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A Survey On Underwater Image Pre-Processing

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Abstract: The ocean is full of mystery and the underwater exploration and prevention of scarce resources have always been exciting topics. There have been many attempts to capture the marine flora and fauna using AUVs and high-pressure resistant, underwater vehicles which are equipped with high-resolution cameras. Still, we haven't been able to completely study the total expanse of marine life around the globe. For the evolution of deep-sea resources, underwater autonomous operation, underwater image processing has a lot of importance. The efficiency of the algorithms used for image processing is comparatively less for underwater image processing as water causes many challenges such as scattering, absorption, etc. affecting the significant details of the image. Here we present a survey of challenges faced by underwater image acquisition, image restoration,and enhancement techniques.

Index Terms **- light attenuation, dark channel prior, non-local means, Bazeille algorithm**

I. INTRODUCTION

Oceans occupy approximately 70% of the planet and contain abundant natural resources, which has long been a cause of concern for human growth. Exploring this mysterious region of the ocean is becoming more popular as marine observation and exploitation advance quickly.

Due to the increased use of marine resources, underwater image processing is now seen as crucial. [15]. Physical properties existing in the underwater environment make underwater imaging very challenging.

India is planning to have its first underwater train in Kolkata [13]. India also built the fourth of six underwater warships with French collaboration. These projects need underwater object detection, communication of underwater vehicles, and exploring underwater sea maps. Also, projects like underwater bridge construction need a detailed study of dynamic environments in underwater regions. Few systems like surveillance need the inspection of underwater infrastructure and detection of any man-made objects. Hence, we aim to discuss a few of the techniques implemented and challenges faced to develop such processing. Typical image processing algorithms can be best described using the following steps:

1] Data acquisition 2] image restoration 3] image enhancement 4]image segmentation 5] feature extraction

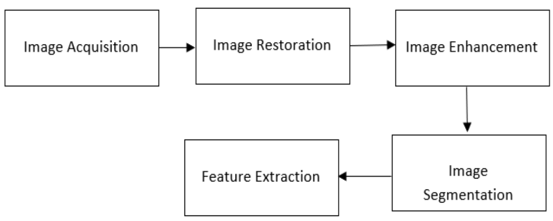

fig. 1. typical image processing block diagram

This paper focuses on various techniques used for image processing and their limitations. A comparative study of the techniques is also presented.

The paper is structured as follows: Section 2 outlines the challenges in image capturing and data acquisition. Section 3 includes techniques of image restoration. Section 4 describes image enhancement techniques following the conclusion of the paper.

II. DATA ACQUISITION

Data gathering is a crucial stage of the image processing process. Collecting underwater images is a difficult task as it faces many challenges. An Endoscopic Camera (which does not require an external light source) which has a long cable to view minute regions on a big screen is used to capture underwater images [13]. Also, an underwater imaging system with range gates is used to capture underwater images using a CCD (charged coupled device) camera which has a 4 to 6 times greater range than that of conventional cameras [2].

Because image pre-processing underwater is a study topic that has been explored a lot in recent years, there are very few data sets dedicated to underwater study. [15] The reasons for a few datasets are:

1]Research in this field began recently.

2] The collection of data requires a lot of time due to many challenges.

The parameters that affect underwater image processing are light attenuation, water density, absorption, short range, and scattering which causes blurring effects, low contrast, non-uniform illumination, diminished colors, and prominent blue or green hues [3] [9]. Thigh-dimensional images are affected by the sediments in the water. The visibility in clear water gets ltoestoredl 20m and < 2m in turbid water by light attenuation [8]. Light attenuation does not provide sufficient light, so an additional resource of light is required but this causes a [8] large bright spot in the center of the image and affects the edges of dark areas. The distance between the scene and the camera results in color attenuation.

Although the previously mentioned Range Gated System captures images that are always smoothened, it eliminates noise caused by backscattering efficiently [2].

III. Image Restoration

Image restoration techniques aim to recover the details of images degraded because of dynamic objects. The images captured successively include dynamic objects which lead to distortions. Image restoration algorithms are used to eliminate these dynamic objects. In the Image restoration method, dynamic objects are recognized and removed by comparing two successively captured frames and subtracting them from each other. The algorithm follows the step: convert the image to grayscale then select points where there is a difference between two images that is greater than the threshold used to estimate the motion of an item. The area of the dynamic object is calculated and finally, this dynamic object is eliminated. To fill the patch, an upgraded total variation model is used which reduces the resolution. For restoring (super-resolution) some detail the s in image e the BP network is upgraded and then applied to the BP network which is trained.

In [9], Image Restoration is performed using

$$g(x,y) = m(x,y) * p(x,y) + q(x,y) \qquad (1)$$

where * denotes convolution. The original image "m" is recovered from the captured image "n" using (if available) explicit knowledge about the degradation function "p" (also called point spread function PSF) and the noise characteristics "q".

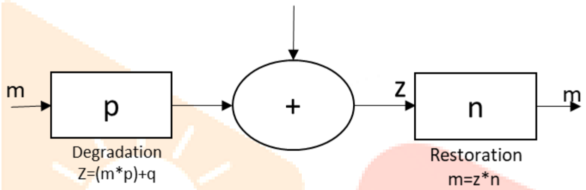

fig.2. image restoration technique [9]

IV. Image Enhancement

Image enhancement aims to enhance the visual appearance of the restored image i.e., enhance the quality and characteristics of an image. The quality and details are refined using image enhancement techniques. Yujie Li et al [11] suggested improved methods of non-Local mean denoising, classical median filtering, and dark channel prior as important steps for underwater image enhancement.

The NLM denoising method searches a similar image block from the full spectrum of images to the central neighborhood window. The value of center pixel value for all similar blocks is based on average weight. But it fails when the complexity computationally is very high causing loss of edges and other details of the information. The improved NLM works on segmentation superpixel segmentation. A region with a flat structure can be thought of as having more similarities in the search window and the largest number of comparable blocks discovered by translating a similar window indicates the window has high similarity. The dark channel prior technique [12] helps to get an image with better contrast, non-blurred effect, and color correction which is affected by light attenuation. The complexity of computation is reduced using the dark channel prior method.

$$I_{dark}(x) = \left(\min\left(I^c(y)\right)\right), y \in \Omega(x) \ . \qquad (2)$$

where x denotes pixels
Ω(x) denotes the pixel windows
C denotes various channels
Ic (x) represents the value of channels RGB

After performing the dark channel prior, the grey world algorithm is used to make the image more eligible for image processing. R, G, and B channel average values frequently match those of the grey world algorithm. A constant coefficient is added to each of the three-color channels, to correct the color reasonably. Grey -world algorithm is described as

$$Gray = \frac{mean\left(I'^r(x)\right)+mean\left(I'^g(x)\right)+mean(I'^b(x))}{3} \qquad (3)$$

The relationship between the colored light propagation distance and the color coefficient is given as

$$w^c = 1 + \frac{d_c}{\sum_c d^c} \ , c\epsilon\{r,g,b\} \qquad (4)$$

Where:
d^c represent the colored light propagation distance
w^crepresent the represent sufficient
So, the final function is given as:

$$I^{n^c}(x) = I^{I^c}(x) * \frac{Gray}{mean\left(I^{I^c}(x)\right)} * (1 + \frac{d_c}{\sum_c d^c}) \qquad (5)$$

Although the basic idea of the dark channel prior algorithm is to fill the scattered light by increasing the dark pixels in the underwater image's intensity values which helps to develop true undisturbed underwater image. The improved dark channel algorithm uses histogram equalization to improve the underwater image pixels' dynamic range and then the resultant image is converted to YUV space to equalize the brightness which enhance the contrast of the image.

Also, the image preprocessing includes classical median algorithms (non-linear filter) which preserves the edges of the signal and works excellent on impulse noise. Thus, the quality of the image is enhances using median algorithms. The improved classical median filtering is an improved median filtering method that incorporates voting statistics and noise detection techniques. By recognizing noise picture blocks based on the number of pixels in noise image block filter windows, the dual-platform histogram equalization improves the image. It has straightforward logic with high efficiency of filtering. However, these improved techniques lack accuracy causing texture smoothness.

Dr. Jamal Khallaayoune et al [9] suggested the Bazeille Algorithm for image enhancement and color correction. Bazeille algorithm is as follows:

The wavy repetitive pattern (Moires effect) is eliminated using Fourier transform which includes the peaks which represent the Moires effect.

The border effect is prevented by extending the image symmetrically.

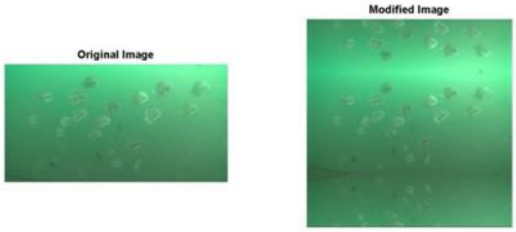

fig. 3. squared image [9]

Color space conversion is to convert RGB to YCbCr which helps to work on a single channel rather than that of RGB channels. The luminance channel is processed which corresponds to the grayscale image.

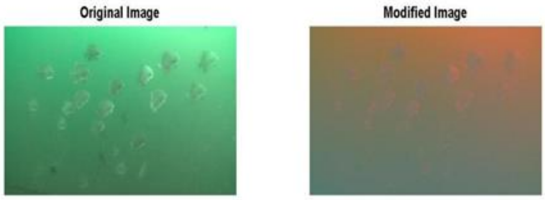

fig. 4. conversion from RGB to YCbCr [9]

Filtration is performed using the homomorphic filter. This enhances contrast, and corrects nonuniform illumination and sharp edges.

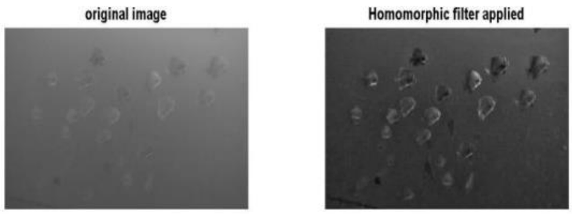

fig. 5. output of homomorphic filter on original image [9]

The next step is used increase contrast. It includes steps such as conversion to RGB and reverses symmetric extension. It is known as the Adjustment of image intensity.

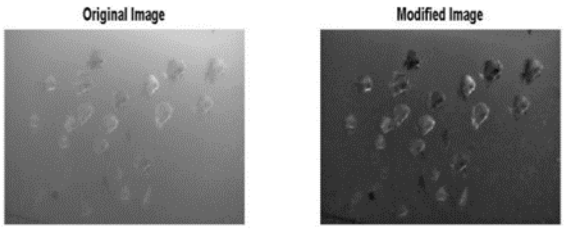

fig. 6. adjustment of image intensity [9]

Color channels are rarely balanced correctly. So, it is necessary to equalize RGB channels. This is step is known as equalizing color.

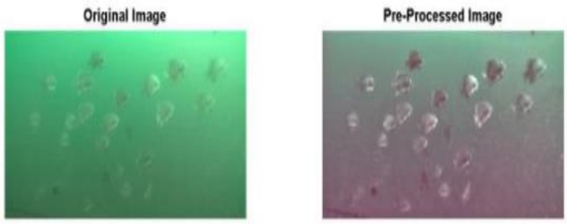

fig.7. equalizing color mean [9]

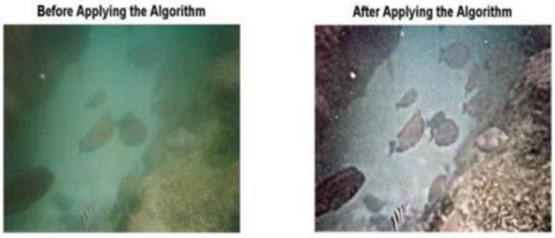

Fig. 8. Bazellie Algorithm Experimental results [9]

An enhancement algorithm is proposed in [1], for upgrading the quality of the images with low signal-to-noise ratios produced by range-gated laser imaging systems. Filtering unwanted noises is the main purpose of this algorithm. The least-square error method is the foundation of this algorithm. The subdivision of each row and column is done and subdivided into several subintervals. A weighting approach with a linear weighting factor is used to combine two neighboring lines. The impacts of the algorithm are investigated through a series of tests. Furthermore, the signal-to-noise ratio demonstrates the ability of the suggested technique to produce high-quality enhanced photos. In [16] common color-correction algorithms include the white balance approach, grey world hypothesis, and grey edge hypothesis. To overcome the limitation of high-frequency information getting lost during de-scattering. It uses a high turbidity underwater image SR algorithm. A high-resolution (HR) image [8] of scattered and scattered images is obtained. Then a convex fusion rule is applied for recovering the final HR image. As compared to the conventional approaches this algorithm has a reasonable noise level after scattering.

Another technique that is used to enhance the quality of Low SNR images is based on Least Square Error. The discrete image is fitted to continuous curves. This is performed by subdividing each row and column into sub-intervals. The image data within sub-intervals is obtained using a curve.

A technique that is better than other state-of-the-art bilateral filtering methods is the trigonometric bilateral filter. This technique is used to overcome problems like the image color getting dropped off as we go deep in the water, the requirement of multiple images, and color distortion. The algorithm for this filter is quick and constant time rather than approximate. The trigonometric bilateral filter is more efficient than the state-of-the-art bilateral filtering method as its computational complexity is O (1) whereas of traditional methods it is O(N2). Other benefits of using trigonometric bilateral filters are edge-preserving and denoising.

V.CONCLUSION

This paper studies underwater image processing steps and different techniques. The challenges in underwater image processing are also analyzed. The image restoration techniques are complicated because of the less knowledge about degraded images. The image enhancement techniques such as improved NLM, dark channel prior, and classical median filtering optimize the underwater image processing and the bastille algorithm improves the image contrasts and edges of objects. The brightness of a dull image and clarity of the image can be enhanced, and the complexity of computation can be reduced using

The dark channel prior method. The underwater noise is also reduced using linear and non-linear filters, guided filters, and adaptive filters.

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