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Enhancement of Underwater Images Using Wavelength Compensation Method

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ABSTRACT: Most important source of distortion in underwater environs are Haze and Hue alteration. Haze is produced because of the effect of light scattering by particle present in the underwater environment. Hue alterations occur when light enter deeper in underwater. These two issues make the picture look darker and low luminosity.Haze removal and Hue altered enhancement is important for this kind of low visibility and low contrast underwater images. The existing Dark Channel Prior method effectively removes Haze but color change is not processed. In this paper underwater image enhancement is carried out in two steps. In the first step Haze in the underwater image is removed using dark channel prior. In the second step Hue alterations handled by wavelength compensation. Once depth map is derived, luminance of foreground and background inside the image can be separated and compared. To regulate the Hue alteration wavelength can be compensated using average RGB channels in the image. After computing the scale value of each RGB component, wavelength is compensated together with the average RGB and scale value of each channel in the image. Performance of the proposed method of wavelength compensated image is evaluated using the PSNR, Focus Measurement, Contrast Improvement Index, and Feature Similarity Index. Performance measurement of the wavelength compensation produces better enhancement results than existing method.

KEYWORDS:hue alteration, hazy image, depth map, color balance, light scattering, light absorption, RGB channel, wavelength compensation.

I. INTRODUCTION

Digital Image Processing involves the modification of digital data for improving the image qualities. Maximizing clarity, sharpness and details of features of interest towards information extraction and further analysis are achieved using digital image processing. It accentuates or sharpens image features such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis. The raw digital data when viewed on the display will make it difficult to distinguish fine features.The enhancement doesn't increase the inherent information content of the data, but it increases the dynamic range of the chosen features so that they can be detected easily. Fig1 shows basic block diagram of image enhancement technique.

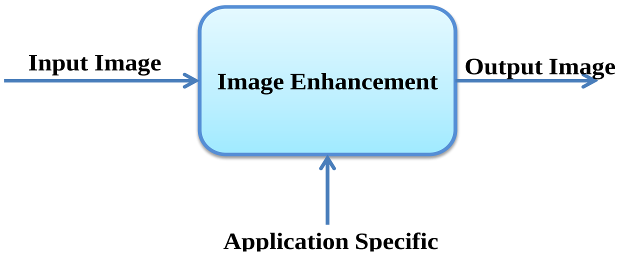

Fig 1 Basic Block Diagram of Image Enhancement

The underwater images raise new challenges and enforce trivial problems due to light absorption and scattering effects of the light and inherent structure less environment. The quality of underwater images plays a pivotal role in scientific missions such as monitoring oceanic populations, and assessing geological or biological atmosphere.

Capturing of underwater images is challenging, mainly due to light scattering effect caused by the particles, Light incident on object reflected multiple directions by the particle present in the water. Particles like sand, minerals, plankton etc. This scattering effect makes an image unclear, as illustrated in Fig.2. Alternative identified problem is relating to density of water than air light. In underwater environment light rays travels to the water and it gets reflected and deflected multiple times. Aggregate of light is degraded when light propagates deeper in water. And hence color wavelengths are plunged one by one. Color wavelengths dropped off when light rays goes deeper in water on their wavelength. Red color has disappeared at the depth of 3m. At the further depth orange and yellow colors goes off. Finally green and purple disappeared. This light absorption due to varying degrees of attenuation encountered by different wavelengths of light, this will always make an underwater image as blue dominated. For example appearance of color model in underwater illustrated in Fig.3.

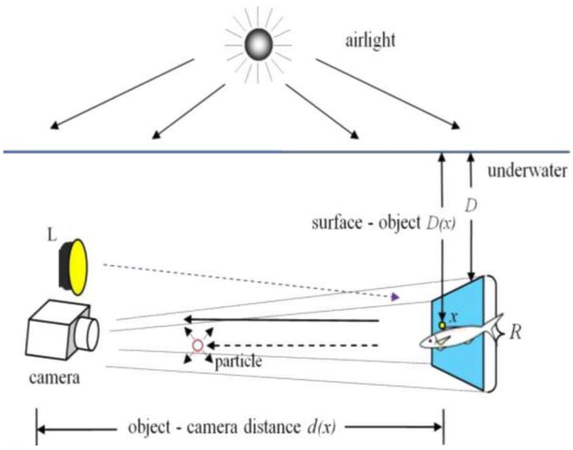

Fig.2. Natural light enters from air to an underwater scene point

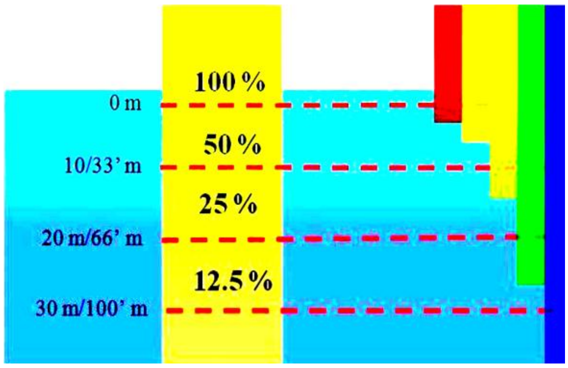

Fig.3. Appearance of Color Model in Underwater

II. RELATED WORK

- The color-change correction techniques estimate underwater environmental parameters by performing color registration with consideration of light attenuation, employing histogram equalization in both RGB and HSI color spaces to balance the luminance distributions of color, and dynamically mixing the illumination of an object in a distance-dependent way by using a controllable multicolor light source to compensate color loss.

- The color 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 color of the image by manually setting a white point and correcting the image uniformly so that the selected point appears white.

- Accurate coloring in water refers to the equivalence between the color spectrum that reaches the imaging device in water to the color spectrum for the same object in air.

- 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 either single or multiple images.

- The gradient along the radial direction from a single image for their vignetting parameter estimation, whereas the camera response, was assumed to be known.

III. PROPOSED METHOD

In wavelength compensation the distance between objects to camera is estimated by using Dehazing algorithm. Based on the depth map the foreground and background area within the image is segmented. The foreground and background light intensities of the image are then compared, to determine an artificial light scattering effect is employed during the image acquiring process; the added luminance is to be eliminated by detecting the artificial light source. The Wavelength Compensation algorithm is utilized to remove the haze effect and color change along the underwater propagation path.

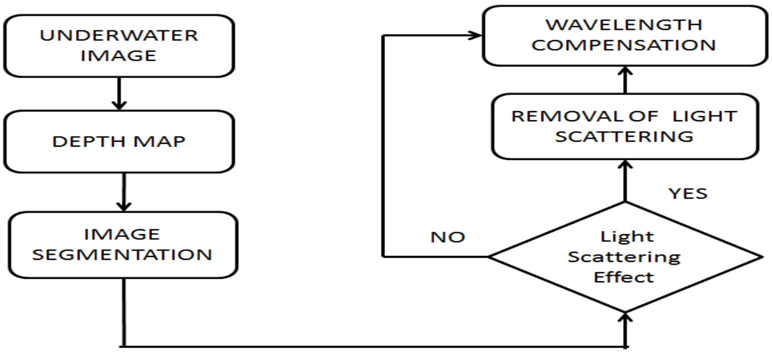

Fig.4. Flow Chart of Proposed Method

A. *Depthmap*

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 modeled by using the Radiative Transport equation,

$$U_\lambda(x) = j_\lambda(x).t_\lambda(x) + (1-t_\lambda(x)). B_\lambda \text{eq.(1)}$$

Where $\lambda \in$ {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 ie 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. $B_\lambda$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 $j_\lambda(x).t_\lambda(x)$ describes the decay of scene radiance in the water. The dark channel can be calculated by using the equation,

$$\text{Darkchannel} = \min(U_\lambda(x)) \qquad \text{eq. (2)}$$

Where $\lambda \in$ {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,

$$B_\lambda = \max(\min(U_\lambda(x))) \qquad \text{eq. (3)}$$

The deepness estimation can be calculated by using the formula

$$\text{Depth map} = 1-\min\{\text{median}(J_\lambda(x))/B_\lambda\} \qquad \text{eq. (4)}$$

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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
.

C.Wavelength compensation

Aim of this proposed algorithm is to Haze removal and compensate the Hue altered image wavelength. Wavelength compensation consists of following steps.

Step 1: Compute average value of R, G, and B components.
Step 2: Gray value is the average of R, G, and B average.
Step 3: Calculate scale value for each component using eq. (5)

R_Scale value= Gray value/ R_Avg
G_Scale value= Gray value/ G_Avg
B_Scale value= Gray value/ B_Avg eq. (5)

Step 4: Estimate wavelength compensated R, G, and B component using eq (6).

WC_R= R_Scale value* im(R)
WC_G= G_Scale value* im(G)
WC_B= B_Scale value* im(B) eq. (6)

IV. Simulation Results And Discussions

The experimental results demonstrate superior haze removing and color balancing capabilities of the proposed algorithm over traditional dehazing and histogram equalization methods. Underwater input image downloaded from youtube website. From the input image minimum intensity pixels are estimated and shown in Fig.8. (a)Input Image, (b) Dark Channel.

(a) Input Image

(b) Dark Channel

After estimating the low intensity value of underwater image Depth of the image is calculated the depthmap after refinement reduces the mosaic effect and captures the contours of objects more accurately. Based on the depth

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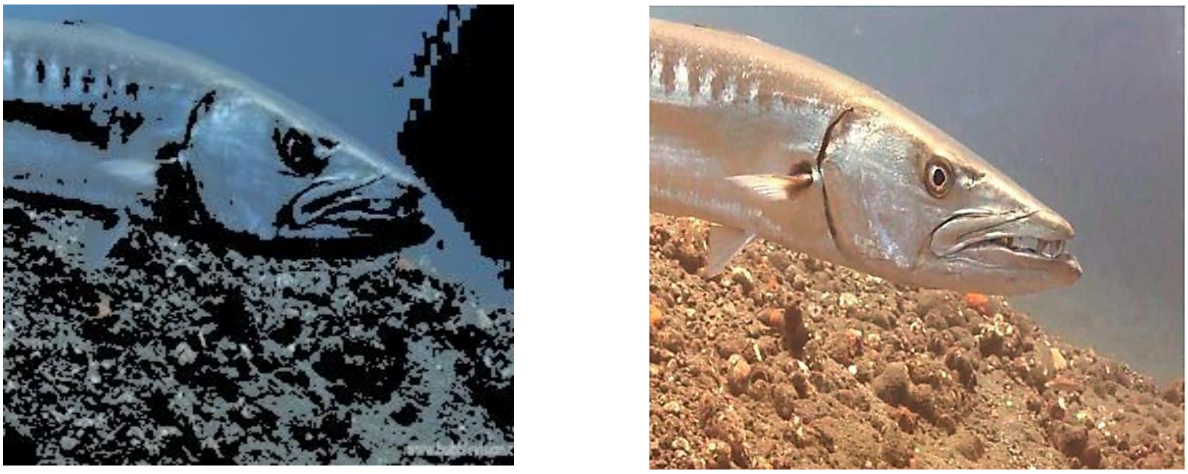
map image is segmented as Foreground and Backgroundfor luminance value of the image shown in Fig.8. (c)Depth Map Image, (d) Foreground Images, (e) Background Images.

(c) Depth Map Image (d) Foreground Images

Using foreground and background segmentation, light scattering effect is removed and Average Scale value of RGB of the image is computed for compensating the wavelength. Fig.8. (f) Wavelength Compensated Image shows the after compensated RGB wavelength.



(e) Background Images (f) Wavelength Compensated Image

Fig.5. Underwater image after processing with wavelength compensation

The performance measure for enhancement of the image can be determined by means of measuring its contrast improvement index, feature similarity index measurement, PSNR and Focus Measurement asshown in Table.1.

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A. *PSNR*

The *Mean Square Error (MSE)* and the *Peak Signal to Noise Ratio (PSNR)* are the two error metrics used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error.

To compute the PSNR, the block first calculates the mean-squared error using the following equation:

$$MSE=\frac{\sum_{M,N}[I_1(m,n)-I_2(m.n)]^2}{M*N} \qquad \text{eq. (7)}$$

In the previous equation, *M* and *N* are the number of rows and columns in the input images, respectively. Then the block computes the PSNR using the following equation:

$$PSNR=20\log_{10}\left(\frac{MAX}{\sqrt{MSE}}\right) \qquad \text{eq. (8)}$$

B. *Tenengrad (Focus Measurement)*

In order to evaluate the effectiveness of the resultant image a well-known benchmark-image focus measure. The tenengrad criterion is based on gradient,at each pixel*(x, y),* were the partial derivatives are obtained by a high-pass filter, eg., The gradient magnitude is given by: sobel operator, with the convolution kernels

$$S(x, y) = \sqrt{i_x * i(x,y)^2 + i_y * i(x,y)^2} \text{eq. (9)}$$

And the tenengrad criterion is formulated as

$$TEN=\sum_x \sum_y s(x,y)^2 > T \text{eq. (10)}$$

Where T is the threshold. The quality of the image is usually considered better if its tenengrad value is higher.

C. *contrast Improvement Index (CII)*

A quantitative measure of contrast improvement is calculated using contrast improvement index (CII). Contrast improvement index can be found by using following equation.

$$CII = C_{enhanced} / C_{original} \text{eq. (11)}$$

Where $C_{enhanced}$ and$C_{original}$ denotes the contrast values for the region of interest in the enhanced and the original images respectively. The contrast C in the image is defined in eq. (12)

$$C=max-min/max+min \text{eq. (12)}$$

D. *Feature Similarity Index Measurement (FSIM)*

Similarity between input image and enhanced image is calculated by using feature similarity index measurement. FSIM can found by using eq. (13).

$$FSIM = \frac{\sum_\Omega S_{PC}(x).\ S_G(x).\ [S_I(x).S_Q(x)]^\lambda\ PC_m(x)}{\sum_\Omega PC_m(x)} \text{eq. (13)}$$

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TABLE 1 PERFORMACE ANALYSIS OF WAVELENGTH COMPENSATION METHOD

Enhancement Method	PSNR	FM	CII	FSIM
Histogram Equalization	16.256dB	1.3417e+004	1.6724	0.8076
Dark Channel Prior	25.4306dB	3.5868e+008	1.7387	0.82112
Wavelength Compensation	43.086dB	5.5482e+008	1.9820	0.9979

V. CONCLUSION

The underwater image suffers from low contrast and resolution due to modest visibility surroundings, consequently object identification become typical mission. The underwater image enhancement of hazy and hue altered images using Wavelength compensation algorithm is to compensate various degree of attenuation along the propagation path, and influence of light scattering effect considered. In this project the impact of the light scattering effect isremoved from the underwater image. 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. Then the presence of light scattering effect is detected by comparing the mean luminance of foreground and background images. If the luminance of foreground is greater than the background, then there exists an artificial light source. If the presence of light scattering effect is detected then the influence of it is eliminated from the hazed underwater image. Then wavelength of underwater image is compensated in two steps. 1) Calculating average of each RGB component in the image. 2) Scale value is calculated from the computed average RGB channel. The haze effect and hue alteration can be effectively removed by using Wavelength Compensation algorithm.From the performance analysis and evaluation chart clear that the wavelength compensation method is better than the Dark Channel prior and Histogram Equalization. The evaluation of the wavelength compensation algorithm is evaluated for underwater images and videos downloaded from youtube. Results demonstrate hue alteration removing of the wavelength compensation algorithm over dark channel prior.

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BIOGRAPHY

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