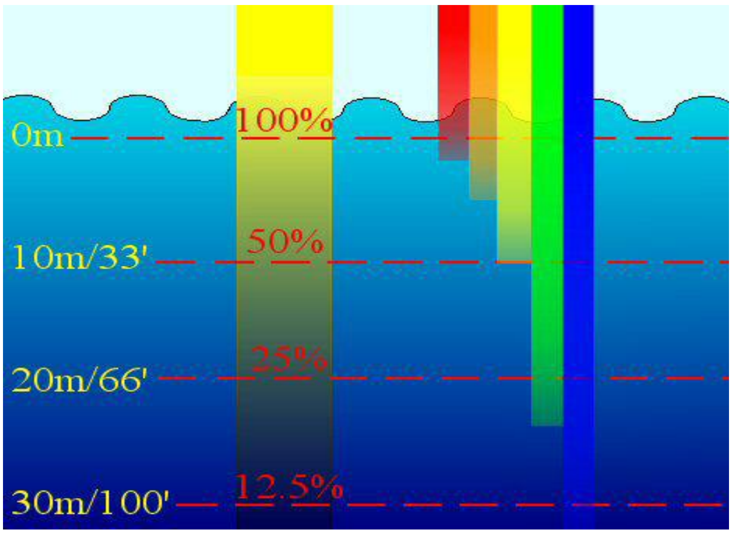

Figure (1.2) Colour appearance in underwater [6]

B. Underwater Image Modeling:

In The underwater image optical model, the acquired image can be modeled as being composed of two components. One is the direct transmission of light from the object, and the other is the transmission due to scattering by the particles of the medium (e.g. airlight). Mathematically, it can be written as

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I(x) =J(x) t(x) + (1-t(x)) A …….1

Where *I* is the achieved image. *J* is the scene radiance or haze free image, *t* is the transmission along the cone of vision, and $t(\boldsymbol{x}) = \exp(-\beta d(\boldsymbol{x}))$, β is the attenuation coefficient of the medium, $d(\boldsymbol{x})$ is the distance between the camera and the object, *A* is the veiling color constant and $\boldsymbol{x} = (x, y)$ is a pixel. The optical model assumes linear correlation between the reflected light and the distance between the object and observer.[8]

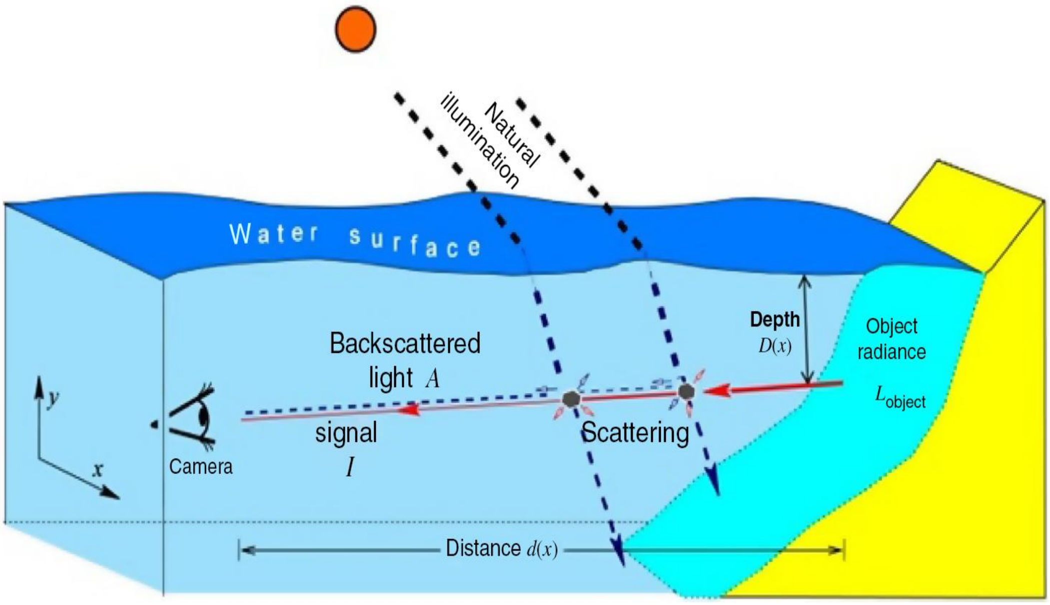

Figure (1.3) Schematic diagram of underwater optical imaging.

The light propagation model is slightly different underwater environment. In the underwater model, absorption plays an important role in image degrading. Furthermore, unlike scattering, the absorption coefficient is different for each color channel, being the highest for red and lowest for blue in seawater. These leads to achieve the following Simplified hazy image formation model:

$$I(x) = J(x)\, e^{(-\beta_s + \beta_a)d(x)} + (1 - e^{-\beta_s d(x)})A \quad \ldots\ldots\ldots 2$$

Where β_s is the scattering coefficient and β_a is the absorption coefficient of light. The effects of haze are highly correlated with the range of the underwater scene. In this paper, we simplify the situation as at certain Water depth, the transmission *t* is defined only by the distance between camera and scene. [8]

III. LITERATURE SURVEY

Kashif Iqbal (1) the work on the "Underwater Image Enhancement Using an Integrated Colour Model"
In order to improve the perception of underwater images, there are proposed an approach based on slide stretching. The objective of this approach is twofold. Firstly, the contrast stretching of RGB algorithm is applied to equalize the colour contrast in images. Secondly, the saturation and intensity stretching of HSI is used to increase the true colour and solve the problem of lighting. Interactive software has been developed for underwater image enhancement.
There are used slide stretching algorithm both on RGB and HSI colour models to enhance underwater images. The advantage of applying two stretching models is that it helps to equalize the colour contrast in the images and also addresses the problem of lighting. By applying the proposed approach, we have produced promising results. The quality of the images is statistically illustrated through the histograms.

Shuai Fang1 (2) The work on the "Effective Single Underwater Image Enhancement by Fusion" Due to the absorption and scattering, the clarity and the observation of the depth of field of the image which is obtained by underwater photoelectric imaging will be reduced. This paper introduces a new single image enhancement approach based on image fusion strategy. The method first applies the white balance and global contrast enhancement technologies to the original image respectively, then taking these two adapted versions of the original image as inputs that are weighted by specific maps .We obtain the enhanced results by computing the weight sum of the two inputs in a per-pixel fashion. Since we do not employ deconvolution (computationally expensive), the algorithm reduce the execution time and can effectively enhance the underwater image. The experimental results demonstrate that our method can obtain good visual quality.

Lintao Zheng (3) The work on the "Underwater Image Enhancement Algorithm Based on CLAHE and USM"
The process of enhancing underwater image proved to be a much more difficult challenge to overcome. Those traditional enhancing techniques like histogram equalization shown strong limitations for such a task. In this paper, we propose an efficient underwater image enhancement method that is able to enhance underwater images based on a single degraded underwater image. In contrast to previous traditional enhancing methods, our approach does not require multiple images and special hardware. Further analysis demonstrates that the original degraded underwater image can be effectively improved by the proposed method. The proposed enhancement method is especially well
suited for image processing applications that demand images with high visual quality. The results are promising. Moreover the method opens a new perspective for image-enhancement applications. In the future, we intend to extend the proposed method to other areas.

Codruta O. Ancuti (4) The work on the "Color Balance and Fusion for Underwater Image Enhancement" **We** introduce an effective technique to enhance the images captured underwater and degraded due to the medium scattering and absorption. Our method is a single image approach that does not require specialized hardware or knowledge about the underwater conditions or scene structure. It builds on the blending of two images that are directly derived from a color compensated and white-balanced version of the original degraded image. The two images to fusion, as well as their associated weight maps, are defined to promote the transfer of edges and color contrast to the output image. To avoid that the sharp weight map transitions create artifacts in the low frequency components of the reconstructed image, we also adapt a multiscale fusion strategy. Our extensive qualitative and quantitative evaluation reveals that our enhanced images and videos are characterized by better exposedness of the dark regions, improved global contrast, and edges sharpness. Our validation also proves that our algorithm is reasonably independent of the camera settings, and improves the accuracy of several image processing applications, such as image segmentation and key point matching.

IV. GUIDED FILTER

We first define a general linear translation-variant filtering process, which involves a guidance image *I*, an filtering input image *p*, and an output image *q*. Both *I* and *p* are given beforehand according to the application, and they can be identical. The filtering output at a pixel *i* is expressed as a weighted average: [9, 10, 12]

$$q_i = \sum_j W_{ij}\ (I) p_j \qquad \text{……..3}$$

where *i* and *j* are pixel indexes. The filter kernel W_{ij} is a function of the guidance image I and independent of *p*. This filter is linear with respect to *p*.

A. Definition

Now we define the guided filter. The key assumption of the guided filter is a local linear model between the guidance I and the filtering output q. We assume that q is a linear transform of I in a window ω_k centered at the pixel k:

$$q_i = a_k\ I_I + b_k\ ,\forall_i \in \omega_k \qquad \text{………4}$$

Where a_k , b_k are some linear coefficients assumed to be constant inω_k. We use a square window of a radius r.
Output image q has edge if and only if guidance image I has edge. [12, 13]
To find linear coefficients, the cost function in window ω_k is defined as:

$$\text{E}\,(a_k,\ b_k) = \sum_{i\in\omega_k}((\, a_k\ I_i + b_k - p_i)^2 + \omega {a_k}^2\,)) \qquad \text{……….5}$$

Where, ε is a regularization parameter penalizing largea_k.
The term εa_k 2 is used to prevent a_k from being too large. E is the blur degree to control the accuracy of edge detection. If the image I has no edges, the output will be an averaged result of input in ω_k . If the edge is present in I which represent the structure of the guidance image, the edge is transferred to the output image.
The cost function can be seen as a linear regression model & its solution can be given by,

$$a_k = \frac{\frac{1}{|\omega\ |}\sum_{i\in\omega_k} I_i\, p_i - \mu_k\, \overline{p_k}}{\sigma_k\ 2-\varepsilon} \qquad \text{…………6}$$

$$b_k = \overline{p}_{\text{k}} - a_k\, \mu_k \qquad \text{…………7}$$

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where, μ_k and $\sigma_k{}^2$ are the mean and variance of I in ω_k ,ω is the number of pixels in ω_k;

$\overline{p}_k = \frac{1}{|\omega|}\sum_{i\in\omega_k} p_i$ is the mean of p in ω_k .

Using linear coefficients (a_k , b_k), the filtering output can be computed as;

$$q_i = a_k\ I_I\ + b_k\ \ ,\forall_i\ \in\ \omega_k \qquad \text{……………..8}$$

But, the values for q_i will be different when calculated for various windows. So, the solution is to find the average value of q_i . For all possible windows in the image, (a_k , b_k) values will be calculated and then the filtered output can be given as;

$$q_i = \frac{1}{|\omega|}\sum_{k/i\in\omega_k}(\ a_k\ I_i +\ b_k\ ) \qquad \text{……………9}$$

The guided filter also can be applied to colour images. In case input image is coloured, the filter should be applied to each channel separately.

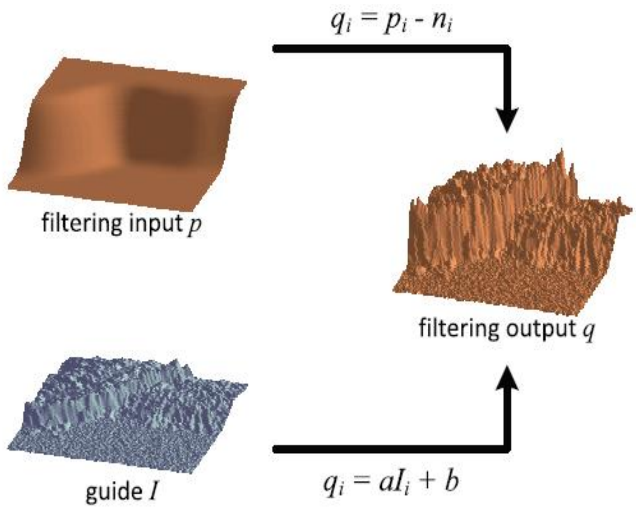

Figure (1.4) Guided Filter Process [10]

B .Guided filter algorithm:

1 Firstly read the guidance image and the input image.

2. Enter the values of r and ε where r is the local window radius
   and ε is the blur degree of the filter.

3. Calculate the values: Mean of I, Variance of I, Mean of P,
   Average cross product of I and P.

4. Compute the value of linear coefficients.
   a = (cross_IP – mean_I.*mean_P)./ (var_ I+ ε)
   b = mean_ P - a. * mean _I

5. Compute the mean of a and b

6. Obtain the filtered output image Q using mean of a and b,

Q = mean_ a. * I + mean _b [10, 11]

V. RELATED FILTER WOEK TO GUIDED FILTER

Edge preserving property is the most appreciated feature of filtering process. Traditional filters like average filter provides the smoothing including edges of the images too. Some edge preserving filters from the literature review are given as follows:

A. Anisotropic Diffusion

Anisotropic diffusion is very notable idea for edge aware image processing. The partial differential equations are the basic idea for anisotropic diffusion. The speed of the process is slow. If the intensity of each pixel is assumed to be heat and is propagated over time to its neighbors. Some improvements have been proposed to minimize operation time which in turn affects the accuracy.

B. Median Filter

The median filter is another important edge aware filter, which can be considered as a special case of local histogram filters. The pixel under consideration is replaced with the median magnitude. It also shows property of noise reduction, while preserving edges more effectively as compared to a linear smoothing filter. Rank order and morphological processing are proposed variations for the basic median concept.

C. Bilateral Filter

The bilateral filter is another no iterative strong approach to preserve edges in images. It produces filter output at the considered pixel as an average of neighboring pixels. The result is that the smoothed output is not consistent with the input at the edges. So detail enhancement like operations which requires the consistency of input signal and output signal has to be performed with better gradient preserving filter

VI. IMPROVE DIFFERENT QUALITY OF IMAGE BY GUIDED FILTER

A. Edge Preservation

In image processing, images are often decomposed into a smooth base layer and one or more detail layers. The base layer describes intensity variations of image which is obtained by applying the filter on image. The difference between the original image and the base layer gives the detail layer. The base layer output is the blurred input image. The degree of blurring should be properly adjusted to avoid artificial edges in the final output image while further processing image. The edge preserving filter which prevents smoothening across the edges is best suited for these cases of image processing. The input image and the guidance image should be same. Also, the derived base layer using guided filter is consistent with the input image, which also represents gradient preserving property. This property avoids unwanted matching discrepancy between the base layer and detail layers. Edge preserving decompositions can be used in various images processing such as detail enhancement, HDR compression, details fusion, etc. For example, in image enhancement operation the base layer and the detail layer are processed in various ways and recombined. The quality of images for human viewing is improved by enhancement process.

B. Image Denoising

In image denoising techniques, image filters are applied to images to remove the different types of noise and fog. Considering the denoising process with guided filter, N is the noisy image as input, while I is reference image as guidance. Basically, noise is nothing but high frequency details contained in the image which do not contain any relevant information. This process retains the structure of the guidance image and provides edge preserving smoothing. As the guidance image is usually free of noise, so is the filtered result. This aspect can be used where a reference image is made available free of noise.

C. Structure Transference

From the definition of the guided filter, it can be seen that the output and the guidance image are related to each other with linear equation. So it is obvious that, if the edge is present in the guidance image, then it will be transferred to the output image. This property can be used in applications like matting, feathering, etc. Image matting is nothing but to distinguish the foreground from background which requires exact mask. The mask can be obtained with the help of segmentation methods, which is later processed by using the guided filter to get accurate outline. In this case, the input image will be the mask and the guidance image is required to be the original image.

For obtaining desired results in a particular aspect, the guided filter parameter values have to be set. Also, the input image and the guidance image selection has to be made, same or different.

D. Extension to Color Filtering

The guided filter can be easily extended to color images. In the case when the filtering input p is multichannel, it is straightforward to apply the filter to each channel independently. A color guidance image can better preserve the edges that are not distinguishable in gray-scale. This is also the case in bilateral filtering. A color guidance image is also essential in the matting/feathering and dehazing applications, as we show later, because the local linear model is more likely to be valid in the RGB color space than in gray-scale. [9,10,11.12.13]

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CONCLUSION

This paper studies various underwater Image enhancement method used in the field of image processing techniques. Differently from the recent trend toward accelerating the bilateral filter, we studies a new filter that exhibits the nice property of edge-preserving smoothing but which can be computed efficiently and non approximately. Our filter is more generic than "smoothing" and is applicable for structure-transferring, enabling novel applications of filtering-based feathering/matting and dehazing. Since the local linear model is a kind of patch-wise unsupervised learning, other advanced models/ features might be applied to obtain new filters.. It is more effective as compared to other existing approaches in aspects such as detail enhancement, denoising, etc. Comparing with previously used bilateral filler it is observed that proposed guided filter has higher PSNR and MSE value. Implementation of proposed work is done by using MATLAB. It is implementing both the spatial domain and wavelet domain method. So the output image is a high quality image.

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