A Study on Under Water Image Enhancement using Color Balance and Fusion

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Abstract—This work is a study about effective technique to enhance the images which are captured underwater. Sometimes these images captured may be degraded due to scattering and absorption.This work examines the technique which focuses on a single image without any prerequisite or prior knowledge about under water conditions and also does not require any specialized hardware.The technique focuses on blending two images from a color compensated and white balanced version of the degraded original image. The two images are fused and the definition of their associated weight maps are used to transfer the edges and color contrast of the input image to the output image. This approach adapts a mutliscale fusion strategy to avoid the creation of artifacts from the sharp weight map transitions. This technique focuses on qualitative and quantitative evaluation to improve the accuracy of the images, their global contrast and their edge sharpness

Index Terms—Under water, multiscale fusion, weight maps

1. INTRODUCTION

Underwater images offer more challenging environment, and are very useful for more under water research, Marine technology, study of underwater animals, fish and different species, marine biology,archeology. Under water images suffer from absorption and scattering effect. Hence the images may be degraded and misty. This images may appear foggy because of the because of reduced light energy and light propagation direction. Many state-of-art methods have been used to improve the visibility of the underwater images and videos, but they have not been fully successful because of their varied issues in practical applicability.

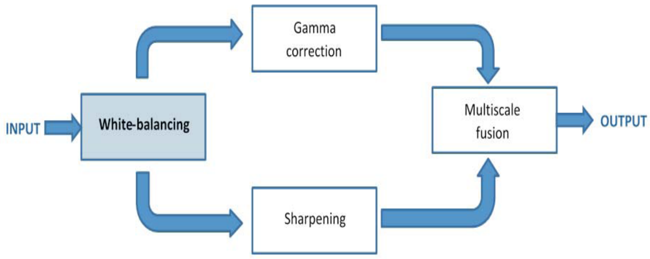

Figure 1: Method overview: White balancing images is taken as input and the multi scale fusion strategy is applied to produce the required enhanced output image

The above figure shows the diagrammatic representation of the enhancement technique used to remove the haze from the image and to produce a enhanced output image using only a single image captured from a camera.

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2. BACKGROUND KNOWLEDGE AND PREVIOUS ART

The optical specificities of the underwater environment are discussed in the following paragraphs.

Light Propagation in under water

The amount of light available in Under water is influenced by many factors like the interaction between the sea and sunlight, the interface between the air and the sea,diving location, the tropical waters etc.The studies of McGlamery and Jaffe have illustrated that the total irradiance incident on a generic point of image plain has three main components in the under water. They are direct component,forward scattering and back scattering.The direct component of the image is expressed by the following:

$$ED(x) = J(x)e^{-\eta d(x)} = J(x)t(x)$$

Where J(x) is radiance of the object, d(x) is the distance between the object and the observer . Forward scattering is caused by the random deviation of the light ray on its way to the camera, and back scattering is due to artificial light such as flash that hits the water particles and gets reflected back to the camera. Back scattering always the cause for the loss of contrast and color shifting in under water images. Mathematically the Back scattered light is expressed as follow:

$$EBS(x) = B\infty(x)(1 - e^{-\eta d(x)})$$

Therefore the underwater optical model is expressed as:

$$I(x) = J(x)e^{-\eta d(x)} + B\infty(x)(1 - e^{-\eta d(x)})$$

The above mentioned optical model is used to characterize the propagation of light in the atmosphere.

3. RELATED WORKS

There are several underwater dehazing techniques, but these techniques are very expensive and time consuming. These techniques are categorized under different classes.The Divergent beam Underwater Lidar Imaging system uses an Optical/Laser sensing technique to capture the underwater images which are turbid.

The next technique is Polarization based methods. This technique uses several images of the same scene captured in different degrees of polarization. However it is used for distant region, but not suitable for video acquisition.The third class of approach uses multiple images or rough approximate image in the scene model. Deep Photo system can be used to restore the images using the existing georeferenced digital

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terrain and Urban # D model. Since images and depth information is available, his method is practical impossible for use.

Another class of methods uses the similarities between the light propagation in fog and under water. Many state-of-art methods are there to restore the images from the outdoor foggy scenes.

Many dehazing techniques which uses heterogeneous lightning conditions and heterogeneous extinction coefficient have been found fruitful for under water images.

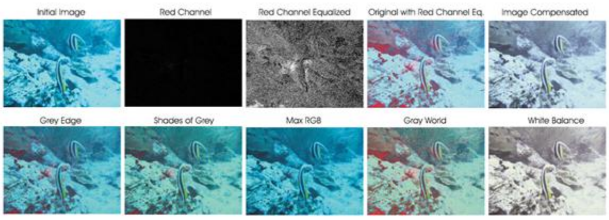
Apart from the above discussed techniques,several algorithms that restore under water images based on (DCP) Dark Channel Prior have been introduced. Another technique known as UDCP (Under water Dark Channel prior has shown to estimate the better transmission of Under Water than the conventional DCP. In the enhanced method discussed , Bilateral and adaptive filters are used to refine the transmission of light. Enhanced method discussed in this work produces High resolution images from denoised and descattered output. A fusion based strategy is used to blend these Intermediate HR images.This fusion strategy preserves the edges and the detailed structure of the noisy , This Fusion strategy aims at improving the color and the color contrast by blending the two intermediate HR images. The main aim of the fusion strategy is to preserve the edgesand detailed structures of the noisy HR image and to reduce the scatter and noise in the second HR image. Thus from the survey it is clear that a enhanced under water image enhancement technique has been introduced as an extension to the previous traditional underwater techniques.

4. UNDER WATER WHITE BALANCE

The image enhancement approach discussed is a two step approach which comprises of the white balancing and image fusion. White balancing compensates for the color cast which is caused by the selective absorption of colors with depth and image fusion enhances the edges and the details of the scene.

White Balancing stage:

White balancing improves the image by removing the unwanted color castings caused due to various illumination or medium attenuation properties. The attenuation and the loss of colordepends on the total distance between the observer and the scene.The comparison of the white balance and the other methods of under water image enhancements have been represented in the image below:



Comparison of Under Water white balancing with other state-of-art approaches. The artifacts are shown in the red channel

To overcome the loss of the red channel the following four principles are used:

1. The green channel: This is preserved under water when compared to blue and red channels.
2. The red attenuation is compensated by adding a fraction of the green channel to the red.
3. It should be taken care that the compensation should be proportional to the difference between the mean value of green and the mean value of red.
4. The compensation of the red channel is performed only in those areas which are highly attenuated.

The red and blue channels are compensated and the mathematical representation of them is as follows:

$$I_{rc}(x) = I_r(x) + \alpha.(\bar{I}_g - \bar{I}_r).(1 - I_r(x)).I_g(x),$$

Once the above compensation is completed the compensation of the illuminantcolor cast is estimated. The next section deals with the hazy effect given to the white balancing stage.

Multiscale fusion:

Multi scale fusion aims at producing a single image as the output of the dehazing scheme. It consists of the following steps:

A. Inputs of the fusion process
B. Weights of the fusion process
C. Naive Fusion process
D. Multi scale Fusion process

A.Input of the fusion process:

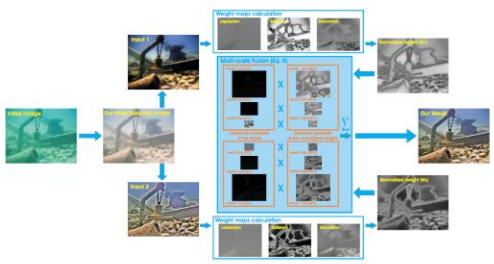
White balance is applied to the original imageand gamma correction is performed to this first input of the white balance image version. These images obtained appear to be very bright and the gamma correction applied increases the difference between darker and lighter regions of the exposed image which may be under or over the exposed region. To compensate for the loss which may occur , we derive a second input to the sharpened versions of the while balanced image. Gaussian filtering is used to the unsharpened version of the image . The sharpened image S is defined as follows:

$$S = (I + \mathcal{N}\{I - G * I\})/2,$$

This sharpening method is called as normalized unsharpmaskup process. The second input helps to reduce the degradation caused by scattering.

B.Weights of the Fusion process

The weights of the fusion process is defined based on a number of local image quality or saliency metrics. The Laplacian contrast weight (W_L) , the Salient weight (W_S),



Overview of the dehazing scheme: The two images are used as input to the fusion process.

Satuartionweight (W_{sat}) are used to enable the fusion algorithm.

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C. Native Fusion Process:

Using the normalized weight maps, the image is reconstructed. The reconstructed image R(x) is obtained by fusing the defined inputs with the weight measures at every pixel location (x). The reconstructed image is obtained by using

$$\mathcal{R}(x) = \sum_{k=1}^{K} \bar{W}_k(x) I_k(x)$$

A multi scale linear and non linear filters are used to remove the undesired halos.

D. Multi scale fusion process:

The fusion process may be independently employed at every scale level. The potential artifacts caused by sharp transitions of the weight maps are minimized.

CONCLUSIONS

An alternative approach for under water computer vision applications and a survey on the different state-of-art approaches related to under water has been discussed. The enhanced approach used in this paper was build on a fusion principle and does not require any additional information related to the image. Only a single original image is required for the fusion principle discussed.The enhancement approach discussed is capable of enhancing the images taken from different cameras, various depths, and different light conditions with very high accuracy.

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