Volume 5, Issue 5, MAY 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

A Review on Underwater Image Enhancement Techniques

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Abstract- ***The underwater image processing area has received great attention of researchers because of its vast achievements. This paper describes various underwater image enhancement techniques. And this paper also describes how underwater images get distorted, causes of underwater image distortion, and methods or techniques to recover distorted image. This paper describes WCID algorithm for underwater image enhancement. WCID means wavelength compensation and image dehazing. We also compare various underwater images processing techniques result with WCID algorithm.***

Keywords*: Underwater Image, light Scattering, Color Change, De-hazing ,wavelength compensation.*

I. INTRODUCTION

From last few years, underwater image processing area has received great a great attention of researchers. To capture a clear underwater image has a crucial importance in oceanic engineering [1]. clear underwater images have a great importance in scientific operations like taking a census of sea population .in general underwater images facing a low visibility problems .For capturing a clear visible underwater image, water must be a limpid or clear, but naturally all the water is turbid with particles such as sand, planktons ,minerals. As outdoor images are distorted because of particles present in the air, like that underwater images also get distorted because of particles present in the water. Underwater Images becomes more and more hazy or less visible as water depth increases. Generally underwater images get distorted because of two reasons. One is light scattering effect and second is color change effect. Sometimes photographer uses artificial light source to overcome insufficient lightning in underwater .but this artificial light source overcompensate the original image. So it is required to remove this overcompensation and reconstruct an original image without artificial light source .In this paper we will see how underwater images get distorted, what are the causes of distortion, which techniques are useful to overcome this distortions. We also compare various underwater images processing techniques .In this paper we also take an overview on Wavelength compensation and image dehazing technique (WCID). This wcid technique shows various advantages over any other underwater image processing technique. The underwater images usually suffer from low contrast, non-uniform lighting, blur and diminished colors i.e. bluish appearance of image. Light scattering is caused by light incident on object and then it is reflected and deflected multiple times by particles present in the water before reaching the camera [6]. Light scattering degrades visibility and results in low contrast of captured image. Attenuation of light causes change in color of underwater image. Light consist of different wavelength, different wavelength of light is attenuated by different degree in water. Underwater images are dominated by bluish color; this is because of shortest wavelength of blue color. Shortest wavelength color travels longest in the water.

The existing research shows that underwater images give new challenges and significant problems because of light scattering effect. From the last few years, a growing interest in marine research has encouraged researchers from different disciplines to explorer the mysterious underwater world. A significant amount of literature is available on underwater image processing. This paper describes various underwater image enhancement techniques.

II. UNDERWATER IMAGE DISTORTION

In this section we will see what are the reasons for underwater image distortions .when objects are measured in liquid, image distortion is caused by the refraction of the light on the interface between air and the liquid [1]. An image of a sea bottom observed through a rough surface is randomly distorted by the refraction of light. The two main causes of underwater image distortion are light scattering and color change effect. We will discuss these two causes in this section.

Light scattering is a form of scattering in which light is the form of propagating energy which is scattered. When camera light incident on objects then it get reflected and deflected number of times by particles present in the water before reaching the camera [6], this phenomenon is known as a light scattering. This light scattering results in a poor visibility and low contrast in the underwater image .Light scattering depends on the frequency or wavelength of the light being scattered. Forward scattering generally leads to blur of the image and results into the low contrast of image.

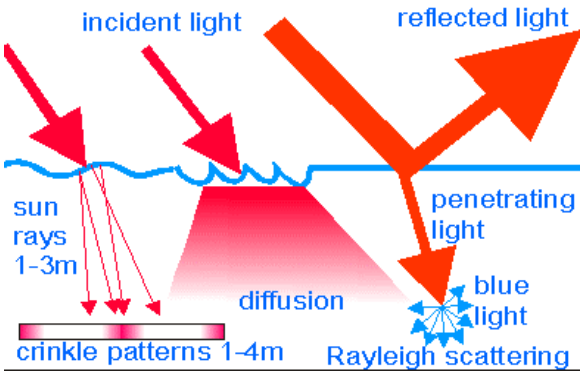

Fig 1: light scattering effect

The second cause for underwater image distortion is color change. Color change is due to varying degrees of attenuation for different wavelengths .Blue color has shortest wavelength so it travels longest distance in the water. This is the reason behind why underwater images are dominated by blue color .And red color has highest wavelength, so it travels a very short distance in water. Suspended particles (sand, plankton, minerals) are responsible for hazy underwater image. As light reflected from objects towards camera, a portion of light meets these suspended particles, this will in turn absorb and scatters light bea.[3].

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 [6].

III. TECHNIQUES TO RECOVER DISTORTED UNDERWATER IMAGES

In this section, we will discuss various underwater image processing techniques used for recovery of distorted underwater images.

3.1 WCID Technique

A WCID means wavelength compensation and image dehazing. WCID is an underwater image enhancement method or technique which compensate wavelength. As discussed above, two main causes of underwater image distortions are light scattering and color change. Sometimes artificial light source is used to overcome insufficient lightening problem. But it introduce additional luminance in the image.WCID is an only technique which handles problems of light scattering, color change and artificial light source presence simultaneously. This technique has a novel systematic approach to enhance underwater images by dehazing algorithm [6] . 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 [6].

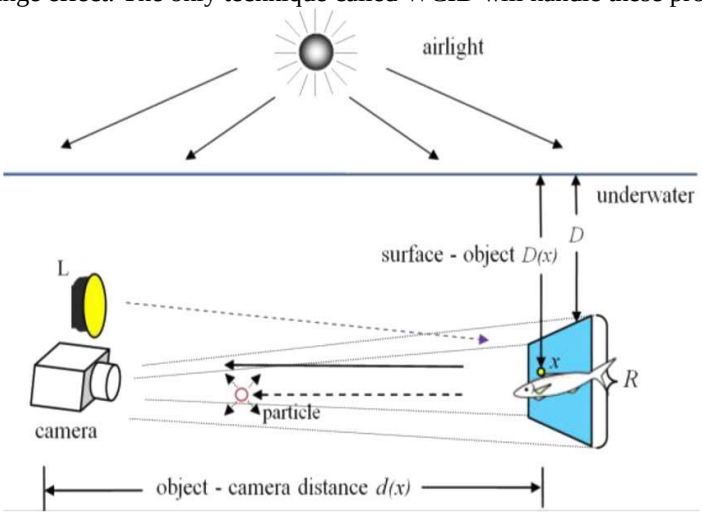

Fig 2: image formation model

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 .based on the depth map derived ,the foreground and background areas are segmented .the light intensities of foreground and background are compared to determine presence of artificial light .if artificial light source is detected ,the luminance introduced by itis removed from the foreground area. Next dehazing algorithm is used to remove haze effect and color change.

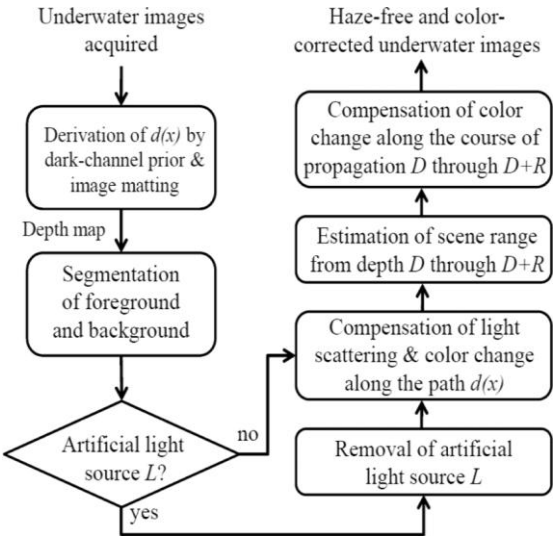

Fig 3: WCID flow diagram

Fig 3 shows WCID flow diagram. It shows how WCID algorithm will work. The WCID algorithm combines techniques of WCID to remove distortions caused by light scattering and color change. Dark channel prior, an existing scene depth method is used to estimate distance between object and camera. Based on depth map derived, the foreground and background areas within the image are segmented. The intensities of foreground and background then compared to determine whether there is presence of artificial light. If artificial light source is detected, then luminance which is contributed by artificial is removed to avoid overcompensation. Then the dehazing algorithm and wavelength compensation are utilized to remove color change effect. The residual energy among different color channels is used to estimate water depth. Following steps are required in WCID algorithm.

Step 1: calculation of distance between camera and object d(x)

A dark channel prior method is used to estimate d(x). The low intensities in the dark channel are due to shadows, colorful objects and dark objects. Depth map required two images for parallax. Generally haze increases as distance increase. The dark channel prior method is based on the observation that in most of the non-background light patches; at least one color channel has a very low intensity at some pixels.

Step 2: Removal of artificial light source

Sometimes artificial light sources are used in underwater photography for obtaining clear image. This light source contributed additional luminance which must be deducted to avoid overcompensation. For this, we compare foreground and background luminance and then compare this luminance's to remove luminance contributed by artificial light source.

Step 3: Calculation of underwater depth (D)

In WCID algorithm, underwater depth is calculated by comparing energy for channels. For above water surface, energy is same for red, green and blue channels. But for below water surface energy of color channels depends on their attenuation.

Step 4: calculation of image depth range (R)

When light penetrates through water covering the depth range R, a disparate amount of color change will be induced at the top and at the bottom of the image. This phenomenon necessitates varying energy compensation adjusted according to the depth of each underwater point to correctly rectify color change.

3.2 Dark-channel prior method

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 ark 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. Dark channel prior is based on the statistics of clear images in air. 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 [7].This approach is physically feasible and can obtain distant objects even in the heavy blur images.

Dark channel prior may not be useful when scene object is inherently similar to the background light over a large local region and no shadow is cast on the object.

3.3 histogram equalization

Histogram equalization is an image processing method which uses images histogram for image contrast adjustment. This method usually increases the contrast of distorted image by adjusting intensities. The method is useful in images with background and foregrounds that are both bright or both dark. Histogram equalization is a technique for adjusting image intensities to enhance contrast.

Histogram equalization method cannot compensate light scattering problem.

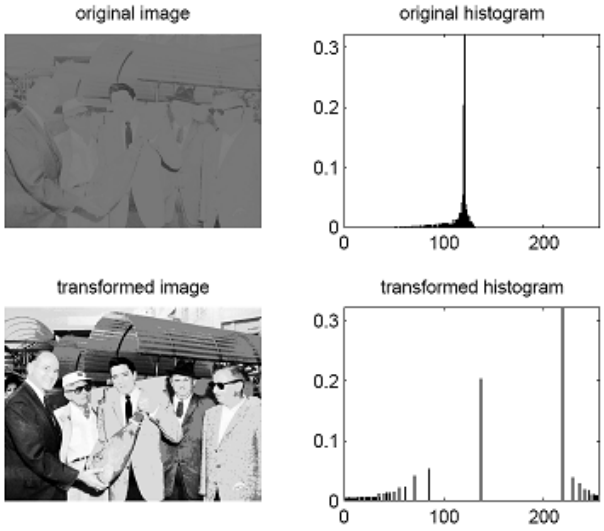

Fig 4: histogram equalization applied to low contrast image

IV. EXPERIMENTAL RESULTS

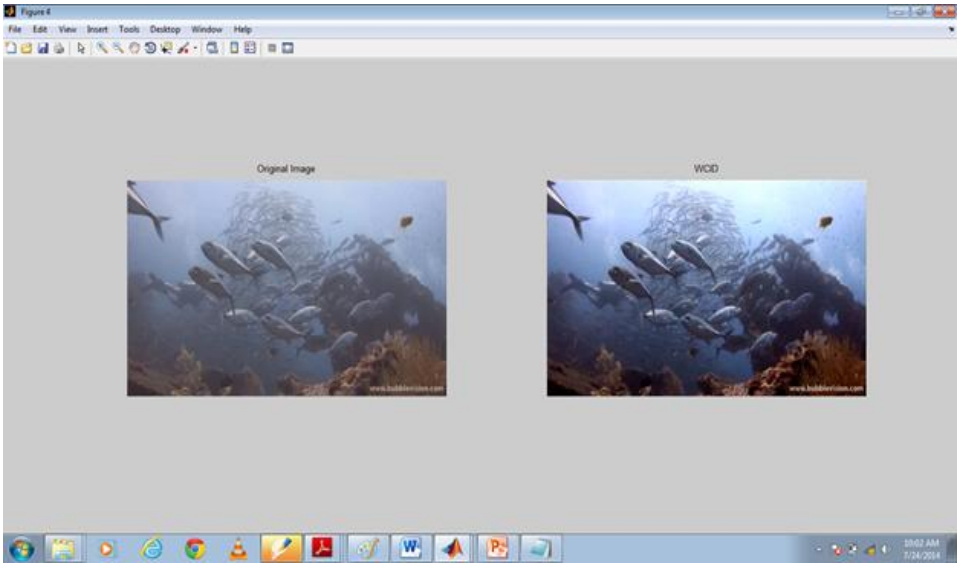

Fig 5: matlab result showing original image and WCID processed image

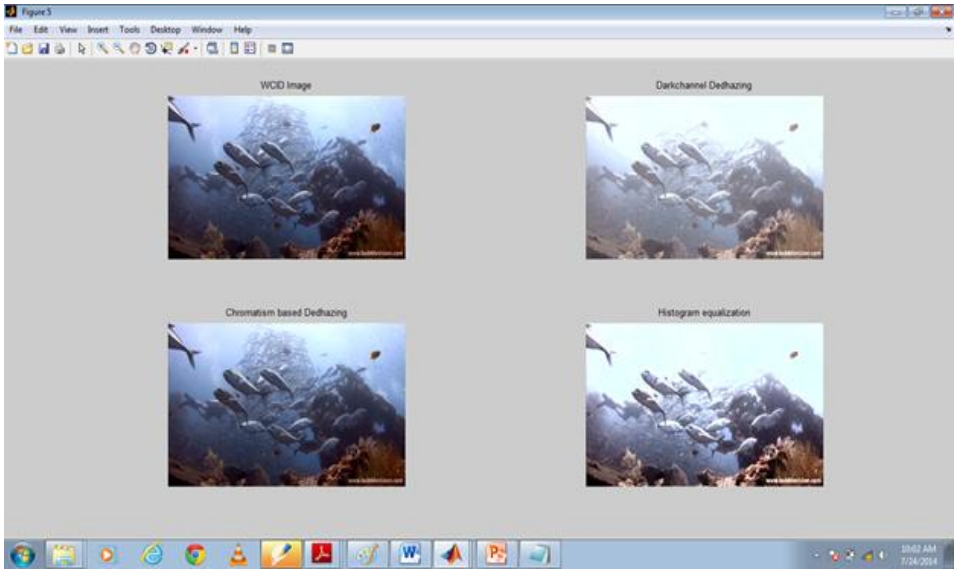

Fig 6: comparison between WCID and other underwater image enhancement techniques a) WCID image b) Dark channel dehazing image c) chromatism based dehazing image d) histogram equalization image

Table 1:Comparision between WCID technique and other image enhancement techniques using PSNR ratio:

Underwater image enhancement techniques	WCID	DARK CHANNEL DEHAZING	CHROMATISM BASED DEHAZING	HISTOGRAM EQUALIZATION
PSNR RATIO	76.5044	58.9247	60.1515	59.1331

V. CONCLUSION

In this paper, we discuss causes of underwater image distortion and various underwater image processing techniques. We also discuss limitations of various underwater image enhancement techniques. We also take an overview of WCID algorithm which is best among other underwater image enhancement techniques. This survey results that wavelength compensation and image dehazing i.e. WCID is a most effective and efficient technique which handles light scattering and color change problem simultaneously.

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