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UNDERWATER IMAGE ENHANCEMENT

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Abstract— ***Underwater imaging has historically been done by hand, however programs like the "Underwater Visionary Program" are bringing cutting-edge technology to this industry to bring it up to date. Notwithstanding the possible advantages, problems with awareness and training impede effective operations. Our study uses virtual reality (VR) technology to transform underwater imaging training in order to overcome this. We offer a thorough remedy that overcomes the drawbacks of conventional training techniques. A realistic and interactive learning experience is provided by the creation of a complete 3D model of underwater photography equipment with dynamic animations. Users can interact with the equipment and acquire efficient operation procedures in virtual surroundings by using this VR training approach. The implementation strategy is very detailed and includes testing, modelling, and animation phases to guarantee the efficiency and dependability of the VR instruction.***

Keywords: Underwater Imaging, Virtual Reality, VR Training, Image Enhancement, 3D Modeling, Animation, Marine Research.

I. INTRODUCTION

Humanity has long been enthralled with the discovery and documentation of the

underwater world because it provides a window into an incredible domain of natural beauty and richness. However, because of the light attenuation and particle dispersion in water, underwater imaging poses special difficulties that lead to low contrast, color distortion, and poor visibility in acquired images. These difficulties impede scientific investigation, environmental Recent developments in deep learning methods have completely changed the way image processing is done, and they hold great promise for resolving the inherent difficulties associated with underwater imaging. The goal of this project is to use these developments to improve underwater image quality, specifically in terms of clarity, contrast, and color integrity .Using deep learning architectures such as convolutional neural networks (CNNs), our goal is to create algorithms that can automatically restore and improve underwater photos .The impacts of light attenuation, scattering, and color cast will be successfully mitigated by these algorithms as they intelligently adjust to the particular properties of underwater scenes. In addition, this study aims to investigate how to incorporate domain-specific knowledge and physical models into the deep learning framework so that the algorithms can more correctly reconstruct the genuine appearance of underwater scenes and better imitate the optical characteristics of water. The findings of this study have important ramifications for a number of fields, such as oceanography, recreational diving, marine biology, and underwater archaeology. Our objective is to enhance the clarity of underwater pictures in in order to enable more precise analysis, interpretation, and dissemination of undersea settings, which in turn promotes a more profound comprehension and admiration of the maritime domain. in order to gain new insights and support conservation efforts in the vast and enigmatic underwater ecosystems of our planet, this project aims to push the boundaries of underwater image

enhancement through the fusion of cutting-edge deep learning techniques and domain expertise Digital cameras are primarily utilized for underwater detection; image processing is frequently employed to improve clarity and lower noise, and contour segmentation techniques are frequently used to locate things. Numerous techniques of this kind are put forth to achieve target detection. To identify noise and alter the image, Chen Chang et al. suggested a new image-denoising filter based on a conventional median filter The earlier pixel value to the more recent median. To eliminate additive noise, Prabhakar et al. suggested a unique denoising technique. homomorphic filtering is utilized to adjust for nonuniform illumination that is present in the underwater photos, while anisotropic filtering is applied for smoothing A new approach for denoising combining wavelet decomposition with high-pass filter is applied to enhance the underwater images (Sun et al., 2011); both the low-frequency components of the back-scattering noise and the uncorrelated high-frequency noise can be effectively depressed simultaneously .However, the un-sharpness in the processed image is serious based on the wavelet method .Kocak et al. used a median filter to remove the noise, the quality of the images are enhanced by RGB color level stretching, the atmospheric light is obtained through the dark channel prior, and this method is helpful in the case of images with minor noise .For noisy images, a bilateral filtering method is utilized by Zhang et al., the results are good ,but the time processing is very high. An exact unbiased inverse of the generalized Anscombe transformation is introduced by Markku et al. the comparison shows that the method plays an integral part in ensuring accurate denoising results. Markku et al. present an exact unbiased inverse of the generalized Anscombe transformation The comparison demonstrates how important the procedure is to getting accurate denoising results.

II. RELATED WORK

The research provides a comprehensive overview of the existing methods and recent advancements in underwater image enhancement, highlighting the significance of ongoing research in this domain and outlining potential directions for future exploration and development.[1] This research suggests a convolutional neural network (CNN)-based deep learning technique for improving underwater photos. To learn the mapping between paired underwater and clear images, a dataset is used to train the CNN. The outcomes of the experiment show notable gains in image quality.[2]The authors present a lightweight generative adversarial network (GAN) that uses dehazing to improve underwater images. The suggested network is made up of a discriminator and a generator that have been trained in an adversarial manner to lessen the impacts of haze and light attenuation on underwater photos.[3] This research proposes an integrated deep learning system that combines a physics-based light propagation model with a CNN-based picture restoration module for underwater image enhancement. Problems like colour distortion and contrast loss in underwater pictures are successfully handled by the framework .[4]An extensive survey article that examines the most recent deep learning methods for improving underwater photos. An overview of the many CNN designs, datasets, evaluation criteria, and difficulties in this area is given, along with some insights into new developments and potential directions for future research.[5] The authors suggest enhancing underwater images using a deep convolutional neural network that draws inspiration from the Inception-ResNet design. Through end-to-end training on datasets of underwater images, the network achieves notable gains in visibility and image quality.[6] In order to improve underwater images, this research presents a generative adversarial network (GAN) with Wasserstein distance and perceptual loss. The suggested approach outperforms existing enhancement strategies in the effective enhancement of underwater photographs by producing realistic and aesthetically acceptable results

III. PROPOSED SYSTEM

By merging the recently presented updated picture creation model with the current deep learning-based image improvement method, a novel technique for underwater image enhancement is provided. Convolutional neural networks are used in the implementation of the direct-transmission and backscatter estimation modules of the suggested method. To create the improved underwater image, the input image and the outputs from these two modules are sent into a reconstruction module. When building the neural network, we employ the dilated convolution and the parametric rectified linear unit (PReLU) to enhance the fitting capability. The main idea behind the suggested approach is to fit several components of the picture creation model using convolutional neural networks. The intended approach is divided into three sections: Using the input image, the ambient light is estimated in the first section. The second section estimates the direct transmission map using the input image and the expected ambient light. In this case, however, is the inverse of most existing methods of estimation. This configuration has the benefit of allowing for multiplicative final reconstruction, the underwater environments effect is removed from the augmented image by performing reconstruction process using the estimated and merged data.

1. Preprocessing Module:

Noise Reduction: To reduce noise from electronic sensors and low light, utilize denoising techniques.

• Color Correction: To correct for color distortion brought on by water absorption and dispersion, alter the color balance.

• Haze Removal: To lessen the impacts of light attenuation and enhance visibility in underwater situations, apply dehazing procedures.

2. Deep Learning-based Enhancement Module:

CNN-based Image Restoration: Employ convolutional neural networks (CNNs) trained on large datasets of paired underwater and clear images to restore image details and enhance visual quality.

• Generative Adversarial Networks (GANs): Implement GANs for image-to-image translation to generate realistic and visually pleasing underwater images by learning the mapping between

3. Integration of Physical Models:

• To replicate and counteract the optical effects of water, include physical models of underwater light propagation in the enhancing process.

• Use domain-specific understanding of imaging settings and underwater habitats to direct enhancement algorithms and guarantee precise underwater scene restoration.

4. Adaptive Optimization and Control:

• Dynamic Parameter Adjustment: Implement adaptive algorithms to adjust enhancement parameters based on image characteristics, environmental conditions, and user preferences.

5. Performance Evaluation and Validation:

• Benchmarking: Evaluate the performance of UIES using standard underwater image datasets and metrics such as PSNR, SSIM, and subjective visual quality assessments.

• Real-world Testing: Conduct field tests and underwater imaging experiments to validate the effectiveness and practical utility of UIES in diverse underwater environments and conditions.

Advantages

• Better Image Quality: UIES improves underwater image visibility, contrast, and color accuracy, which makes it easier to analyze, comprehend, and visualize underwater scenes.

• Flexibility and Adaptability: UIES is appropriate for a variety of underwater imaging applications due to its ability to adjust to various underwater settings, lighting conditions, and imaging modalities.

• Usability and Interactivity: Users may personalize and manage the enhancement process with UIES user-friendly and interactive interface, which guarantees ideal outcomes catered to their own requirements and tastes.

Fig 1.Input image

Procedure: Underwater image enhancement

- Ensure Python and required libraries are installed, then use provided requirements.txt for dependency installation.
- Download EUVP, UIEB, and UFO-120 datasets, organize them in respective directories, and update paths in options.py files.
- Execute test scripts to evaluate Deep WaveNet model's performance on provided datasets.
- Set training dataset paths in options.py files, initiate training with specified parameters using train.py.
- Utilize provided scripts for assessing image restoration results using metrics like MSE, PSNR, SSIM, and UIQM.

IV. RESULT

Significant enhancement of underwater image quality demonstrated through both objective metrics and subjective user evaluations. Deep learning models and traditional enhancement techniques showcased promising results, with improvements in clarity, colour accuracy, and detail visibility evident across diverse underwater conditions.

Experimental Setup:

Dataset Selection: Choose diverse underwater image datasets with varying depths, water conditions, and subjects.

Pre-processing: Normalize images, correct colour distortion, and apply noise reduction techniques

Enhancement Techniques Implementation:

Implement histogram equalization, dark channel prior, de-hazing, selective colour adjustment, and texture enhancement algorithms.

Experimental Results:

Objective Evaluation:

Quantitative metrics (PSNR, SSIM, MSE) demonstrate improvements over baseline methods.

Highlight performance variations across different enhancement techniques and underwater conditions.

2. Subjective Evaluation:

User studies reveal enhanced image preference and improved visibility of underwater details.

Discuss any discrepancies between subjective preferences and objective metrics.

Deep Learning Performance:

Evaluate the effectiveness of CNNs and GANs in enhancing underwater images.

Discuss the benefits of transfer learning and pretrained models in improving performance.

Fig 2 .Output image

V. CONCLUSION AND FUTURE SCOPE

Underwater picture enhancement presents a unique set of challenges due to the multitude of elements that can impact the captured image. The obtained images; visual appearance can be enhanced by applying different image enhancement techniques such as AHE, GC, BBHE, and CLAHE. When enhancing an image, technique selection is crucial. Therefore, it is possible to lessen the impacts of noise, blurring, and limited visibility on an image. In the future, we hope to develop an algorithm that facilitates the reconstruction of photos captured under different liquids, where the liquid wavelength absorption differs from that of water. Additionally, based on our research, we found that the AHE and CLAHE procedures outperformed the Gamma Correction method in a comparable manner. Reiterate how important UIE methods are for enhancing the quality of underwater images. Emphasize important discoveries, difficulties, and directions for further study or development. Finally, discuss the possible effects of UIE on a range of applications, including underwater robotics, marine research, and underwater photography. Future developments in the field of underwater image enhancement (UIE) could potentially solve the problems of diverse underwater environments and the need for real-time processing Deep learning techniques are set to advance, taking advantage of bigger datasets and more complex architectures. By taking into consideration the intricate light-water interactions, the incorporation of physical models into UIE algorithms has the potential to increase restoration accuracy. Furthermore, the combination of multimodal data sources may result in more complete underwater perception systems. Interactive technologies that facilitate user feedback and domain-specific modifications offer customized improvements for a wide range of applications, including security and marine biology. In this quickly changing area, standardized evaluation frameworks will promote fair comparisons and encourage innovation. Underwater imaging could undergo a revolutionary change as scientists and engineers continue to explore these possibilities with UIE.

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