Underwater Image Quality Enhancement Methods & Problems: A Review

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Abstract— Underwater environments generally cause color cast or color scatter while photography. Color scatter is due to haze effects appearing when light reflected from thing which absorbed or may be scattered several times by particles of water. This cause lowers the visibility and less contrast of the image. Color cast is due to the varying attenuation of light in various wavelengths, and this is cause underwater environments bluish. To mention distortion from color scatter and color cast, this paper proposes a method to reconstruct underwater images that which is a combination of a wavelength compensation and de-hazing algorithm (IDWC). One has to determine the distance between the objects and the camera using dark channel prior, then haze effects cause by color scatter can be removed by the de-hazing algorithm. Next, one has to estimation the photography scene depth using residual energy ratios for each. According to the attenuation of every wavelength, reverse compensation conducted to restore all distortion from color cast.

Key words: HSMF: HSI Stretching & Median Filter, ACCLAHE: Adaptively Clipped Contrast Limited Histogram Equalization, WCID: Wavelength Compensation & Image Dehazing

I. Introduction

Capturing a clear image in underwater environments is an appropriate issue in ocean engineering [1]. Effect for applications like as underwater environment evaluation or navigational monitoring have significant role for quality for underwater images. Taking clear images underwater is tough; mostly due to haze mainly due to Color scatter also addition to Color cast by varying light attenuation on various wavelengths [2]. Color scatter and Color results a blurred subjects and with lowered contrast in all underwater images. In Figure 1, shows a example, yellow coral reef (a kind for sea tree) at right bottom corner for image and one yellow fish in right-upper corner are not distinguishable due to Color cast; fish and reef in back are unclear due to scattering.

Fig. 1: Haze and Color cast in Underwater Images due to Blurry and Bluish Effects

Haze is because by many suspended particles like as sand, plankton and minerals that always exist in lakes, rivers and oceans. When camera capture images reflected light from objects goes to camera, few portion for light meets suspended particles, which absorbs few for light and scatters light (Fig. 2). In environments which do not have blackbody emission [3], scattering normally expands to multiple scattering.

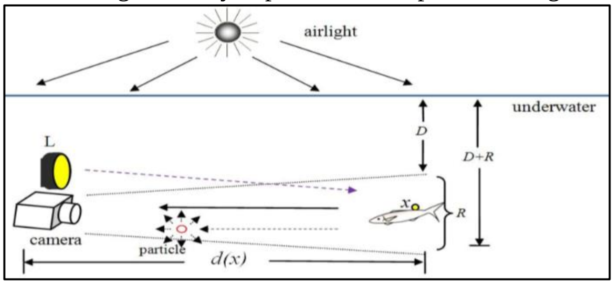

Fig. 2: Natural Light Illuminates an Underwater target point x and Reflected Light goes to Camera by Direct Transmission with Scattering

The underwater image after scattering may be represent as weighted sum for transmitted reflected light and scattered background light [4]

$$I_\lambda(x) = J_\lambda(x)t_\lambda(x) + B_\lambda(1- t_\lambda(x)), \lambda \in \{R,G, B\}$$

$$t_\lambda(x) = \frac{\mathbf{E0(\lambda,d(x))}}{\mathbf{E1(\lambda,0)}} = 10^{-\beta(\lambda)d(x)} = (Rer(\lambda))^{d(x)}$$

Here x is a point for object; λ is wavelength for light in underwater; $I_\lambda(x)$ is image captured by camera; $J_\lambda(x)$ is quantity for reflected light that was directly transmitted. Light gets attenuated when through a medium (water) [5]; residual energy ratio (Rer) shows ratio between residual energy to initial energy in order to each unit for distance. Considering energy for a light beam earlier and after it propagates through a water with a length d(x) is $E_I(\lambda,0)$ and $E_O(\lambda, d(x))$. $t_\lambda(x)$ presents residual energy ratio for light beam propagating through medium. Due to that $t_\lambda(x)$ also depends on wavelength λ and length d(x), distance between x and camera, $t_\lambda(x)$ also affected by Color scatter and Color cast.

A. Image Equaliser

Histogram equalization often produces unrealistic effects in photographs; however it is very useful in order to scientific images like thermal, satellite or x-ray images, often same class for images to which one would apply false-color. Also histogram equalization may produce undesirable effects (like visible image gradient) when applied to images with low color depth. In order to example, if applied to 8-bit image displayed with 8-bit gray-scale palette it will further reduce color depth (number for unique shades for gray) for image. Histogram equalization [4] will work best when applied to images with much higher color depth than palette size, like continuous data or 16-bit gray-scale images.

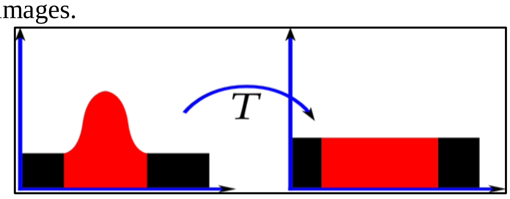

Fig. 3: Image before and after Equalization

There are two ways to think about and implement histogram equalization, either as image change or as palette change. Operation may be expressed as P(M(I)) where I is original image, M is histogram equalization mapping operation and P is a palette. If we define a new palette as P'=P(M) and leave image I unchanged then histogram equalization is implemented as palette change. On other hand if palette P remains unchanged and image is modified to I'=M(I) then implementation is by image change. In most cases palette change is better as it preserves original data.

II. LITERATURE REVIEW

John Y. Chiang et al [3] Light scattering and color change are two major sources of distortion for underwater photography. Light scattering is caused by light incident on objects reflected and deflected multiple times by particles present in the water before reaching the camera. This in turn lowers the visibility and contrast of the image captured. Color change corresponds to the varying degrees of attenuation encountered by light traveling in the water with different wavelengths, rendering ambient underwater environments dominated by a bluish tone. No existing underwater processing techniques can handle light scattering and color change distortions suffered by underwater images, and the possible presence of artificial lighting simultaneously.

Jie Li et al [2] This paper reports on WaterGAN, a generative adversarial network (GAN) for generating realistic underwater images from in-air image and depth pairings in an unsupervised pipeline used for color correction of monocular underwater images. Cameras onboard autonomous and remotely operated vehicles can capture high resolution images to map the seafloor; however, underwater image formation is subject to the complex process of light propagation through the water column.

Sonal Dixit et al [1] Abstract-Image enhancement (IE) methods present as a preprocessing step in object detection and recognition in computer vision applications. The excellence of underwater images is negative in view that of precise propagation residences of light in water. So, underwater image enhancement is crucial to increase visual pleasant. In this research, presented an underwater IE using dark channel prior (DCP) with adaptively clipped contrast limited histogram equalization (ACCLAHE) and homomorphism filtering (HF). Using DCP, estimate blur region and remove them. With the help of ACCLAHE, it takes the maximum bin height in the local histogram of the sub-image and redistributes the clipped pixels equally to each gray-level.

Year	Author	Title	Approach	Result
2016	Sonal Dixit	Underwater Image Enhancement using DCP with ACCLAHE and Homomorphism Filtering	adaptively clipped contrast limited histogram equalization and homomorphism filtering	Enhanced Illumination and Contrast
2017	Jie Li	WaterGAN: Unsupervised Generative Network to Enable Real-time Color Correction of Monocular Underwater Images	Using WaterGAN, we generate a large training dataset of corresponding depth, in-air color images, and realistic underwater images. restoration of underwater Images	Good in extreme turbid water
2012	John Y. Chiang	Underwater Image Enhancement by Wavelength Compensation and Dehazing	Wavelength compensation and image dehazing	Decrease in implementation time
2011	John Y. Chiang	Underwater Image Enhancement: Using Wavelength Compensation and Image Dehazing (WCID)	haze effects from color scatter were removed by the dehazing algorithm	De-hazing and improvement in quality in deep water
2013	Huimin Lu	Underwater scene enhancement using weighted guided median filter	using weighted guided median filter and wavelength properties	Having better marine imaging applications
2007	Kashif Iqbal	Underwater Image Enhancement Using an Integrated color Model	Contrast stretching of RGB algorithm is applied to equalize the colour contrast in images.	Improves visual quality for underwater images

Table 1: Literature Work for Underwater Image Enhancement

Objects at a distance for more than 10 meters are almost indistinguishable, because colours are faded owing to characteristic wavelengths that are filtered according to water depth [8]. Many researchers have developed techniques to restore or enhance underwater images. Y.Y. Schechner et al exploited a polarization filter to compensate in order to visibility degradation [9], while Bazeille et al proposed an image pre-processing pipeline in order to enhancing turbidly underwater images [10]. Fattal designed a graphic theory based independent component analysis model to estimate synthetic transmission and shading to recover clean image [11]. He et al estimated dark prior channel (DCP) through images laws for nature, then used soft matting to refine depth map and got final clearly image [12]. Nicholas et al. improved dark prior channel, and took graph-cut segmentation instead for soft matting to refine depth map [13]. Hou et al combined a point spread function (PSF) and modulation transfer function to reduce effects for blurring [14]. Ouyang proposed bilateral filtering based on an image de-convolution procedure [15]. Ancuti et al used an exposed fusion procedure to reconstruct a clear image in a turbid medium [16]. Chiang et al considered wavelength properties on underwater imaging, and obtained reconstructed image by dark prior channel model [17]. Although aforementioned approaches may enhance image contrast, these methods have demonstrated several drawbacks that reduce their practical applicability. First, equipment in order to imaging is tough to use in practice (e.g., a range-gated laser imaging system, which is rarely applied in practice [14, 15]). Second, multiple input images are required [9] (e.g., various polarization image or various exposed images) in order to fusing a high quality image. Third, image processing approaches may not suitable in order to underwater images [10, 12, 13]. Not only time consuming, however ignore imaging environment. Fourth, manual operation is needed in processing, which leads to lack for intelligence [11].

III. Conclusion

The literature work discuss the problem for Color scatter and Color casting also enhanced image contrast and calibrated Color cast and produces high quality underwater images or videos. With the basis of the available work it can be concluded that stretching algorithm applies on both RGB and HSI color models in order to enhancing underwater images. Main advantage for using two stretching models is because helps to equalize color contrast any type for images and also mention problem for lighting.

References

[1] Sonal Dixit, Sandeep Kumar Tiwari, Pankaj SharmaUnderwater Image Enhancement using DCP with ACCLAHE and Homomorphism Filtering, International conference on Signal Processing, Communication, Power and Embedded System (SCOPES)-2016, 978-1-5090-4620-1/16/2016 IEEE
[2] Jie Li, Katherine A. Skinner, Ryan M. Eustice3, and Matthew Johnson-Roberson, WaterGAN: Unsupervised Generative Network to Enable Real-time Color Correction of Monocular Underwater Images, IEEE ROBOTICS AND AUTOMATION LETTERS. PREPRINT VERSION. ACCEPTED JUNE 2017, 2377-3766 / 2017 IEEE.
[3] John Y. Chiang and Ying-Ching Chen Underwater Image Enhancement by Wavelength Compensation and Dehazing, IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 21, NO. 4, APRIL 2012, Digital Object Identifier 10.1109/TIP.2011.2179666
[4] John Y. Chiang, Ying-Ching Chen, and Yung-Fu Chen, Underwater Image Enhancement: Using Wavelength Compensation and Image Dehazing (WCID), J. Blanc-Talon et al. (Eds.): ACIVS 2011, LNCS 6915, pp. 372–383, 2011. Springer-Verlag Berlin Heidelberg 2011
[5] Huimin Lu, Seiichi Serikawa, UNDERWATER SCENE ENHANCEMENT USING WEIGHTED GUIDED MEDIAN FILTER
[6] Kashif Iqbal, Rosalina Abdul Salam, Azam Osman and Abdullah Zawawi Talib, Underwater Image Enhancement Using an Integrated color Model, IAENG International Journal of Computer Science, 34:2, IJCS_34_2_12, Advance online publication: 17 November 2007
[7] Balvant Singh , Ravi Shankar Mishra , Puran Gour, Analysis of Contrast Enhancement Techniques For Underwater Image, International Journal of Computer Technology and Electronics Engineering (IJCTEE) Volume 1 , Issue 2
[8] R. Schettini and S. Corchs, "Underwater image processing: state for art for restoration and image enhancement methods," EURASIP Journal on Advances in Signal Processing, 746052, 2010.
[9] Y.Y. Schechner, N. Karpel, "Recovery for underwater visibility and structure by polarization analysis", IEEE Journal for Oceanic Engineering, Vol. 30 , No. 3 , pp. 570-587, 2005.
[10] S. Bazeille, I. Quidu, L. Jaulin, J.P. Malkasse, "Automatic underwater image pre-processing", in : Proc. for Caracterisation Du Milieu Marin (CMM '06), pp.1-8, 2006.
[11] R. Fattal, "Single image dehazing", ACM Transaction on Graphics, vol.27, no.3, pp.1-8, 2008.
[12] K. He, J. Sun, and X. Tang, "Single image haze removal using dark channel prior", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol.33, no.12, pp.2341–2353, 2011.
[13] C-B Nicholas, M. Anush, R.M. Eustice "Initial results in underwater single image dehazing", in: Proc. for IEEE OCEANS 2010, pp.1-8, 2010.
[14] W. Hou, D.J. Gray, A.D. Weidemann, G.R. Fournier, J.L. Forand, "Automated underwater image restoration and retrieval for related optical properties," In: Proc. for IEEE International Symposium for Geoscience and Remote Sensing, pp.1889–1892, 2007.
[15] B. Ouyang, F.R. Dalgleish, F.M. Caimi, A.K. Vuorenkoski, T.E. Giddings, and J.J. Shirron, "Image enhancement in order to underwater pulsed laser line scan imaging system," In: Proc. for SPIE 8372, 83720R, 2012.

