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Image Enhancement for Under Water Depiction using Homomorphic Filter

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ABSTRACT:

Underwater images are essentially characterized by their poor visibility because light is exponentially attenuated as it travels in the water and scenes results poorly contrasted and hazy. Underwater images play a key role in ocean exploration but often suffer from severe quality degradation due to light absorption and scattering in water medium. The underwater depiction processing area has received considerable attention within the last decade, showing important achievements. In this project it is proposed to develop the image enhancement methods to improve the quality of a underwater image. Both spatial domain and transform domain image enhancement methods are propose to improve the underwater image. Therefore, expanding the dynamic range of the image provides a way for enhancing the visibility of underwater image. The transform-domain image enhancement methods commonly transform the spatial domain image into the frequency domain (e.g., through the Fourier transform or wavelet transform) and improve the quality by amplifying the high- frequency component and suppressing the low-frequency component, simultaneously by using homomorphic filter or high-boost filter.

INTRODUCTION:

The underwater image processing area has received considerable attention within the last decades, showing important achievements. In the human exploration and exploitation of ocean, the underwater mission is challenging. In order to deal with underwater image processing, we have to consider first of all the basic physics of the light propagation in the water medium. Physical properties of the medium cause degradation effects not present in normal images taken in air. Underwater optical image provides an important source of underwater information. However, due to the characteristic attenuation and scattering of light in water, underwater imagesthrough camera sensors are apt to degrade. Typically, the attenuation results in color shift while scattering of light makes an underwater image blurred and a decrease of contrast. Although the physical characteristics of underwater light emission have a great impact on underwater images, they are not the only phenomena that affect underwater visibility and quality of underwater images. For example, the movement of water or fish shoal can cause so-called motion blur. Dissolved organisms and tiny suspended particles in waters often lead to noises in underwater images and the influence of light backscattering on underwater imaging will be amplified.

The propagation of light differs in water and air. When the light propagates in water, there are several important factors that result in attenuation and scattering of light. The density of water is greater than air, which causes the attenuation of light. Water selectively scatters and absorbs certain wavelengths of visible light. Suspended particles in water affect the light transmission and produce scattering of light. Various types of noise occur for example marine snow that causes additional light backscattering. Temperature and salinity also cause the light scattering. To summarize, the light attenuation and scattering are more serious in water than air. As a result, underwater optical images are apt to blur along with lower contrast.

The light received by an underwater camera can be divided into three components: direct component, forward scattered component and backward scattered component. The total light intensity received by the camera sensor can be expressed as

$$E_{T=}E_d+E_f+E_b \quad 1)$$

Where E_T represents the total light intensity

Ed represents the direct component

E_f represents the forward scattered component

E_b represents the backward scattered component

The three componentrs can be calculated a component,it can be calculated as

$$E_d=J.e^{cd} \quad 2)$$

where J is the reflection part from the object after receiving light from an illumination source; c is the attenuation co-efficient; d is the distance between the object and the sensor for forward scattered component, it is given by

$$Ef = Ed * g = J.t * g \quad (3)$$

where g is the point spread function (PSF) for predicting beam propagation and imaging system performance, t is defined as t= e-cd.

For backward scattered component, it can be expressed as

$$Eb = B\infty\ (1 - t) \quad (4)$$

where B ∞represents the background light at infinity in the image.

Because the effect of forward scattered component Ef on underwater imaging is much smaller than that of direct component and backward scattered component, the forward scattered component can be ignored in the calculation of total light intensity. As a result, the simplified underwater imaging model can be expressedas

$$ET = J.t + B\infty(1 - t) \quad (5)$$

To obtain high-quality underwater images, one can resort to an advanced imaging equipment like the divergent-beam underwater Lidar imaging (UWLI) system or multistate underwater laser line scan system . The main obstacle for usersis the expensive cost with the equipment. Another alternative to obtain high-quality.

PROPOSED METHOD:

Generally, underwater image processing concerns two techniques, i.e. image restoration and enhancement. Image restoration is based on a physical model about original image and recovered image. Degradation of image is focused in a restoration process. For image enhancement, the focus is mainly on the enhancement of pixels of images according to some subjective qualitative criteria, rather than the degradation process and the physical model of imaging for image restoration. During the last decade, many kinds of underwater image enhancement algorithms have been proposed. Commonly used methods include wavelet transform and Retinex algorithm. Over the past decade, these classic algorithms have been applied widely and developed. Although these enhancement algorithms can process underwater images and have been widely used, there exist some inherent shortcomings. However, some details of the processed image might disappear. Moreover, there might be excessive enhancement at the peak of histogram. For wavelet transform, it is usually successful to deal with images captured in shallow waters, while fails in deep waters where the red-light attenuation is severe. For Retinex algorithm, adaptive enhancement can be achieved by pixel dynamic range compression, edge enhancement and color constancy. However, halo effect might produce in areas with large brightness difference. In recent years, some improvement of classic underwater image enhancement methods should be noted. Due to the disadvantage of each algorithm in enhancing underwater images, fusion algorithms are preferred for more and more researchers. In this proposed method, the restoration and enhancement of underwater images are investigated. To obtain high-quality underwater images, a fusion algorithm is proposed that refers to color balance, contrast enhancement and histogram stretching. In the study, the contribution to color balance is the reallocation of the single channel value of the three-color channels.

The contribution to histogram stretching is that the algorithm is based on the average single channel value of red channel. Instead of refining the transmittance in DCP based restoration conventionally, an optimized contrast algorithm is employed by which the optimal transmittance can be determined. Todemonstrate the validity of the proposed fusion algorithm, some underwater images with obvious colour deviation and different ambiguity are processed and compared with several commonly used algorithms. In the study, some of the underwater images to be processed are taken from datasets Real world Underwater Image Enhancement (RUIE), some from internet and the others from experiment.

LITERATURE SURVEY:

- **Iqbal proposed enhancement method based on histogram sliding stretching.**

  The proposed method is twofold. Firstly, the contrast stretching of RGB algorithm is applied to equalize the color contrast in images. Secondly, the saturation and intensity stretching of HSI (hue, saturation, intensity) is used to increase the true color and solve the problem of lighting. Interactive software has been developed for underwater image enhancement.

- **Henke proposed a color constancy hypothesis algorithm based on gray world hypothesis to solve the color distortion problem of underwater images.**

He proposed a novel low-level image feature-based color constancy hypothesis for underwater scenes. Based on this hypothesis, he proposed an algorithm, using a distance map to estimate multiple gain factors to remove the color cast.

- **Gurak sin addressed the use of a method formed by the wavelet transform and the differential evolution algorithm.**

In this method, differential evolution algorithm was employed to find the optimum w parameters for Entropy and PSNR in separate approaches. Finally, unsharp mask filter was used to enhance the edges in the image. As an evaluation approach, performance of the proposed method was tested by using the criteria of entropy, PSNR, and MSE.

- **Abdul Ghani and Isa proposed a method for Underwater image quality enhancement through Rayleigh-stretching and averaging image planes**.

The proposed method aims to improve underwater image contrast, increase image details, and reduce noise by applying a new method of using contrast stretching to produce two different images with different contrasts. The proposed method integrates the modification of the image histogram in two main color models, RGB and HSV The histograms of the color channel in the RGB color model are modified and remapped to follow the Rayleigh distribution within certain ranges. The image is then converted to the HSV color model, and the S and V components are modified within a certain limit. Qualitative and quantitative analyses indicate that the proposed method outperforms other state- of-the-art methods in terms of contrast, details, and noise reduction. The image color also shows much improvement.

HOMOMORPHIC FILTERING:

Block Diagram

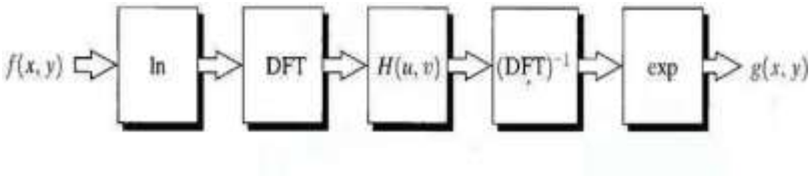


Figure1: Homomorphic filtering approach for image enhancement

The illumination-reflectance model can be used to develop a frequency domain procedure for improving the appearance of an image by simultaneous gray- level range compression and contrast enhancement. An image f(x, y) can be expressed as the product of illumination and reflectance components:

$$f(x, y) = i(x, y)r(x, y).$$

Equation above cannot be used directly to operate separately on the frequency components of illumination and reflectance because the Fourier transform of the product of two functions is not separable; in other words.

$$\Im\{f(x, y)\} \neq \Im\{i(x, y)\}\Im\{r(x, y)\}.$$

Suppose, however, that we define

$$\begin{aligned} z(x, y) &= \ln f(x, y) \\ &= \ln i(x, y) + \ln r(x, y). \end{aligned}$$

Then

$$\begin{aligned} \Im\{z(x, y)\} &= \Im\{\ln f(x, y)\} \\ &= \Im\{\ln i(x, y)\} + \Im\{\ln r(x, y)\} \end{aligned}$$

or

$$Z(u, v) = F_i(u, v) + F_r(u, v)$$

where Fi (u, v) and Fr (u, v) are the Fourier transforms of ln i(x, y) and ln r(x, y), respectively. If we process Z (u, v) by means of a filter function H (u, v)then, from

$$\begin{aligned} S(u, v) &= H(u, v)Z(u, v) \\ &= H(u, v)F_i(u, v) + H(u, v)F_r(u, v) \end{aligned}$$

where S (u, v) is the Fourier transform of the result. In the spatial domain, Now we have

$$s(x, y) = i'(x, y) + r'(x, y).$$

$$s(x, y) = i'(x, y) + r'(x, y).$$

Finally, as z (x, y) was formed by taking the logarithm of the original image f(x, y), the inverse (exponential) operation yields the desired enhanced image, denoted by g(x, y); that is, Now we have

$$s(x,y) = \Im^{-1}\{S(u,v)\}$$
$$= \Im^{-1}\{H(u,v)F_i(u,v)\} + \Im^{-1}\{H(u,v)F_r(u,v)\}.$$

By letting

$$i'(x,y) = \Im^{-1}\{H(u,v)F_i(u,v)\}$$

and

$$r'(x,y) = \Im^{-1}\{H(u,v)F_r(u,v)\},$$

Finally, as z (x, y) was formed by taking the logarithm of the original image f(x, y), the inverse (exponential) operation yields the desired enhanced image, denoted by g(x, y); that is,

$$g(x,y) = e^{s(x,y)}$$
$$= e^{i'(x,y)} \cdot e^{r'(x,y)}$$
$$= i_0(x,y)r_0(x,y)$$

where

$$i_0(x,y) = e^{i'(x,y)}$$

$$r_0(x,y) = e^{r'(x,y)}$$

are the illumination and reflectance components of the output image. The enhancement approach using the foregoing concepts is summarized in figure

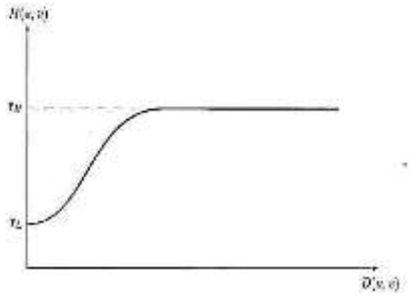
This method is based on a special case of a class of systems known as homomorphic systems. In this particular application, the key to the approach is the separation of the illumination and reflectance components achieved. The homomorphic filter function H (u, v) can then operate on these components separately.The illumination component of an image generally is characterized by slow spatial variations, while the reflectance component tends to vary abruptly, particularly at the junctions of dissimilar objects. These characteristics lead to associating the low frequencies of the Fourier transform of the logarithm of an image with illumination and the high frequencies with reflectance. Although these associations are rough approximations, they can be used to advantage in image enhancement.

A good deal of control can be gained over the illumination and reflectance components with a homomorphic filter. This control requires specification of a filter function H (u, v) that affects the low- and high- frequency components of the Fourier transform in different ways. Figure 9.2 shows a cross section of such a filter. If the parameters γL and γH are chosen so that $\gamma L < 1$ and $\gamma H > 1$, the filter function shown in Fig. 9.2 tends to decrease the contribution made by the low frequencies (illumination) and amplify the contribution made by high frequencies (reflectance). The net result is simultaneous dynamic range compression and contrast enhancement.

Figure2:Graphical representation of Homomorphic filter.

HISTOGRAM:

A histogram is a graphical representation of a grouped frequency distribution with continuous classes. It is an area diagram and can be defined as a set of rectangles with bases along with the intervals between class boundaries and with areas proportional to frequencies in the corresponding classes. In such



representations, all the rectangles are adjacent since the base covers the intervals between class boundaries. The heights of rectangles are proportional to corresponding frequencies of similar classes and for different classes, the heights will be proportional to corresponding frequency densities.

According to the figures one to four, we can see that how homomorphic filtering is used for correcting non-uniform illumination in image, and the image become clearer than the original image. On the other hand, if we apply high pass filter to homomorphic filtered image, the edges of the images become sharper and the other areas become dimmer. This result is as similar as just doing high pass filter only to the original image.

HISTOGRAM

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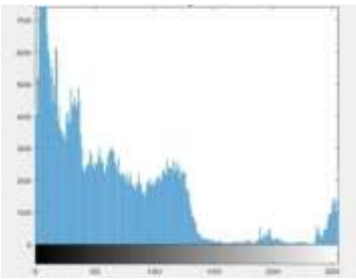
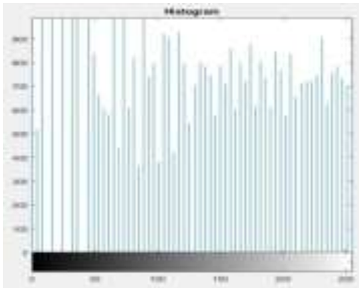
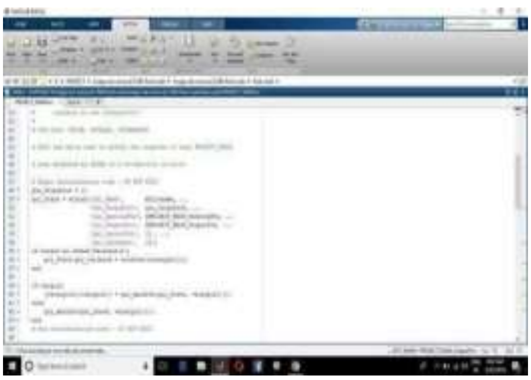
MATLAB is a high-performance language for technical computing. It integrates computation visualization and programming in an easy-to-use environment. MATLAB stands for Matrix Laboratory. It was written originallyto provide easy access to matrix software developed by LINPACK (linear system package) and EISPACK (Eigen system package) projects. MATLAB is therefore built on a foundation of sophisticated matrix in which the basic element in matrix that does not require pre dimensioning which to solve many technical computing problem especially those with matrix and vector formulations, in a fraction of time. MATLAB features of applications specific solutions called toolbox. Very important to most users of MATLAB, toolboxes allow learning and applying specialized technology. These are comprehensive collections of MATLAB functions that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control system, neural networks, fuzzy logic, wavelets, simulation and many others.





Application development and including graphical user interface building. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix problems, especially those with matrix and vector formulations, in a fraction of the time take to write a program in a scalar non- interactive language such as C or FORTRON. MATLAB features a family of add-on application-specific solutions called toolbox. Very important to most users of MATLAB, toolbox allows you to learn and apply specialized technology. Toolbox is comprehensive collections of MATLAB functions that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation and many others.



SIMULATION RESULTS

Simulation output for Gray Scale Image:

Input Image

Figure 1: Input Image

Figure2 Output Image

Figure 3: After applying the natural logarithm

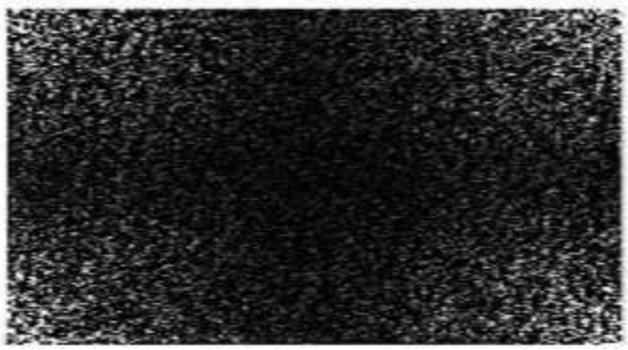


Figure 4: Afte Fourier Transform

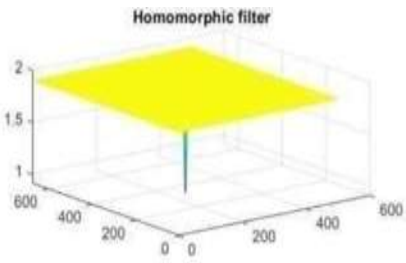


Figure 5: Homomorphic Filter

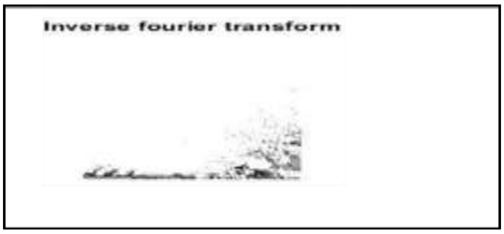
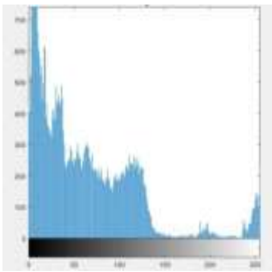


Figure 6: IFT

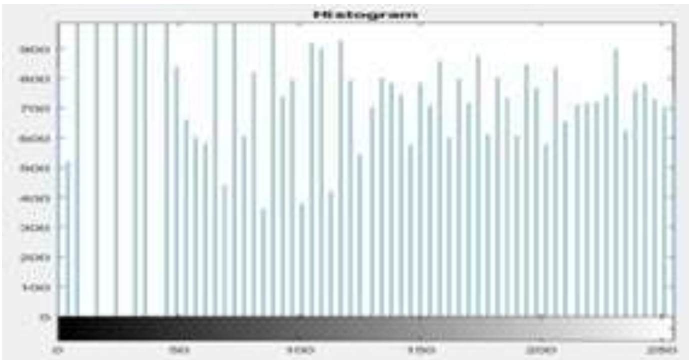
INPUT IMAGE

SIMULATION INPUT WITH THEIR HISTOGRAMS



SIMULATION OUTPUT

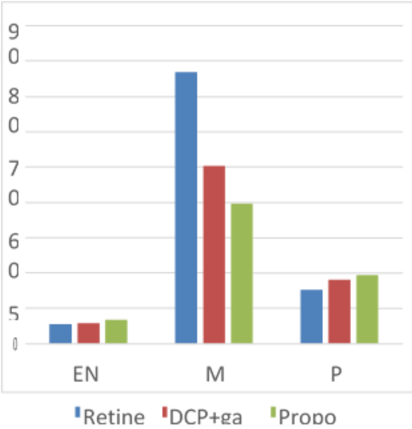
Simulation output with their histograms comparison of proposed method parameters with existing methods



Bar Graph comparison of proposed method parameters with existing methods

The Input image that is taken from the underwater consisting of low brightness and noissy that is estimates by the each channel extraction, those we obtain the enhanced output image The result shows that this proposed method improves the visibility of underwater images and produce the results MSE, PSNR and entropy values when compared to other existing methods.

Method	Entropy	MSE	PSNR
Retinex algorithm	5.488	76.768	15.13
DCP+gamma correction	5.7763	50.26	18.069
Proposed method	6.6312	39.657	19.4929



CONCLUSION:

Underwater imaging and enhancement is the area of image processingand it isa dynamic field. For enhancement of underwater images new techniques and methods are reported routinely in new product development. For enhancement of underwater image dehazing here we proposed a new algorithm that work on underwater images and remove artificial lighting and increase image quality. Future work involves to place the dehazed frame in the input underwater image for better quality of underwater images. An approach to enhance the underwater captured degraded image has been introduced. This method includes homomorphic filtering and HE method. The homomorphic filtering can reduce the non-uniform illumination and minimizes the noises present in an image. The quantitative and qualitative result also shows that this proposed method improves the visibility of underwater images and produce low MSE, higher PSNR and entropy values when compared to other existing methods. This method can be used for wide range of underwater enhancement applications. Future work could be the enhancement of underwater captured videos and to remove total darkness view in the captured images.

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