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UNDERWATER IMAGE DEHAZING USING COLOR CORRECTION AND INTEGRATION

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Abstract: **This paper implements a novel single-image approach for enhancing underwater images that are degraded due to medium scattering and absorption. The method does not require specialized equipment or knowledge of underwater conditions or scene. It relies on blending 2 images that are arrived from a color-compensated and white balanced version of the original affected image. Weight maps are used to promote the transfer of edge's and colour contrast to the output image, and a multiscale fusion method is employed to avoid artifact in the reconstructed image. Both qualitative and quantitative analyses reveal that the improved photos and movies have sharper edges, better global contrast, and better exposure of dark areas. The technique also enhances the accuracy of numerous images processing applications, including segmentation and key point matching, and is mostly independent of camera settings.**

Index terms: **Image, Fusion, Image processing, Underwater images dehazing, Color correction.**

I. INTRODUCTION

The underwater environment is important for several reasons. It is home to a diverse range of marine life, which plays a important role in the ecological balance of our planet. Underwater ecosystems gives vital resources for human beings, such as food, medicine, and minerals. In addition, underwater environments offer many unique attractions for tourism and recreational activities, such as scuba diving and snorkeling.

In addition, underwater research is important for various scientific fields, including marine biology, oceanography, and environmental science. Studying the underwater environment can help us better understand our planet, its history, and its future. It can also help us identify and address environmental problems, such as pollution and climate change, that affect both marine and human life. Finally, the evolution of technologies and techniques for exploring and working in the underwater environment can have various practical applications, such as offshore oil and gas exploration, underwater construction, and defense operations.

Underwater imaging faces unique challenges due to light attenuation caused via the actions of absorption and scattering effects. This results in poor visibility, with distant objects appearing misty and colors appearing faded. Traditional enhancement techniques are limited, and additional challenges such as colour casts and backscatter further reduce visibility. Underwater imaging is also complicated by movement, water currents, and specialized equipment and techniques are required to capture clear and detailed images.

This paper implements a method for removing haze in underwater image using a single, conventionally captured image. The approach involves fusing two inputs: a contrast-corrected version and a sharpened, white-balanced version. The white balancing stage removes color distortion caused by light scattering. The multi-scale fusion process ensures a seamless blending without artifacts, resulting in a more natural-looking image. This method offers an effective solution for enhancing underwater image quality.

II. SYSTEM ARCHITECTURE

1. Underwater White Balancing

This white balance technique focuses on restoring the colours that have been damaged by white light that has travelled through water. Underwater photographs typically have a greenish-blue tint as a result of wave scattering as depth increases. Waves with a higher wavelength are absorbed first. Red will so absorb first, followed by other colours. The amount of colour loss varies with the observer-to-plane separation. There are two parts in this process: first, adjust the red channel, then use the Gray-World Algorithm to determine the white-balanced image.

Based on four measurements, the red channel is compensated.

- Red channel is degraded first when it passes through the water and green channel is almost safe because of shorter wavelength compared to red channels.
- Compensating Compensate the red channel by adding the fraction of green channel to the red channel to restore the red channel to retrieve the natural appearance of the underwater images.
- Compensation of red channel by using the green channel is done with the mean values of green channel and red channel. To have a balanced output, the difference between the mean values of the green channel and the mean value of the red channel must be proportionate.
- Red channel compensation is used to first modify the small red channel pixel values in order to minimise red channel degradation

during the Grey World process. In situations where the red channel information is already considerable, the green channel pixel information will not be transferred to the red channel. Therefore, avoid having reddish areas appear over locations that the Grey World algorithm has exposed. Red channels that have suffered severe deterioration will be compensated, whereas red channels that have suffered less degradation and are closer to the observer do not require compensation.

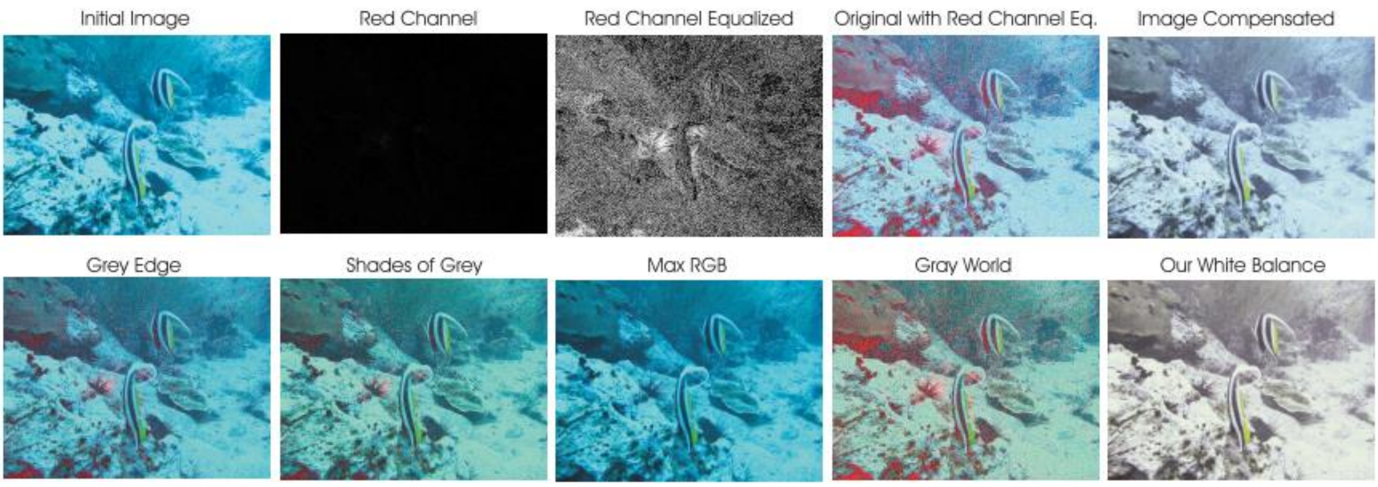


Figure 1: Underwater White Balancing

2. Multiscale Fusion Process

Fusion method is a technique used to enhance underwater image quality, with various options available for this process. One approach is to use the Laplacian pyramid method to reduce the negative effects of backscattering and achieve better results for enhancing underwater images. The fusion process involves using two input images, followed by white balancing and CLAHE in three main steps: defining weight maps, and then fusing the weight maps and inputs.

A. Inputs of the fusion process

Color correction is crucial for enhancing underwater images, and white balancing techniques are commonly employed for this purpose. To obtain the first input, the Contrast-Limited Adaptive Histogram Equalization (CLAHE) technique is applied, which helps improve the overall contrast and produce a brighter image. Gamma correction is then performed to achieve global contrast correction. These steps result in a first input that has undergone color correction and contrast enhancement, making it suitable for the fusion process.

The second input is derived from the sharpened version of the image that is outputted from the white balanced section. A Gaussian filter is used to apply the principle of imperfect masked,, which either blurs or sharpens the image. This process is mathematically expressed as S = I +(I G I), where I is the image to be sharpened, GI is the Gaussian filtered version of I, and is a parameter. A small value of fails to sharpen the image effectively, while a very large value results in regions that are oversaturated, with darker shadows and brighter highlights. To get around this problem, a sharpened photo S is defined as (I +N{I GI})/2, where N{.} denotes the operator of linear normalization or histogram stretching. Second input mainly reduces the attenuation caused by scattering, which is important for the fusion process.

Figure 2: Two Inputs derived from White Balance version

B. Weights of the Fusion Process

Weight maps are used to estimate each pixel's contribution to the final image during the blending process. In this situation, saliency measurements and picture quality are used to build weight maps. Applying the Laplacian filter to the input luminance channel results in the global contrast, which is used to calculate the Laplacian contrast weight (WL). However, this is insufficient on its own to improve underwater images. For comparison metric assessment, an additional weight is used to get around this.

The saliency weight (WS) is focused on regaining the important thing that degraded in the underwater image. The saliency level is calculated using the saliency estimator developed by Achantay et al. The weight mainly focuses on brightened areas. Another weight map is obtained for the observation, reducing the saturation in brighter regions to avoid focusing on them. The saturation weight (WSat) is used to accept by taking advantage of chromatic information acceptance heavily saturated regions. The weight map for each input image is calculated by deriving the difference between the luminance and the R, G, B color channels. The aggregate weight map Wk is obtained by adding the three weight maps, WL, WS, and WSat, for each input k. Each k is normalized based on pixel by pixel for each input, denoted by k=(Wk +)/(+ K.), where a small regularization term secures each input's contribution to the output, with the value set to 0.1. Using two inputs and the weight maps exposedness amplifies the relevant artifacts and helps to reduce overall complexity.

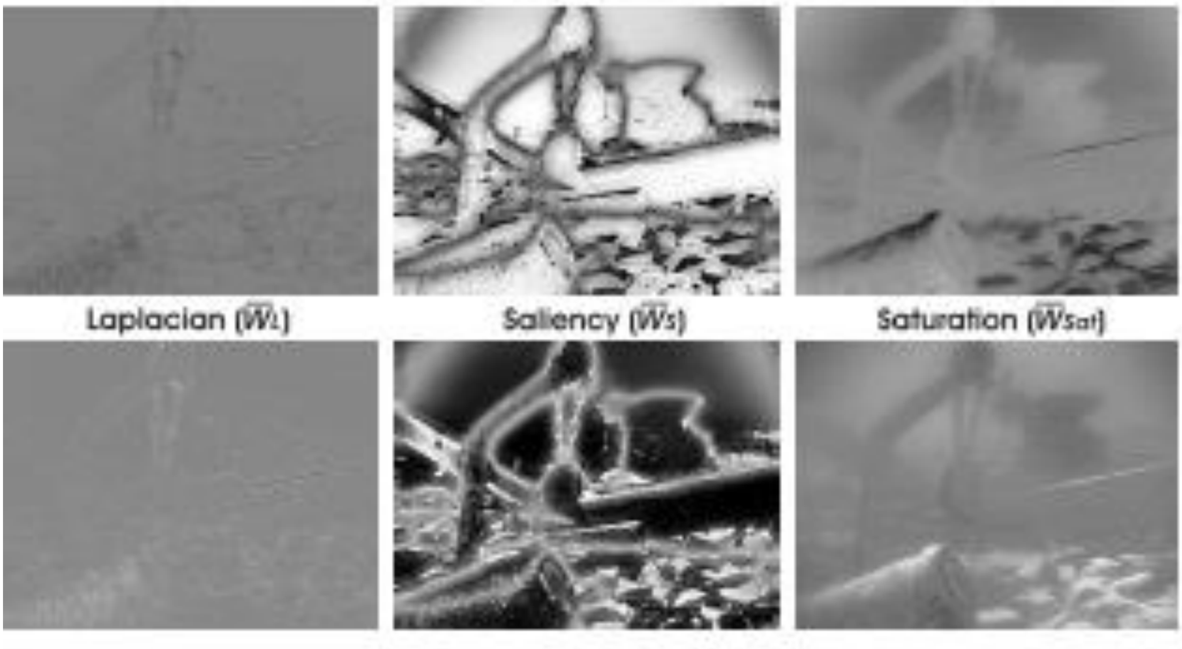


Figure 3: Three corresponding normalized weight map

C. Native Fusion Process

Laplacian pyramid approach is a common technique for preventing the undesirable halos that can appear during the reconstruction of fused pictures. With this technique, the input photos are divided into pyramid-shaped band-pass images. The input images are filtered at each level of the pyramid using a low-pass Gaussian kernel, and the filtered images are then decimated by a factor of 2 in both directions. To obtain the high-pass image, also known as the Laplacian image, the resulting low-pass picture is subtracted from the input image. The decimated low-pass image is then used as the input for the relevant levels of the pyramid once the inverse Laplacian algorithm has been used. Then, independently, each pyramidal level is executed with Gaussian normalised weights to yield fused image

Multi-scale fusion method is highly sensitive to edges and sharp regions, which are highly motivated by the human visual system. This approach provides a better result for underwater image enhancement. The number of levels in the pyramid typically depends on the image size. By using this method, the fused image is reconstructed at every pixel of the input images with given weight maps. The reconstructed image is obtained by fusing the input images with the weight maps at each pixel location. Laplacian pyramid implementation is commonly used to avoid the halos that can occur in the fusion process. The resulting fused image obtained using this approach provides better visual quality compared to the traditional methods.

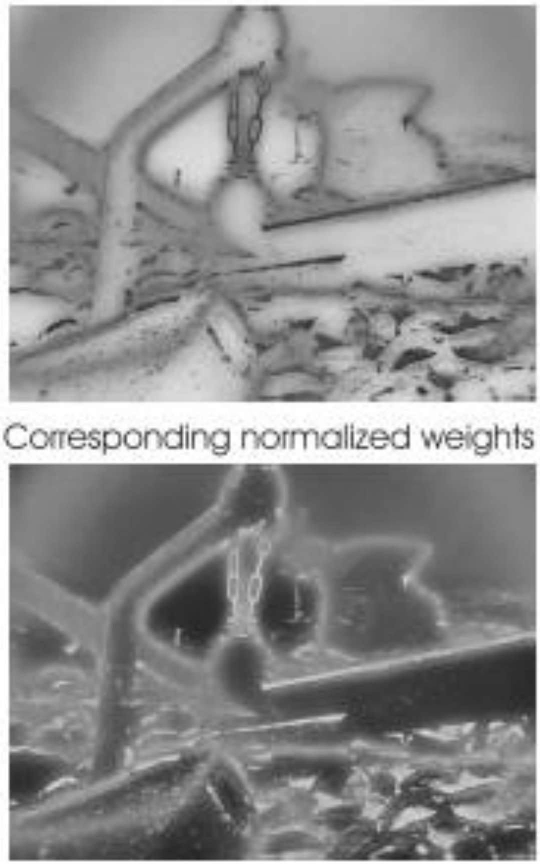


Figure 4: Native Fusion

III. METHODOLOGY

Step 1: Input image is taken. Here there are various types of images that are collected and used. The data sets used here are obtained from UIEB, TURBID, and WHOI(Woods Hole Oceanographic Institution).

Step 2: The input image is preprocessed using histogram equalization and contrast stretching. Then, dehazing is performed on the second input image using the dehaze function where the input image is subjected to contrast stretching and then sent to guided filter for haze removal. Here, the haze removal process is fastened by the help of box filter. The first and second input images are then displayed.

Step 3: A weight map is generated for both the histogram equalized image and the contrast stretched image. The luminance and saliency weight maps are calculated for the first (Histogram equalized image) and the second (contrast stretched image after haze removal) input image. The resultant weight maps for both inputs are calculated by adding the luminance and saliency weights map.

Step 4: Normalized weight maps for both inputs are calculated by dividing the resultant weight maps by the total of the weight map results. The normalised weight maps are then transformed into Gaussian pyramids.

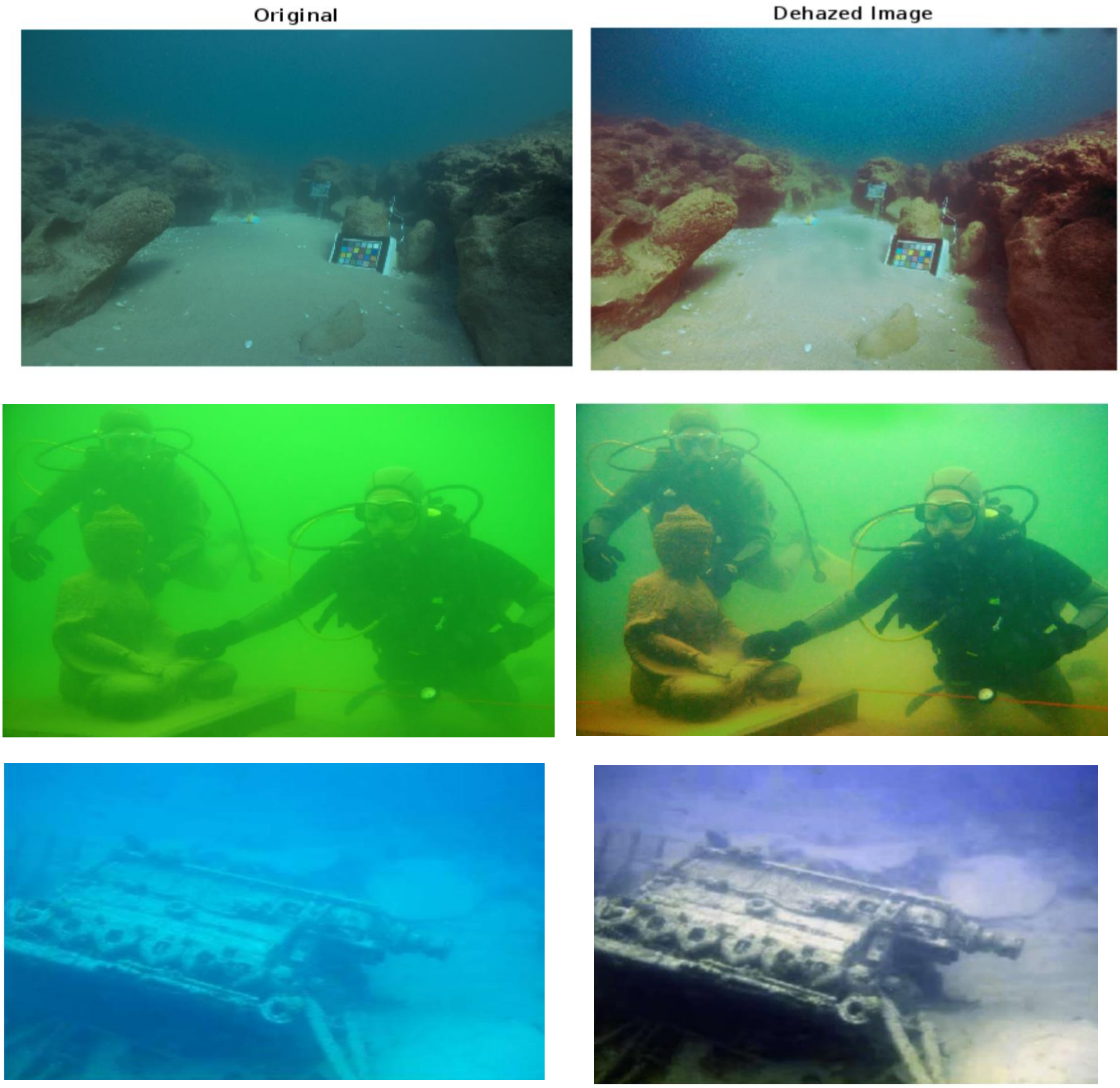
Step 5: Laplacian pyramid decomposition is performed on each color channel of both input images separately. Laplacian pyramid consists of several levels of high-pass filtered images, each level capturing different scales of detail in the image.

Step 6: The fusion process is then performed by multiplying each level of the Laplacian pyramid of each color channel with the corresponding level of the Gaussian pyramid of the normalized weight map for each input image. The resultant pyramids are then added to obtain the fused pyramid.

Step 7: A fused image is reconstructed by performing pyramid reconstruction on each color channel separately. The reconstructed color channels are then combined to obtain the final fused image.

IV. RESULTS

By using this method, an enhanced image for the underwater image is obtained. This is achieved by combining the various methods, which are white balance, fusion and also CLAHE.



A description of our dehazing strategy. The (too light) white balanced image is split into two images, Input 1 and Input 2, using edge sharpening and gamma correction, respectively. The fusion process uses the two images as inputs, from which it produces normalised weight maps and blends the inputs based on a multi-scale approach. Three levels of the Laplacian and Gaussian pyramids serve as an example of the multi-scale fusion technique.

V. CONCLUSION

This study presents a method for improving underwater pictures to correct color distortion caused by attenuated wavelengths, fog, blur, and other factors. The approach relies on a combination of white balancing and fusion methods. Specifically, a Laplacian fusion method is employed, which is inspired by the visual system in human and well-suited to underwater images due to its ability to mitigate back-scattering effects. The resulting output is significantly improved in terms of image quality and clarity.

Our plan for future work is to enhance the camera by using a high-quality one with a wide field of view. Additionally, we aim to increase the system's reliability by incorporating audio detectors that can identify the sound of emergency vehicles.

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