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Under Water Image Enhancement by Fusion

T. Santosh kumar[1], V. Poojitha[2], S. Manisrinivas[3], D. Anilkumar[4], B. Hemanth Nag

[1,2,3,4,](B.Tech), ECE, Lendi Institute of engg And Tech, Vizianagaram, India.
M.Tech. Assistant Professor, ECE, Lendi Institute of Engg. And Tech., Vizianagaram, India.

Abstract: *This paper describes a strategic approach to enhance underwater images. The image gets degraded due to the absorption and scattering of light falling on the objects.This degraded version of the image is enhanced by fusion principles by deriving inputs and weight measures from it. Our strategy is very simple in which white balance and global contrast technologies are applied to the original image. This implementation is followed by taking these two processed outputs as inputs that are weighted by specific maps. This strategy provides better exposedness of the dark regions, improves contrast and the edges, preserved and enhanced significantly. This algorithm effectively enhances the underwater images which is clearly demonstrated in our experimental results of our images.*

I. Introduction

Underwater imaging is difficult due to the illumination properties existing in different environments. The underwater images degrades more than a normal image which have poor visibility due to the improper illumination and obstruction of the propagated light. Generally the light gets exponentially decreases with the distance and depth due to scattering and absorption of the light. The light direction gets affected which eventually blurs the image. The attenuation of light is not fixed in a particular direction. It instantly varies depending on the external conditions. This attenuation of light causes muddled appearance while the scattered light back vitiates the contrast. The objects in the sea water which are more than 10 meters are almost hazy with faded colours as their wavelengths are affected. Finally, these all factors results in an image with poor contrast which appear blurred and hazy.

There are several methods and strategies to restore the degraded image. The degraded image can be Enhanced by different complex techniques which are not much efficient. The image can be restored by using multiple images [1], specialized hardware [2] and by using polarization filters [3]. Though, these techniques have produced effective results on underwater images, they are not efficient concerned to practicability. The Hardware techniques like using camera can deal with dynamic scenes but it is trouble-some, expensive and complex. The multiple image methods requires many images in different environmental conditions while polarization requires several images that have different degrees of polarization.

Figure 1original image

In this paper, we introduce an efficient strategy that is able to enhance underwater images based on a single image. This approach is simple which is able to perform relatively fast on any hardware. This approach is fusion based approach which can be used in several applications such as image compositing [4], multispectral video enhancement [5], defogging [6] and HDR imaging [7]. The magnificence of this approach lies in its

requirement of just a single image. This approach does not require multiple images, only single image is enough which is processed by several enhancing techniques. These techniques consists of derivation of inputs and the weights only from the degraded image. Traditional enhancing techniques like white balance, colour correction, histogram equalization show strong limitations but the use of these techniques cumulatively elicits best results. The efficiency of fusion technique is highly dependent on the choice of inputs and the weights eventually a set of operators in order to get clear enhanced images in all underwater environments.
The undesired noise is supressed from the initially restored version. Our approach enhances the images by several weight maps. The weight maps of our algorithm gauge the several image qualities that specify the spatial pixel relationships. To improve the image quality, these weights assign higher values to pixels. This is a multi-resolution process which is robust to artifacts.

II. Our Enhancing Approach

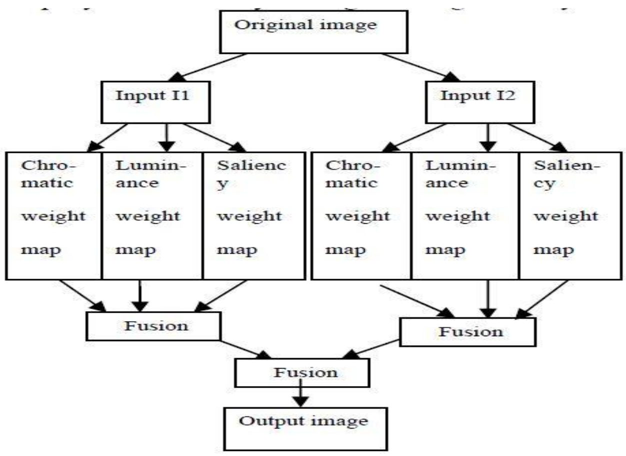
In this approach we use a single image based approach built on fusion principle. This is a simple and fast approach that is able to increase the visibility of underwater images. The considered weights and specified inputs were carefully taken to overcome the limitation of such environments even though specialized optical models are not used. The original image is processed by using two inputs. First the image is processed and white balance is done. Then the weights are applied to this image followed by fusion of these resulting weighted images. In the same way image is processed by the second input. The two resultant images are further undergone fusion and the enhanced image is obtained.

Inputs:

We get the enhanced images using fusion algorithm, which involve in proper application of the inputs and weights to the images.so as to achieve the final image from the degraded image.
So, here we use few fusion techniques to enhance the underwater images. By combining several input images preserving the most significant features. Here we consider an appropriate feature in at least one of the input images. And the whole obtained images are then combined to form a fusion based image featuring those important features among them.so, we use here the fast and easiest techniques to achieve fusion process, so we use here a derived inputs to tackle this process. Due to the different wavelengths of light, like light Absorption and scattering cause part of the light of shorter Wavelength scattering, and the rest of the light of other length.

$$\mu_I = 0.5 + \lambda \; \square_{ref}$$

Wavelength will cross the medium. This will inevitably lead to the offset of the color. Simultaneously, Light Absorption will make the light intensity weaker .Therefore, we need an input methodology to handle this problem that is called white balancing method. This white balance is used to restore the natural light. Whereas global contrast enhancement is another e input methodology used because the global contrast of the image become weaker after the attenuation of the light. In order to get a clear image, we will be bound to improving a global contrast of the source image. Now after applying the input to the original image that is white balancing method we get an image (I1) and later when we apply global contrast enhancement methodology we get another input image (I2).



White balancing:

White balancing is a significant process that aims to enhance the image appearance by discarding unwanted color casts, due to various illuminants. In water deeper than 30 ft.White balancing suffers from noticeable effects since the absorbed colours are difficult to be restored.This White balance refers to no matter in any kind of the light source, it can revert the white objects to White in images. For the color cast while taking pictures under certain light source, it will be compensated through the strengthening of the complementary color. White balance is an indicator which can describe the accuracy of the white color which is generate by mixing three primary colours red (R), green (G), blue (B) .So we use the white color as the standard to restore color offset. The brightness value of images will be normalized and compressed within the range of [0, 1].

$\mu_I = 0.5 + \_\mu_{ref}$

This step can effectively reduce the significant difference between the brightness values and prepare for the next step of image enhancement. As a result, we get the first input image I1.

Figure 2white balanced image

Global contrast enhancement:

To enhance the images using global contrast enhancement we use histogram stretching to increase the contrast. this can amplify the visibility in the regions of haze but yielding some degradation in the rest of the image.so for this we use certain enhancing operators like gamma correction etc. but to avoid the rest of degradation in the image we could apply better weight maps to the images and the output image obtained after applying global contrast enhancement technology to the original image gives the second input image (I2)

Weights:

We are considering weight maps because to recreate the original image back. Mainly any image is mutually related to colour appearance and as a result the measurable values such as salient features, local and global contrast or exposedness are difficult to integrate by naive per pixel blending, without risking to introduce artifacts.so we required higher values of weights because to get final and clear image.in RGB, generally to the image white balance and improving the image is the inception process. Actually the RGB model is not well adapted to explain the color for the human visual.While we trace the colour entity because to explain the hue, contrast, saturation and in this process we are using Weight maps like the luminance weight map、chromatic weight map and saliency weight map to measure and to find information from the input image. Then integrated into one image, we can get more accurate results. In this approach we have three weight maps they are:

Chromatic weight map: It is used here to control the saturation gain in the output image. Also it is used to explain the saturation of the of the image .the higher the saturation is, the more realistic the colour is to acquire the weight Map, so we are calculated the distance between saturation value S and the maximum of the saturation range using the gauss in curve:

$$d = exp\left(-\frac{(S - S_{max})^2}{2\sigma^2} \right)$$

Figure 3 Chromatic map

The standard deviation σ =0.3. Thus, weights close to zero are assigned to the pixels with smaller saturation while the most saturated pixels have weights close to one.

LUMINANCE WEIGHT MAP: This map come through the luminance gain in the output image. This map explain the standard deviation between every R, G, B colour channels and each pixel luminance L of the input. Here the two input images are regenerate from RGB HSV space, for the component of V is the component of luminance .the luminance weight map plays a key role of balancing the brightness.

Figure 4 luminance map

Saliency weight map: The main aim of the saliency weight map is identifies the property with respect to the neighbourhood regions. The main information of the image is concentrated in only a small number of critical areas. This map reflects the distinction between a particular region and its neighbouring areas. If the area's distinction become more understandable, it will be easier to attract people's attention, and it will have greater impact. Different with the method in enhancing the global contrast which was mentioned previously, saliency map can make the edge of the original image to be highlighted. After extracting the contours of the local area. We increase the equivalent weight value, so as to accomplish the result of image distinction enhanced. Here, we use a newer method to generate Saliency map. They propose a regional contrast based Saliency extraction algorithm, which simultaneously calculates global contrast differences and spatial Coherence. The proposed algorithm is simple, efficient, and yields full resolution saliency maps .this algorithm is consistently beat current saliency detection method, yielding higher precision and better recall rates. This algorithm can produce the full-resolution map. It is better than the previous method. The example for the weight map is show in Figure below,

Figure 5 saliency map

Laplacian contrast weight: We denoted it with (W_L) and it is mainly deals with global contrast simply by smearing a Laplacian filter on each input luminance channel and figuring the exact value of the filter result. It used in different applications such as tone mapping and extending depth by directly accomplishments naive blending results not related image. On the other hand, by employing the multi-scale approaches based on WLS filter and Laplacian pyramid yield significant improvements. As may be observed, the difference between WLS and Laplacian pyramid is negligible.

Local contrast weight (w_{LC}): In this approach each relation between each pixel of the image and neighbourhoods average were comprises. .by measuring this approach we reinforce the local contrast appearance, so this we can get a changes mainly in the highlighted and shadowed parts of the second input. The (W_{LC}) is calculated as the standard deviation between pixel luminance level and the local average of its surrounding region.

WLC(x, y) = ‖ Ik-Ik w hc‖

Where I^k represents the luminance channel of the input and the I^k_{hc} represents the low-passed version of it.

Figure 6contrast enhanced image

Image fusion: In the last step we have implemented a multi scale image fusion.Image fusion is a process in which the inputs are weighted by exact computed maps to preserve the most important perceived features. The main aim is just to combine the input weights various maps. In this approach we are combining the input data in a per pixel manner to minimize the loss of the image structure. Now we got two images as inputs, we have to extract the three weight maps for each individual image, they are :

wL _ 1， *wL _ 2*

（Luminance weight map ），

wC _ 1 ， *wC _ 2*

（chromatic weight map）and

wS _ 1 ， *wS _ 2*

（Saliency weight map).

In order to ease the consequent weighted fusion each weight map must first normalized.

The normalized luminance map of the input I1 is:

$NwL\_1 = wL\_1 /(wL\_1 + wL\_2)$(3)

$NwL\_2 = wL\_2 /(wL\_1 + wL\_2)$ (4)

The same process is implemented for other values for 2I.

In the following step we use linear integration of the three weighted values.

W_i=a*NwL_i+b*NwC_i+c*NwS_i (5)

Where a,b,c are the weighted value of the coefficient. We have to set the a, b, c values to 1.

$$F^{(i,j)} = \sum m_k * W_k^{(i,j)} I_k^{(i,j)} \qquad (6)$$

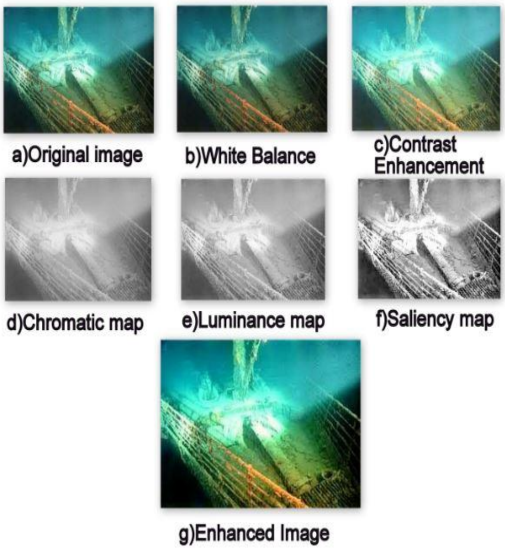
Where k,m are the coefficients of the two input images.Here every pixel image of the outputF is Calculated by adding the inputs Ik weight by consistent normalised weight maps kW.In our approach each and every input is decomposed.

Into a pyramid by applying a operator at dissimilar scales, likewise for each and every normalised weight map Wa Gaussian pyramid is calculated.

Result: Here from the above discussion we are taking different under water images from different sources and process them by applying the corresponding weight maps we can get the final image as shown in the figure 7.At first we are white balancing the image so that we can avoid the unwanted colour casts during various illuminants. After that we are now applying the weights to our white balanced image. In our approach we can get a picture of an underwater image with good colour clear details of the background. When compared with other techniques the mail structural alteration to our method is the amplified contrast.Our approach emphasize details without disturbing the colour. This technique requires very less computational means and is wellappropriate for real time applications.Finally in our approach it shows a good strength to protect the consistency in the appearance of colour for various cameras.

Figure 7final result

More Results:



III. Conclusion

In this paper, we propose an efficient and low complexity underwater image enhancement method. The proposed approach contains two mainly procedures, the direct reflection of light from the object and the reflection from the particles of the medium. We have shown that by choosing appropriate weight maps and inputs, the fusion strategy can be used to effectively underwater images. Our technique has been tested for a large data set of underwater images. The method is faster than existing single image enhanced strategies yielding accurate results and the color contrast of the object in underwater. The experimental results show that the proposed approach can effectively enhance the underwater image. To future work we would like to test our method for videos.

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