Underwater Color Image Enhancement Using Wavelength Compensation and Dehazing

M.S.Jayasree[1] , G.Thavaseelan[2]
PG Scholar[1],Assistant Professor[2],
St.Peter's University, TN, India.

Abstract:-The paper describes underwater image enhancement methods. While capturing under-water images, the quality of the image is degraded by absorption and scattering of light. Such problems should be addressed in order to analyse the underwater images effectively. In this paper we propose histogram equalisation and contrast stretching algorithm to enhance the underwater image quality. In both the cases WCID- Wavelength compensation and image dehazing algorithm is used. Using this techniques both scattering and absorption effects are eliminated.

Index Terms — Image enhancement, histogram equalization, contrast stretching, WCID.

INTRODUCTION

Analysis of underwater image is challenging due to the effects of scattering and absorption of light in underwater environment. These effects are addressed using technique such as image enhancement, histogram equalisation, etc. Contrast enhancement is the process of adjusting contrast and brightness of images or the process of removing undesired characteristics of image. Histogram equalisation is the process of graphical representation of number of pixels in the captured image. Today, several researches are carried out for processing and analysing of underwater images to improve underwater image quality. In aquatic environment scattering and absorption of light degrades the quality of the captured underwater image since contrast reduction and non-uniform colour cast takes place under water. KashifIqbal proposed unsupervised colour correction method (UCM) as pre-processing stage of underwater image enhancement.

In underwater situations, one colour dominates the image due to scattering and absorption. In order to improve the quality of the underwater image an approach based on slide stretching is proposed. This includes contrast stretching of RGB algorithm and saturation and intensity stretching of HSI.

Segmentation of underwater image without losing object details, becomes difficult since clarity of underwater image is poor. So image segmentation approach has been developed in which contrast limited adaptive histogram equalization method is first used to enhance the image quality. Then segmentation of objects is performed using histogram thresholding.in underwater situations contrast and resolutions are low which leads to poor visibility making object identification Difficult. To find better contrast enhancement technique Balvant Singh compares contrast limited adaptive equalization method with contrast stretching and histogram equalization method using mean square error and SNR as parameters. Cosmin Ancuti proposed a strategy for underwater video and image enhancement. Using fusion principles input and weight measures are derived only from degraded version of the underwater image. In underwater images contrast varies across the scene and scene depth which disables proper operation of standard computer vision algorithms. An experiment with real underwater images with different degrees of turbidity shows that underwater scenes are reconstructed more accurately using physically-based light propagation model than by using standard stereo algorithms alone.[1]

Since quality of underwater image is poor, success rate of scale-invariant feature transform (SIFT) image registration reduces while capturing underwater image. Pulung nurtantio andono proposed pre-processing of image based on the Contrast Limited Adaptive Histogram image Equalization (CLAHE) algorithm. He assumes that Rayleigh scattering dominates the distribution of pixel intensity values of recorded image. The underwater ultrasonic image includes speckle noise. Reduction of speckle noise and enhancement of image contrast has to be performed at the same time. For this purpose anisotropic diffusion model based on wavelet transform is proposed. This model provides improved speckle reduction and image enhancement.

The clarity of underwater photoelectric image is reduced due to light scattering and absorption. Shuai Fang proposed single image enhancement based on image fusion strategy. He used the images to which white balance and global contrast enhancement is performed as inputs and computed weight sum of the inputs for each pixel. This improved the image enhancement.

Imaging using acoustic lens is better than sonar imaging although acoustical imaging has low resolution compared to optical imaging. Due to this the lens data has to be processed by taking denser sample of underwater image. Behzad Kamgar-Parsi also provides method for reconstructing the object by combining several data regarding the object, obtained by passing over the scene. Prabhakar proposes underwater image processing technique to enhance the image quality. The technique involves filtering using filters such as homomorphic filter, wavelet denoising, bilateral filter and contrast equalization, in order. Evaluation of the technique is carried out using parameters such as gradient magnitude histogram and peak signal to noise ratio (PSNR). The proposed technique can be used before applying computer vision technique. Various filtering techniques are used for processing underwater images. To find better filter that improves quality of the image, Padmavathi compares performance of filters such as homomorphic filter, anisotropic filter and wavelet denoising by average filter. It is found that peak signal to noise ratio and mean square error of wavelet denoising by average filter is desirable. Chung-Chang proposes a method for obtaining 3-D underwater image of object captured by a remotely tele operated robotic manipulator system. Fast image segmentation approach and Synchronous Feature Tuning (SFT) merging algorithm are applied to the raw image of the object, captured by two CCD cameras to obtain image of the object accurately. Red-light laser is focussed on the object to calculate 2-D coordinates based on which 3-D coordinates are determined. MATLAB underwater image tool box is developed for implementing mosaicking algorithms and optical image processing. Some of the algorithms used are contrast limited adaptive histogram specification (CLAHS), Fourier based methods, local normalized correlation and multi resolution pyramidal image blending method. Mathematical formulation of the algorithm is provided using unified framework. Imen Mandhouj proposes detection algorithms such as homomorphic filtering algorithm for sonar image processing of objects residing on sea bed. He considers that high quality images are provided by sonar system with high resolution.

Jin-Hwan Kim proposes single image dehazing algorithm to restore original image from hazy image having low contrast. First air light in the hazy image is estimated based on quad-tree subdivision. As a second step transmission map is estimated to increase contrast of the output image. The proposed algorithm removed haze efficiently. Nicholas Carlevaris-Bianco proposes an algorithm which is applied to single image, to remove light scattering effects in medium containing large suspended particles. Scene depth is estimated considering that in water three image channels gets attenuated in a different manner. This estimate is used to reduce the effect of haze. The method works irrespective of prior knowledge of scene and specialized hardware. This paper describes underwater image enhancement techniques. The paper is organised as follows: Section II describes previous work, Section III presents proposed method, and Section IV discusses the result and concludes this paper.

II PREVIOUS WORK

Various researches are carried out to enhance underwater video images captured through video camera. Some of the techniques used are histogram equalisation, Contrast Limited Adaptive Histogram image Equalization (CLAHE) method, unsupervised colour correction method (UCM) and contrast stretching. Every method had some improvement over other. Out of which histogram equalisation is simple and effective.

III PROPOSED METHOD

In underwater image clarity degradation is mainly due to scattering and absorption of light by particles in water, between the object and the observer. In order to get clear image these effects are to be eliminated.

Removal of scattering effect scattering effect is removed during the process of colour correction and contrast enhancement. Colour correction automatically takes place during contrast enhancement which is performed using histogram equalisation and contrast stretching algorithm.

Histogram equalisation enhances contrast of the image by providing uniform distribution of gray levels. It adjusts dynamic range of histogram to improve the overall contrast. This technique is popular because of its simplicity and effectiveness. Contrast stretching is performed by stretching the range of colour values.

Fig 1 Images before and after contrast enhancement

The original image is captured by suspending camera mobile phone inside water to record the video. A snapshot or frame is obtained by using MATLAB program.

Histogram Analysis

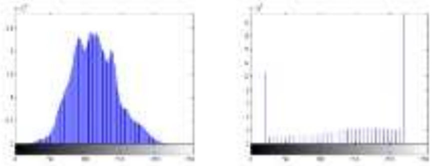
Histogram transformation is a digital image enhancement technique which transfers the probability density function of the gray levels in an image to be enhanced by using a mapping function constructed from the probability density function. In discrete case, the histogram of a digital image is an approximation of the probability density function. The well-known histogram equalization technique transfers any image into a new one whose gray levels have a uniform distribution. However, its application in image enhancement is limited because it generates only one result - an approximation to a uniform histogram. It is often desirable to be able to specify interactively particular histograms capable of highlighting certain gray level ranges in an image such that the contrast of image intensity in portion of the image can be increased effectively. The traditional approach to map the histogram of a given image into a specified histogram takes two steps:

The histogram of the original image is first equalized; Next step involves calculation of CDF (cumulative distributive function).

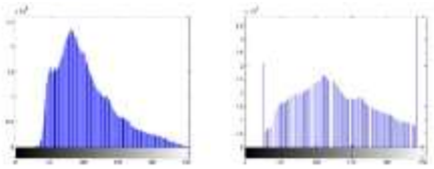
The inverse of the mapping function from the specified histogram to equalized histogram will transfer a gray level in the equalized image into a new gray level, such that the new image has the specified histogram. Another well-known contrast enhancement technique is called Intensity Windowing.It selects a subrange of the original data and scales this range into the display range. The contrast in that interval can be properly enhanced, while gray levels outside the intensity window will be mapped either to black or to white. It is easy to see that Intensity Windowing technique is a special case of histogram specification in terms of functionality. It transforms the intensity values so that the histogram of the output image approximately matches the flat (uniform) histogram.

Histogram of a digital image with gray levels in the range [0-L-1] is a discrete function h(r)=n, where r is the gray level and n is the number of pixels in the image having gray level r. An image histogram is a type of histogram which acts as a graphical representation of the tonal distribution in a digital image.[1] It plots the number of pixels for each tonal value. By looking at the histogram for a specific image a viewer will be able to judge the entire tonal distribution at a glance. Image histograms are present on many modern digital cameras. Photographers can use them as an aid to show the distribution of tones captured, and whether image detail has been lost to blown-out highlights or blacked-out shadows.

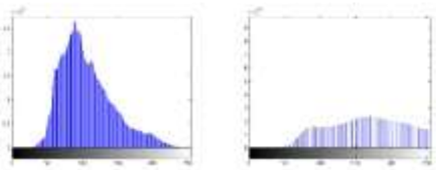
The horizontal axis of the graph represents the tonal variations, while the vertical axis represents the number of pixels in that particular tone. The left side of the horizontal axis represents the black and dark areas, the middle represents medium grey and the right hand side represents light and pure white areas. The vertical axis represents the size of the area that is captured in each one of these zones.



R input R output



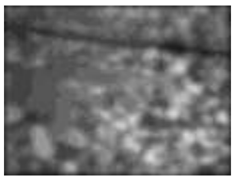
G input G output

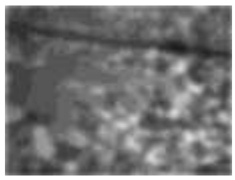


B input B output

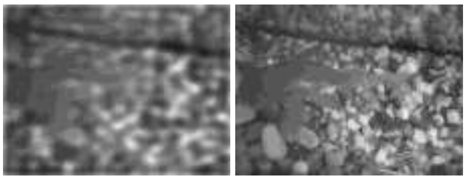
Fig 3 Input and output histograms

Removal of absorption effect the absorption effect is removed through filtering. Experiment is conducted with various filters, namely Fourier Butterworth filter, homomorphic Fourier Butterworth filter, homomorphic Fourier ideal filter, homomorphic wavelet filter, Fourier ideal filter, median filter, wavelet filter to find which one provides better filtering of the underwater image.

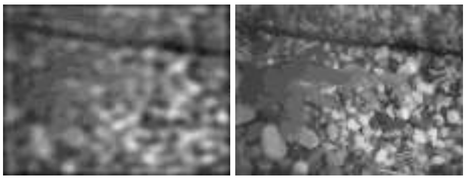




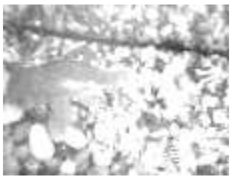
Fourier Butterworth Filter Homomorphic Fourier Butterworth Filter



Homomorphic Fourier Ideal filter   Homomorphic wavelet filter



Fourier Ideal filter   Median filter



Wavelet filter

FIG 4 Comparison of filter outputs

Filter Type	MSE	PSNR	SNR
Fourier Butterworth filter	0.004287	71.80932	80.73252
Homomorphic Fourier Butterworth filter	0.004583	71.51914	80.44234
Homomorphic Fourier ideal filter	0.00571	70.56448	79.48768
Homomorphic wavelet filter	1.66E-05	95.92005	104.8432
Fourier Ideal filter	0.005429	70.78385	79.70704
Median filter	4.38E-05	91.71667	100.6399
Wavelet filter	0.198143	55.16101	64.0842

Table 1 Comparison of performance metrics for different filters

IV RESULT AND CONCLUSION

Contrast of underwater image captured through camera mobile phone is enhanced effectively using wavelength compensation and image dehazing algorithm. Statistical analysis of the image quality is illustrated through histograms. Homomorphic wavelet filter provides better filtering of the image, in terms of PSNR, to remove absorption effect. Both scattering as well as absorption effects are eliminated efficiently by the proposed method. Future work will include further evaluation.

REFERENCES

[1] Iqbal, Kashif, M. Odetayo, A. James, Rosalina Abdul Salam, and A. Z. H. Talib. "Enhancing the low quality images using Unsupervised Colour Correction Method." In Systems Man and Cybernetics (SMC), 2010 IEEE International Conference on, pp. 1703-1709. IEEE, 2010.

[2] Iqbal, Kashif, Rosalina Abdul Salam, Mohd Osman, and Abdullah Zawawi Talib. "Underwater Image Enhancement Using an Integrated Colour Model." IAENG International Journal of Computer Science 32, no. 2 (2007): 239-244.

[3] Kumar Rai, Rajesh, Puran Gour, and Balvant Singh. "Underwater Image Segmentation using CLAHE enhancement and thresholding." International Journal of Emerging Technology and Advanced Engineering 2.1 (2012): 118-123.

[4] Singh, Balvant, Ravi Shankar Mishra, and Puran Gour. "Analysis of Contrast Enhancement Techniques for Underwater Image." International Journal of Computer Technology and Electronics Engineering (IJCTEE) Volume 1.

[5] Ancuti, Cosmin, Codruta Orniana Ancuti, Tom Haber, and Philippe Bekaert. "Enhancing underwater images and videos by fusion."In Computer Vision and Pattern Recognition (CVPR), 2012 IEEE Conference on, pp. 81- 88. IEEE, 2012.

[6] Queiroz-Neto, Jose P., Rodrigo Carceroni, Wagner Barros, and Mario Campos. "Underwater stereo." In Computer Graphics and Image Processing 2004. Proceedings. 17th Brazilian Symposium on, pp. 170-177. IEEE, 2004.

[7] Andono, Pulung Nurtantio, I. PURNAMA, and Mochamad Hariadi. "underwater image enhancement using adaptiv filtering for enhanced sift-based image matching." Journal of Theoretical & Applied Information Technology 52.3 (2013).

[8] Li, Yueqin, Ping Li, Huimin Chen, and Xiaopeng Yan. "Aspeckle reduction and image enhancement anisotropic diffusion method for underwater ultrasonic imaging based on wavelet technology." In International Symposium on Photo electronic Detection and Imaging: Technology and Applications 2007, pp. 662511-662511. International Society for Optics and Photonics, 2007.

[9] Fang, Shuai, Rong Deng, Yang Cao, and Chunlong Fang. "Effective Single Underwater Image Enhancement by Fusion." Journal of Computers 8, no.4 (2013): 904-911.

[10] Kamgar-Parsi, Behzad, Lawrence J. Rosenblum, and Edward O. Belcher. "Underwater imaging with a moving acoustic lens." Image Processing, IEEE Transactions on 7, no. 1 (1998): 91-99.

[12] Padmavathi, G., P. Subashini, M. Muthu Kumar, and Suresh Kumar Thakur. "Comparison of filters used for underwater image pre-processing." IJCSNS 10, no. 1 (2010): 58.

[13] Wu, Chung-Chang, Chun-Jen Huang, and Jung-Hua Wang. "Image processing for remotely teleoperated robotic manipulator system for underwater operations." Underwater Technology,2004. UT'04. 2004 International Symposium on. IEEE, 2004.

[14] Eustice, Ryan, Oscar Pizarro, Hanumant Singh,and Jonathan Howland. "UWIT: Underwater Image Toolbox for optical image processing and mosaicking in MATLAB." In Underwater Technology, 2002. Proceedings of the 2002 International Symposium on, pp. 141-145. IEEE, 2002.

[15] Mandhouj, Imen, Hamid Amiri, Frederic Maussang, and Basel Solaiman. "Sonar Image Processing for Underwater Object Detection Based on High Resolution System." In SIDOP 2012: 2nd Workshop on Signal and Document Processing, vol. 845, pp. 5-10. 2012.

[16] Kim, Jin-Hwan, Jae-Young Sim, and Chang-Su Kim. "Single image dehazing based on contrast enhancement." Acoustics, Speech and Signal Processing (ICASSP), 2011 IEEE International Conference on. IEEE, 2011.