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Algorithms for Underwater Video Enhancement

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Abstract :- — **The paper describes the techniques for underwater images and videos enhancement. Initially the conventional approaches like wavelength compensation and image dehazing (WCID), dark channel prior method, contrast limited adaptive histogram equalization (CLAHE) have been studied and analysed. Analysis of all the three methods have highlighted the shortcomings of the individual methods. The fusion method is described in this paper which has exhibited comparatively better results for the enhancement of underwater images and videos. In the proposed method the inputs are taken from the degraded images, the colour correction and the contrast enhancement techniques are applied on the input image. The weighted maps are used for increasing the visibility of the degraded object due to absorption and scattering. The resultant output is characterized by lower noise, improved contrast and better exposed dark regions.**

Keywords: **CLAHE, dark channel prior, fusion, WCID, white balancing.**

I. INTRODUCTION

The physical conditions of the underwater environment lead to degraded images or videos. The main reason for this degradation is due to inadequate amount of light or scattering of light. The reason for this phenomenon is the exponential attenuation of light. The exponential attenuation of light has two basic reasons, first absorption and second scattering of light. Scattering can be classified as forward scattering and backward scattering. Forward scattering is the reason for blurring of image whereas backward scattering is the reason for limiting the contrast of the image. This has a significant impact on the quality of the video or the image.

Thus it becomes vital to enhance these images and videos for various application purposes. There are various algorithms which are used conventionally for this purpose. These include contrast limited adaptive histogram equalization (CLAHE). The CLAHE has the following disadvantages Noise amplification in flat region and ring artifacts at strong edges, It operates on small data regions (tiles), rather than entire image, It is computationally expensive (in software). The other algorithm is the dark channel prior algorithm it has the drawback that it is invalid when the scene objects are inherently similar to the atmospheric light and no shadow is cast on them. Similarly wavelength compensation and image dehazing (WCID) has its own drawback.

The fusion method introduced in this paper gives better visual quality enhancement. The fusion principle provides a novel method enhance the image or the video. The colour correction and the contrast enhancement by converting the video from RGB format to HSV format and then the weighted addition has given significant results for the desired purpose.

II. VARIOUS ENHANCEMENT TECHNIQUES

A. Clahe Technique

[3]Adaptive histogram equalization and contrast limited adaptive histogram equalization were proposed to overcome the over amplification of noise problem. While performing AHE if the region being processed has a relatively small intensity range then the noise in the region gets more enhanced. It can also cause some kind of artifacts to appear on those regions. To limit the appearance of such artifacts and noise, a modification of AHE called contrast limited AHE can be used. Contrast limited adaptive histogram equalization (CLAHE) is an adaptive contrast histogram equalization method , where the contrast of an image is enhanced by applying CLAHE on small data regions called tiles rather than the entire image.

Advantages

- In contrast limited adaptive histogram equalization technique, first the distance between the scenes objects to camera is estimated by using a low complexity dark channel prior algorithm. Based on the depth map derived the foreground and background area within the image is segmented. The light intensities of foreground and background are then compared, to determine whether an artificial light source is employed during the image acquiring process. If an artificial light source is detected, the added luminance is to be eliminated. The CLAHE technique is utilized to remove the haze effect and color change along the underwater propagation path.

- CLAHE, though able to increase contrast more than other techniques It introduces large chances in the pixel grey levels.
- CLAHE may lead to introduction of the processing artifacts and affect of decision making process.

Disadvantage

- Noise amplification in flat region and ring artifacts at strong edges.
- It operates on small data regions (tiles), rather than entire image.
- It's quite complex (in Hardware).
- Implementing recursion in hardware can be complex, necessitating the Implementation of control flow and of storage for intermediate results.

Results

Depth (in m)	**WCID**	**Dark-channel**	**CLAHE**
5m	19.72dB	13.29dB	13.39dB
15m	18.41dB	10.33dB	11.51dB

Fig.Input Image

Fig. Output Image

B. Dark-Channel Prior Method

[4]A dark channel method is an efficient and effective method to restore original clarity of the underwater image. Images taken in the underwater environment are distorted because of light attenuation. Using dark channel prior ,the depth of the turbid water can be estimated by the assumption that most local patches in water free images contains some pixels which have very low intensities in at least one color channel. In pure water, it is very often that some pixels have very less intensity. Such pixels are known as dark pixels. In underwater images, the intensity of these dark pixels is contributed by background light. Therefore these dark pixels can directly provide accurate estimation of water transmission. Combining an underwater imaging model and a soft matting interpolation method, we can recover a high quality water free image and produce a good depth map.

Advantages

- Simple but powerful.
- Bad haze image can be put to good use.

Disadvantages

- Invalid when the scene objects are inherently similar to the atmospheric light and no shadow is cast on them.

Result

Fig. Input Image

Fig. Output Image

***C.* Wavelength Compensation And Dehazing Algorithm (Wcid)**

A WCID means Wavelength Compensation and Image Dehazing. Two main causes of underwater image distortions are light scattering and color change. WCID is an only technique which handles problems of light scattering, color change and artificial light source presence simultaneously. A number of underwater image processing techniques used to remove light scattering and color change effect. Generally most of the processing techniques focus on removing either light scattering effect or color change effect. The only technique called WCID will handle these problems simultaneously.

A WCID is based on an underwater image formation model. the algorithm for wavelength compensation and image dehazing combines techniques to remove distortion caused by light scattering and color change .First, Dark channel prior method is used to estimate distance between camera and object.

Advantages

- WCID results in superior haze removal and color balancing capabilities over dehazing and histogram equalization.
- Highest SNR values are obtained.
- Performance of WCID is most robust through different water depths.

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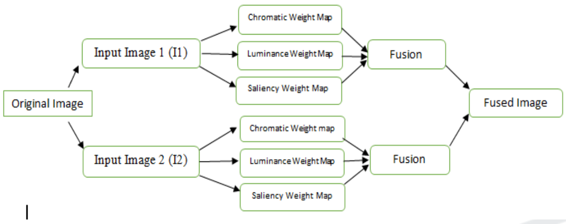
Results


Fig. Input Image


Fig. Output Image

III. Fusion Method

Block Diagram



i. White Balance (INPUT 1)

The white balance operation (also called color balance, illuminant correction) uses the color white as the standard for adding the correct overall color 'bias' to a captured image. The aim of this is to basically want all white objects in the scene to be white in the image. White balance (WB) is the process of removing unrealistic color casts, so that objects which appear white in person are rendered white in your photo. Proper camera white balance has to take into account the "color temperature" of a light source, which refers to the relative warmth or coolness of white light. Our eyes are very good at judging what is white under different light sources, but digital cameras often have great difficulty with auto white balance (AWB) and can create unsightly blue, orange, or even green color casts. Color balancing is sometimes performed on a three-component image (e.g., RGB) using a 3x3 matrix. This type of transformation is appropriate if the image was captured using the wrong white balance setting on a digital camera, or through a color filter.


Fig. Input Image


Fig. Output Image

ii. Contrast Enhancement (INPUT 2)

The contrast enhancement is one of the commonly used image enhancement methods. Many methods for image contrast enhancement have been proposed which can be broadly categorized into two methods: direct methods and indirect methods. Among the indirect methods, the histogram modification techniques have been widely utilized because of its simplicity and explicitness in which the histogram equalization (HE) is one of the most frequently used techniques. The fundamental principle of HE is to make the histogram of the enhanced image approximate to a uniform distribution so that the dynamic range of the image can be fully exploited. Contrast enhancement changing the pixels intensity of the input image to utilize maximum possible bins. Contrast enhancement is based on five techniques such as local, global, partial, bright and dark contrast.


Fig. Input Image


Fig. Output Image

iii. Temporal Bilateral Filter

The bilateral filter is technique to smooth images while preserving edges. The bilateral filter is a non-linear technique that can blur an image while respecting strong edges. Its ability to decompose an image into different scales without causing haloes after modification has made it ubiquitous in computational photography applications such as tone mapping, style transfer, relighting, and denoising. This text provides a graphical, intuitive introduction to bilateral filtering, a practical guide for efficient implementation and an overview of its numerous applications, as well as mathematical analysis.
The bilateral filter is defined as

$$I^{\text{filtered}}(x) = \frac{1}{W_p} \sum_{x_i \in \Omega} I(x_i) f_r(\|I(x_i) - I(x)\|) g_s(\|x_i - x\|),$$

iv. Colour Correction

Change the color intensities reported by your color imaging system so that they match those snapped at some initial time-point (same system), or to another system (the "gold standard" system). I also call this "RGB Matching" Slide 5 of 30 Color Correction. This can be done in color or monochrome. Image from your "sample" system will be changed into what it would

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look like if it were snapped on your standard system. Standard system can be time-point zero on the same system, another system, or an average of several systems.

v. Weights of the Fusion Process

[1]The design of the weight measures needs to consider the desired appearance of the restored output.

Laplacian Contrast Weight:

We denoted it with (WL) 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 (Wlc):

[1]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 (WLC) is calculated as the standard deviation between pixel luminance level and the local average of its surrounding region. WLC(x, y) = ǁ Ik-Ik w hcǁ Where Ik represents the luminance channel of the input and the Ik hc represents the low-passed version of it.

Fig. Input Image Fig. Output Image

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. 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.

Fig. Input Image ***Fig. Output Image***

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.

Fig. Input Image ***Fig. Output Image***

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 color 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:[1]

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

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Fig. Input Image

Fig. Output Image

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.

Result

Here from the above discussion we are taking different under water images from different sources and process them by applying the corresponding weights maps we can get the final image as shown in fig. 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 underwater image with good colour clear details of background. When compared with other techniques the mail structure alteration to our method is the amplified contrast. Our approach emphasize details without disturbing the colour.This techniques requires very less computational means and is well appropriate for real time applications. Finally in our approach it gives good Output result.

Fig. Input Image

Fig. Output Image

Fig. Input Image

Fig. Output Image

IV. APPLICATIONS

Underwater video enhancement has various applications. Underwater video enhancement has special applications in the fields related to marine researches. Hence the scope of the project extends to much greater possibilities. Currently there are many applications like Subsea inspection, Marine archaeology, Aquaculture, ROV operations, commercial diving. Similar concept can used for correction of foggy videos in case of the automobile applications.

V. CONCLUSION

The haze free videos and images can be obtained by the fusion method of underwater video enhancement. The fusion method has a characteristic of being specific for a particular video or image as the constants defined are as per the input. A more generalized approach can be considered for this purpose, but it compromises with the output quality. A case specific approach has better image quality at the input in the fusion method

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