UNDERWATER IMAGE ENHANCEMENT THROUGH DEHAZING AND COLOR CORRECTION TECHNIQUES

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Abstract

Underwater photography and videography suffer from significant challenges due to the inherent properties of water, such as light absorption, scattering, and color distortion. When capturing images or videos underwater, the medium's particulate matter and water molecules cause haze and loss of color fidelity, resulting in poor visual quality and reduced visibility. To address these issues and improve the overall quality of underwater imagery, researchers have developed various image enhancement techniques that aim to dehaze the images and correct color distortions. The traditional approach to underwater image enhancement involved simple post-processing methods, such as contrast stretching and histogram equalization. While these techniques might help to some extent, they often fail to produce satisfactory results due to the complex and non-linear nature of underwater light attenuation and scattering. Moreover, these methods are not specifically designed for addressing the unique challenges posed by underwater environments, leading to limited improvements in image quality. Therefore, the need for effective underwater image enhancement techniques arises from several factors such as, underwater imagery is crucial in various fields, including marine biology, underwater exploration, environmental monitoring, and underwater archaeology. In addition, high-quality images are essential for accurate data analysis and interpretation. Further, an improved underwater image quality aids in enhancing the capabilities of underwater robotics, surveillance systems, and underwater imaging devices. Thus, this project presents an innovative and comprehensive approach to address the challenges associated with underwater imagery. The study proposes a novel combination of dehazing, and color correction techniques tailored specifically for the unique characteristics of underwater environments.

1. Introduction

Underwater images get degraded due to poor lighting conditions [1] and natural effects like bending of light, denser medium, reflection of light and scattering of light etc. As the density of sea water is 800 times denser than air, when light enters from air (here lighting source) to water, it partly enters the water and partly reflected reverse. More than this, as light goes deeper in the sea, the amount of light enters the water also starts reducing. Due to absorption of light in the water molecules, underwater images will be darker and darker as the deepness increases. Depending on the wavelength also, there will be colour reduction. Red colour attenuates first followed by orange. As the blue colour is having shortest wavelength it travels longest in seawater there by dominating blue colour to the underwater images affecting the original colour of the image. The overall performance of underwater [2] vision system is influenced by the basic physics of propagation of light in the sea. The overall performance of underwater vision system is influenced by the basic physics of propagation of light in the sea. One must take care about absorption [3] and scattering [4] of light when considering underwater optical imaging systems. Most often accurate values of attenuation and thorough knowledge of forward and backward scatter is required for restoring underwater images performance of underwater vision system is influenced by the basic physics of propagation of light in the sea. One must take care about absorption and scattering of light when considering underwater optical imaging systems. Most often accurate values of attenuation and thorough knowledge of forward and backward scatter is required for restoring underwater images. Due to apprehension [5] regarding the present conditions of the world's oceans many large-scale scientific projects have instigated to examine this. The underwater video sequences are used to monitor marine species [6]. Underwater image is inundated by reduced visibility conditions making images deprived of colour variation and contrast. Due to this restriction other methods like sonar ranging have been preferred previously. Since alternate methods yield poor resolution images which are hard to understand, nowadays for close range studies visible imaging are preferred by scientists. The emphasis of these work deceits primarily in implementation of vision system [7] which involves analysis of enhanced images. Image enhancement techniques [8] are usually divided in frequency domain and spatial domain methods. The frequency domain methods [9] are normally based on operations in the frequency transformed image while spatial domain methods [10] are based on direct manipulation of the pixels in the image itself.

2. Literature Survey

In article [11] it is potential to eliminate the complex interference and rebuild the underwater images by enhancement techniques. The underwater images are enhanced by using the algorithms like grey world for clearance and dark channel prior for processing of underwater images by applying the BP network for restoration of details in the underwater image. The TV model procedure is executed because to covering the blank area after the recognition and elimination of object. The article [12] describes the enhancement technique by using the wavelet fusion for underwater images which is due to the absorption and reflection of light while capturing the images in water. By using this implementation, we can evaluate and Dehazed or enhance the contrast and color of the image. Owing to the scattering and absorption of light color alteration is emerged in underwater images. For improving the underwater images color distortion CC-Net [13] is used and for contrast enhancement we are using HR-Net which consist of single transmission coefficient. These two Nets are the grouping of UIE-Net [14] which is one of the frameworks in CNN architecture. This implementation progresses the learning process and convergence speed simultaneously [15]. It overcomes the several optical transmissions, hazing and color distortions. For features extraction these two are trained to the CNN framework.

G. Yadav, S. Maheshwari and A. Agarwal research in [16] describe that in order to raise the visibility of the hazy image or video we utilize the contrast limited adaptive histogram equalization. When compared to other enhancement techniques MEF algorithm gives better enhancement results because it applies for both color and gray images for both regions. A new frame is generated after the adjustment of intensity values over the image is named as histogram equalization. Based on the neighboring pixel values AHE [17] adjust the intensity levels over a particular region of any fog (homogeneous) type of images only. For histogram equalization shape in MEF Distribution parameter is utilized. For noisy image we are applying clip limit. The light travelling in the water with altered wavelengths leads to the color variation due to the attenuation. Here, by employing the image processing techniques we can enhance the underwater images. In this paper we have both enhancement and restoration operations. There are different types of image enhancement techniques [18] for enhancing the image. Image restoration is nothing, but the degradation is used to restore the loss of information. In this paper, UIQM is utilized for measuring the quality of the underwater images. This implementation gives the better-quality results when compared with other enhancement techniques [19]. In [20] authors proposed the deep learning architecture for underwater image enhancement using the white-balancing-Multiple Underexposure versions reduction prior (WB-

MUV) model. The WB-MUV method for enhancing the underwater images is by using the deep residual architecture. This is one of the networks in CNN which is used to convert the low-resolution image into high resolution image. The underwater images are less in contrast and color distortion. Generally, we are considering the input image as reference. First, we consider a cell after training the dataset. Here we are using the YCbCr color space for conversion of input image and the whole procedure is performed in Y component only. By utilizing the bicubic interpolation we can change the image into low resolution image. For bicubic interpolation, the block uses the weighted average of four transformed pixel values for each output pixel value. For improving or enhancing the underwater images there are various filters are used as image enhancement techniques. The network which we are used is a deep learning network. The layers which we are used in a novel architecture is an Image input layer, convolution and ReLU layers. Due to this residual network degradation was occurred and consists of saturated accuracy while using deep residual blocks. These blocks are helpful to transmit the information (data) between layers. By increasing the number of layers, it may be chances to rise the accuracy of the network.

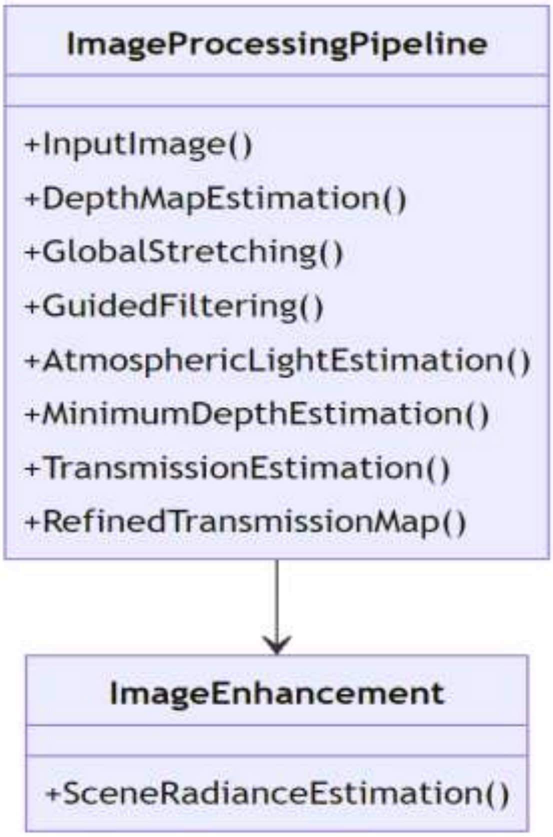
To overcome the drawbacks of the WB-MUV approach, we are using different layers of DLCNN for enhancing the underwater images including such as BN layer, ResNet layer and CycleGAN. The resultant enhanced underwater image has less visibility and contrast. Edge difference loss (EDL) plays a significant role in order to know the pixel difference between the two images. Mostly in case of WB-MUV usage of MSE loss in more to calculate the peak signal to noise ratio (PSNR). The depth which we are using in this process is 20. The low-resolution image is resized based on the reference image size and difference is measured between them. The combination of the resultant upscale and difference images is called as the train data. The residual network is trained after assigning the layers and training options. In order to get the high-resolution image, the difference image is calculated by considering the test image. For WB-MUV technique of enhancement there is no need of same size of images are needed. By training the proper dataset it gives the better results of enhanced image.

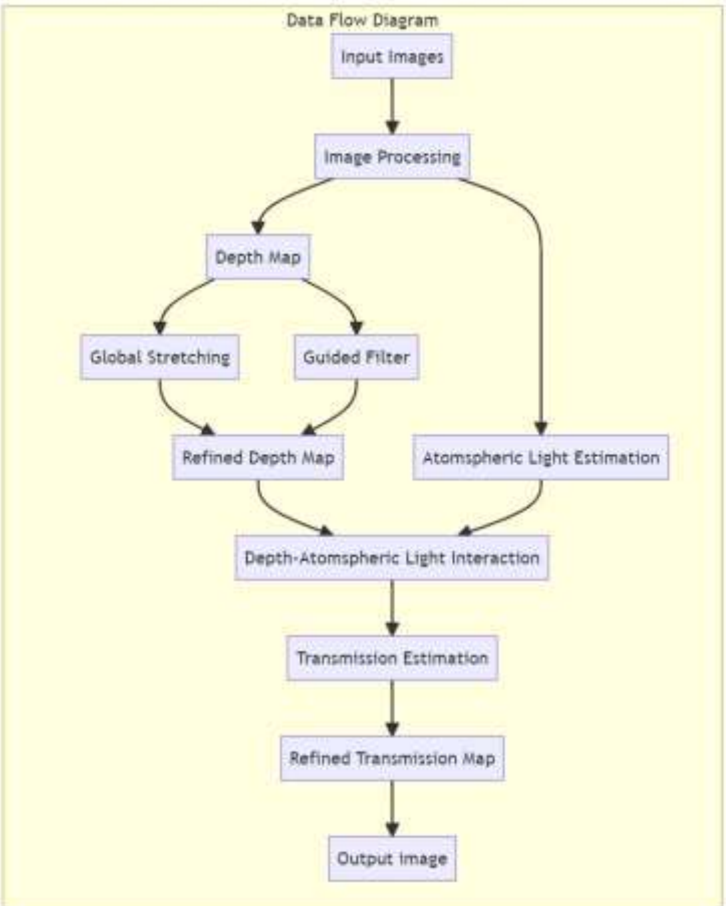
3. Proposed System Model

This research provides underwater image enhancement using a technique called "ULAP" (Underwater Light Absorption Prior). The project’s main goal is to improve the visual quality of underwater images by compensating for the effects of light absorption and scattering that occur when capturing images underwater

Class Diagram: The class diagram is used to refine the use case diagram and define a detailed design of the system. The class diagram classifies the actors defined in the use case diagram into a set of interrelated classes. The relationship or association between the classes can be either an “is-a” or “has-a” relationship. Each class in the class diagram may be capable of providing certain functionalities. These functionalities provided by the class are termed “methods” of the class. Apart from this, each class may have certain “attributes” that uniquely identify the class.

Data flow diagram: A Data Flow Diagram (DFD) is a visual representation of the flow of data within a system or process. It is a structured technique that focuses on how data moves through different processes and data stores within an organization or a system. DFDs are commonly used in system analysis and design to understand, document, and communicate data flow and processing.


ImageProcessingPipeline
+InputImage()
+DepthMapEstimation()
+GlobalStretching()
+GuidedFiltering()
+AtmosphericLightEstimation()
+MinimumDepthEstimation()
+TransmissionEstimation()
+RefinedTransmissionMap()
ImageEnhancement
+SceneRadianceEstimation()


Data Flow Diagram
Input Images
Image Processing
Depth Map
Global Stretching
Guided Filter
Refined Depth Map
Atomspheric Light Estimation
Depth-Atomspheric Light Interaction
Transmission Estimation
Refined Transmission Map
Output Image

4. Results description

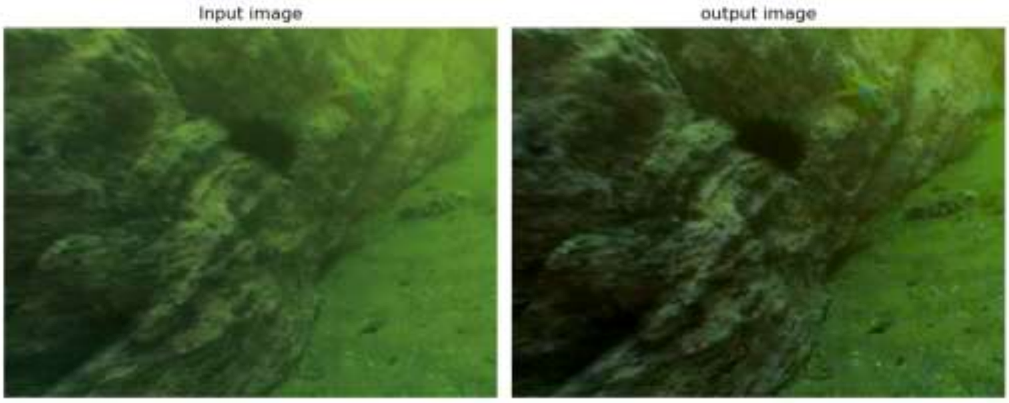


Fig. 1: Underwater performance enhancement on sample image 1.

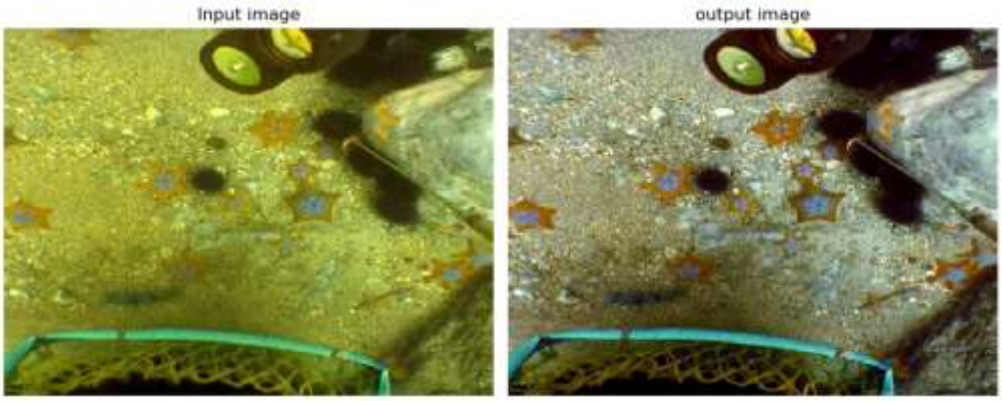


Fig. 2: Underwater performance enhancement on sample image 2.

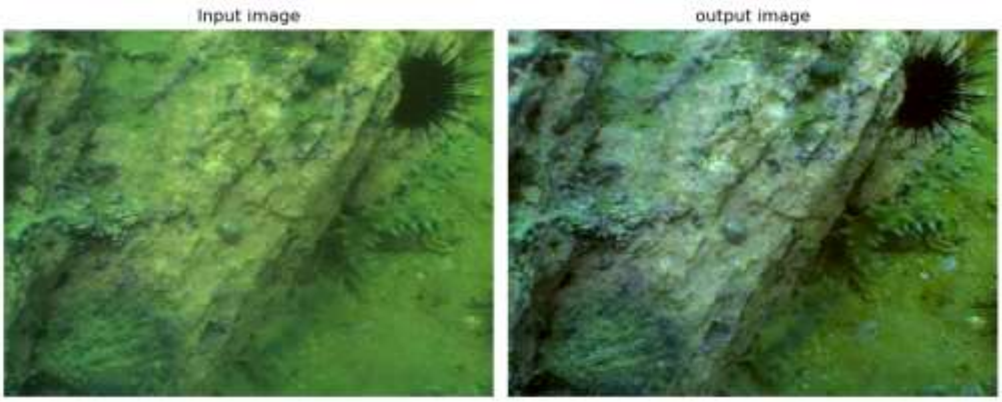


Fig. 3: Underwater performance enhancement on sample image 3.

5. Conclusion

This project utilized the ULAP technique for underwater image enhancement, demonstrates a significant improvement over traditional methods like histogram equalization. This project leverages a physics-based approach, considering the intricate interactions between light and water in underwater environments. As a result, it offers a range of advantages, including depth-aware enhancement, atmospheric light estimation, transmission map modeling, and guided filtering for noise reduction. Furthermore, the incorporation of quality metrics facilitates an objective evaluation of the enhancement process. One of the standout features of ULAP is its adaptability to varying underwater conditions. It achieves this through the estimation of depth maps, allowing for context-aware enhancements that consider the depth-related variations in the scene. This depth awareness is particularly valuable in underwater imaging, where objects are often located at different depths, each requiring tailored correction. Atmospheric light estimation, another key element of ULAP, enhances the correction process by accurately compensating for light absorption and scattering. This ensures that the final enhanced images better represent the true colors and features of the underwater scene, a critical factor in underwater research, exploration, and surveillance.

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