Generalized Equalization Model for Underwater image enhancement

D. Shofia Priyadharshini

Assistant Professor, Department of Electronics and Communication Engineering, Vel Tech High tech Dr.Rangarjan Dr.Sakunthala Engineering College, Chennai, India.

Mohamed Nassar N. V. S.

UG Scholar, Department of Electronics and Communication Engineering,Vel Tech High tech Dr.Rangarjan Dr.Sakunthala Engineering College, Chennai, India.

Gopala Krishnan B.

UG Scholar, Department of Electronics and Communication Engineering,Vel Tech High tech Dr.Rangarjan Dr.Sakunthala Engineering College, Chennai, India.

Abhjit R.

UG Scholar, Department of Electronics and Communication Engineering,Vel Tech High tech Dr.Rangarjan Dr.Sakunthala Engineering College, Chennai, India.

Abstract

The field of underwater image processing has attracted a significant amount of interest over the course of the last several decades, resulting in significant advancements. An underwater images have been essentially characterised by with there poor exposure and since illumination is exponential rate inactivated as it travels through the water, resulting in scenes that are inadequately contrasted and hazy. This is the case because light is absorbed exponentially more as it travels through the water. Due to the fact that blue light has the shortest wavelength, it is able to go the farthest through the water. As a result, blue colour predominates most prominently in photographs that were taken underwater since blue light is able to penetrate the water the longest. In conclusion, the photos suffer from a narrow range of vision, poor contrast, inconsistent illumination, blurring, colour diminishment (a blue look), and noise. Post-processing, which enhances the image's quality and helps increase the sense of depth in underwater photography, is performed with the goal of enhancing the perception. In this study, we suggest an equalisation model that is more generic for the purpose of picture improvement. Based on our investigation of histogram with contrast adjustment balancing interactions, we first propose a generalised equalisation model that integrates image contrast as well as white balanced into an unified model of convex code of image histogram. The experimental findings, both subjective and objective, indicate that the suggested algorithm has favourable performance in the context of applications including picture enhancement, white balance, and tone correction. The convergence speed of the approach that is being offered is also investigated.

Keywords: *Underwater, Image Processing, generalized equalization model, image enhancement, histogram and contrast enhancement.*

1 INTRODUCTION

Since light is progressively attenuated as it passes through the water, underwater photos are fundamentally defined by their low visibility. This is because the sceneries that come from underwater photography are poorly contrasted and fuzzy. The vision distance is restricted to around twenty metres in ocean and no more than five metres in muddy water as a result of light attenuation. Absorption and scattering are the two processes that contribute to the attenuation of light [1]. The overall efficacy of submerged imaging systems is affected by the light's ability to be absorbed and scattered as it travels through water [2]. The visual characteristics will often become more blurry as a result of forward scattering. Backscattering, which is the other side, has a tendency to reduce the intensity of the pictures. Not only is the water itself responsible for the absorption and scattering effects, but also the various components of the water, such as the dissolved organic matter [3].

The visible range may be expanded by artificially illuminating the ground of the item; however, this results in a non-uniform distribution of light over the object's exterior and creates a bright point in the middle of the picture with weakly lighted areas on either side of it. As we travel deeper, the quantity of light that reaches us decreases, and the colours that we see change depending on the wavelengths of the light. Because of its shorter wavelength, blue light penetrates the water the deepest and stays there the longest [4]. The images taken underwater suffer from a lack of range visibility, poor contrast, inconsistent illumination, blurring, bright artefacts, colour diminishment, and noise.

Image augmentation is often necessary as a result, and this is true because of the aesthetic and the practical reasons. Contrast enhancement techniques have already found widespread use in imaging equipment for the purpose of tone mapping [5]. For instance, in a conventional digital camera, the photons captured by the lens are sent to the CCD or CMOS array, where they are read, and then the resulting charge levels are converted into the original picture. To this day, the technique of contrast enhancement continues to play a significant role in the improvement of the quality of underwater photos. Some earlier investigations shown that contrast enhancement methods are able to remove undesirable noises and improve the brightness and contrast of pictures.

2 RELATED WORKS

There have been a great many different approaches to the processing of underwater images established. Many other avenues of attack have been contemplated, including the reversal of the wavelength - dependent phenomena, colour filter, frequencies filtering, and others [6].

To know more about these living beings, divers tend to capture them and showcase the deep blue ocean images to the world. Researchers always want to capture the best quality images under the water however some of them might not be clear, mostly because of some disturbances, noises that occurred while taking, additional problems like color deviation, uneven brightness, etc [7]. So, to overcome these drawbacks we are introducing an underwater image improvement technique where an already captured image that was captured by the photographer will be simply uploaded to the site and we get a clear enhanced image [8]. Our model will be clearing all the disturbances caused within the image and set the color corrections, clear hue, saturation, intensity, and stretching is completed and conjointly the environmental radiance is about uniform throughout the image which indeed helps us producing the quality underwater image [9].

Usually, when underwater images are taken, they are often blurry due to lack of illumination in the dark water environment [10]. So, a model called Underwater image colour constancy. Based on Deep Sparse Non-Negative Matrix Factorisation. This model will help us to estimate the illumination of the images. Here the image is divided into small patches and each Chanel patch is reshaped into a particular [R, G, B] matrices [11]. These layers are going to be factorized into certain layers and the final layer with more sparseness constraint adjusts the appearance of the output image. Though it is a simple implementation it follows a factorization method where to get a high-quality image we need to follow some sequence of factorization to get an accurate image. Hence it becomes a daunting task to run it consequently and that too it takes a lot of time [12].

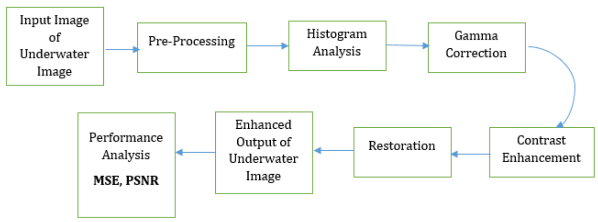
The ability to effectively remove noise from underwater images is an essential component for a wide variety of applications. Images taken underwater are plagued with two primary issues: colour shifts and light scattering, which both affect the direction in which light travels. Absorption and scattering are the two primary mechanisms at play in the transmission of light through the water [13]. The majority of the noises that may be heard underwater are either man-made (such as the sounds of ships and equipment) or natural (such as the sounds of wind, seismic activity, and rain). Denoising is required to enhance the picture quality after it has been degraded by noise caused by underwater environments. The frequency determines the attenuation of sound that occurs underwater [14].

In image processing, we are having a technique called as histogram equalization technique in this the image will be adjusted to a certain contrast and change the intensity distribution. This technique can also be used for producing images with good contrast [15]. We can also call it a contrast improvement technique. But the major drawback of the technique is that sometimes it can increase the contrast of the background noise which makes the image look more over amplified. Also, it doesn't concentrate on the exact background of the image so it might give us unsatisfactory results.

3 PROPOSED METHODOLOGY

In spite of the vast amount of writing that has been done on the subject of improving underwater images, such as the samples that have been given above, there are still two difficult challenges that need to be addressed. First, the question is how to improve contrast while yet maintaining a pleasing overall tone. Second, the question is how to conceptually connect the various categories of improvement algorithms to one another. The purpose of this research was to offer a generalised equalisation model for the improvement of underwater images. Our investigation into the connections between the pixel intensities and edge enhancement as well as white balancing led us to develop a generalised equalisation model. This model incorporates image contrast as well as white stabilising into a coherent model of convex coding of the image histogram, as shown in figure 1.

Figure 1. Overall Workflow of Proposed Method



3.1 Image acquisition

Image is obtained from the underwater environment by way of the camera's input. The picture that was taken is in the format of an RGB image, which means that it has red, green, and blue regions. The picture that was acquired then goes through a step known as pre-processing. The larger the pixel values, the more the shot will be focused on the subject. As a consequence of this, the algorithm selects the portions of each shot that will be brought into focus by selecting the pixel value that provides the best overall outcome for the image as a whole. This results in a highly focused output. After analysing each image, the value of the pixel P ij) is determined and then compared to the values of the other pixels.

3.2Pre- Processing

The red, green, and coloured components of a picture may each be seen in their own window using the RGB panel. An RGB picture is the overlap of three two-dimensional matrices, which is something that has been brought up before. Transform RGB colormap into HSV colormap. The number of processes that are carried out throughout the steps of pre-processing in image processing is variable and is determined by the picture that is being read in. The pre-processing phases are performed on the input picture, which is an image that has been obtained from some source. The RGB picture is the one that is being input. The RGB picture is transformed into a grayscale image, which may contain pixel values ranging from 0 to 255. The filtering step falls within the pre-processing stage of the production pipeline. This filtering step brings the level of noise that is contained in the picture down to a lower level.

3.3 Histogram-Based Analysis on gamma Correction

In the process of contrast enhancement, histogram-based algorithms have seen a lot of application. The intensity of a screen or device display is referred to as the gamma setting. When the appropriate gamma correction is applied, the display's brightness and contrast are improved, resulting in pictures that are both brighter and seem to have a more realistic appearance. The red colour channel is often considered to be one of the lesser important colour channels, while the green and blue colour channels are considered to be the primary colour channels. The proportion of the red colour channel generally the lowest, while the percentage of the green or blue colour channel is often the largest. These histograms will generate two separate photos, one with an under-enhanced effect, and the other with an over-enhanced effect. As a result, using the three fundamental percentile channel of red, green, as well as blue will result in the production of six distinct histograms.

3.4 Contrast Enhancement

Image contrast may be improved with the use of an automatic enhancement approach that is based on the gamma correction method. The cumulative histogram is used as the basis for the calculation of the gamma value. In this method, the input picture is divided into four rectangular sections that are all the same size. The average value is then determined for each section, and the standard error is then removed out from average value.

$$Score_l = \frac{1}{3N}\sum_{\lambda \epsilon r,g,b}\sum_{x=1}^{N} I_l^{\lambda}(x) - \frac{1}{3}\sum_{\lambda \epsilon r,g,b}\sqrt{\frac{\sum_{x=1}^{N}\left(I_l^{\lambda}(x) - \hat{I}_l^{\lambda}\right)^2}{N}} \quad (1)$$

In this equation, represents each of the four regions that make up the input pictures, and N is the total number of pixels. The zone with the least amount of variation is the one that will be chosen for the sample. These processes are done several times until the target value that has been predetermined is reached. We determine the mean vector while focusing on the area with the lowest variation. The value that corresponds to the gradient magnitude and the light that was produced is regarded as having the highest brightness.

Algorithm for Proposed Method (Enhancement of Transmission):

1. Inv=inverse_transform(r_fft);
2. Rabs=abs(RInv);
3. rlog=log(r);
4. Rablog=log(Rabs);
5. Rlog=rlog-Rablog;
6. GInv=inverse_transform(g_fft);
7. Gabs=abs(GInv);
8. glog=log(g);
9. Gablog=log(Gabs);
10. Glog=glog-Gablog;
11. BInv=inverse_transform(b_fft);
12. Babs=abs(BInv);
13. blog=log(b);
14. Bablog=log(Babs);
15. Blog=blog-Bablog;

After the refining, a rather continuous spatial information is created as a result of frequently updating the weights during each iteration of the process. The use of the enhanced transmission map results in improvements to the game's textures as well as its details. As a result, it is possible to divide the picture into two distinct components: the flattening element as well as the comprehensive component. You may achieve the smoothing component by using the blurring filtering, as well as a low-pass Adaptive method is also an excellent way for smooth filtering.

$$t = t_{smooth} + t_{detail} \quad (2)$$

The kernel for the Gaussian convolution may be expressed mathematically as follows:

$$G(x,y) = \frac{1}{2\pi\sigma^2} \cdot e^{\frac{(x^2+y^2)}{2\sigma^2}} \quad (3)$$

The smoothing component may be accomplished by applying a Gaussian filter on the revised transmission map in order to provide a smoother surface.

$$t_{smooth} = t * G \quad (4)$$

Moreover, the component level details are available to be retrieved as

$$t_{detail} = t - t_{smooth} \quad (5)$$

Because of this, it is possible to compute the increased transmission map as

$$t_{enhanced} = t_{smooth} + \alpha \cdot t_{detail} \quad (6)$$

Algorithm for Restoration Method:

```
[nrows mcolumns] = size(r);
for i=1:1:nrows
    for j=1:1:mcolumns
        ired(i,j)=r(i,j)./(r(i,j)+g(i,j)+b(i,j));
        igreen(i,j)=g(i,j)./(r(i,j)+g(i,j)+b(i,j));
        iblue(i,j)=b(i,j)./(r(i,j)+g(i,j)+b(i,j));

icolor(i,j)=ired(i,j)+igreen(i,j)+iblue(i,j);
    end
end
```

There are two aspects that may be used to define the fundamental nature of the picture f(x,y):

1. the quantity of light coming from the source that is hitting the area that is being seen

2. the light that is being reflected off of the various things that are in the scene. These sections of light are referred to as the illumination and reflectance components, and they are designated i(x,y) and r(x,y) accordingly. They are also termed the illumination component and the reflectance component.

3. The imaging function f may be obtained by applying the multiplicative operation to the variables I and r.

$$f(x,y) = i(x,y).r(x,y) \qquad (7)$$

where 0 goes to infinity for i(x,y) and 0 goes to one for r(x,y). Since the Fourier of the combination of two variables is not separable, we cannot simply utilise the product described above to act independently on the spectral analysis of illumination and reflection. This means that we are unable to use the product to separate illumination and reflection.

$$F[f(x,y)] \neq F[i(x,y)].F[r(x,y)] \quad (8)$$

However, suppose that we define

$$z(x,y) = \ln f(x,y) = \ln i(x,y) + \ln r(x,y) \quad (9)$$

$$\begin{aligned} F[z(x,y)] &= F[\ln f(x,y)] \\ &= F\{\ln i(x,y)\} \\ &\quad + F\{\ln r(x,y)\}\ or \end{aligned}$$

$$Z(u,v) = Fi(u,v) + Fr(u,v) \qquad (10)$$

Where Z, Fi, as well as Fr are the transformations of z, ln I as well as ln r correspondingly using the Fourier algorithm. The Discrete wavelet transform of both the sum of two pictures, a lower frequencies lighting image as well as a spectral reflectance image, is represented by the function Z. These images are low frequency and high frequency, respectively.

We may suppress the light component and boost the reflectance component if we now use a filtering with a converter that improves high frequency components while suppressing low frequency components. Thus

$$\begin{aligned} S(u,v) &= H(u,v)Z(u,v) \\ &= H(u,v)Fi(u,v) \\ &\quad + H(u,v)Fr(u,v) \quad (11) \end{aligned}$$

where S represents the outcome after being transformed by the Fourier series and

$$H(u,v) = (rH - rL)(1 - exp(-(u2 + v2)/2\ 2\ )) + rL \qquad (12)$$

where the maximum and lowest values for the coefficients are rH = 2.5 and rL = 0.5, respectively, and a factor that regulates the cut off frequency is a. The empirical method is used to choose these parameters. Calculations using the Fourier transform in its inverse form to return in the spatial domain, followed by obtaining the exponent in order to produce the filtered picture.

3.5 ADVANTAGES

With the strong effects of absorption and scattering that the material has, taking photographs underwater that are both clear and high in resolution will prove to be a challenging endeavour. Thus, several methods of image enhancement are used in order to eliminate noise in images and enhance the overall quality of images.

The enhancement of images taken underwater has many potential applications across a wide variety of industries. The study of undersea infrastructure and the identification of any unreal items are two applications for its utilisation. It is also used for the study of marine life, the study of the environment, the study of monuments that have been submerged in water, and for the observation of underwater guiding in submarines.

The development of better underwater images is also essential for the operation of undersea vehicles and for observing the rich traditions of archaeological sites that are buried below. In addition, the development of underwater images is very important for the study of underwater structures such as coral reefs.

4 Performance Measures

Typical image reliability assessment measures comprise mean absolute error, normalised mean square error (NMSE), peak-to-average ratio (PSNR), and mean square error. An SNR that is between 30 and 40 dB generally produces a satisfactory image with appropriate distortion; an SNR that is between 20 and 30 dB typically produces poor picture quality; an SNR that is below 20 dB generates an image that is unusable. An SNR that is greater than 40 dB seems to provide a high-quality image that is very close to the quality of the original image. The following is a presentation of the several approaches that may be used to calculate PSNR and NMSE:

PSNR and NMSE: $PSNR = 10\log_{10}\frac{255^2}{MSE}$

(13)

If MSE refers to the mean square error between the original picture (x) and the smoothed image (x) and size M and N are greater than each other:

$$MSE = \frac{1}{M*N}\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j) - \hat{x}(i,j)]^2$$

(14)

4.1 Results and Discussion

The experimental instrument for simulation is MATLAB, and the simulation experiments are carried out on a diver image to validate the correctness of the method. By adjusting the amount of noise in the simulations between 0 dB to 15 dB, it is possible to get PSNR values ranging between 30 dB to 60 dB. As can be seen in figures 2 through 5, the brightening filter is applied in the order of 10.

Figure 2. Input Image

Figure 3. Histogram Based Gamma Correction

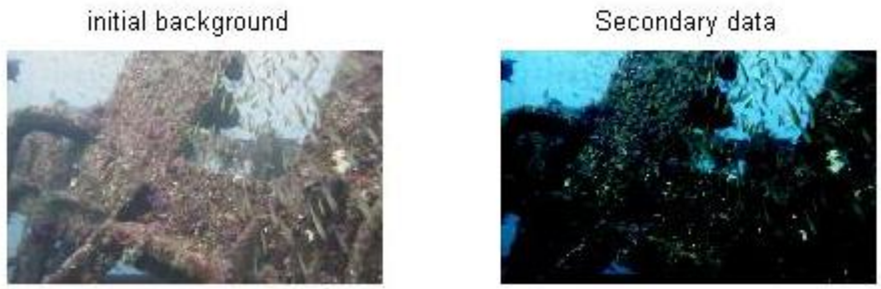


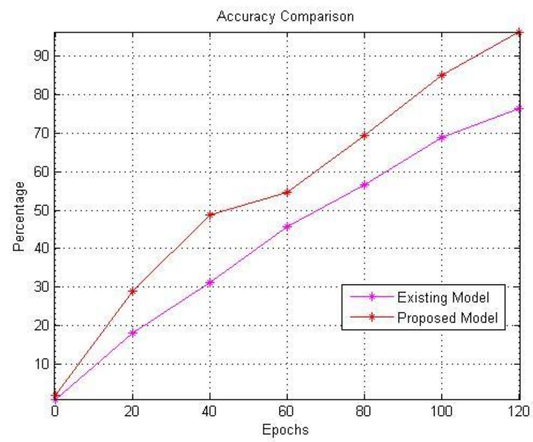
Figure 4. Image Enhancement and Restoration Method

Figure 5. MSE and PSNR Value of Proposed Method

```
image MSE:    0.28
image MSE:    0.19
image MSE:    0.17
image PSNR: 53.6454563 dB
image PSNR: 55.4241756 dB
image PSNR: 55.8537638 dB>>
```

The PSNR as well as MSE values are determined by using the individual noise power levels as inputs.

Figure 6. Accuracy Comparison



In light of this, the work that is being presented has a relatively low rate of errors and a large precision range. As a result, the improvement procedure may be executed with a greater accuracy range, as seen in figure 6.

5 CONCLUSIONS

The enhancement of underwater pictures may be a challenge in itself, due to the assorted factors moving the no heritable image the employment of varied image sweetening techniques like AHE, GC, BBHE and CLAHE may be want to improve the no heritable picture's visual look. The selection of the technique plays a major role in image sweetening. The consequences of noise, blurring, restricted visibility on a image will thus be reduced.Post-processing, which enhances the image's quality and helps increase the sense of depth in underwater photography, is performed with the goal of enhancing the perception. In this study, we suggest an equalisation model that is more generic for the purpose of picture improvement. In the first step of this process, we construct a generalised equalisation model, which incorporates image contrast with white balanced into a coherent model of convex coding of pixel intensities. This is done based on our investigation into the correlations that exist between pixel intensities and white balancing and contrast enhancement. The experimental findings, both subjective and objective, indicate that the suggested algorithm has favourable performance in the context of applications including picture enhancement, white balance, and tone correction. The complexity of the approach that is being offered is also investigated.

REFERENCES

[1] T. Arici, S. Dikbas, and Y. Altunbasak, "A histogram modification framework and its application for image contrast enhancement," IEEE Trans. Image Process., vol. 18, no. 9, pp. 1921–1935, 2019.

[2] M. Ashikhmin, "A tone mapping algorithm for high contrast images," in Proc. 13th Eurographics Workshop Rendering, 2020.

[3] K. Barnard, L. Martin, B. Funt, and A. Coath, "A data set for colour research," Color Res. Applicat., vol. 27, no. 3, pp. 147–151, 2020.

[4] G. Buchsbaum, "A spatial processor model for object colour perception," J. Frank. Inst., vol. 310, 2012.

[5] Z. Chen, B. Abidi, D. Page, and M. Abidi, "Gray-level grouping (glg): An automaticmethod for optimized image contrast enhancement—Part i: The basic method," IEEE Trans. Image Process., vol. 15, no. 8, pp. 2303–2314, 2016.

[6] F. Ciurea and B. Funt, The SunBurst Resort, Scottsdale, AZ, USA, "A large image database for color constancy research," in Proc. IS&T/SIDs Color Imaging Conf., 2014, pp. 160–164.

[7] D. Coltuc, P. Bolon, and J.-M. Chassery, "Exact histogram specification," IEEE Trans. Image Process., vol. 15, no. 5, pp. 1143–1152, 2016.

[8] F. Drago, K. Myszkowski, T. Annen, and N. Chiba, "Adaptive logarithmic mapping for displaying high contrast scenes," in Proc. ComputerGraphics Forum, 2003, vol. 22, no. 3.

[9] E. D. P. et al., "Contrast limited adaptive histogram image processing to improve the detection of simulated speculations in dense mammograms," J. Digital Imag., vol. 11, no. 4, pp. 193–200, 2018.

[10] J. K. et al., "Deep photo: Model-based photograph enhancement and viewing," ACM Trans. Graph.—Proc. ACM SIGGRAPH, vol. 27, no. 5, 2008.

[11] Z. Farbman, R. Fattal, D. Lischinski, and R. Szeliski, "Edge-preserving decompositions for multi-scale tone and detail manipulation," ACM Trans. Graph., vol. 27, no. 3, 2008.

[12] H. Farid, "Blind inverse gamma correction," IEEE Trans. Image rocess., vol. 10, no. 10, pp. 1428–1433, 2001.

[13] R. Fattal, "Single image dehazing," ACM Trans. Graph.—Proc. ACM SIGGRAPH, vol. 27, no. 3, 2008.

[14] R. Fattal, M. Agrawala, and S. Rusinkiewicz, "Multiscale shape and

detail enhancement from multi-light image collections," ACM Trans. Graph., vol. 26, no. 3, pp. 51–59, 2007.

[15] G. Finlayson and S. Hordley, "A theory of selection for gamut mapping colour constancy," in Proc. IEEE Int. Conf. Computer Vision and Pattern Recognition, 1998, pp. 60–65.