

A Survey on Underwater Image Enhancement Techniques

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ABSTRACT: Underwater Image Enhancement is a process of improving the quality of image. Generally most of the processing techniques focus on removing either light scattering or color effect, sources of underwater image distortion are light scattering and color change. The enhancement of underwater image captured is necessary because the quality of underwater images affect and these images leads some problems occurred such as a lot of haze occurs due to low contrast, poor visibility conditions, absorption of natural light and little color variations and blur effect in the underwater images because of all these reasons number of algorithms and number of techniques are there to rectify these underwater images. Haze occurred because of light scattering by particle present in the underwater environment. There exists a lot of image enhancement techniques to improve the quality of underwater images. This paper describes the various existing techniques for underwater image enhancement for underwater images. Haze removal technique is important for these kinds of low visibility and low contrast which are in underwater images. Different dehazing algorithms are also available in the literature for enhancement of underwater images.

KEYWORDS: Underwater Image, Light Scattering, Colour effect, Wavelength compensation and Image Dehazing.

I. INTRODUCTION

Digital Image Processing has different techniques to modifying and improving the image qualities. Underwater water images causes light dispersion and colour effect are two major sources of distortion for underwater image. Light scattering lowers the visibility and contrast of captured image. And colour change leads to the varying degrees of attenuation. The particles are sand, minerals, plankton etc., are present in the water and absorption of natural light, these scattering affects an image which is taken in underwater. As light reflected from objects proceeds towards the camera, a portion of the light meets these suspended particles, which absorbs and scatters the light.

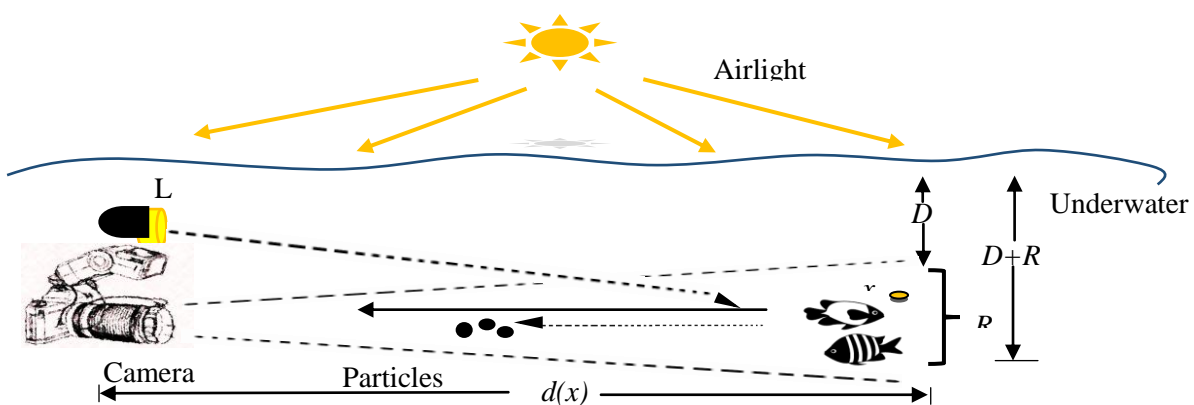


Fig-1: Underwater image

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One more problem in underwater images is related to the density (depth meter) of the water under sea which is considered 800times denser medium than air while taking pictures of underwater. As light travels in water, a rapid exponential loss of light intensity occurs depending on the colour spectrum wavelength. Light attenuation limits the visibility distance at about 20 m in clear water and 5 m or less in turbid water. In clear open waters, visible light is absorbed at the longest wavelengths first. Red, the most affected colour at the depth of 3m and is essentially lost orange colour after a distance of 4 m to 5 m and most of the yellow goes off at the depth of 10m and finally green colour and purple colour lost at further depth of underwater.

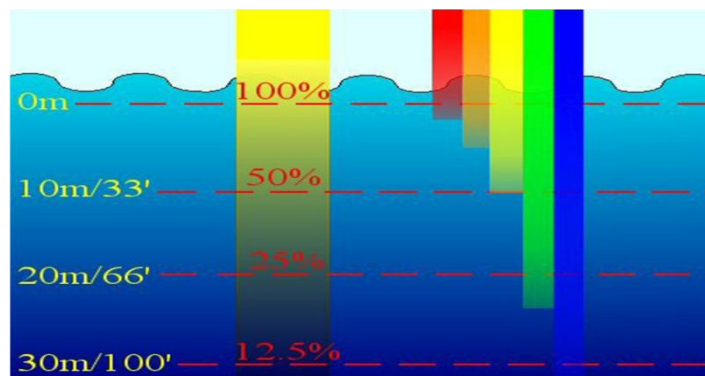


Fig-2: Depends on the depth the colour components in water is automatically reduced

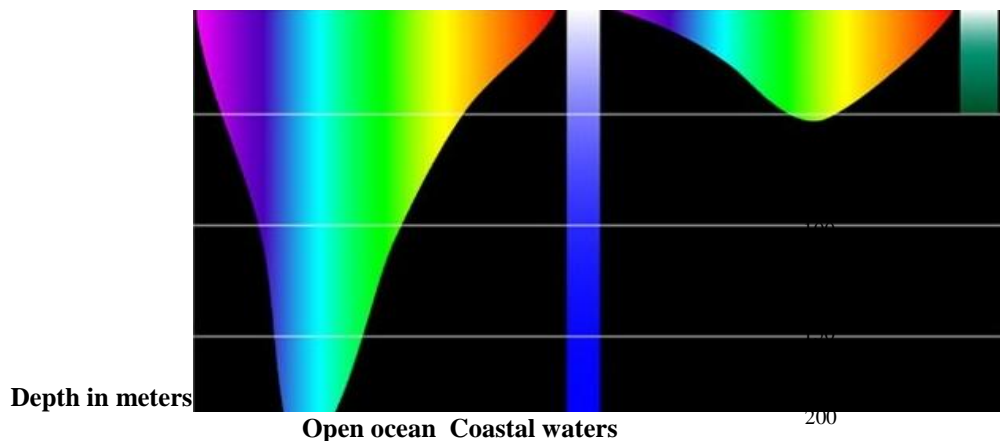


Fig-3:light penetrating in Open Ocean and coastal waters (Depth in meter)

II. RELATED WORK

The colour-change correction techniques estimate underwater environmental parameters by performing colour registration with consideration of light attenuation, employing histogram equalization in both RGB and HIS colour spaces to balance the luminance distributions of colour, and dynamically mixing the illumination of an object in a distance-dependent way by using a controllable multicolour light source to compensate colour loss[9].The colour imaging underwater rely on flooding objects with white light from close distances (e.g. less than 0.5m), possibly followed by post-processing. The post-processing step approximates the colour of the image by manually setting a white point and correcting the image uniformly so that the selected point appears white [9].Accurate colouring in water refers to the equivalence between the colour spectrum that reaches the imaging device in water to the colour spectrum for the same object in air[9].The vignetting is typically assumed to be continuous, circular in shape, centered at the image centre, and is approximately the same in all frames. The parameters for these models can be estimated using

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either single or multiple images[9].The gradient along the radial direction from a single image for their vignetting parameter estimation, whereas the camera response, was assumed to be known [9].

III. ENHANCEMENT TECHNIQUES OF UNDERWATER IMAGES

To enhance the underwater image Wavelength compensation and dehazing algorithm is most appropriate (WCID). Enhanced visibility and superior colour fidelity can be obtained by WCID algorithm. Image dehazing helps to restore clarity of underwater images. [22].

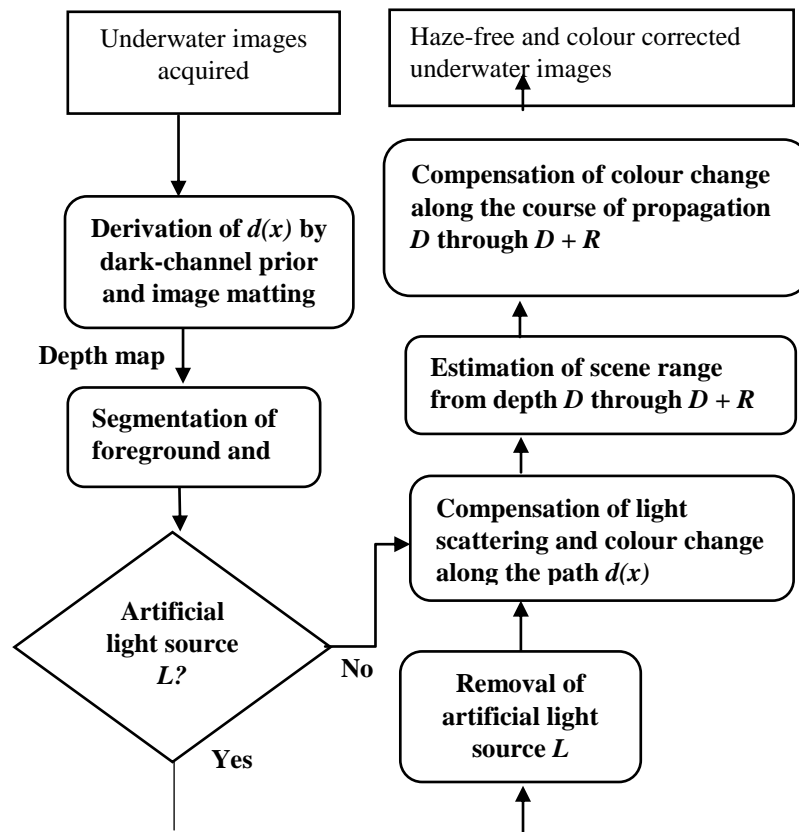


Fig-4:Flowchart of WCID algorithm

A. Depth map

The dark channel, which is an existing scene depth derivation method, is based on the fact that, in most of the non-background light patches on a haze free underwater image, at some pixels as a minimum hue channel has a very little intensity. The minimum intensity in such a patch should have a very low value, called a dark channel. Pixels with a very low value cannot be found in the local patch, which implies the existence of haze. The concentration of haze can be quantified by dark channel prior algorithm. This in turn provides the object camera distance, i.e. the depth map. The underwater hazy image can be modelled by using the Radioactive Transport equation, [9]

$$U\lambda(x) = j\lambda(x).t\lambda(x) + (1-t\lambda(x)). B\lambda \quad \text{eq. (1)}$$

Where $\lambda \in \{\text{Red, Green, Blue}\}$

Here „x“ is a point on the underwater scene, $I\lambda(x)$ is the image captured by the camera, $j\lambda(x)$ is the scene radiance at point x i.e. the actual amount of light source reflected from point x, $t\lambda(x)$ is the lingering energy proportion of $j\lambda(x)$ after reflecting from point x in the underwater scene before reaching the camera. [9].

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$B\lambda$ is the homogeneous background light and λ is the light wavelength. The lingering energy proportion is a function of both the wavelength λ and the object camera distance $d(x)$. The direct attenuation $\lambda(x) \cdot t\lambda(x)$ describes the decay of scene radiance in the water. The dark channel can be calculated by using the equation, [9]

$$\text{Dark channel} = \min (U\lambda(x)) \quad \text{eq. (2)}$$

Where $\lambda \in \{\text{red, green, blue}\}$

$U\lambda(x)$ is the submerged image captured by camera. The background light $B\lambda$ is usually assumed to be the pixel intensity with the highest brightness value in an image. The brightest pixel value among all local minima corresponds to the background light as follows, [9]

$$B\lambda = \max (\min (U\lambda(x))) \quad \text{eq. (3)}$$

The deepness estimation can be calculated by using the formula,

$$\text{Depth map} = 1 - \min \{ \text{median} (J\lambda(x)) / B\lambda \} \quad \text{eq. (4)}$$

The median filter is used to smoothing technique.

B. Image segmentation

Initially the image is considered and segmented at foreground and background using depth map. Then luminance value is estimated at both foreground and background. When the luminance is comparatively high at foreground than that of background it is generally stated to be less scattering. If less scattering is determined it should be removed by updating the foreground and background luminance value. Then wavelength compensation method is adopted. [9]

C. Artificial light Source L

Artificial light sources are often supplemented to avoid insufficient lighting commonly encountered in underwater photographic environment, as shown in Fig.4s. If an artificial light source L is employed during image capturing process, the luminance contributed by L must be deducted first to avoid over-compensation for the stages followed, as illustrated in Fig.5. The existence of artificial lighting can be determined by the difference between the mean luminance of the foreground and the background, L_f and L_b . In an underwater image without artificial lighting, the background directly transmits natural light without reflecting off of objects and is therefore the brighter part of the image. Higher mean luminance in the foreground of an image than in the background indicates the existence of an artificial light source. The difference between L_f and L_b is also the luminance of the artificial light source; that is to say, the luminance of the artificial light source is: [9]

$$L(\lambda) = L_f(\lambda) - L_b(\lambda)$$

Supposing the artificial light radiates spherically, the influence of the light is in inverse proportion with the square of the distance. The closer the object, the more it is affected by the artificial light source, and vice versa. After incorporating the variable of artificial light source, [9]

$$E(I_\lambda(X)) = E(I_\lambda(X)) / \text{Rer}(\lambda)^{\delta(\alpha)^D} - (L(\lambda) * (1 - d(x)^2)), \lambda \in \{R, G, B\}.$$

The result following removal of the effects of the artificial light source L is shown in Fig-7



Fig-5: Illuminated by an artificial light source, the intensity of the foreground appears brighter than that of the background

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Fig-6: when the luminance contributed by an artificial light source is not deducted first, an over-exposed image will be obtained after the compensation stages followed



Fig-7: The underwater image obtained after removing the artificial lighting present in Fig-6

D. Wavelength compensation and Image Dehazing

In analysis of underwater image processing that utilizes the Wavelength Compensation and Image Dehazing technique to eliminate some colour & lightening problems in images. There are four steps needed in WCID algorithm they are, [9]

Step 1: Estimation of distance between object and camera D (oc).

Step 2: Artificial light source (AL) elimination.

Step 3: Estimation of depth of underwater and image (U & I)

The above flow chart of WCID fig.4. shows how to enhance underwater image by using techniques.

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YEAR	AUTHOR	TITLE	APPROACH	RESULT
2010	Dr.G.Padmavathi, Dr.P.Subashini, Mr.M.Muthu Kumar and Suresh Kumar Thakur	Comparison of Filters used for Underwater Image Pre- Processing	Filtering method	Enhance and smoothen the image
2011	Hung-Yu Yang; Pei- Yin Chen Chien- Chuan Huang; Ya- Zhu Zhuang; Yeu-Horng Shiau	Low Complexity Underwater Image Enhancement Based on Dark Channel Prior	Dark Channel Prior	Decrease in implementation time
2012	Chiang, J.Y.; Ying- Ching Chen	Underwater Image Enhancement by Wavelength Compensation and Dehazing	Wavelength Compensation and Dehazing	Dehazing and improvement in quality In deep water.
2013	Pulung Nurtantio, Andono, Ketut Eddy Purnama, Mochamad Hariadi	Underwater Image Enhancement Using Adaptive Filtering For Enhanced Sift- Based Image Matching	Adaptive Filtering For Enhanced Sift- Based Image Matching	success of SIFT increased by 41% compared to the reference method
2014	Pooja Sahu, Neelish Gupta ,Neetu Sharma	A Survey on Underwater Image Enhancement Techniques	RGB Color Level Stretching	Enhance the color contrast of the object in underwater and remove different noise particles

Table-1: Shows different techniques approached from 2010 to 2014. [6]

IV. CONCLUSION

This survey is that the underwater image suffers from low contrast and resolution due to modest visibility surroundings etc. (WCID)Wavelength compensation algorithm is used to avoid the attenuation and influence of light scattering effects... For removing the influence of light scattering effect, initially the deepness of the image map is derived. Based on the depth map derivation the image is segmented to foreground and background images. Enhancement methods are available in this paper which are Depth map, Segmentation, Wavelength Compensation. there is no other existing techniques can handle light scattering and colour change distortions suffered by underwater images simultaneously as per the above techniques which are discussed. No other existing techniques can handle light scattering and colour change distortions suffered by underwater images simultaneously. This survey paper describes that wavelength compensation and image de-hazing algorithm based technique is most effective algorithm as it handles all possible problems which are occurred on underwater image.

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