Underwater Image Enhancement and Restore Using MATLAB

1.Nagamma.(Research Scholar) 2.Prof.S.V.Halse(Research Guide)
ntelamani@yahoo.in and drsvhalse@rediffmail.co.in
Department of Electronics, Akkamahadevi Karnataka State Women's University, Vijayapur.

Abstract: The reconstruction of the image which are capture underwater is hard and quality of reconstructed image is considerably less for the traditional methods of reconstruction. The problems for reconstruction of images in underwater are capturing image in the moving water is hard and introduces noise. The atmospheric light or colour doesn't penetrate to deeper water hence capturing the image becomes tough. To address the above problem veiling light estimation method is adopted. This paper introduces a single image dehazing approach for underwater images with novel veiling light and transmission estimation steps which deal with issues arising from bright objects. We use features to hierarchically rank regions of an image and to select the most likely veiling light candidate. A region-based approach is used to find optimal transmission values for areas that suffer from oversaturation. We also locate background regions through superpixel segmentation and clustering, and adapt the transmission values in these regions so to avoid artefacts. The proposed method is implemented in MATLAB2015a. We validate the performance of our approach in comparison to the state of the art in underwater dehazing through subjective evaluation and with commonly used quantitative measures.

Key terms: Image Restore, Veiling Light estimation, environmental light, hazy lines.

I Introduction

The research on underwater imaging is important for ocean resources exploration, marine ecological research, and marine military applications. However, underwater environment is severe, since the light is highly absorbed and scattered by medium. The light is scattered by large suspend particles reflecting into different directions, which leads to the captured image fuzzy. Moreover, the light is absorbed by water reducing the energy of light rays, which results in image under-exposure [1] and color cast. The reason of color cast is that the different wavelength of light has different absorbing rate [2]. When reaching to a certain depth, the longer wavelengths of light will disappear first. In short, underwater imaging processing will meet three main difficulties, including color cast, fuzz, and under-exposure. To make the captured images more suitable for observation, it needs to be processed to restore the relatively genuine color and natural appearance.

Many approaches are proposed to enhance underwater image.

At early stage, underwater image enhancement method comes from generic image enhancement methods, such as Histogram Equalization method, Generalized Unsharp Masking method and Probability-Based method. Gradually, some dehazing methods are adopted in underwater enhancement filed, since the underwater imaging has the similar foggy condition as terrestrial imaging. Fattal's SID method [3] used the fact that the surface shading and transmission functions are statistically uncorrelated in local to remove the fog. They DCP [4] method proposed the dark channel prior that hazefree images have at least one color channel with a very low intensity, one can estimate the transmission map with the dark channel prior. However, the dehazing methods can't provide satisfactory color correction for the reduction in the red channel caused by the absorption, since only considering the effect of scattering. Method in [5] makes a fusion with different filters to reconstruct a clear underwater image. Fu's method [6] exploits the Retinex model to decompose the observed image into the reflectance component and illumination component. Then it makes post-processing on reflectance and illumination components, respectively. Fu's method can get a good result, but the complexity is too high.

The contribution of the proposed work is as follows,

The proposed framework uses the color correction method and reduces the environmental light which are the two good solution to solve the color cased and under/over exposed images.

We had applied the segmentation and veiling light estimation method to determine the haze in the image.

Methods for acquiring the images from camera

1 Acquisition of image by contact

It is performed by touching the object surface on each relevant side with an instrument. These instruments are quite slow and cannot be used on some typology of objects. Moreover, they do not provide information on object appearance. The illustration of acquiring the underwater image with the contact of camera with object is as shown in the below figure,

Figure 1: Image acquisition by contact.

2 Acquisition without contact

Acquisition without contact is performed by indirect techniques based on a certain energy source. The returned signal is measured by the use of digital cameras or special sensors. The optical and laser technologies are the most used. The illustration of acquiring the underwater image with the contact of camera without object is as shown in the below figure,

Figure 2: Method to capture the image without the contact of object.

The section II provides the information about the people already carried work on the image restore and removing the hazy environment. Section III briefs the methodology employed for proposed work. Section IV describes about the results and comparison between the traditional methods and proposed method by considering different dataset. The last section is about the conclusion and future scope.

II Literature Review

In this subsection we are going to discuss about the works which are already carried out by the scientists or research scholars in the field of the underwater-image reconstruction.

In this paper [2], the nonlinear approximation of the reconstruction of images is explained by using the Huygens Fresnel diffraction patterns, here again the SAR images is used as a target images which can be used to make up a knowledge of a hologram for all the frequencies and angles to inspect target.

In this paper [3], describes about a method of recording by combining back-illumination of the in-line objects with an off-axis reference beam which produces the low-aberration holograms. The experiments conducted in their paper concluded by saying that the use of off-axis scheme with the normal incidence of the object beam on the holoplates which can provide the reduction of the aberrations without any additional compensation at the reconstruction stage.

In this paper [4], Reconstruction of an underwater object from a sequence of the images distorted by moving the water waves is a challenging task. Here they use the bispectrum technique to analyse the raw images in a sequences and recover the phase information of the true object. The limitations of the paper consists of, it doesn't support on large computer memory and high computation (if dimension of image >3).

In this paper [5], presents the three dimensional vision techniques in the field of the computer vision aims mainly for the reconstructing a scene which finds its three dimensional geometrical information. the scene of the geometry and the pose of the camera are unknown with the problem to be addresses is very close to the problem of the computer vision and in the computer vision namely SFM (structure from Motion). The reconstruction method developed in this paper is very well extended for further to the segment of the top of the surfaces of the cuboid shaped objects which are considered as the interest at which the objects can be reconstructed using some of the reconstruction process.

Flow chart of the proposed system is shown below,

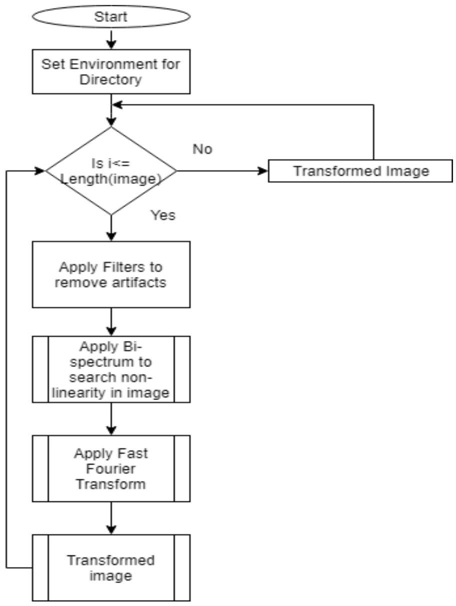


Figure 3: Flowchart of proposed system

III Proposed Methodology

The flow chart of the proposed method is shown in Fig.3. The method contains two steps: color correction to solve the color cast and illumination adjustment to improve the lightness.

The steps of the proposed work are as follows,

Set the environment: The directory has been reserved for storing the results.

Obtain the peak sensitivity of the camera: The sensitivity is derived from the ISO which are used to obtain the clear image. The properties like shitter speed, exposure time are provided and these are performed to capture perfect picture underwarter.

Take Attenuation ratio:

The BR and BG pairs are derived in this step. These pairs are the standard ratios provided by the JERLOU database based on the water types. These types are different for different water. Later this is fed to tool through text file.

Correct the image format:

If the input image is not processed or if its dimensions is more than or equal to three convert that raw file into image using the Adobe-convertor.

Linear Stretch:

It is a process that changes the range of pixel intensity values. The process is as follows,

For the grayscale image I with intensity values in the range [Min(0), Max(255)] is converted into new range provided by user I([New MIN value, New Max value].

For example, if the intensity range of the image is 50 to 180 and the desired range is 0 to 255 the process entails subtracting 50 from each of pixel intensity, making the range 0 to 130. Then each pixel intensity is multiplied by 255/130, making the range 0 to 255.

Contrast stretch:

Contrast stretch without clipping is another enhancement method to improve the contrast of the image without disturbing the relative gray-level intensities too significantly.

Contrast stretch with clipping and contrast stretch without clipping are the two special cases,

Contrast stretch without clipping actually means that the spreading of the pixels throughout the range of pixels from 0 – 255 using threshold method. Before applying contrast stretch the upper and lower limits are given 0 and 255. The pixels of image which is less than 0 is given as 0 and pixels more than 255 is equated to 255. The illustrated image is shown below,

Obtain the color correction parameters

The color correction parameters are obtained from the database and these values are fed using the Text file.

Estimate Radius and Transmission

The radius is computed first and the procedure for performing the radius is as follows, Perform the distance from ait light for RGB channel in every direction. After performing the distance estimate the binary masking and extract only the light exposed pixels. For the extracted exposed pixels perform the square root and absolute the results to avoid negative numbers and store the results in variable radius.

Perform Transmission: In this section we are applying KDTreeSearcher for the dominant points and store results. Perform the KNN search for the previous result (KDTreeSearcher) and computed radius.

Veiling Light Estimation

Obtain the texture-less component (commonly water has no texture) in the image, perform the edge detection of the image and find the median for the texture-less pixels.

Bi-spectrum: It is used to search non-linearity in the image. This is achieved by applying the convolution theorem. It states that the fourier transform is applied to the two signals belongs to different domain (Time and frequency domain). The equation of above explanation is shown below,

$$B(f_1, f_2) = F^*(f_1 + f_2) \cdot F(f_1) \cdot F(f_2)$$

Where F is fourier transform of signals, the fourier transform is explained below,

Fast Fourier transform

Let f and g be two signals with convolution f*g.

If F denotes the fourier transform operator, then F(f) and F(g) are the fourier transforms of f and g. Then

F(f*g) = F(f).F(g), where . denotes point-wise multiplication. It also denoted in another format.

$$\mathcal{F}\{f \cdot g\} = \mathcal{F}\{f\} * \mathcal{F}\{g\}$$

Transformed image

Once the veiling light is estimated the post-processing is performed using the guided filter. The masked region pixels perform averaging of pixels, and reduce the artifacts using the transmission refined image obtained in step 8. This is repeated for every R, G and B channels individually and unite it to remove artifacts. The above stated steps are repeated for the rest of the images.

Main aspects of the bi-spectrum

It is used to describe the two different wavelengths. These two wavelengths are used to reconstruct the image. Instead of storing the more information these wavelength can be used to reconstruct.

IV Result and Discussion

In this sub-section, we focus on development of a novel approaches to solve our second research problem i.e extraction of features from underwater images for reconstruction of the images which are captured under-water. The detection of the image is through the types of water, peak sensitivity of camera, estimate veiling light, constrast stretching with and without clipping are the topics which are going to be discussed in this chapter. The feature points are detected and compared with the JERLOV database using the KNN searching mechanism to successfully reconstruct the image. For testing of the proposed system the two databases are used and these two database results are compared with the SURF and the results are showing that the proposed methods provides the efficient results.

Variation of light while taking the picture and its effects

In the underwater environment, the natural illumination typically varies spatially and temporally. The incident light on the water surface is refracted into the water by waves in a spatiotemporal varying manner. This effect leads to variation in illuminated light in the underwater. By taking the two dataset we care comparing the effect of illumination on the images. The below figure and table summarizes the above things.

Table 5.1: Comparison of light effects with proposed and SURF method

Sl. No.	Features type need to be collected	Methods	
		Proposed	SURF
Image1/dataset1	Number of Features collected	500	476
	Distance	88%	86%

	calculated efficiency		
	Veiling light estimation during match and fusing of image	89%	87%
Image2/Dataset2	Number of Features collected	500	492
	Distance calculated efficiency	87%	86%
	Veiling light estimation during match and fusing of image	89%	88%

Performance Evaluation for the feature matching

The performance of the proposed system is compared with the SURF matching techniques based on the number of correct and false matches between a pair images. In order to find the accuracy of the matching algorithm we had used the two steps, firstly the correlation between the pixels are identified and Euclidean distance is obtained for the every pixels of the image. Finally the incorrect matches are found by human. The results are formulated in the table. The recall and precision is given by the below equation.

$$recall = \frac{\#\text{correct matches}}{\#correspondences} \quad \text{eq 1.1}$$

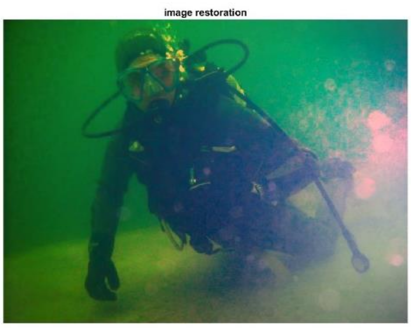
The number of false matches relative to the total number of matches is represented as precision.

$$1 - precision = \frac{\#\text{false matches}}{\#\text{correct matches} + \#\text{false matches}} \quad \text{eq 1.2}$$

The screenshots of the proposed work is shown in the below figure

(a) Original Image

(b) Estimate Peak Sensitivity of Camera



(c) Polyfiting based on water

d) Normalized Image

e) Linear Stretch Image

f) Contrast stretch without clipping

g) Contrast stretch with clipping

h) Veiling light estimated image

Figure 4 The various steps involved in performing the image restoration

Conclusion and Future scope

Conclusion

The salient contribution of the proposed work are as follows,

1. We had proposed a novel approach for enhancing the quality of the degraded underwater images. We had illustrated that our approach works well for the underwater images as it improves the image visualization, better normalization results, increase in contrast values as these are compared with the existing techniques.

2. We had proposed a novel approach for estimating the hazy lights for the underwater color images using the filters and correlation. In the proposed approach before obtaining the dominant features the normalization of the image is performed (which considerably helps in making all the values in the image as in same range). Later for the processed image the dominant features are calculated and correlation is computed. We had shown that the proposed methodology is considerably performed better compared to other existing methods in terms of decreasing the haze, quality of image.

3. We have presented an approach for reconstructing the underwater by estimating the veiling light and a textureless map of the image i.e. usually a background other than objects in the underewater. The process includes, if the image is raw convert it into linear image. The next step is to perform the edge detection using the edge detection toolbox of MATLAB. The output from this blocks includes the estimation of the veiling light from the scene and the region without texture (usually water

is texture less, object have texture hence whichever has texture then those are masked for improving that area) from which the veiling light is measured.

4. We had presented an approach for detecting the dominant features points present in the underwater image. The proposed methodology's collected feature points are compared with the famous SURF matching method and it is helpful for the underwater vehicle for real-time tracking, motion estimation.

5. The proposed reconstruction method performed the following process, the inputs for this block includes an underwater image, veiling light of the scene (specific region where filtering is essential), color correction parameters from text file, masked pixel – a binary mask to ignore the water region. The results from this blocks provides the transformed image which is considerably better reconstructed image.

Future scope

The proposed work has been carried out on the static images which means that the camera and the underwater object is held constant while capturing the underwater image. The outcome of the research works clearly to shows the better reconstruction of the image by removing the environmental light on the underwater image by collecting the dominant features. The proposed work can be extended to the video sequence instead of the static images. We can work further on video frames and which helps in detection of underwater objects in real time tracking and navigation of submarines in the underwater environment.

In our research work, we conducted experiments for the images are acquired with controlled environment which neglects the different constraints. But for the real time applications we have to consider the various constrains like occlusion of objects detection and their constraints, visibility constrain and effects of sunlight flicking.

References

[1] C. Y. Li, J. C. Guo, R. M. Cong, Y. W. Pang, and B. Wang, "Underwatervimage enhancement by dehazing with minimum information loss and histogram distribution prior," *IEEE Transactions on Image Processing*, vol. 25, no. 12, pp. 5664–5677, 2016.

[2] S. Q. Duntley, "Light in the sea*," *Journal of the Optical Society of America*, vol. 53, no. 2, pp. 214–233, 1963.

[3] R. Fattal, "Single image dehazing," *ACM Transactions on Graphics*, vol. 27, no. 3, p. 1, 2008.

[4] K. He, J. Sun, and X. Tang, "Guided Image Filtering (ECCV)," *European Confenrence on Computer Vision*, vol. 35, no. 7, pp. 1–14, 2010.

[5] C. Ancuti, C. O. Ancuti, T. Haber, and P. Bekaert, "Enhancing underwater images and videos by fusion," in *Computer Vision and Pattern Recognition (CVPR), 2012 IEEE Conference on*. IEEE, 2012, pp. 81–88.

[6] X. Fu, P. Zhuang, Y. Huang, Y. Liao, X.-P. Zhang, and X. Ding, "A retinex-based enhancing approach for single underwater image," in *Image Processing (ICIP), 2014 IEEE International Conference on*. IEEE, 2014, pp. 4572–4576.

[7] E. H. Land and J. J. McCann, "Lightness and retinex theory," *JOURNAL OF THE OPTICAL SOCIETY OF AMERICA*, pp. 1–11, 1971.

[8] K. Zhang, W. Jin, Q. Su, and X. Wang, "Multi-scale retinex enhancement algorithm on luminance channel of color underwater image," *Infrared Technology*, vol. 3, pp. 1003–1006, 2011.

[9] L. Xu, Q. Yan, Y. Xia, and J. Jia, "Structure extraction from texture via relative total variation," *Acm Transactions on Graphics*, vol. 31, no. 6, p. 139, 2012.

[10] N. Carlevaris-Bianco, A. Mohan, and R. M. Eustice, "Initial results in underwater single image dehazing," *MTS/IEEE Seattle, OCEANS 2010*, 2010.

[11] J. Y. Chiang and Y. C. Chen, "Underwater image enhancement by wavelength compensation and dehazing," *IEEE Transactions on Image Processing A Publication of the IEEE Signal Processing Society*, vol. 21, no. 4, p. 1756, 2012.

[12] K. Panetta, C. Gao, and S. Agaian, "Human-visual-system-inspired underwater image quality measures," *IEEE Journal of Oceanic Engineering*, vol. 41, no. 3, pp. 541–551, 2016.