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A survey on: Visual Enhancement and Restoration of Sub-Aqua Image

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Abstract: In Underwater Image processing, the basic physics of light propagation in the water medium comes into extinction. When light enters the water, it is exponentially attenuated, and so the visibility distance is limited. Underwater images suffer from blurring, non uniform lightening, noise, low contrast, etc. Therefore, underwater image processing is necessary. The filters used in the enhancement methods improve the image quality, suppress the noise, preserves the edges in an image and smoothen the image. Object recognition is done based on color, shape, background scenery, suspended particles and object features. The proposed technique comprises a combination of four filters such as homomorphic filtering, wavelet denoising, weiner filter and contrast equalization. These filters are applied sequentially on degraded underwater images. There are four different algorithms discussed with respect to this. The preprocessing technique comprises of homomorphic filtering to correct non-uniform illumination of light, wavelet denoising to remove additive Gaussian noise present in underwater images, weiner filtering to removes the blurred portion of the image and contrast stretching to normalize the RGB values. The proposed technique enhances the quality of the underwater images and can be employed prior to apply computer vision techniques.

Keywords: Homomorphic-Filter, Wavelet-Denoising, Bilateral-Filter, Histogram-Equalization, Color-Stretching, Polarizing-Filter, weiner filter.

I. INTRODUCTION

Underwater image is crucial for scientific research and technology. Underwater vision is plagued by poor visibility conduction. According to [1] most computer vision method like stereo triangulation or on structure from motion cannot be employed directly. This is due to challenging environmental conditions creates a complication in image matching and analysis. Computer vision method are being used in a different areas e.g mine detection, inspection of underwater power and telecommunication cables, pipelines, nuclear reactor and columns of offshore platforms[1] and also for research in marine biology[2], mapping[3], archaeology[4]. The quality of underwater images plays a pivotal role in scientific mission.

Generally an object can be identified by its appearance which may be characterized by shape, size its colour, texture. But in underwater environment (which is contrary to a terrestrial one). Is very difficult to recognize simply by observing the colour and shape of the object.

As we move deeper in to the water the Intensity of light beam are attenuated and scattered and radiance of an object decay exponentially. Water with particles is actually hydrosol which creates a veiling glow that limits the contrast of underwater images and leads to image blur, and backward light scatter [6].

The light attenuation process is caused by absorption and scattering, which influence the overall performance of underwater imaging systems. Forward scattering generally leads to blur of the image skin texture. On the other hand, backscattering generally confines the contrast of the images, generating a characteristic veil that superimposes itself on the image and hides the scene because rarely all the water is turbid by the organic(viruses, colloids, bacteria, phytoplankton) and inorganic(ground quartz sand, clay minerals, or metal oxides in the micro size range) particles.

The research on sunken image processing can be addressed from two different points of view such as an image restoration or an image enhancement method. The image restoration aims to recuperate a degraded image using a model of the degradation and of the original image formation; it is essentially an inverse problem. These methods are rigorous, but they involve many model parameters like attenuation and diffusion coefficients that characterize the water turbidity and can be extremely variable. Whereas image enhancement uses qualitative subjective criteria to produce a more visually pleasant image and they do not rely on any physical model for the image construction. These kinds of approaches are usually simpler and faster than deconvolution methods.

The main reason behind the colour degradation is the variation in the wavelength of colour as we go deeper in to the water. Colours drop off one by one depending on the wavelength of the colours. Every colour has its own wavelength like red colour consist the high wavelength. As the matter of fact, due shortest wavelength of blue colour it travels a longest distance inside the water. It makes the underwater images having been conquered only by the blue colour [9].

II. LITERATURE REVIEW

A. Shuai Fang, Rong Deng, Yang Cao, and Chunlong Fang(2013)

Fang et al. Introduces a single image enhancement approach based on image fusion strategy. In this method,it 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. Enhanced results are obtained by computing the weight sum of the two inputs in a per-pixel fashion. Since they do not employ Deconvolution (computationally expensive), the algorithm reduce the execution time and can effectively enhance the Underwater image.

The two main steps are the direct reflection of light from the object and the reflection from the particles of the medium.

They have shown that by choosing appropriate weight maps and inputs, the fusion strategy can be used to effectively underwater images. The method is faster than existing single image enhanced strategies yielding accurate results and the color contrast of the object in underwater.

B. John Y. Chiang and Ying-Ching Chen(2012)

John et al. proposed a novel efficient approach by dehazing algorithm, which compensate the attenuation discrepancy along the propagation path, and to take the influence of the possible presence of an artificial light source into consideration. Distances between the objects and the camera, is estimated, the foreground and background within a scene are segmented. The light intensities of foreground and background are compared to determine whether an artificial light source is employed during the image capturing process. After compensating the effect of artificial light, the haze phenomenon and inconsistency in wavelength attenuation along the underwater propagation path to camera are corrected. Next, the water depth in the image scene is estimated according to the residual energy ratios of different color channels existing in the background light. Based on the amount of attenuation consequent to each light wavelength, color change compensation is conducted to reinstate color balance.

The main advantage of this paper is it can handle light scattering and color change distortions suffered by underwater images simultaneously but is unproductive in removing the image blurriness caused by light scattering.

C. Guoliang Yang, Fuyuan Peng, Kun Zhao (2012)

Guoliang et al. proposed a dual-band underwater image denoising and enhancement algorithm, the aim of enhancement algorithm is to enhance the detail, sharpen the edge and filter the noise. In order to do that, Initial the original image was decomposed into high-frequency part H and low frequency part L, and then H was filtered into F by mean shift algorithm which was improved by using the intermediate iteration results. Based on the haze imaging model a contrast enhancement method was proposed and was applied on L and F.

D. Kashif iqbal,Rosalina abdul salam, azam osman and Abdullah zawawi talib(2007)

Iqbal et. al. introduces a slide stretching algorithm both on RGB and HSI colour models to enhance underwater images. An interactive software tool has been developed used for underwater image enhancement First of all, it performs contrast stretching on RGB colour model. Secondly, it performs saturation and intensity stretching on HSI colour model.

The main advantage of applying two stretching models is that it helps to equalize the colour contrast in the images. It also addresses the problem of lighting and the quality of the images which is statistically illustrated through the histograms.

E. Prabhakar c.j.,Praveen kumar p.u. (2011)

prabhakar et, al. proposed a preprocessing technique for enhancing the quality of degraded underwater images.The proposed technique includes four filters such as homomorphic filtering, wavelet denoising, bilateral filtering and contrast equalization, which are applied sequentially.

The main contribution of this paper is inclusion of bilateral filter for smoothing in addition to existing other filtering techniques. Bilateral filtering is a simple, non-iterative scheme for edge preserving smoothing. Traditional filtering is a domain filtering, and enforces closeness by weighing pixel values with coefficients that fall off with distance. The range filtering, this averages image values with weights that decay with dissimilarity. Range filters are nonlinear because their weights depend on image intensity or color. The combination of both domain and range filtering is termed as bilateral filtering

It has observed that combination of Coif4 filter bank and Modified BayesShrink function yields higher PSNR values.
The main advantage over anisotropic filtering is its processing time which is very low in this proposed technique when compared to the anisotropic filtering.

F. Dr.G.Padmavathi, Dr.P.Subashini, Mr.M.Muthu Kumar and Suresh Kumar Thakur. (2010)

Padmavathi et. al. Compare and evaluate the performance of three famous filters namely, homomorphic filter, anisotropic diffusion and wavelet denoising by average filter used for under water image pre-processing.

The performances of the filters are compared and analyze by the PSNR and MSE vales for underwater images. 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 should be low for an image and peak signal to noise ratio should be high in an image.

The experimental result shows that the wavelet filter gives high and low for PSNR and MSE respectively. Moreover the elapsed time of the three filters is also studied to identify the suitable filters that process the operation quickly by preserving the image quality. The SRAD filter perform its operation in less number of seconds when compare to other filters.

G. Stephane bazeille, isabelle quidu, luc jaulin, jean-phillipe Malkasse (2006)

In this paper bazeille et. al. present a novel underwater pre-processing algorithm.

- Initially, Moir´e pattern is removed via spectral analysis by detecting peaks in the Fourier transform and deleting them assuming that they represent the moir´e effect.
- Symmetric extension prevents from potential border effects and resizing to squared image speeds up the following process by enabling to use fast Fourier transform and fast wavelet transform algorithms.
- Converted the color space from RGB to YCbCr (Luminance Chrominance). This color space conversion allows us to work only on one channel instead of processing the three RGB channels. This step speeds up again all the following processing's avoiding to process each time each RGB channels.
- Homomorphic filtering is a frequency filtering which corrects the non uniform illumination Enhance contrasts in the image and sharpens the edge at the same time
- Then the wavelet denoising method is used to remove the Gaussian noise present in the natural image and it was preferred to many others algorithms [7] because of it performances of speed in comparison of its denoising quality.
- Nextly, the anisotropic filtering simplify the image features to improve image segmentation. This filter smooth's 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.
- After adjusting image intensity in order to improve contrast, they convert back the image in the RGB space, and cut out the symmetric extension part of the image to recover the image with Original size to recover colours.

This preprocessing algorithm is automatic and requires no parameter adjustment and no a priori knowledge of the acquisition conditions. And this filters greatly enhances edge detection and also often increase image visual quality.

H. Yan Chen and Jin Hua (2012)

Chen proposed an approach in which the formation mechanism of local motion-blur is analyzed, and a new restoration algorithm aimed at local motion-blur in a complex background. In the algorithm, the problem of restoration of blurred image with complex background is simplified. First, the blurred part is extracted from the complex background, and then it is pasted onto a bottom with monochromatic background. After restoration in the monochromatic background, the restored part is pasted back to the original complex background. All the operations can be completed in spatial domain. Because the restoration of blur image with monochromatic background is easier, so the algorithm proposed in this paper is simple, fast and effectual. It is an effective method of blur image restoration.

Wiener filter and constrained least squares filtering are two typical method of constrained restoration. Wiener filter can be attributed to the deconvolution (or reverse filter) algorithm.

The blur and restoration algorithm proposed in this paper are based on the physical process of the image; the main operations are matrix operations and cycles, and the method can be implemented in space domain.

J. Halleh Mortazavi, John P. Oakley and Braham Barkat (2012)

In this proposed work, a filter is used to detect the level of optical backscatter in each spectral band from a set of multispectral images. Extraction of an underwater object spectrum can be done by subtracting the estimated level of optical back-scatter and scaling the remainder in each spectral band from the captured image in the corresponding band.

The experimental results show that the proposed method can estimate the accurate level of optical back-scatter and compensate for it at different spectral bands in visible wavelengths and for different levels of water turbidity. Therefore, the original pixel value can be recovered from the degraded pixel and as a result the pixel spectral information of an underwater scene can be found.

The advantage of the proposed method is that it compensates the effect of optical back-scatter with no Information of the physical properties of the medium But the recovery is limited for very high level of turbid water because of the effect of extinction.

K. Liu Chao, Meng Wang (2010)

Chao et. al. proposed a dark channel prior method to restore the original clarity of the images underwater. Using dark channel prior, the depth of the turbid water can be estimated by the assumption that most local patches in water-free images contain some pixels which have very low intensities in at least one color channel.

The dark channel prior is based on the statistics of clear images in air. the intensity of these dark pixels in that channel is mainly contributed by the background light. This approach is physically valid and is able to recover distant objects even in the heavy blurry image without any preconfiguration.

This simple method is better than the "brightest pixel" method. But is not an ideal prior for the distant regions underwater without adaptation.

The main limitation is that it may be invalid when the scene object is inherently similar to the background light over a large local region and no shadow is cast on the object. The original colours are not recovered, but the clarity of the images is improved greatly.

In this proposed technique the scattering problem has been solved but the absorption is not solved.

L. Yan Wang and Bo Wu (2010)

Wang et. al. proposed a method which analyzes the physical effects of visibility degradation, and present an algorithm which inverts the image formation process. In this paper, they have considered the visibility restoration from a single underwater image as a particular filtering problem and use median filter to infer water veil. Mainly they have focused on to recover objects at close distances from the lens (0.5 – 5 meters).This approach unveil more details and recover bright color information when we compare with chao[5] result. The estimated water veils are sharp and consistent with the input images.

The main advantage of this method is its speed since its complexity is only a linear function of the input image size and it also achieves good result.

M. Tali Treibitz, and Yoav Y. Schechner (2009)

Treibitz et. al.addresses the need for a no scanning recovery method which uses active scene irradiance. And presented an approach for recovering the object signal. Backscatter is a major cause of contrast deterioration[8] rather than signal blur. This method can work with compact simple hardware, having active wide-field polychromatic polarized illumination. The camera is fitted with a polarization analyzer. Two frames of the scene are instantly taken, with different states of the analyzer or light-source polarizer. A recovery algorithm follows the acquisition. This allows both the backscatter and the object reflection to be partially polarized. Thus it unifies and generalizes prior polarization-based methods, which had assumed exclusive polarization of either of these components.

This approach is limited to an effective range due to image noise and falloff of wide-field illumination. The main goal in this research are, First is to estimate the backscatter component, in order to remove it from the raw image and reveal the object signal. Second is to study the potential use of the backscatter component for extracting information about the distance map of the scene. The analysis in this paper used the single scattering approximation.

N. Yoav Y. Schechner and Nir Karpel (2005)

Schechner et.al. Proposed a computer vision approach that removes degradation effects in underwater vision. They analyze the physical effects of visibility degradation. It is shown that the main degradation effects can be associated with partial polarization of light. Then, an algorithm is presented, which inverts the image formation process for recovering good visibility in images of scenes. The algorithm is based on a couple of images taken through a polarizer at different orientations. this paper also analyzes the noise sensitivity of the recovery.

Underwater scattering involves polarization effects. These effects are exploited to compensate for underwater visibility degradation.

Since it is physics based, the method also recovers information about the scene structure (distances). The algorithm does not require any calibration of the environmental parameters and exploits natural lighting. It is best compatible with horizontal photography rather than acquisitions in the downwards direction.

As is the case in deep-water explorations the uniform lighting assumption is invalid if artificial sources are used.

III.CONCLUSION

In Underwater Image Processing the basic physics of light propagation in the water medium comes into existence. Underwater Image pre-processing is done to improve the image quality by correcting non uniform lightening; removing noise, color contrasting. Underwater image enhancement improves the object identification in underwater environment. Homomorphic filtering is used for correcting non uniform illumination. It enhances the contrasts in the image. Wavelet denoising is used to suppress the noise called Gaussian noise which is present in camera images and also in instrumental images. Bilateral filter is an edge-preserving and noise reducing smoothing filter. Recognition of objects in images depends on local image features. Color is an important cue for object recognition Contrast stretching is a simple enhancement technique in which contrast in an image is improved by stretching the range of intensity values. Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. Weiner filter can be used to deblur the image.

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