As per UGC guidelines an electronic bar code is provided to seure your paper

International Journal for Modern Trends in Science and Technology
Volume 9, Issue 08, pages 32-38
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol9issue08.html
DOI: https://doi.org/10.46501/IJMTST0908006

Underwater image enhancement using edge detection filter and histogram equalization

Mahananda Math[1], S.V.Halse[1], Basavaraj N Jagadale[2]

[1] Karnataka State Akkamahadevi Women's University, Vijaypur
[2] Kuvempu University, Shivamogga
Corresponding Author Email Id: namratapuranik1975@gmail.com

To Cite this Article
Mahananda Math, S.V.Halse and Basavaraj N Jagadale. Underwater image enhancement using edge detection filter and histogram equalization. International Journal for Modern Trends in Science and Technology 2023, 9(08), pages. 32-38. https://doi.org/10.46501/IJMTST0908006

Article Info
Received: 08 July 2023; Accepted: 28 July 2023; Published: 05 August 2023.

ABSTRACT

Major issue in underwater imaging is the ejection or removal of hazy scenes which are caused by some natural phenomena like scattering, absorption, refraction, attenuation of light as it travels in the water. The visual appearance of the underwater images needs to be improved. The absorption and scattering processes of the light in water influence the overall performance of underwater imaging systems. Haze removal and contrast improvement algorithms are used to improve the visual quality of an image. In this paper the proposed method uses prewitt filter which acts as high pass filter, when applied to the gray scale images, it filters high frequency signals (sharp edges) and these signals are subtracted from original image and we get a difference image which is fused with original image. where sharpness of the image is improved. Further histogram equalization is applied to improve the intensity component of the image. Here first image is converted in to HSV format then histogram equalization is performed on intensity component. The enhanced image is obtained. Qualitative and quantitative analysis are performed on the enhanced underwater images to observe the effectiveness of the algorithm used. The performance measure entropy before and after processing are calculated and compared .

Keywords: Image enhancement. Prewitt filter, Histogram equalization. Sharpening

1. INTRODUCTION:

At present, underwater imaging technology has been applied in many fields, such as marine biology research, inspection of the underwater infrastructure and the control of underwater vehicles.[1] The underwater images have poor visibility due to the absorption and scattering effect of light. The presence of dissolved organic compounds and floating particles increases the absorption and scattering effect and often leads to noises. These noises include salt and pepper noise, Gaussian noise and marine snow[12]. This causes contrast degradation and the images looks like foggy, making distant objects misty. Due to the fact that the fading of colors increase with increase in water depth, the objects at a distance of more than 10 meters from the water surface are harder to distinguish.[2]

To obtain high quality underwater image is a task that has been studied by many scholars all over the world. Underwater image enhancement methods can be divided into three categories, the first category is based on underwater image degradation model image, the second method is based on the contrast and histogram equalization method and the third is based on image fusion method. [1]

Simple dark channel prior to remove haze from a single input image was used to deal with underwater images[3]. A fast dark channel prior descattering method is used to enhance shallow ocean optical images or videos, which reduces the noise level, highlights the dark region, improved contrast and fine details are enhanced[4]. The underwater image enhancement using dark channel prior with adaptively clipped contrast limited histogram equalization and homomorphic filter is used. By using adaptively clipped contrast limited histogram equalization, it takes the maximum bin height in the local histogram of the sub-images and it distributes the clipped pixels equally to individual gray-level. Further homomorphic filter is used to improve the edges of underwater images[5].

A new image contrast enhancement method has been used. It divides the histogram into two parts and performs histogram equalization for each sub-histogram separately. The dividing procedure is applied only once to improve enhancing effect while reduce processing time. The results show that the developed technique outperforms[6]. The multi-peak generalized histogram equalization (multi-peak GHE) is proposed. In this method, the global histogram equalization is improved by using multi-peak histogram equalization combined with local information. Different local information is employed. The proposed method enhanced the images effectively[7]

The multiscale fusion method is proposed, here sequence of operations such as white balancing, gamma correction, sharpening and manipulating the weight maps are performed, finally multiscale fusion using pyramidal fusion is done[2]. The Principle Component Analysis (PCA) fusion based method to develop the correlated variable to uncorrelated variables in images. The homomorphic filter and adaptive histogram equalization applied for individual colour channels followed by median filter, as two images are fused by using PCA fusion. Further, colour contrast applied on fused images for better results[8]. A fusion technique for underwater image and video is proposed. Here first white balancing is used, then bilateral filtering and other methods to reduce noise and colour correction and finally fusing all by pyramid fusion[9].

In this paper an enhancement technique which employs high pass filter and histogram equalization is presented. In the preprocessing part, each RGB channel of the image is filtered separately using prewitt filter and image is reconstructed. This filtered image is subtracted from the original image. We obtain difference image (sharp edges) and it is again added to original image, which increases the sharpness of the image. This sharpened image is subjected to histogram equalization on intensity component by converting RGB colour space to HSV colour space. We get a enhanced image. Evaluative parameter entropy is calculated before and after process. The proposed method shows a remarkable improvement in the entropy value. The outline of the proposed method is shown in fig 1. The rest of the work is organized as follows : Some of the recently used enhancement techniques are reviewed in section 2. Section 3 explains, the steps involved in the proposed method. Section 4 gives the evaluation measure (comparison of ENTROPY parameter) and conclusion is given section 5.

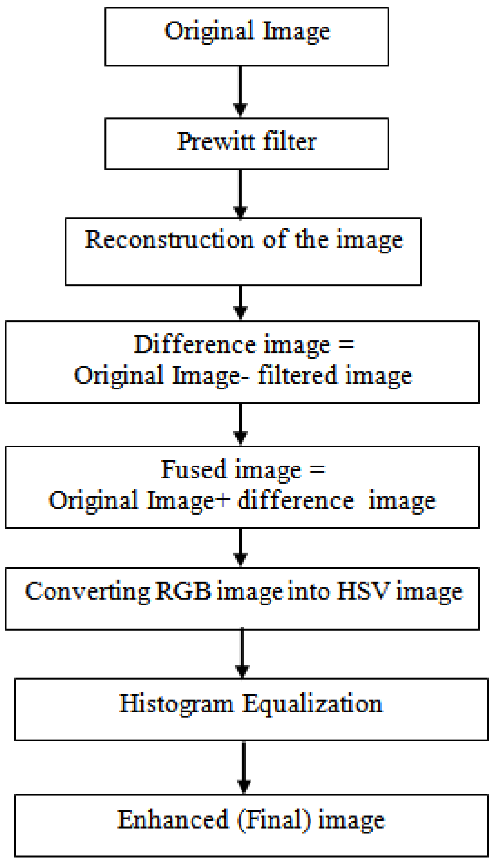

Figure 1 : Outline of the proposed method

2. LITERATURE REVIEW

Can Zhang et al [1] In their method, the image is restored on the base of underwater image model. Then they obtain white balance and contrast enhancement of the restored image. These two inputs are fused with multiscale fusion technique using saturation and contrast metrics to weight each input. The resultant final image shows better visual quality and execution time is also reduced.

Sangeetha Mohana et al [2], they operated a sequence of operations on degraded under water images such as white balancing, gamma correction, sharpening, manipulating the weight maps are performed. At last multiscale image fusion of the inputs is done to obtain the resultant output.

Omer Deperlioglu et al [10]: In this method first the image under test is separated into three separate Red(R), Green (G) and Blue (B) components and is been converted from RGB colour space to HSV colour space. In the next stage extension of V element is coordinated under the control of the start and the end of the interval. Then, it is converted from HSV color space to RGB color space and the histogram equalization is applied to each R, G, B components. After that, R, G, B components are combined to form a color image. Finally, Gaussian low-pass filter is applied to the underwater image. To evaluate its performance the parameters, mean and entropy were calculated and compared with the other method. The comparison result shows, the praposed method shows remarkable improvement in the result.

S. Selva Nidhyanandhan et al [11]: In this method two stage process of image fusion is used first part deals with applying the double stage gaussian filter (DSGF) with high, low, and medium sigma values on the individual R, G and B components of input RGB images and second part deals with applying colour component wise contrast limited adaptive histogram equalization (CLAHE) followed by median fltering. The outputs of these two parts are fused by Principal component analysis(PCA) fusion technique. Colour contrast correction is applied for fused image. The performance measures such as entropy, SSIM, and AMBE are calculated and these results are compared with Single stage gaussian filter method. The method with DSGF shows improved results.

Weilin Luo et al [12]:A fusion algorithm for both enhancement and restoration of underwater images is proposed. To highlight the effect of colour shift in an underwater image the scalar values of R, G, B channels are renewed so that the distributions of the three channels in histogram are similar. An optimized contrast algorithm is employed by which the optimal transmittance is determined. To further improve the brightness and contrast of underwater images, a histogram stretching algorithm based on the red channel is given. Results show that the quality of underwater images is improved significantly, both in term of subjective visual effect and objective evaluation.

3. PROPOSED METHOD :

a. *Image acquisition*

Images are captured from the underwater with the camera. This captured image is in the form of RGB which consists of red, green & blue regions. The captured image undergoes the preprocessing stages.

b. *Pre processing*

This stage consists of various processing stages which depends upon the nature of input image. The input image captured from the camera undergoes pre processing stages. The input image is in RGB form and it is converted into grayscale form which have the pixel range of 0 to 255. Filtering process also comes under preprocessing stage which reduces the noise and blurring regions of the input image.

Prewitt Filter:

Prewitt operator is used for detecting edges horizontally and vertically. Edges are calculated by using difference between corresponding pixel intensities of an image. All the masks that are used for edge detection are also known as derivative masks. All the derivative masks should have the following properties:

- Opposite sign should be present in the mask.
- Sum of mask should be equal to zero.
- More weight means more edge detection.

Prewitt operator provides us two masks one for detecting edges in horizontal direction and another for detecting edges in an vertical direction.

-1	0	+1
-1	0	+1
-1	0	+1

G_x

+1	+1	+1
0	0	0
-1	-1	-1

G_y

Figure 2: Prewitt operator 3x3 vertical and horizontal mask

When we apply this mask on the image vertical mask prominent vertical edges and horizontal mask prominent horizontal edges. It simply works like as first order derivate and calculates the difference of pixel intensities in a edge region. As the center column is of zero in vertical mask and center row is zero in horizontal mask, so it does not include the original values of an image but rather it calculates the difference of right and left pixel values around that edge in vertical mask and difference of top and bottom pixel values around the edge in horizontal mask. This increase the edge intensity and it become enhanced comparatively to the original image[13][14].

$$G = \sqrt{Gx^2 + Gy^2} \text{ or } G = |Gx| + |Gy| \qquad (1)$$

c. *Detection*

When we subtract the Prewitt filtered image from the original image, sharp edges of the image are detected (Difference image) and these sharp edges are added to original mage, where we obtain enhanced image of the original image.

d. *Contrast Enhancement of the image using Histogram equalization*

After obtaining sharpened output image from the preprocessing stage, before image is subjected to histogram equalization. Sharpened image is converted from RGB colour space to HSV colour space then histogram equalization is performed on intensity component.

HSV Colour Space: The Hue, Saturation, Value (HSV) color space is more commonly used color system which has the ability separating between color and intensity. HSV can rebuild images better than the RGB color space does. Hue is the color type such as red, blue, or yellow. The corresponding colors vary from red through yellow, green, cyan, blue, magenta as hue ranges from 0 to 1.0. For example, 0 is red or 55 is a shade of yellow. Saturation is the intensity of the color. As saturation ranges from 0 to 1.0, the corresponding colors vary from unsaturated (0) that is a shade of grey between black and white, to fully saturated (1) that means intense color. Value is the brightness of the color. As value, or brightness ranges from 0 to 1.0, the corresponding colors become increasingly brighter[10]

Histogram Equalization

Considered a digital image, $F(i, j)$, with a total of N pixels and a gray level range of [0, K-1]. Thus, the probability density function of the image is calculated according to Equation 2:

$$P(k) = \frac{n_k}{N} \quad \text{for } k = 0,1, \Lambda, K\text{-}1 \qquad (2)$$

where n_k is the total number of pixels with the number of grayscale k in the image. Then, the cumulative distribution function (CDF) of the image $F(i, j)$ can be found by Equation 3:

$$C(k) = \sum_{m=0}^{k} P_m \quad \text{for } k = 0,1, \Lambda, K\text{-}1 \qquad (3)$$

Using the CDF values found in Equation 3, HE matches an input level k to an output level H_k using the level mapping equation as Equation 4:

$$H_k = (K\text{-}1).C_k \qquad (4)$$

Thus, the gain Hk at the output level for the conventional HE that is previously described above can be obtained as in Equation 5:

$$\Delta H_k = H_k - (H_k - 1) = (K\text{-}1).\ P(k) \qquad (5)$$

In other words, the increase in the level of Hk is proportional to the probability of the corresponding level of k in the original image. Theoretically, for images with continuous intensity levels and probability density functions, such a mapping scheme can perfectly equalize the histogram [10][16].

As a result an image having higher contrast than the original is obtained. Evaluation parameter entropy of this higher contrast (output) image and original image are computed and compared.[15].

4. RESULTS:

We have conducted experiments to evaluate the proposed technique on several noisy underwater images with unknown noise characteristics. These images suffer from haze, non-uniform illumination, low contrast and suspension of micro-organisms present in the underwater environment. Experiment was conducted in two stages. The first stage is preprocessing stage undergoes following steps : Reading the noised underwater image. Filtering each RGB channel separately using prewitt filter which reduces the noise and blurring regions of the image. Reconstructed the image. The difference of original and filtered image (sharp edges) is obtained and this difference image is added to original image, where we get an enhanced image. Histogram equalization is performed on the sharpened image by converting RGB image into HSV image. We get a more enhanced image than preprocessed stage. Evaluation measure ENTROPY of original and denoised images are computed and compared. Here results of 10 images are shown.

The result were obtained on an Intel Pentium Core i3 processor of speed 3.30 GHz and 4 GB of RAM

Entropy:

The image information content is obtained on measuring the entropy. For the assessment of the quality of underwater images, the color information entropy assessment method is adopted. The RGB color space is selected; then, the information entropy is obtained based on the three color channels of the image, and the average value is finally obtained. The formula for information entropy is[2][17][18]

$$H = -\sum_{i=0}^{255} p_i \log_2 p_i \quad (6)$$

Image1

Image2

Image3

Image4

Image8

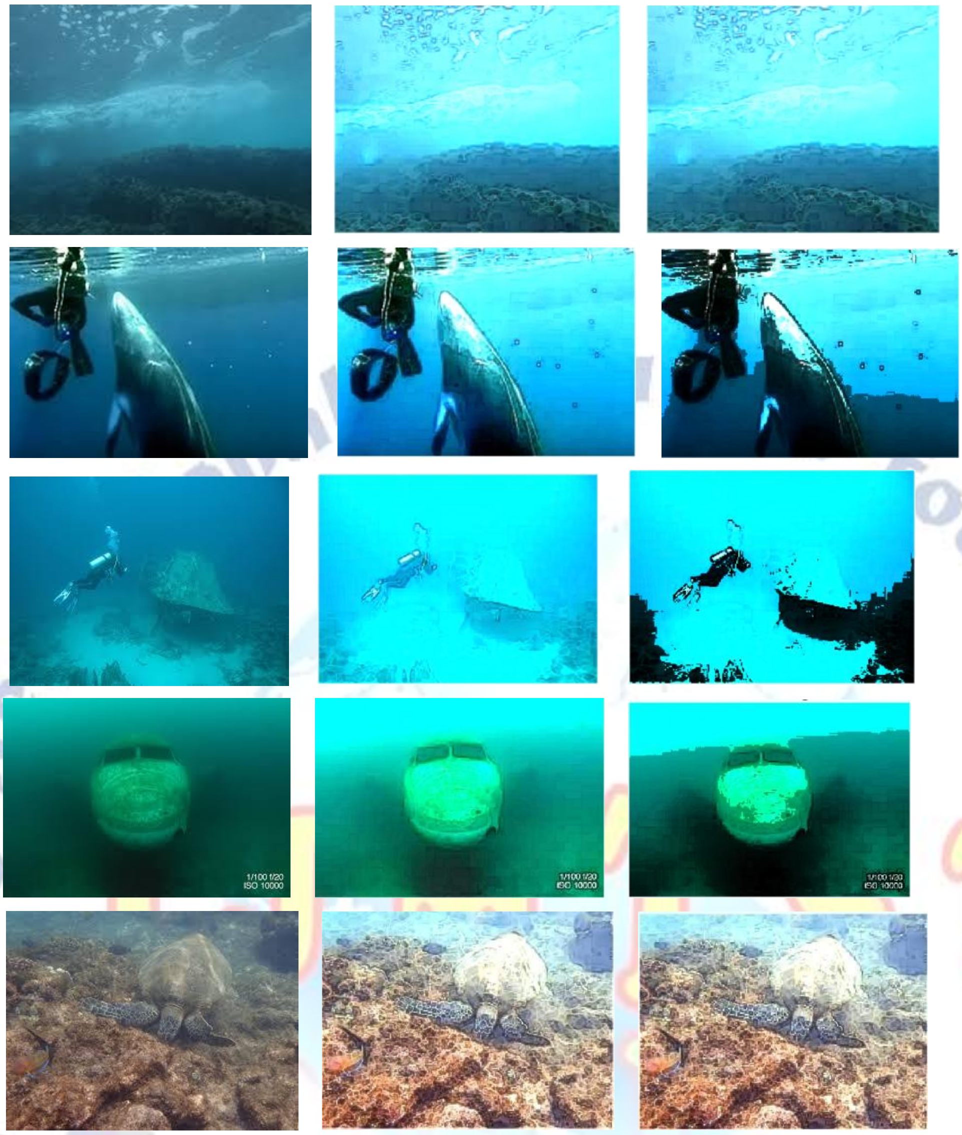

Image9

Image10

Image11

Image12

Tortoise

Figure 2: First column-original images, Second column–pre-processed images, Third column–histogram equalization images

Image	Entropy before processing	Entropy after processing
Image1	7.079	10.60
Image2	6.29	9.214
Image3	6.74	7.44
Image4	6.26	13.02
Image8	8.94	10.04
Image9	6.73	11.16
Image10	6.17	9.020
Image11	5.52	10.84
Image12	5.62	7.37
tortoise	7.99	9.35

Table 1: Results of ENTROPY before and after Processing

5. CONCLUSION:

In this paper, we have proposed enhancement technique of degraded underwater images using prewitt filter and histogram equalization by converting RGB image to HSV image. The evaluation measure ENTROPY is calculated, before processing and after processing. The images with sky blue background and high brightness shows double improvement in ETROPY value (Image 4 & Image 11), images with low brightness (dark background) shows less improvement in ENTROPY value (Image 3 & Image 8)and other images with moderate brightness shows medium improvement in the ENTROPY value. Over all the proposed enhancement technique shows improvement in the value of ENTROPY after preprocessing for all types of images. This technique is experimented for several images.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Can Zhang, Xu Zhang and Dawei Tu "Underwater Image Enhancement by Fusion " https://doi.org/10.1007/978-981-10-5768-7_8.

[2] Sangeetha Mohana, Philomina Simonb "Underwater Image Enhancement based on Histogram Manipulation and Multiscale Fusion "Procedia Computer Science, Volume 171, 2020, Pages 941-950.

[3] He K, Sun J, Tang X (2010) Single image haze removal using dark channel prior. In: 2013 IEEE conference on computer vision and pattern recognition. IEEE, pp 2341–2353.

[4] Li Y, Lu H et a1 (2015) Underwater image enhancement using inherent optical properties. In: 2015 IEEE International conference on information and automation. IEEE, pp 419–422.

[5] Dixit, S., Tiwari, S. K., et al. (2016). Underwater image enhancement using DCP with ACCLAHE and homomorphism fltering. In International conference on signal processing, communication, power and embedded system (SCOPES)-2016. https://doi.org/10.1109/scopes.2016.7955807.

[6] Yang Li, Runmin Sun, Yijun Zhou "A modified Histogram Equalization approach for Image Contrast Enhancement" **DOI:** 10.1109/ICCECE54139.2022.9712841.

[7] H.D. Cheng, X.J.Shi "A simple and effective histogram equalization approach to image enhancement" https://doi.org/10.1016/j.dsp.2003.07.002.

[8] Borker, S., & Bonde, S. (2017). Contrast enhancement and visibility restoration of underwater optical images using fusion. International Journal of Intelligent Engineering and Systems. https://doi. org/10.22266/ijies2017.0831.23.

[9] Ancuti CO, Ancuti C, Haber et a1 (2011) Fusion-based restoration of the underwater images. IEEE International conference on image processing. IEEE, pp 1557–1560.

[10] Omer Deperlioglu , Utku Kose , Gur Emre Guraksin "Underwater Image Enhancement with HSV and Histogram Equalization" 7th International Conference on Advanced Technologies (ICAT'18) https://www.researchgate.net/publication/325722819.

[11] S. Selva Nidhyanandhan1 · R. Sindhuja1 · R. Shantha Selva Kumari "Double Stage Gaussian Filter for Better Underwater Image Enhancement" Wireless Personal Communications https://doi.org/10.1007/s11277-020-07509-6.

[12] Weilin Luo , (Member, Ieee), Shunqiang Duan, And Jiwen Zhen "Underwater Image Restoration and Enhancement Based on a Fusion Algorithm With Color Balance, Contrast Optimization, and Histogram Stretching" IEEE AccessVOLUME 9, 2021.

[13] Ahmed Shihab Ahmed "Comparative Study Among Sobel, Prewitt And Canny Edge Detection Operators Used In Image Processing" Journal of Theoretical and Applied Information Technology 15th October 2018. Vol.96. No 19, ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195.

[14] Wand Dong, Zhou Shisheng "Color Image Recognition Method Based on the Prewitt Operator" **DOI:** 10.1109/CSSE.2008.567.

[15] Raimondo Schettini & Silvia Corchs, "Underwater Image Processing: State of the Art of Restoration and Image Enhancement Methods"EURASIP Journal on Advances in Signal Processing volume 2010, Article number: 746052.

[16] Q. Wang and R. K. Ward, "Fast Image/Video Contrast Enhancement Based on Weighted Thresholded Histogram Equalization", IEEE Transactions on Consumer Electronics, 53, (2), pp. 757-764, 2007.

[17] K. Srividhya M. Ramya "Fuzzy-Based Adaptive Denoising of Underwater Images"International Journal of Fuzzy Systems 2017.

[18] Keerti Gupta , Prof. Priya Jha "Underwater Image De-Hazing Using Weight Map Fusion With Gamma Correlation" International Journal Of Innovative Trends In Engineering (Ijite) Issn: 2395-2946 Issue: 69, Volume 45, 2018.

[19] Mahananda Math, S.V.Halse, Basavaraj N Jagadale "Underwater Image Enhancement Using Histogram Equalization and Low Pass and Sharpening Filters" GOYA Journal, volume-6, issue-VI, June-2023.