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Object Detection and Filtering Techniques of Underwater Images : A Review

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Abstract- As going deep under the water nothing can be seen properly as well as it is difficult to identify any substance residing or present under water. This survey basically focuses on the detection of the underwater image which are taken through various self-ruling submerged vehicles and remotely controlled vehicles, in order to improve the quality of the pictures. The factors include the low contrast, blur, non-uniform lighting and faded colors. This paper analyzed an image enhancement technique along with the image restoration technique that will help to acquire images that are of better quality. The algorithms applied on the degraded images comprises of two domains- Spatial Domain Methods, Frequency Domain Methods. The literature reviews used in this paper explained that the preprocessing algorithms used by various authors uses a standard filter techniques contain different combinations. The survey includes analysis in terms of qualitative and quantitative factors on hundreds of underwater images. The images taken in offshore water characterized by a heavy concentration of colored dissolved organic matter and total suspended matter, thus various methods have been applied on the images in a proper way so as to obtain a fresh image.

Keywords—Offshore, underwater image restoration, under water imaging, underwater optical model.

I. INTRODUCTION

Submerged vision is one of the sensible fields of consideration for scientists. The beneficial information of underwater mines, wrecks, coral reefs, submerged condition of pipelines and media transmission links etc. are normally retrieved from Self-ruling Autonomous Underwater Vehicles (AUV) and Remotely Operated Vehicles (ROV). Submerged images are basically depicted by their poor perceptibility since light is exponentially lessened as it goes in the water, and the scene results ineffectually differentiated and blurred. Incapacitate light limits the perceptibility at around twenty meters in translucent water and five meters or less in turbid water.

The light constriction process is brought by ingestion and dispersing, which influence the general execution of submerged imaging frameworks. Forward dispersing for the most part prompts obscure of the picture highlights. The contrast of the images is generally limited by the backscattering, which generates a characteristic veil that superimposes itself on the image and hides the scene. Assimilation and dispersing effects are due to the water itself as well as due to the segments such as a broke up natural issue. The perceptibility range can be expanded with fake light enlightment on the article, though it produces non-uniform light on the outside of the object and creating a splendid spot in the focal point of the image with ineffectively lit up zone encompassing it. When we go further, the measure of the light is diminished and hue drops off contingent upon their wavelengths. The blue shading has the briefest wavelength, so it traversed the longest in the water. Submerged images experience restricted range perceptibility, low complexity, non-uniform lighting, obscuring, brilliant curios, decreased shading and commotion. The distinctive light of the longest wavelength is consumed first in the translucent untamed water. The most influenced shading, red, is diminished to 33% of its power after 1 m and is primarily lost after a separation of 4 m to 5 m submerged [10]. Blue and violet lights with contrasted and different wavelengths are assimilated at last. Thus, clear untamed sea water appears dark blue to the human eye.

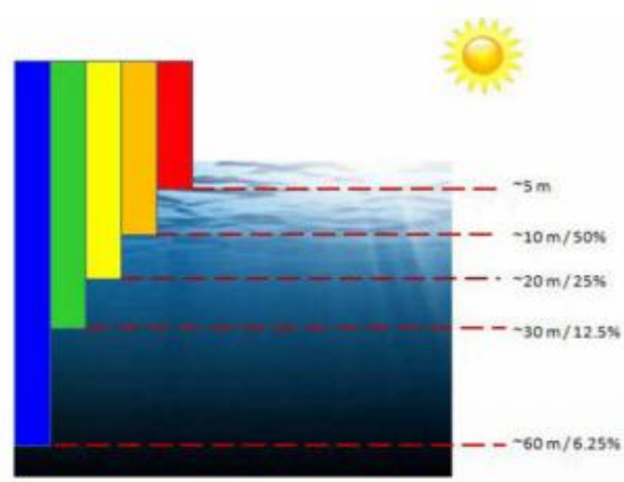

Figure 1: Illustration of diminishing under water color (reference Hitam et al., 2013).

Figure 1 signify a visual description of reducing underwater shading. The figure illustrate that at the depth of 5 m, the red shading is first absorbed by water. Ingestion is then trailed by orange, yellow, green, and blue (Hitam et al., 2013). As these shading parts are retained at the last, the underwater images appear green-blue in the light.

The survey on submerged image handling can be tended to from two distinct perspectives i.e., image reclamation (image restoration) or an image upgrade strategy (image enhancement). The image rebuilding means to recuperate a corrupted image utilizing a model of the corruption and of the first image development; it is primarily a converse issue. This technique is rigorous, but it demand many model parameters like attenuation and diffusion coefficients that characterize the water turbidity and can be acutely variable. While image improvement utilizes subjective abstract criteria to deliver an all the more outwardly satisfying image and they dont depend on any physical model for the image development.

These type of methodologies are typically less difficult and expeditious than deconvolution techniques. As of late, numerous specialists have created pre-processing strategies for underwater images utilizing image improvement techniques. The strength of the technique was analysed by using angle greatness histograms and moreover the rule applied by Arnold-Bos et al. [2] was connected. This measure assume that all around differentiated and commotion free images have a dissemination of the inclination size histogram near exponential, and it features an imprint from zero to one. Bazeille et al. [3] propose a calculation to pre-process underwater images. It reduces submerged annoyances and improves the quality of the image. The calculation is programmed and demands no parameter amendments. The strategy was used as a starter progress for locating the edge.

Recently, many researchers have developed pre-processing techniques for enhancement and restoration of the underwater images. In the next section, we have discussed the various preceding work which has been done for the improvement of the submerged pictures.

II. IMAGE ENHANCEMENT TECHNIQUES

Picture upgrade is essentially enhancing the interpretability or impression of data in pictures for human spectator and giving better contribution for other mechanized image preparing methods. The important target of image improvement is to adjust credits of an image to make it progressively appropriate for a given undertaking and a particular observer. There exist countless methods that can upgrade a computerized image without spoiling it. The improvement strategies can comprehensively be categorised into the following two classifications:

1. Spatial Domain Methods
2. Frequency Domain Methods

Spatial domain: Spatial Filtering can be explained as particularly emphasizing information at different spatial scales over an image. Filtering methods can be performed by the Fourier transform in the frequency domain or in the spatial domain by convolution.

Frequency Domain: In this technique, the image is first transmitted in to frequency domain. Then all the Fusion operations are applied on the Fourier transform of the image and the Inverse Fourier transform is performed in order to obtain the resultant image.

In this section, we will briefly review the various image enhancement techniques using wavelet transform, K-L, and Contourlet transform.

1. **Wavelet Transform**: Synthetic aperture sonar are used to obtain the acoustic images. In this paper, Searcher et al [4] differentiated the target response and the background reverberation noise by utilizing a coherence-based wavelet shrinkage method. The major source of interference are the sea floor sediment and multipath reveberation. The targets which are used to generate the independent looks, are much more coherent than the sea floor sediments. The discrete wavelet transformation is applied on the independent as well as on the compliment look. The weights assigned to the wavelet coefficients of the looks are compared using the coherent metric. Then inverse wavelet transformation is applied so as to get the enhanced acoustic image.

This method is used for generating the independent looks. The disadvantage is that the multipath reverberation which cannot be resolved is assumed to be a speckle noise.

2. **K-L Transform**: Acoustic images can be enhanced in the wavelet domain than in the spatial domain because the techniques which are used to enhance the digital images are not appropriate for processing the submerged acoustic images. In this paper, Priyadharsinia et al [5] described the discrete wavelet transformation on acoustic image that decomposes the picture into four frequency sub-bands namely LL, LH, HL, and HH. The KL transform is used to enhance the smooth areas in the LL component. The other high frequency bands LH,HL, HH are added with enhanced LL band and then the inverse wavelet transform is applied in order to obtain an enhanced acoustic image.

As compared to generalized histogram equalization, the images obtained in this technique has better contrast and resolution.

3. **Contourlet Transform:** Images that are caught in lacking light, for the most part have low complexity and dim shadows. These variables truly influences the picture preparing plans in face identification, security observation, picture combination. Asmare et al [6], exhibited contourlet change as another picture upgrade calculation. Another change work is created by utilizing existing sigmoid capacity and the tan h functions. Contourlet transform involves sub-band decomposition and directional transform. In Sub-band decomposition stage, point discontinuities are captured using Laplacian pyramid. Directional channel bank is utilized to connect the point intermittence into straight structures.

This paper manages that, in speaking to the picture remarkable highlights, for example, edges, lines, bends and forms the execution of the contourlet change is superior to wavelets for its anisotropy and directionality. As the contourlet change utilizes straightforward numerical change work, the calculation gives quick outcomes. For pictures which are experiencing low enlightenments or non-uniform lighting conditions, these change work have intriguing properties with regards to improving the pictures. This procedure did not acquaint any disfigurement with the first picture, since the pictures are very much spoken to utilizing the contourlet change.

These are a few methods that are utilized to improve the nature of the picture. In the following segment, we will see the procedures for remaking the photos.

III. IMAGE RESTORATION TECHNIQUES

Image restoration is the process of restoring distorted pictures which cannot be taken again or obtaining the same image again is a costlier process. We can restore the pictures by preliminary knowledge of the noise or the disturbance that causes the bending in the picture.

The rebuilding of the picture is done in two areas: spatial space and recurrence area.

(i)In spatial area, the sifting activity is finished by legitimately working on the pixels of the computerized picture.

(ii)In recurrence area, the sifting activity is finished by mapping the spatial space into the recurrence area by taking Fourier transform of the image function.

Figure 2: Image Restoration (reference https://www.stephenpaulphotography.co.uk/imagerestoration)

The improved quality of the restored image is measured by the signal-to-noise ratio improvement.
Basically, the image restoration techniques can be categorised into blind restoration techniques and non-blind restoration techniques.

(i) Blind restoration algorithm is used when no information of distortion is known. The advantages of this algorithm are higher resolution and better quality.

(ii) Another technique which is used for restoration of the images key features including-image contrast, blurriness etc. this techniques is known as the non-blind technique which is used for the classification of the degraded function of the images into linear and non-linear restoration methods. It works on the principle of PSF prediction wiener filter, inverse filter, come under the linear non-blind technique. The example of the non-linear restoration method is lucy-richardson algorithm. Further is a discussion for the techniques which are used:

1. **Inverse Filtering:** This is one of the fast and the easiest method to restore the degraded images as it works- on the principle if any of the blurring function is found in the image then this techniques tends to start works. This technique uses high pass filters in order to reconstruct the blur image in the absence of any external efforts. But the problem comes whenever the the noise becomes small or zero [7].

2. **Wiener Filter:** This is a highly standard technique for the remaking or the restoration of the images which works by taking two parameters they are- degradation and statistical functions in the restored function. This technique is supposed to be the best deblurring linear method as it uses some well-known PSF for the reconstruction of the image from the degraded one. High and low pass filters are used in order to reduce the noise [8].

$$f = g \times (f + n)$$

The resultant output image is obtained by above equation in which the additive noise and frequency characteristics are well-known.

3. **The Richardson–Lucy calculation**: The rebuilding techniques which are talked about above are straight. They straightforwardly pass on that, when the rebuilding channel is determined, the arrangement is acquired in one go. Amid the previous two decades, the non-direct iterative strategies are picking up there acknowledgments and the outcomes got are superior to those gotten with straight techniques. The Lucy Richardson (LR) calculation is an iterative nonlinear rebuilding technique. The L-R calculation emerges from greatest probability plan in which picture is demonstrated with toxic substance measurements. Augmenting the probability capacity of the model yield a condition that is fulfilled when following emphasis meets:

$$\hat{f}_{k+1}(x,y) = \hat{f}_k(x,y)\left[h(-x,-y) * \frac{g(x,y)}{h(x,y) * \hat{f}_k(x,y)}\right]$$

In this strategy, there emerges an apparent inquiry of where to end. It is difficult to express a specific incentive for the quantity of emphasess; a great arrangement relies upon the size and multifaceted nature of the PSF lattice. The calculation for the most part achieves a steady arrangement all around quickly (few stages) with a conservative PSF grid. The picture possibly smooth, on the off chance that one stops after a not very many cycles. On expanding the quantity of emphasess, the computational procedure is backed off however it additionally intensifies the clamor and presents the ringing impact. Thus for the great nature of reestablished picture, the ideal number of emphasess are resolved physically for very picture according to the PSF estimate.

The comparison has been done on the basis of the advantages and disadvantages of the techniques.

Table 1: Comparison among algorithms.

AUTHORS	TECHNIQUES	DESCRIPTION	ADVANTAGES	DISADVANTAGES
[1] Miao Yang	**Restoration Model**	This technique is based on the dark channel reflection-illumination decomposition and local backscattering lighting estimation. Miao et al experimented with three datasets: CelebFaces Attributes (CelebA), SUN397 Scenes, and the Denoising Benchmark 11 (DB11) which provided various under water images.	It provides the clarity of edge detail and the colorfulness of the output image.	Decomposed (blurred or faded) images are not well identified.
[4] Alan J. Hunter and Robbert van Vossen	**Wavelet Transform**	Alan J. Hunter et al worked on datasets of TNO MUD sediment-penetrating sonar which obtained by synthetic aperture sonar. This dataset gives the images of underwater burried objects. The discrete wavelet transformation is applied on the images in order to investigate the location of the object.	This technique is used to generate the independent looks which are much more coherent than the sea floor sediments.	The multipath reverberation which cannot be resolved is assumed to be a speckle noise.
[5] R. Priyadharsini	**K-L Transform**	It experiments with AE signal from the noise-influenced datasets of submerged images. The results are found to be satisfactory. The enhanced LL band is added with other high frequency bands and given to the inverse wavelet transform in order to produce an enhanced acoustic image.	The resultant enhanced image has better contrast and resolution compared to the images obtained by Generalized Histogram Equalization (GHE).	This technique is good for enhancing the digital images but not suitable for processing the underwater acoustic images.
[6] Melkamu Hunegnaw Asmare	**Contourlet Transform**	It experiments on 2 datasets of multispectral (MS) and panchromatic (PAN) images such as landset and satellite images and two pairs of hyperspectral (HS) to provide multiresolution localization. By using existing sigmoid function and	This technique removes low illuminations or non-uniform lighting conditions.	Security is the issue that needs to take seriously.

		the tan h functions on the orginal images a new transformation function is developed to enhance the landset images.		
[7] Achyuth Rao MV	**Inverse Filtering**	It is a type of the lowpass filter which recovers images without degradation. It has taken posterior datasets and panchromatic (PAN) image such as remote sensing images from satellite and applied the blurring function of the degraded image is to be known for processing.	It is the quickest and the easiest way to restore the degraded picture.	Inverse filtering cannot be applied if the additive noise is very small.
[8] N.A.Sheela Selvakumari	**Wiener Filter**	It uses high and low pass filters which is applied on some images which contains patch of random noise images datasets. It incorporate both parameters, degradation function and statistical characteristic of noise in the restoration function.	It is one of the best deblurring linear technique that uses known PSF for reconstructing image from degraded image	It requires degraded function to be known.
[16] Fouad Aouinti1	**The Richardson–Lucy Algorithm**	A property of the Munsell data set which contains the satellite images is used in order to obtain the best outcomes by using optimal regularization parameter.	A stable solution can be obtained very quickly.	In order to achieve better results, it is necessary to perform optimal number of iterations.

The above table 1 explains about the algorithms which were used, with their key features, advantages and disadvantages.

IV. CONCLUSION

Image processing provides an area of research where different type of knowledge can be aquired by denoiseing and filtering approaches. Underwater objects and image processing over the underwater images has drawn attention in last few years. The degraded underwater images experience non-uniform brightening, low difference, clamour and decreased hues. This paper gives an analysis on various picture improvement procedures that upgrades these degraded images in different way. In this paper, we have analysed the advantages , disadvantages and remarks given by their work. Algorithm such as wiener filter is one of the best deblurring linear technique for reconstructing the degraded image. In the same way inverse filtering is the quickest and the easiest way to restore the degraded picture. Whereas contourlet transform and K-L filtering works to obtain the better contrast and resolution of the image. These reseraches has led to an exponential increase in the amount of images regularly collected on research expeditions related to the assessment of underwater objects. Along with their advantages, these algothims have the disadvantages too such as, inverse filtering can not be applied on the images that have small noise and the multipath reverberation noise can not be resolved by the wavelet transform.Thus a more improved work can be done on the object analysis on underwater images such as fish and other moving objects using image processing model.

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