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UNDERWATER IMAGE ENHANCEMENT BASED ON DEHAZING AND COLOR CORRECTION

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Abstract: Underwater image enhancement plays a critical role in improving the visibility and quality of images captured in aquatic environments. This abstract discusses an innovative approach to underwater image enhancement that combines dehazing and color correction techniques. The goal of this study is to mitigate the challenges posed by poor underwater visibility, such as reduced contrast and distorted colors, which can impede scientific research, underwater exploration, and recreational photography. The proposed method leverages dehazing algorithms to remove the scattering effects caused by water particles, thereby enhancing image clarity. Additionally, a color correction process is applied to counteract the color shifts and cast typically observed in underwater imagery. By integrating these two techniques, the resulting underwater images exhibit improved sharpness, contrast, and color fidelity. The effectiveness of the approach is evaluated using a diverse dataset of underwater images, demonstrating significant enhancements in image quality, and making it a valuable tool for a wide range of applications, from marine biology research to underwater archaeology and recreational photography.

Index Terms **- Underwater image enhancement, Dehazing, Color correction, Water scattering, Remote sensing, Color accuracy, Hazy underwater images.**

I. INTRODUCTION

The underwater environment has long fascinated humanity with its enigmatic beauty, teeming with diverse marine life and vibrant ecosystems. Yet, capturing the stunning underwater world through photography and videography is a challenging endeavor. The medium's inherent optical limitations, such as light attenuation and color distortion, pose significant obstacles for underwater imaging. Consequently, underwater images often suffer from reduced contrast, poor visibility, and color shifts, making them less appealing and informative. This necessitates the development of advanced image enhancement techniques to restore the vibrancy and clarity of underwater scenes.

Underwater image enhancement is a crucial field of research with applications spanning from marine biology to archaeology and recreational underwater photography. Two fundamental components in this realm are dehazing and color correction, which aim to mitigate the negative effects of the underwater medium on image quality. In this article, we delve into the principles, challenges, and recent advancements in underwater image enhancement using dehazing and color correction. Underwater imaging faces numerous challenges that are notably absent in terrestrial photography. The primary issue is light attenuation, where water absorbs and scatters light, resulting in a gradual reduction in visibility with increasing depth. As a result, underwater images often suffer from reduced contrast and a hazy appearance. Moreover, the selective absorption of different wavelengths of light by water molecules and suspended particles causes Color distortion, resulting in an overall bluish or greenish cast in images. These challenges can significantly hinder the interpretation and appreciation of underwater scenes.

Dehazing, a fundamental technique borrowed from the field of computer vision, plays a critical role in enhancing underwater images. It aims to recover the scene's original contrast and reduce the haze induced by light attenuation. Several dehazing methods have been adapted for underwater image enhancement. These methods often involve estimating the scene's transmission map, which quantifies the degree of light attenuation at each pixel. Algorithms then use this map to recover the dehazed image. Recent advancements in machine learning and deep neural networks have also revolutionized underwater dehazing, enabling the automatic enhancement of underwater images. Color correction is another essential component of underwater image enhancement, as it addresses the issue of Color distortion. Water selectively absorbs and scatters different colours, leading to a shift in the perceived Colours in underwater images. To correct this, Color correction methods aim to restore the natural Color balance and remove the dominant bluish or greenish cast. Various approaches, including manual adjustments and automated algorithms, have been employed for underwater Color correction. Recent developments incorporate machine learning techniques to refine the process, offering efficient and effective Color correction.

II. LITERATURE SURVEY

Underwater optical imagery is frequently obtained using cameras, yet it exhibits distinct statistical characteristics compared to natural images. This disparity arises from the refraction and scattering of light in various water conditions, resulting in alterations to the colours and shapes of objects that can undermine their visual appeal. Consequently, the development of algorithms aimed at enhancing underwater images becomes crucial. Additionally, the assessment of image quality underwater is employed as a pivotal criterion for evaluating the effectiveness of image enhancement techniques. Over the past decade, these issues have garnered considerable attention within the scientific community. This comprehensive review paper [1] offers insights into the techniques related to underwater image enhancement and outlines their most recent accomplishments. Of note is the noteworthy trend of integrating deep learning into the field of underwater image processing, even with limited available data. It is our aspiration that this review will prove beneficial to both newcomers and experts in this field, as it serves as a valuable resource for exploring intriguing and challenging research avenues. This survey contributes to the body of knowledge within this domain.

A new Retinex-based variational model has been proposed in this work [2] for enhancing single underwater images as part of a survey. This model incorporates Gaussian curvature priors to improve the quality of both illumination and reflection. To efficiently estimate illumination and reflection, we utilize Gaussian curvature filters in the solution of this variational model. These filters effectively capture finer underwater image details and prevent excessive image enhancement. Furthermore, they significantly reduce the runtime required for underwater image enhancement, as they eliminate the need for calculating partial derivative operations and the gradient of the overall energy functional. A series of experiments have been conducted to validate the effectiveness of this method. The results demonstrate its superior performance in terms of image enhancement, visual improvements, and runtime when compared to several other underwater enhancement algorithms.

In the realm of underwater exploration, underwater optical imagery plays a crucial role. However, a myriad of factors contributes to the distortion of underwater optical scenes, including phenomena like light refraction, absorption, scattering, and more. The enhancement of these images is imperative for both basic and advanced underwater vision tasks. Consequently, this paper introduces a novel method that employs Generative Adversarial Networks to address this issue, enabling the restoration of lost information within distorted underwater images. When employing our approach, the improvements in underwater images are substantial, encompassing enhancements in Color, detail, and texture. Furthermore, this paper [3] offers an innovative solution to the challenge of lacking a paired dataset, which is typically required for network training. Finally, a series of qualitative and quantitative experiments have been conducted to demonstrate the robustness and effectiveness of the approach presented in this paper.

III. METHODOLOGY

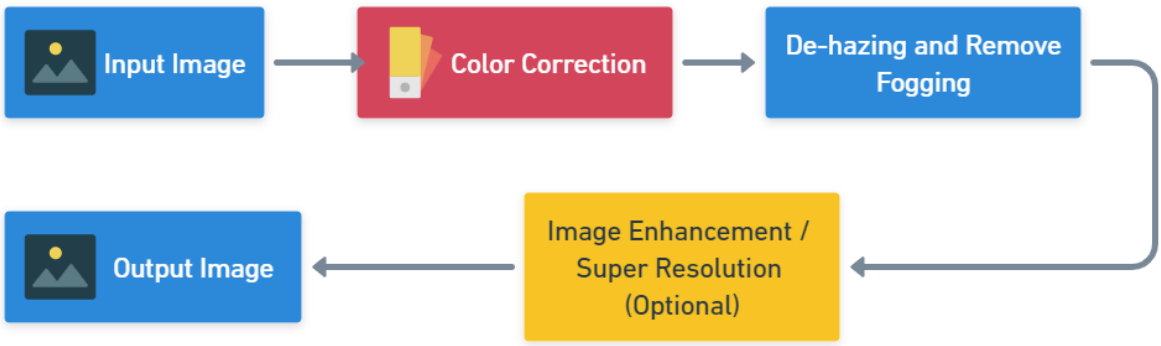

Figure 1 System Architecture

Enhancing underwater images often requires a combination of dehazing and Color correction techniques to mitigate the effects of scattering, absorption, and low light conditions. The following methodology outlines a three-step approach for underwater image enhancement:

1. **Preprocessing and Dehazing:** The first step are to address the inherent haziness in underwater images caused by the scattering of light. To do this, utilize a dehazing algorithm, such as the Dark Channel Prior or a deep learning-based method. This algorithm helps in estimating and removing the scattering and haze in the image, revealing more details hidden in the haze. Adjust parameters like the degree of dehazing and the transmission map to control the extent of haze removal.

2. **Color Correction:** After dehazing, focus on Color correction to restore the natural colours that are often distorted or muted in underwater images. This step can involve white balancing to correct the Color temperature and remove Color casts. Adjust the saturation, contrast, and brightness to enhance the overall appearance of the image. Be mindful of the

specific conditions and characteristics of the underwater environment to achieve a visually appealing and accurate representation of colours.

3. **Post-processing and Fine-tuning:** The final step involves fine-tuning the enhanced image. This may include noise reduction, sharpening, and contrast adjustment to improve the overall visual quality. Apply post-processing filters or techniques to further enhance the image's details and consider manual adjustments to ensure that the image meets your specific requirements. Continuously evaluate the quality of the image and make iterative adjustments to achieve the desired enhancement level.

4. Throughout the process, it's essential to maintain a balance between removing haziness and preserving the natural characteristics of the underwater scene. Regularly review the results and adapt the methodology to the unique features and challenges of each image to achieve the best possible enhancement.

IV. CONCLUSION

The methodology outlined for underwater image enhancement, incorporating dehazing and Color correction, offers a systematic and effective approach to improve the quality of underwater photographs. By first addressing the haze and scattering effects using dehazing techniques, we can unveil hidden details and structures in the image. Following this, the Color correction step restores the true colours of the underwater scene, making the image visually appealing and accurate. The post-processing and fine-tuning stage further refine the output, ensuring that the final enhanced image meets specific requirements and quality standards.

This methodology is versatile and adaptable, making it suitable for various underwater imaging conditions and environments. It enables photographers, researchers, and professionals to bring out the beauty and detail of underwater scenes while maintaining a faithful representation of colours. Regular assessment and iterative adjustments are crucial to fine-tune the results and ensure that the enhanced images are both aesthetically pleasing and informative. Overall, this methodology serves as a valuable tool for anyone working with underwater imagery, helping them to overcome the challenges posed by the aquatic environment and produce striking, high-quality visuals.

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