VISUAL QUALITY ACCOMPLISHMENT OF UNDERWATER IMAGES

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ABSTRACT

Image enhancement is a process of improving the clarity of image by improving its characteristic. Object identification inside the water is a typical task as it suffers from low contrast, colour diminishing and low resolution due to poor visibility conditions. In order to improve the clarity of image a method has been proposed which restore then enhance the degraded image. Here we are estimating the dark prior channel then applying a soft matting which restore the degraded image followed by an HSV filter in order to enhance it. This approach reduces the scattering and colour diminishing effect, on comparing the PSNR and MSE parameters with others approach, it gives a much better result.

Keywords*: Image Dehazing, The Dark Channel Prior, Underwater Dehazing, Soft Matting, HSV Filter.***

I INTRODUCTION

Image enhancement is the upgrading of digital image quality (wanted e.g. for visual inspection or for machine examination), without knowledge about the source of degradation. If the source of degradation is recognized, one calls the process image restoration. Among efforts to recover blurred underwater objects, many researchers resort to a physical-based solution as well as traditional image restoration theory. Both are iconical process, viz input and output is image. Underwater imaging is widely used in ocean discovery and other fields as it is crucial for scientific research and technology. Computer vision method are being used in a different areas e.g mine detection, inspection of underwater power and telecommunication cables, pipelines, nuclear reactor and columns of offshore platforms[1] and also for research in marine biology[2], mapping[3], archaeology[4] hence the quality of underwater images plays a pivotal role in scientific mission. Underwater images are basically characterized by their poor visibility because light is exponentially attenuated as it travels in the water. Haze is usually caused by the turbid environment(caused by organic particles like viruses, colloids, bacteria, phytoplankton's and inorganic like ground quartz sand, clay minerals or metal oxides).hence The irradiance received by the camera from the scene point is attenuated along the line of sight. Two types of scattering occurs first, forward scattering which usually leads to blur of the image quality. On the other hand, backscattering [18] generally restrict the contrast of the images, generating a characteristic veil that superimposes itself on the image and hides the scene. As water is 800times more denser than air (rarer medium). The main reason behind the colour degradation is the variation in the wavelength of colour as we go deeper into the water, colour drop off one by one depending on the wavelength of the colour. Due to the reason of having shortest wavelength of blue colour it can travels a long distance results more dominant than other colour in water.

II LITERATURE REVIEW

The research on underwater image processing, many researchers have developed preprocessing techniques for underwater images using image enhancement methods. Bazeille et al. [10] and prabhakar C. J.[11] propose an algorithm to pre-process underwater images. Recently single image haze removal [25] has made a significant approach for dehazing using dark channel prior in order to recover the degraded image. John et al.[12] proposed a novel efficient approach by dehazing algorithm, which compensate the attenuation discrepancy along the propagation path, and to take the influence of the possible presence of an artificial light source into consideration. The main advantage of this paper is it can handle light scattering and color change distortions suffered by underwater images simultaneously but is unproductive in removing the image blurriness caused by light scattering. Fang et al. [13] Introduces a single image enhancement approach based on image fusion strategy.

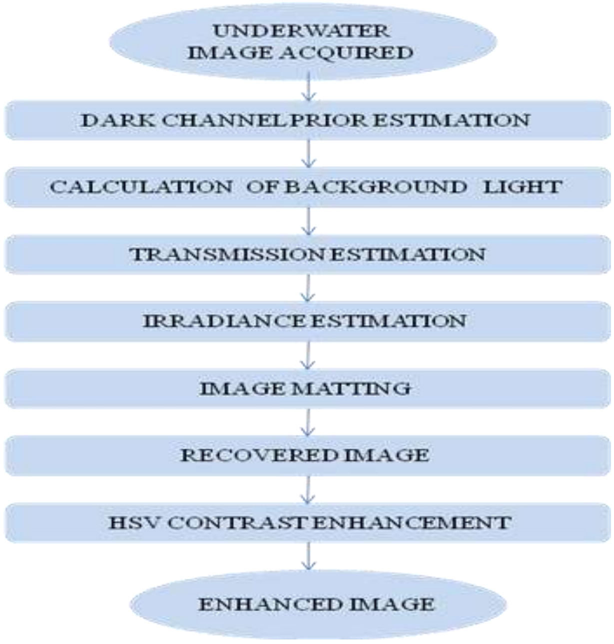

Fig.1 Block Diagram of the proposed method

They have shown that by choosing appropriate weight maps and inputs. Zhyang et al. [14] proposed a new restoration method called removing water-compensating attenuation–optimization. Guoliang et al.[15] proposed a dual-band underwater image denoising and enhancement algorithm in this the original image was decomposed into high-frequency part H and low frequency part L, and then H was filtered into F by mean shift algorithm which was improved by using the intermediate iteration results. Based on the haze imaging model a contrast enhancement method was proposed and was applied on L and F. Iqbal et. al.[16] introduces a slide stretching algorithm both on RGB and HSI colour models to enhance underwater images. The main advantage of applying two stretching models is that it helps to equalize the colour contrast in the images. It also addresses the problem of lighting and the quality of the images which is stastically illustrated through the histograms. The main degradation in the image quality is due to forward scattering and backward scattering. Halleh[18] proposed a method to compensates the effect of optical back-scatter with no Information of the physical properties of the medium. Chao et. al.[19] proposed a dark channel prior method to restore the original clarity of the images underwater. Yoav[21] discussed about the image degradation due to backscatter. analysis in this paper used the single scattering approximation. Mohit et al.[24]presented a technique of polarized light striping based on combining polarization imaging and structured light striping.

Our approach is focusing on recovery of degraded image followed by enhancement. Proposed methodology is related to dark channel prior phenomenon. Where we combine the haze imaging model with a soft matting interpolation method, in order to get a hi-quality haze-free underwater images followed by HSV filter.

III. IMAGING MODEL

Underwater hazy image [5,6,7] can be described by the following equation:

$$I(x) = J(x)t(x) + B(1- t(x)) \qquad (1)$$

Where **I** is the obtained hazy image, **J** is the surface radiance, **B** is the backscattering. As **B** is assumed to be constant globally, it is independent from location x. t is the medium transmission which is not scattered and reaches the camera. The goal of proposed method is to recover J, B and t from I.

On the right hand side of equation(1) the first term J(x)t(x) is called *direct attenuation* and the second term B(1-t(x)) is called scattered light.

t is the medium Transmission, which is expressed as:

$$t(x) = e^{-\beta d(x)} \qquad (2)$$

Where β is the scattering coefficient of the medium. This equation (2) describes that the scene

Radiance is attenuated exponentially with the depth. If we can recover the transmission, we can also recuperate the depth up to an unknown scale.

3.1 Dark Prior Channel

The dark channel of an underwater image approximates the hydrosol darkness well; we can use the dark channel to recover the particle spherical light estimation.

The dark channel prior is based on the following observation on turbid free or haze-free images: In most of the patches, at least one among the three color channel (R,G,B) has some pixels whose intensity are very low and close to zero.

The low intensities in the dark channel are mainly due to two factors:

- Shadows, for example, shadow of underwater dark creatures, planktons, plant life or rocks in sea bed images.
- Colourful substance or surface, for example, colourful plant life and sands, and colourful rocks/minerals lacking color in any color waterway will result in low values in the dark channel.

Equivalently, the lowest intensity in such a patch is close to zero.

$$J^{dark}(x) = \min_{c\in\{r,g,b\}} \left(\min_{y\in\Omega(x)} \left(J^{c}(y)\right)\right), \qquad (3)$$

Where J^c is the colour channel of J and Ω(x) is called local patch centered at x.

To verify how good the dark channel prior is, we have captured some real underwater images and collected few images from bubble.com .The images are resized so that the maximum of width and height is 300x300 pixels and their dark channels are computed by taking a patch size 15x15.

Figure 2. Haze removal using a single image. (a)input underwater hazy image (b) image after haze removal using our method (c) our recovered depth map

Using the concept of a dark channel, our observation says that if J is the haze-free image, the intensity of J's dark channel is low and tends to be zero:

$$J^{dark} \rightarrow 0 \quad (4)$$

3.2 Estimating the Transmission

Here, assume that the transmission in a local patch Ω(x) is constant. We denote the patch's transmission as $\tilde{t}(x)$. By taking the min operation in the local patch on the underwater haze image we have:

$$\min_{y\in\Omega(x)}\left(I^c(y)\right)\tilde{t}(x) = \min_{y\in\Omega(x)}\left(J^c(y)\right) + \left(\left(1 - \tilde{t}(x)\right)B^c\right) \quad (5)$$

Observe that the min operation is performed on the three colour channels independently. Hence the equation will be equivalent to:

$$\min_{y\in\Omega(x)}\left(\frac{I^c(y)}{B^c}\right) = \tilde{t}(x)\min_{y\in\Omega(x)}\left(\frac{J^c(y)}{B^c}\right) + (1 - \tilde{t}(x) \quad (6)$$

By applying the min operator among three color channels on the above equation we get:

$$\min_c\left(\min_{y\in\Omega(x)}\left(\frac{I^c(y)}{B^c}\right)\right) = \tilde{t}(x)\min_c\left(\min_{y\in\Omega(x)}\left(\frac{J^c(y)}{B^c}\right)\right) + (1 - \tilde{t}(x)) \quad (7)$$

According to the dark channel prior, J^{dark} of turbid free image radiance J should be tends to zero ie;

$$J^{dark}(x) = \min_c\left(\min_{y\in\Omega(x)}\left(J^c(y)\right)\right) = 0 \quad (8)$$

As B^c is always positive, which tends to:

$$\min_c\left(\min_{y\in\Omega(x)}\left(\frac{J^c(y)}{B^c}\right)\right) = 0 \quad (9)$$

Substituting the equation (9) into equation (7), the transmission $\tilde{t}$ can be estimated:

$$\tilde{t}(x) = 1 - min_c\left(\min_{y \in \Omega(x)} \left(\frac{I^c(y)}{B^c}\right)\right) \qquad (10)$$

If we take out the haze methodically, the image may appear unnatural and we may possibly lose the feeling of depth. So, we can optionally keep a very little amount of haze for the far objects by introducing a constant parameter ($0 < \omega \leq 1$) into equation (10):

$$\tilde{t}(x) = 1 - \omega\, min_c\left(\min_{y \in \Omega(x)} \left(\frac{I^c(y)}{B^c}\right)\right) \qquad (11)$$

The value of ω is totally based on application, here we are assuming it 0.95. fig (2(a)) is the estimated transmission map for raw input image with patch size of 15x15. Nextly we need to refine the image by using soft matting method.

3.3 Soft Matting

We notice that the haze imaging equation (1) has a similar form as the image matting [9] equation:

$$I = \tilde{F}\alpha + \beta(1 - \alpha) \qquad (12)$$

Where $\tilde{F}$ and $\tilde{B}$ are foreground and background colors, respectively, and α is the foreground opacity. A transmission map in the haze imaging equation is exactly an alpha map. Therefore, we can apply a closed-form framework of matting [8] in order to refine the transmission. By denoting the refined transmission map by t(x).we can Rewrite t(x) and $\tilde{t}(x)$ in their vector forms as t and $\tilde{t}$, we minimize the following cost function:

$$E(t) = t^T L t + \lambda(t - \tilde{t})^T(t - \tilde{t}) \qquad (13)$$

Here, the first term is a denoting the smoothness term and the second term is denoting a data term with a weight λ. The optimal t can be obtained by solving the following sparse linear system:

$$(L+\lambda U)t = \lambda\, \tilde{t} \qquad (14)$$

Where, U is an identity matrix of the same size as L. We set a small value on λ (10^{-4} in our experiments) so that t is softly constrained by $\tilde{t}$.

3.4 Restoring Radiance J(X)

By using the transmission map, we can get back the scene radiance according to Equation (1). But the direct attenuation term J(x) t(x) can be very close to zero when the transmission t(x)$\longrightarrow 0$. The directly restored scene radiance J is prone to noise. Therefore, we confine the transmission t(x) to a lower bound to, which means that a small certain amount of haze are conserved in very dense haze regions. The final scene radiance J(x) is recovered back by:

$$J(x) = \frac{I(x) - B}{\max(t(x), t_0)} + B \qquad (15)$$

The typical value of t_0 is 0.1.Since the scene radiance is generally not as bright as the atmospheric light, the image after haze removal looks faint. So, we increase the exposure of J(x) for display.

Figure .3 estimating the background light. (a) Input underwater image (b) dark region (c) and (d): two patches that contain pixels brighter than the background.

This method, the clarity of the images is improved greatly and by using the HSV filter the colour can be enhanced. In the next [F] subsection we will discuss about HSV filter.

3.5 Estimating the Background Light

First we pick the brightest pixels in the dark channel according to the size of the image. These pixels are most opaque (dense) but lighted by the background light. Among these pixels, the input pixels which is having the highest intensity is selected as the background light,

$$B(RGB) = I(X) \qquad (16)$$

Where

$$x = \max (J_{dark} (i , j)) \qquad (17)$$

These pixels may not be the brightest pixel in the entire image. This simple method based on the dark channel prior is superior than the "brightest pixel" method.

3.6 Colour Enhancement Using HSV Filter

Finally the enhancement is done by HSV filter which convert an RGB colour map m to an HSV colour map. Both colour maps are in between 0 to 1. The column of the input matrix M represents intensities of red, green blue respectively. HSV is returned as an M-by-N-3 image array whose three planes contains the hue, saturations and value components for the image.

IV EXPEIMENTAL RESULT

4. 1.(a) (b) (c) (d) (e)

4.2.(a) (b) (c) (d) (e)

4.3. (a) (b) (c) (d) (e)

Fig4.1(a),2(a),3(a) are the real underwater images captured by the camera, (b) showing the dark channel,(c) transmission map(underestimated), (d) result obtained by the preprocessing enhancement techniques, (e) result obtained by our technique.

IMAGE	MSE(after image matting)	PSNR(after image mating)	MSE(after HSV)	PSNR(after applying HSV)
1.	**0.034**	**65.213**	**0.0242**	**67.78**
2.	**0.014**	**63.108**	**0.0040**	**66.067**
3.	**0.0102**	**57.592**	**0.0100**	**59.9268**

Table.1 MSE and PSNR values of fig.4

V CONCLUSION

On seeing the experimental results, it has been proved that it gives a better result than previous enhancement technique. The scattering problem and colour diminishing problem has been solved. The only drawback of this method is, it is time consuming. The dehazing technique by using the dark channel prior is more powerful for outdoor images, but it also gives the comparative better results than the any other techniques used for underwater images. Lastly after introducing the HSV filter we obtained the enhanced image.

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