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UNDERWATER IMAGE RESTORATION AND ENHANCEMENT BY USING CLAHE AND DSIHE

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ABSTRACT: Many researchers and practical applications in ocean engineering, ocean biology, and ocean science require clear underwater visibility. Visibility issues, such as low brightness and contrast, are common in underwater images. The interaction of light and medium usually obscures underwater scenes (low intensity, absorption, etc).This paper shows the restore and enhancement of underwater images using CLAHE and DSIHE. Contrast Limiting Adaptive Histogram Equalization (CLAHE) and Dual Sub image Histogram Equalization (DSIHE) is methods of image restoration and enhancement. Underwater images are observed in the same way as haze images in the first phase because they share the same low contrast and color shift issues. This enabled to remove fogging in underwater images using dark channel haze removal technology. The results of the proposed method are compared with the results of existing approaches using performance criteria such as RMSE (Root Mean Square Error), PSNR (Peak Signal to Noise Ratio), contrast, and entropy. Other methods such as MSRCR (Multiscale Retinex with Color Restoration) and AHE (Adaptive Histogram Equalization) are superior to the proposed methods. The final image has been enhanced with contrast and color correction.

KEYWORDS: image restoration, Underwater images, Butterworth Filter, CLAHE and DSIHE.

I. INTRODUCTION

Underwater vision is crucial for marine science research, marine engineering, archaeology, surveillance, and other applications [1]. ROVs (Remotely Operated Underwater Vehicles), AUVs (Autonomous Underwater Vehicles), and AUVs (Autonomous Underwater Robots) are all commonly employed for navigation, exploration and surveillance in underwater environments. Due to recent improvements in a number of technologies [2].These underwater vehicles and robots are frequently equipped with optical sensors that enable them to capture underwater images. Underwater imaging is critical for a variety of academic and industrial applications, including archaeology, mine detection, marine biology, underwater fauna identification and assessment, and mechanical inspection of offshore wind power turbines [3]. However, acquired images are commonly deteriorated with blurring, darkening, low contrast, and color loss due to the peculiar propagation qualities of light absorption and scattering, as well as the camera's unstable water and light changing turbid environment. As a result, it is critical to increase the image's contrast, correct the attenuation effect, and restore the color image for further processing and analysis.

Due to the effects of absorption and scattering, light attenuation reduces the overall effectiveness of an underwater imaging system as the distance from the camera rises [4]. It's not easy to increase underwater visibility. Because light behaves differently than it does on land, despite technological advancements in equipment, the quality of underwater images remains significantly lower than that of images taken in air gases due to physical limitations of the aquatic environment.

The density of water is hundreds of times that of air. When light travels through water, it loses a significant amount of energy, resulting in underwater images with poor color and low contrast, as well as distorted image information [5]. Artificial light has been recommended as a solution to this problem, however this raises another issue. Artificial light produces an intense bright point in the image's centre, which fades as a travel away from it, resulting in uneven illumination. In addition to the non-uniform lighting circumstances, underwater images suffer from peculiar light absorption and scattering characteristics.

Because the underwater environment is so unpredictable, underwater image restoration is difficult. Several strategies for investigating underwater image features have been developed, with the goal of creating clear, color-corrected sceneries while keeping distinct textures useful for image analysis. The modification of an observed image to compensate for faults in the imaging technology that created the observed image is frequently referred to as image restoration. By eliminating noise and inverting degradation, image restoration seeks to simulate a true underwater scene. This frequently necessitates the development of mathematical models of attenuation as well as the application of various signal processing filtering techniques.

An important factor that determines image quality is the environment in which it was shot. If you shoot under abnormal lighting conditions, the image quality will deteriorate. If a handshake occurs while capturing an image, the image will be distorted, blurred, or noisy. Image enhancement is the process of converting captured image content into more visually appealing content. The original image is the digital image captured by the digital sensor, and the content of the original image may be degraded or visualized. Image enhancement is the process of changing the original image's damaged content into a more understandable image.

The image improvement process includes a range of technologies such as filters, frameworks, and algorithms to retain image sharpness, which is commonly harmed by noise, blur, and artifacts [7]. Many application-oriented areas benefit greatly from digital image processing. Image processing is used in a variety of applications, including military, biometrics, robotics, genetics, radar images, satellite images, medical images, and more. If the image shifts from a normal to an aberrant shape, it suggests that there are fluctuations in brightness, contrast level, resolution, and so on.

The rest of the Paper is organized as follows: Section II includes literature reviews, Section III includes underwater image restoration and enhancement methods using the CISHE and DSIHE methods, Section IV includes results analysis, and Section V concludes the paper.

II. LITERATURE SURVEY

C. O. Ancuti et. al. [8] discussed to improve underwater image, color balance and fusion are used. The author took a single underwater shot and used multiple variations of the same input image to apply gamma and white balance modifications. These two photos are combined into a single output image via multiscale fusion. This method restores faded features and edges with a single input, but it does not restore colors or completely remove haze.

Hou et al. [9] presented a method for preserving hue in underwater colour images The HSI (Hue Saturation Intensity) and HSV (Hue Saturation and Value) colour models were addressed using wavelet domain filtering and boundary histogram stretching methods, respectively. By preserving the hue components, this method improves image quality in terms of contrast, color rendering, uneven lighting, and noise reduction.

Yafei Wang Ding et al. [10] described a Underwater image enhancement method based on wavelet decomposition and fusion. This programme improves underwater photos in the frequency domain by using the framework's fusion method. The process of recovering a degraded image from a degraded model and the original image capture is known as image restoration.

Peng and Cosman et. al. [11] have created a depth estimation method based on image blur and light absorption to restore underwater images. Candidates for blurry areas were evaluated using background light. The restoration results were superior compared to other imaging model-based methods.

Abdul Ghani and Mat Isa et al. [12] described a method for stretching RGB and HSV color models (hue, saturation, value) has been developed to improve underwater image quality. To improve contrast, the author used the Rayleigh distribution to remove less than 0.2 percent and more than 99.8 percent of the histogram intensity and increase the remaining intensity across the dynamic range. This issue will be resolved with images that were either too dark or too bright.

K. Iqbal et. al. [13] presents Stretching the contrast of the RGB component of the input image, as well as the saturation and intensity of the HSI component of the image, to improve the contrast of the underwater image and rectify the distorted image. The color channel is stretched using contrast stretch so that the whole range of values can be represented. The completed image is then converted to HIS color space to boost the contrast. In the last stage, the HSI domain intermediate image is transformed to an RGB domain image and shown. This technique cannot guarantee positive outcomes in most dirty underwater conditions. Because it merely boosts the contrast without recovering the image, the final image enhancement appears false.

Baseille et al. [14] created an algorithm for removing underwater clutter and improving image quality, Among the continuous and independent processes used in this technique were homomorphic filtering, wavelet denoising, anisotropic filtering, histogram equalization, and color model modification.

Y. Schechner and N. Karpelet.al [15] described by used a splitter to capture the image in different orientations, the above method is used to rectify the degradation of an underwater photograph. The main degrading effect is generated by light partial polarization, according to this method. The software technique, on the other hand, does not require specialist hardware and instead seeks to reproduce the image using a number of image processing approaches.

III. UNDERWATER IMAGE RESTORATION AND ENHANCEMENT

The flow chart of Underwater Image Restoration and Enhancement by using CLAHE and DSIHE is represented in below Fig. 1

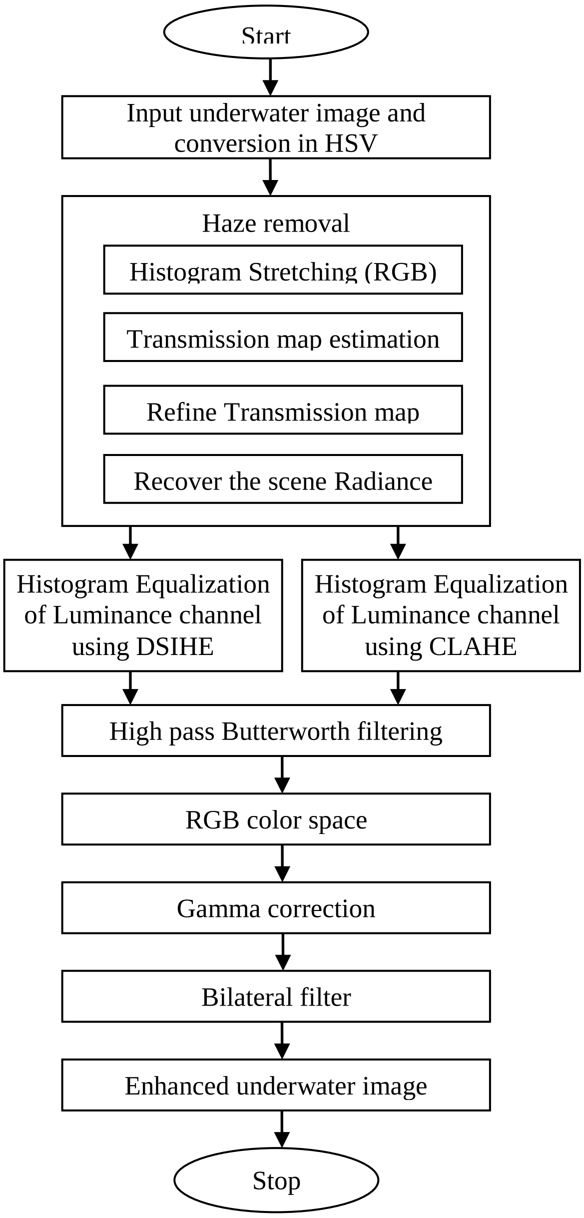

Fig. 1: FLOWCHART OF DESCRIBED MODEL

This paper describes two methods for underwater imaging based on DSIHE, CLAHE, gamma filter, and Butterworth filter, as shown below. This approach uses a common image model widely used in computer vision to describe a blurry image formation model. Reads an RGB image and converts it into a hue, saturation, and value (HSV) color space.

Haze reduction is a technique for removing haze from underwater photographs. due to its shortest wavelength, blue travels the farthest in water. As a result, blue (to green) hues are often dominant in underwater images. Before beginning the haze removal technique, use the histogram stretch method to increase the brightness of the red absorbed by the water in the red channel. To estimate the transmission coefficient function, calculate the dark channel map using the general statistics of anhydrous pictures. After obtaining the transparency map, apply the Matting-Laplace matrix method to obtain a more sophisticated transparency map. Matt Laplacian optimizes the transparency map by using a cost function to find the minimum value.

The next step is to equalize the histogram using a contrast stretch. For the same reason, pixel force circulation is not uniform in underwater images. To solve shading issues, global histogram equalization is insufficient. CLAHE (Const Limited Adaptive Histogram Equalization) was created to improve low contrast medical images. Adaptive Histogram Equalization (AHE) has been expanded in this way. CLAHE contrast limits are not the same as AHE contrast limits. The clip limit is a user-specified setting that CLAHE uses to limit gain. The clipping level determines how much noise in the histogram is smoothed and how much contrast is boosted. Adaptive Histogram Clipping (AHC) is another technique for reducing contrast.

Dual sub images HE (DSIHE) also divides the original image into dual sub images and evens out the histograms of the individual sub images. In contrast to degrading the image in terms of average gray value, DSIHE technology decomposes the image to enhance the Shannon entropy of the output image.

A high-pass filter is a filter that maintains high frequencies and attenuates low frequencies. Images with close cutoff frequencies ring. Ringing is the term for this type of behavior. The highest level fixed channel is the Butterworth channel.

The upgraded image's perceived quality is then improved by converting the changed color space to an RGB color space and applying gamma correction with a value of 2.2. The R, G, and B channels are then individually equalized using histogram equalization. As a result, excessive noise amplification occurs. To preserve the edges and reduce noise, a bilateral filter is applied to the distorted image.

The adjusted augmented image is subjected to bilateral filtering to reduce noise while keeping the edges. The bilateral filter, like a Gaussian convolution, produces a weighted average of adjacent pixels. The bilateral filters smoothen these edges while compensating for pixel intensity changes between adjacent pixels.

The diameter near each pixel is fixed at 5 to provide real-time processing capabilities. The color space standard deviation and the coordinate space standard deviation are set to be the same. The suggested algorithm uses the ideal value of 30 to account for the perceived quality of the produced image. The resulting image has been enhanced, noise has been reduced, edges have been preserved, and colors have been restored.

IV. RESULT ANALYSIS

Use Python 3.6.4, OpenCV 3.4.6, scikit-learn 0.20, and matplotlib 3.1.1 to run the simulation. For the images of the actual situations, many underwater images from aquatic life image websites and national geographic databases were used. The suggested method's performance is compared to that of other approaches like MultiScale Retinex with Color Recovery (MSRCR) and Adaptive Histogram Equalization (AHE). The sensory quality of the two image samples was evaluated using existing algorithms such as AHE, MSRCR, and the proposed hybrid approach (CLAHE and DSIHE). The proposed method is optically superior to all existing methods, as shown in the following figure.

Fig. 2: INPUT RAW SAMPLE IMAGES

Fig. 3: RESTORATION RESULTS AFTER USING MSRCR

Fig. 4: RESTORATION RESULTS AFTER USING AHE

Fig. 5: RESTORATION RESULTS AFTER USING HYBRID MODEL (CLAHE AND DSIHE)

The selected metrics are as follows:

Peak Signal-to-Noise Ratio (PSNR): Signal-to-Noise Ratio (SNR) is a mathematical measurement of image quality. It is based on the difference in pixels between two images. The SNR measurement is an estimate of the improved image quality compared to the original image. PSNR is determined according to the following equation:

$$PSNR = 10\ \log_{10}\left[\frac{R^2}{MSE}\right] \ldots\ldots (1)$$

Signal strength is taken into account by PSNR. The value was used to assess the image's quality. If R indicates the image's greatest fluctuation or value, the value for an 8-bit unsigned number is 255.

Root Mean Square Error (RMSE): RMSE is given from,

$$\sqrt{\frac{\sum_{i=1}^{N}\sum_{j=1}^{M}\left(R(i,j)-D(i,j)\right)^2}{N\times M}} \ldots..(2)$$

Entropy: Entropy represents the randomness of gray levels (colors) and is defined as follows:

$$E = \sum_{i=0}^{2^B-1} P_i \log_2 P_i \ldots\ldots.(3)$$

Where B is the total quantity of bits of the digitized image,

$$P_i = \frac{k_i}{m1 * m2} \ldots\ldots.(4)$$

P_i is the probability of color i occurring in the image, while k_i is the frequency of color i appearing in the image. m1 is the number of rows in the image, and m2 is the number of columns.

Contrast: The difference in brightness or hue that distinguishes an object is called contrast. The difference in hue and brightness between items in the same field of view and other objects determines contrast in real-world vision.

The comparative performance analysis is represented on below Table 1.

Table 1: COMPARATIVE PERFORMANCE ANALYSIS

Methods	PSNR	RMSE	Entropy	contrast
MSRCR	16.2	39.4	7.14	30.5
AHE	15.8	35.23	7.54	28.7
CLAHE and DSIHE	20.7	28.4	6.91	15.94

According to the findings, underwater image restoration and enhancement using CLAHE and DSIHE is highly efficient in terms of performance parameters. PSNR, AHE, and MSRCR all provide great results using these approaches. AHE and MSRCR yield the best RMSE values, followed by the suggested approaches. The proposed methods provide quite satisfactory underwater images, according to the overall results.

V. CONCLUSION

Underwater Image Restoration and Enhancement Using CLAHE and DSIHE Methods are described in this paper. This proposed a new underwater image recovery algorithm with three stages: dehaze removal, filtering, and Gamma correction. These methods are aimed at fairly effectively eliminating problems with color contrast and appearance. These methods are enhanced to the existing methods based on CLAHE and DSIHE. In the results section, a comparison of different methods such as MSRCR, AHE, and the described hybrid method is performed (CLAHE and DSIHE). In terms of PSNR and RMSE, as well as graphical output, the presented methods outperform other methods. This approach can be used on a variety of underwater images for a variety of purposes.

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