PERFORMANCE EVALUATION ON IMAGE ENHANCEMENT TECHNIQUES FOR UNDERWATER IMAGES

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ABSTRACT

Images that are taken in an underwater environment are often influenced by the absorption of light, depth of the image taken from the surface as well as fuzz being created. There are many algorithms that enhance the quality of the images that are taken underwater considering various aspects. In every paper, they present a new approach to solving the problems faced by underwater images comparing the existing approaches. In this paper, I would explain a few best approaches along with their experimental comparisons where the outcomes could give a broad idea on implementing the methods along with the submerged conditions they are specified to use. Specifically, I chose three notable techniques from the best in class that is Multi-scale Retinex with Color Restoration, Jointly Adversarial Network to Wavelength Compensation and Dehazing, and Low-Light Underwater Images Using Local Contrast and Multi-Scale Fusion. These experiments with some underwater images of different submerged destinations with various states of profundity, turbidity, and light.

Keywords - *Dehazing, Multi-scale Fusion, Multi-scale Retinex, Underwater images, Wavelength compensation*

1. INTRODUCTION

Underwater Imaging is catching the eye in different applications like Seafloor exploration, Fish-pond monitoring, Biological monitoring, Military surveillance, Navigation purposes, and so on. Because of the drawbacks in submerged photolithographic imaging, deep-sea vision isn't at the center of underwater detection until late many years. There are three major challenges faced by underwater images: Color cast. crinkle pattern and haze.

Water has a property to absorb the color based on its wavelength and frequencies. The shading nature of images while diving deep into the water is caused due to its absorption property[1]. Having the highest frequency, red color is absorbed first and blue color is absorbed last due to its lowest frequency. This results in a challenging situation of color distortion in the images. Due to a property of light energy to retain. This causes imperceptibility in the objects resulting in underexposure. There are plenty of particles scattered all along the ocean which further dissipate the image forming disturbances and fuzz in the images[2]. The absorption of various colors based on depth is shown in Fig1.

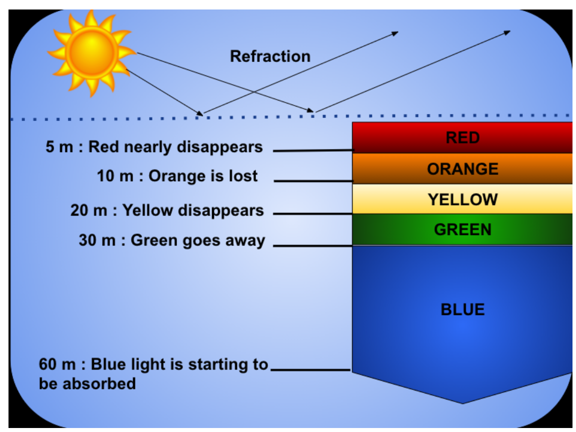

Fig1. Illustration of color distortion with respect to underwater depth..

Enhancing underwater images is being one of the most demanded solutions in many use-cases. Overcoming the above-stated hurdles can result in bringing up new innovations in many fields. Many enhancing strategies that are proposed by various researchers are paving a new path in the development of image processing. Multi-scale Retinex with Color Restoration, Jointly Adversarial Network to Wavelength Compensation, and Dehazing and Low-Light Underwater Images Using Local Contrast and Multi-Scale Fusion are the three approaches that are going to be discussed in this paper.

2. RETINEX HYPOTHESIS

The retinex speculation depends on the actual eye and the mind are related to taking care of. Retinex theory communicates the picture as an aggregation of the reflectance and glow of the article. The traits of the reflectance depend upon the item's inclination. In view of Retinex theory, mathematically we can say, edification can be surveyed by apportioning the image with the reflectance. Considering Image as I(r, s), it is viewed as

$$I(r, s) = R(r, s) \cdot L(r, s)$$

It is shaped as the aftereffect of both R(r, s) the reflectance part which advice to the mirrored light from each article imaged, and L(r, s) which sp to the enlightenment source as in the going with the condition.

MSR with Color Restoration: MSRCR is the advanced technique of MSR(Multi-scale Retinex), where it can reduce the problem in images that do not follow the grey world assumption of equally distributing red, green, and blue components[3][4]. In this approach, initially, the chromaticity values of each color band are calculated. The MSRCR is calculated as follows

$$R_{MSRCR}(r, s) = f\,[I_i(r, s)] * \sum_{n=1}^{N} w_n Ri(r, s)]$$

$f\,[I_i(r, s)] is\ the\ color\ restoration\ function$w

$w_n\ is\ the\ weight\ of\ each\ scale\ and\ Ri(r, s)\ is\ the\ SSR\ valu$

Implementation of the MSRCR is done through the following steps.

Algorithm: Retinex Enhancement using MCRCR

Input: Underwater Image I

1. Calculate original proportions of RGB channels in the image I as Ir, Ig, and Ib.
2. Set the three Gaussian kernels.
1. Calculate Color Restoration Value.
2. Separately operation on R, G, and B channels with MSRCR equation.
3. Performing the weighted summation.
4. Combining the three-channel image.

Output: Enhanced Underwater Image

The outputs obtained using this algorithm are placed in Fig2. for comparing it with other techniques

3. JOINTLY ADVERSARIAL NETWORK TO WAVELENGTH COMPENSATION AND DEHAZING:

Unique in relation to the majority of past submerged picture enhancing strategies that register light constriction which occurs in the camera way. Xueyan Ding came up with a new approach that considers both the wavelength debilitation from the surface of the water to the location of the object and scattered light. This could help in solving the major challenges faced by underwater images. By inserting an improved submerged development model into the mode, we can together gauge the transmission map, frequency lessening, and foundation light by means of various modules, it also utilizes the streamlined submerged picture arrangement model to recuperate debased submerged pictures[5].

This model produces submerged pictures with characteristic optical properties of various water types. The blended strategy can reproduce the shading, difference, and haziness appearance of certifiable submerged conditions all the while. Broad investigations on manufactured and genuine submerged pictures show that this method gives a tantamount or comparatively good outcome

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Algorithm: Wavelength Compensation and Dehazing

Input: Underwater Image I

1. Convert the image into the white-balanced image and storing it in Iwb
2. Enhance the contrast of the image by Iec = gamma * (original image components - avg of the image components)
1. Compute weight maps for Iwb and Iec separately wm_1 and wm_2.
2. Normalize wm_1 and wm_2
3. Compute the results to compute the Gaussian and Laplacian pyramids from the normalized weight maps.
4. Combine the outputs of the above step of both the white-balanced image and contrast-enhanced image and reconstruct the final image.

Output: Enhanced Underwater Image

The outputs obtained using this algorithm are placed in Fig2. for comparing it with other techniques

4. L2UWE: LOCAL CONTRAST AND MULTI-SCALE FUSION

Contrast guided methods could simplify the challenges of the underwater image but may not give its best in low light environments. This turns out the image with a brighter part even where it is not needed. T.P Marques proposed a unique enhancing technique for underwater images that is more realistic to human eyes. In his research, he paved a path in dealing with underwater images by a two-step process. In the first step, the model collects detailed information from tiny regions in order to remove the haze in the environment[6]. The other one would take the information from large parts of the image to result in better light distribution. In the end, both the outputs are fused together with the help of the multi-scale fusion process. The final output will thus contain details of the original image as well as color contrasted. The implementation of this model is as given below:

Algorithm: L2UWE

Input: Underwater Image I

1. Convert the input image into 3 channeled image
2. Compute the CCI of the input image.
3. Dehazing the original image with the help of a transmission map and dark channel
4. Compute saliency, luminance, and contrast weight maps of the dazed images.
5. Normalize the three weight maps
6. Compute the results to compute the Gaussian and Laplacian pyramids from the normalized weight maps.
7. Computing the fused pyramid from the computed weight maps.
8. Reconstruct the fused pyramid to get the final image.

Output: Enhanced Underwater Image

To start with, to determine the modified variant of the image we calculate contrast guided inputs. It is then used to start with, to determine the modified variant of the image we calculate contrast guided inputs. It is then used to determine two environmental models with respect to light that think about neighborhood brightening. These maps create the contributions of a fusion measure.

5. PERFORMANCE ANALYSIS:

The correlation between different enhancement strategies for underwater images is done depending on many parameters[7]. In this experimental research we are using the following parameters:

* Mean Square Error(**MSE**): It is the cumulative squared error between the enhanced and the original image. More MSE implies more Quality.

* Peak Signal to Noise Ratio(**PSNR**): It represents a measure of the peak error. A less PSNR value provides less image quality.

* Structural Similarity Index(**SSIM)** - is used for measuring image quality. It ranges between 0 and 1. Smaller the value implies lesser the quality.

* Normalized Cross-correlation(**NK**): It is used to evaluate the degree of similarity between two images (original and enhanced). Values are of more significance.

* Average Difference(**AD**): It gives us the average change in the image after enhancement. Lesser its value implies more quality.

* Maximum Difference(**MD**): It gives the maximum difference between two images. small values give better images.

* Structural Content(**SC**)t: It gives information about image degradation with respect to its quality. The high value of SC gives us low quality.

* Normalized Absolute Error(**NAE**): It also gives us focused measures in the image. the large value of NK means that the image is of poor quality.

On evaluating the images obtained from three different enhancement techniques, we are comparing the images based on the above-mentioned metrics. The resultant values are mentioned in the table1 that is given below. Upon observing all the outputs, Retinex based approach has enhanced the image with high MSE values and low SC values[8]. It gave color restoration to the images and worked with three different shaded images. Wavelength Compensation and Dehazing technique have improved the contrast of the image with high PSNR values. The color is not fully restored but the enhancement is found with respect to the removal of haze in the pictures. The L2UWE approach has distributed the light evenly containing the details of the original image better. The below given Fig2 and Table1 illustrates more in detail the comparison.

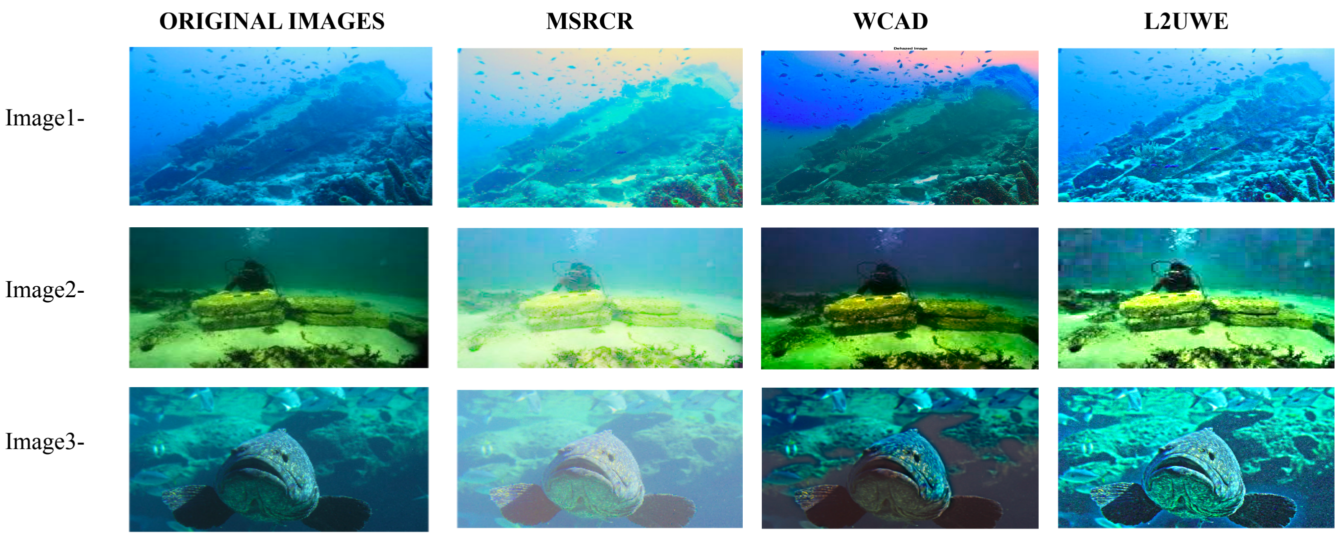

Fig. 2. The comparison between the original and enhanced underwater images obtained using three enhancement techniques: MSRCR: Multi-Scale Retinex with CR, WCAD: Wavelength Compensation and Dehazing, and L2UWE: Local Contrast and Multi-Scale Fusion.

Table 1: Table measuring all the qualitative metrics for the three models A: Multi-Scale Retinex with CR, B: Wavelength Compensation and Dehazing and C:Local Contrast and Multi-Scale Fusion.

	MODEL	MSE	PSNR	NK	AD	SC	MD	SSIM	NAE
IMAGE1	A	8.22	15.28	1.32	-43.29	0.56	-6	0.38	0.88
	B	2.66	63.876	0.78	0.093	1.43	0.70	0.52	0.28
	C	7.96	6.49	0.006	112.5	9.36	211	0.99	0.009
IMAGE2	A	26.79	8.7092	0.69	12.07	0.79	235	0.008	0.91
	B	2.01	65.09	0.800	0.06	1.371	0.722	0.532	0.27
	C	6.73	8.10	0.006	89.35	8.67	234	0.009	0.993
IMAGE3	A	20.09	10.145	0.66	19.07	0.96	255	0.01	0.80
	B	2.01	65.09	0.800	0.06	1.371	0.722	0.532	0.27
	C	26.6	8.73	0.006	85.5	8.56	254	0.008	0.99

6. **CONCLUSION**:

In this paper, the three most significant enhancement techniques are considered to compute on underwater images satisfying different environments. Though the measure of quality in the enhanced images may vary for different persons working in different fields. Total of 8 metrics which are widely used to evaluate the image in its enhancement. From the results, Wavelength compensation and dehazing worked well irrespective to the surrounding conditions when compared with the other two techniques. The basic concept behind this approach is in creating a network module that can understand the background color, transmission maps as well as the strength of the wavelength present. There are many techniques evolving in the current growing era. Thus Simplifying the tasks in getting detailed information from the underwater images is done through such kinds of techniques.

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