International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 3s
DOI: https://doi.org/10.17762/ijritcc.v11i3s.6232
***Article Received**: 16 December 2022 **Revised**: 24 January 2023 **Accepted**: 08 February 2023*

Analysis of Image Processing Strategies Dedicated to Underwater Scenarios

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Abstract

Underwater images undergo quality degradation issues of an image, like blur image, poor contrast, non-uniform illumination etc. Therefore, to process these degraded images, image processing come into existence. In this paper, two important image processing methods namely Image restoration and Image enhancement are compared. This paper also discusses the quality measures parameters of image processing which will be helpful to see clear images.

Keywords— Underwater Images, Image restoration techniques, Image Enhancement techniques, Quality measure parameter**.**

I. INTRODUCTION

Earth is an aquatic planet and like the fact, about 70% of its surface is covered by water. Due to poor visibility conditions, the environment of the world's oceans remains not well explored. Lately, there is a strong interest in knowing more about what lies inside it. To achieve this curiosity it is absolutely necessary to use clear images. It is for this purpose underwater image enhancement and restoration techniques are used[1][2].

Due to stated difficulty, underwater imaging suffers many problems [3][5]: first, the quick attenuation of light requires attaching a light source to the vehicle providing the essential lighting. Unluckily, synthetic lights tend to illuminate the scene during a non-uniform fashion producing a bright spot within the non-solidity of the sunken vehicle affects once again image contrast the center of the image and poorly illuminated area surrounding. Then blue or green color generates between camera and scene. Thirdly because of floating particles and marine snow inside color absorption and dispersion effects increases that generates blur images. Lastly the non-solidity of the sunken vehicle affects once again image contrast[4][6].

Image restoration technique is used to recover a ruined images. To restore the original image, degradation model has been used, which can be viewed with following system [7].

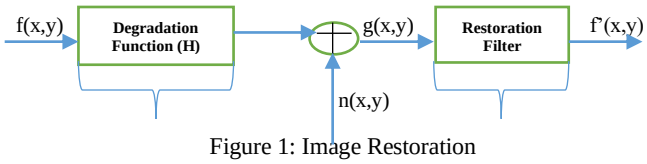

Figure 1: Image Restoration

This model is designed for 2D images, so here the original input image is f(x,y). This image is operated on h(x,y) with noise n(x,y) and generates degraded image g(x,y). After that apply image restoration method/algorithm on received degraded function g(x,y) to recover approximate image as f^(x,y)[3][7].

Image Enhancement is a process to improvement in an input image so that resultant image are more suitable for specific application.

In order to improve the image so that object can be easily identify, image restoration and image enhancement plays a vital role. In this research survey, we are studied various fundamental performance limits of image restoration and enhancement methods/ algorithms.

II. IMAGE RESTORATION TECHNIQUES

A. Median Filter

Median filter is most popular technique of filtering and best known to its tremendous noise reduction ability with its statistical method. This method calculates the pixel median and then replaces it with the median of the grey levels in the vicinity of those pixels. [7].This method removes the salt and pepper noise.

B. Linear Filter

Linear filter is widely used to eliminate noise from their input image in image processing. This filter removes salt, pepper and Gaussian noise.in this filtering, each pixel is replaced with linear combination of its neighbors. Main features of linear filters are smoothing, sharpening and edge enhancement [20].

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C. Adaptive Filter

It is a linear function that uses gray and color space to remove impulsive noise in an input image. Adaptive filter preserves edges, thin lines & it is also best in noise suppression as compare to other filters [7][20].

D. Iterative Blind Deconvolution

Iterative Blind Deconvolution has ability of anti-noising. In this process, less knowledge of degrading PSF is used for image recovery with high resolution. It is based on Fourier Transformation [20].

III. IMAGE ENHANCEMENT TECHNIQUES

In an digital era, Image Enhancement techniques has a significant part of image processing such as medical image processing, satellite image analysis, surveillance, underwater images, remote sensing, astrophotography etc.

It is broadly classified as: Spatial Domain and Frequency Domain techniques [21][22].

A. Spatial Domain Techniques

Spatial Domain techniques operate directly on the pixels in an image.

It is defined as: g(x,y) = T[f(x,y)];

Where f(x,y) : participated image

g(x,y): output Image

T: Operator to find neighborhood about a point (x,y).

This technique is easily understood & less complex. Spatial domain technique is classified into two categories [6]:

a. Point Processing Operation

b. Spatial Filter Operation

Point processing operation is used when the neighborhood is pixel itself. This method is used for contrast enhancement, whereas spatial filter operation is used to enhance the image. In this method, filtering is neighborhood operation where processed value of current pixel is depends on surrounding pixel and pixel itself.

B. Frequency Domain Techniques

This is very popular techniques, in these techniques input image first transform into frequency domain to calculate Fourier transform of given image which is most suitable form for image processing. Frequency domain techniques centered on convolution theorem. Fourier transform technique are helpful for detect noise, smooth shadows and less computational.

It is defined as: g(x,y) = h(x,y)f(x,y)];

Where f(x,y) : Input image

h(x,y) : Transferred Function

g(x,y) : Processed Image

C. Low Pass & High Pass Filtering

Filtering method is essential to amend image such as remove or highlight features of an image. Smoothing, edge enhancement and edge sharpness are the common features of filtering. Obligation of The Fourier Transform's low-frequency contents often represents the image's look across smooth areas. It can be accomplished in Fourier transform by attenuating the high frequency with cutoff frequency r_0.

$$H(u,v) = \begin{cases} 1, & \text{if } \sqrt{u^2+v^2} \le r_0 \\ 0 & \text{, if } \sqrt{u^2+v^2} > r_0 \end{cases}$$

Liability of High frequency contents in Fourier Transform are to sharp transition and edges. It can be accomplished in Fourier transform by attenuating the low frequency with cutoff frequency r_0.

$$H(u,v) = \begin{cases} 0, & \text{if } \sqrt{u^2+v^2} \le r_0 \\ 1, & \text{if } \sqrt{u^2+v^2} > r_0 \end{cases}$$

D. Popular Image Enhancement Techniques

1. Integrated Color Model (ICM)

This model features a far better human perspective than the HSI model. The HSI model could also be a model of hue, concentration, and strength. The color of the cast is reduced by first measuring all the color values. Second, the event of variance adjustment is used to extend the histogram values in red [8]. It is also made in blue and green. Third, the concentration and intensity of the HSI color sample material is used for comparative adjustment to magnify truth color and solve the lighting problem, respectively [9].

2. Adaptive Histogram Equalization

Adaptive Histogram Balancing (AHE) could also be a computer-generated image processing system, used to increase contrast in images. There are many histograms during a standard histogram equalization. They each correspond to a special neighborhood of the image. It's used to reallocate the sunshine values of the image. It's therefore appropriate to reinforce the image contrast. Contrast Limited AHE (CLAHE) varies in its variance limits with varying histogram evaluation. In CLAHE, a finite procedure is applied to each location where the transformation function is obtained. It's designed to prevent excessive noise amplification which can create variable histogram balance. Controls magnification by

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exceeding the histogram within a clip limit: a user-defined value range.

The determining level determines how consistent the noise should get on a histogram, which is why the difference should be improved [10].

3. CLAHE on RGB Color Model

Additive color class is another name for the RGB color model Here the Red, Green, and Blue lights combine in different ways to create multiple colors. R, G and B items are the appropriate nationality and number of functions of the incoming light. In the RGB color space, CLAHE is used for all three individual components and the full RGB color effect can be achieved by combining them [11].

4. Image Based Technique Using Four Filters

This method has a combination of four filters. Homomorphic filtering, frequency measurement, double test and parallel comparisons. These filters are applied to the underwater films that have been damaged in sequence.

(a) Homomorphic Filtering

Homomorphic filter is used to enhance image and eliminate repetitive sound. Sometimes it adjusts the brightness of the image and enhances the contrast. Homomorphic filters are often used for contrasting lighting in photos[14]. The brightest sample of the image format is the intensity of any pixel, which is the amount of light that is reflected by a point in an object the visual light and the display of objects in the scene.

$$I(x,y) = L(x,y)* R(x,y)$$

Where I denote the image, L refers to scene illumination and R signifies scene reflectance.

(b) Wavelet Denoising

A straightforward indirect process is thresholding. It operates on one bandwidth coefficient at a time. The coefficient is set to zero if it is below the limit; otherwise, it is kept in a modified state. A change in the frequency of the audio signal should first be considered and the block function applied to it. Finally, the output must be adjusted for the maximum bandwidth scale [12].

(c) Bilateral filtering

Bilateral filtering is an indirect filtering method used to move images. This is done with an offline combination of nearby image values. It is a filter, which saves in the end and reduces the noise of the images. The size of each pixel in the image is adjusted by the approximate estimates from the nearest pixels. This forces the pixel weight closer with different coefficients. The filter distance estimates image values of different rotting weights. The combination of domain filtering and scope is called double filtering [15].

(d) Contrast stretching and color correction

Avoiding comparisons is often referred to as normal. It is an image enhancement technique that seeks to increase image variability by "increasing" the range of excess value. Measuring each color does color correction. Colors are rarely measured in underwater images. Without considering the absorption qualities, this method blocks the Blue or Green colour. [13].

IV. Parameters Used In Image Enhancement & Restoration

Entropy: It measures information from an image which aims to describe randomness and uncertainty of an image. Entropy should be higher of an image.

Claude Shannon written a paper entitled "A mathematical theory of communication", in his paper he proposed a formula for entropy for discrete random variable X as:

$$H(X) = -\sum_{x \in X} p(X) \log p(X)$$

Different types of studies we have studied with their importance; In 1-D entropy, we have to maximize the grey levels of background and foregraound information.2-D entropy is used when we want to takes spatial correlation among pixels in an image or video. 2-D approach is also used 1-D entropy method. Whereas Non extensive entropy used for image segmentation by introduced new physical quantity [20].

Mean Square Error (MSE) & Peak Signal to Noise Ratio (PSNR): Mean Sqaure Error and Peak Signal to Noise Ratio measure the image quality.

Where Mean square error aims to compute the average of square errors which is the difference of average squared error of expected value and actual value. Typically MSE is not to be zero because of their randomness.it is derived from Euclidean distance formula.MSE can be understand as[23][24]

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(yi - yi')^2$$

Where as n is sample data, y is a observed values & $\hat{y}_i$ is a predicted values.

Peak Signal to Noise Ratio, on the other hand, uses the relationship between highest signal strength and noise to characterise image quality. Higher Peak Signal to Noise ratio gives the better generated image; it is measured in decible (dB).

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PSNR can be calculated with MSE as:

$$PSNR = 10\log_{10}(\frac{R2}{MSE})$$

Where R is higher fluctuation of the applied picture data type, such as 1 for double precision floating point or 255 for 8 bit unsigned integer data type, and MSE is mean square error.

Execution Time: Time which is spent to execution of task is execution time, generally measure in ms.

Parallelism of program, I/O bound, recursion, reusability are some affected factors of execution time. Various execution time optimization algorithms are also available to reduce the time.

Mean Average Precision (mAP): It is the average of average precision.Term Precision is used to check the accuracy of prediction of object, whereas Average Precision metric measures the object detectors accuracy with average precision value.Average Precision value must between 0 to 1.

Structural Similarity Index (SSIM): Structural Similarity index metric is a reference maric, which objective is to quantity the relationship between two predefined images, which have value between -1 to +1. Here -1 indicates that two images are different and viceversa [24]. SSIM is a advance version of Universal Image Quality Index. SSIM have three components i.e. Luminance, Contrast and Structure. Luminance is the average of all pixel values μ, Contast is to standard deviation of all pixel values σ and Structural comparison completed with following formula, here x is input image $(x - \mu x)/\sigma x$.

Features Similarity Index Matrics (FSIM): FSIM method is used to identify the similarities among two images with their features. Phase Congruency and Gradient Magnitude are two standards to understand Features Similarity Index Matrics [24].

Gradient Magnitude is a traditional method.In this method multiple convolution masks are used to calculate the gradient. On the other side, Phase Congruency is a novel approach to detect more image features.It focuses on image features in a domain frequency[18].

Underwater Image Quality Measure (UIQM): Poor contrast, blurry photos, and other issues with underwater photography have led to the development of three different underwater image quality measures: the underwater image colorfulness measure (UICM), underwater image sharpness measure (UISM), and underwater image contrast measure (UIConM) [16].

UICM, Color has attenuated according to their wavelength in the water, therefore underwater image enhancement techniques are used for better color execution.

Sharpness of image plays an important role to measure the quality; UISM provides information about border among various colortones. Blurness creates break continue sharpness of image so fristly edge detection technique has to applied in each RGB Component.

Underwater Image Contrast Measure is all about contast measure with its bright and dark part in underwater image. Low contrast value means shadows up whereas higher the value of contrast backward scatters the light[17].

Underwater Color Image Quality Evaluation (UCIQE):

UCIQE aims to measure color degredation in water due tolight attenuation and scattering.it generates quality image due to attenuation, on the other hand UIQM studies poor contrast quality[19].

Table 1
Comparison of Existing & Proposed Method

Method/Parameter	EL	CNN	RNN	Proposed Method
Accuracy (%)	91.5	93.7	94	94.2
Error rate (%)	8.5	6.3	5.8	5.8
Sensitivity (%)	91.3	93.5	94.7	94.3
Specificity (%)	91.2	92.5	90.6	90.4

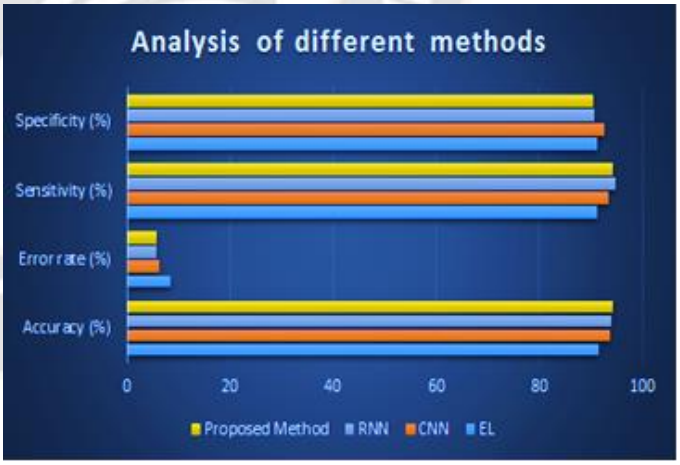

Figure 2: Analysis of Different Methods

V. CONCLUSION

This Paper show the comparison between existing approach of image processing and proposed method. Underwater images undergo quality degradation issues of an image, like blur image, poor contrast, non-uniform illumination etc. Therefore, to process these degraded images, image processing come into existence. In this paper, two important image processing

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methods namely Image restoration and Image enhancement are compared. The proposed approach is better from the existing approach on the basis of 4 parameters: Accuracy, Error Rate, Sensitivity and Specificity. Only 3 parameter of RNN method is equal to proposed method but accuracy is better.

ACKNOWLEDGMENT

I would like to prompt my special thanks and gratitude to my supervisor Dr. Yogesh Kumar Gupta for his continuous support and guidance throughout my work.

REFERENCES

[1] Sethi Rajni, "Fusion of Underwater Image Enhancement and Restoration", 2020, International Journal of Pattern Recognition and Artificial Intelligence, Vol.34 no. 3, DOI: 10.1142/S0218001420540075

[2] Han Fenglei, Yao Jingzheng, Zhu Haitao, and Wang Chunhui, "Underwater Image Processing and Object Detection Based on Deep CNN Method", 2020, Hindawi Journal of Sensors, DOI: 10.1155/2020/6707328

[3] Chiang, J. Y., & Ying-Ching Chen, "Underwater Image Enhancement by Wavelength Compensation and Dehazing" 2012, IEEE Transactions on Image Processing, Vol. 21 no.4, pp.1756-1769. DOI:10.1109/tip.2011.2179666

[4] Huimin Lu, Yujie Li, "Underwater Optical Image Processing: A Comprehensive Review", 2017, Computer Vision and Pattern Recognition, arXiv:1702.03600

[5] Anwar Saeed and Li Chongyi and Porikli Fatih, " Deep Underwater Image Enhancement", 2018, arXiv: 1807.03528v1

[6] Hu Yan, Wang Keyan, Zhao Xi, Wang Hui, Li Yunsong, "Underwater Image Restoration Based on Convolutional Neural Network. Proceedings of Machine Learning Research", 2018, pp. 296-311.

[7] Maru Monika, Parikh M, " Image Restoration Techniques : A Survey", 2017, International Journal of Computer Applications, Vol. 160, No.6, pp.15-19.

[8] Wang, Y., Zhang, J., Cao, Y., & Wang, Z. "A deep CNN method for underwater image enhancement",2017 IEEE International Conference on Image Processing (ICIP), , DOI:10.1109/icip.2017.8296508, pp. 1382–1386

[9] Kashif Iqbal, Rosalina Abdul Salam, "Underwater Image Enhancement Using an Integrated Colour Model", 2007, IAENG Vol.34, Issue 2,pp. 312-318.

[10] Duarte, A., Codevilla, F., Gaya, J. D. O., & Botelho, S. S. C. " A dataset to evaluate underwater image restoration methods", OCEANS 2016 - Shanghai. DOI:10.1109/oceansap.2016.7485524

[11] C. Li, J. Guo, R. Cong, Y. Pang and B. Wang , " Underwater Image Enhancement by Dehazing With Minimum Information Loss and Histogram Distribution Prior", 2016 *IEEE Transactions on Image Processing*, 25(12), 5664-5677, DOI: 10.1109/TIP.2016.2612882.

[12] Gao, C., Zhou, J., Liu, C., & Pu, Q., "Image enhancement based on fractional directional derivative", 2014 International Journal of Machine Learning and Cybernetics, 6(1), pp. 35–41. DOI: 10.1007/s13042-014-0247-z

[13] Peng, Y.-T., Zhao, X., & Cosman, P. C., "Single underwater image enhancement using depth estimation based on blurriness" 2015 IEEE International Conference on Image Processing (ICIP), pp. 4952-4956, DOI:10.1109/icip.2015.7351749

[14] Mustafa W, Ibrahim Zunaidi, "Image Correction Based on Homomorphic Filtering Approaches: A Study", 2018, IEEE International Conference on Computational Approach in Smart Systems Design and Applications, DOI:10.1109/ICASSDA.2018.8477634.

[15] Tomasi C., Manduchi R, "Bilateral filtering for gray and color images", 1998, IEEE Sixth International Confrence on Computer Vision, doi:10.1109/iccv.1998.710815 pp. 839-846

[16] Chau Yi Li, Riccardo Mazzon, Andrea Cavallaro, "An Online Platform for Underwater Image Quality Evaluation", 2018.

[17] Priya Sahotra and Simrandeep Singh, "Quality Measures Technique for Underwater Image Using Artificial Neural Network", Journal of Engineering and Applied Sciences vol. 13, 2018,pp. 3916-3921.

[18] Umme Sara, Morium Akter, Mohamad Shorif Uddin , "Image Quality Assessment through FSIM,SSIM,MSE and PSNR – A Comparative Study", Journal of Computer and Communication, 2019, pp. 8-18.

[19] Miao Yang, Arcot Sowmya, "An Underwater Color Image Quality Evaluation Metric", 2015, IEEE Transactions on Image Processing, Vol.24, issue 12, pp. 6062-6071.

[20] Bashir Ishfaq, Majeed Adil, "Image Restoration and the Various Restoration Techniques used in the Field of Digital Image Processing", 2017, International Journal of Computer Science and Mobile Computing, Vo.6 Issue 6, pp. 390-393

[21] Negi Shailendra, Gupta Bhumika, "Survey of Various Image Enhancement Techniques in Spatial Domain using MATLAB", 2014, International Journal of Computer Application, Vol 0975, Issue 8887, pp. 8-18.

[22] Vashisth Anshu, Sharma Rohit, "A Survey of Various Image Enhancement Methods on Different Types of Images", 2020, International Journal of Computer Science and EnGINNERING, Vol.3, Issue 2, pp. 10-14.

[23] M Manju, P. Abarna, "Peak Signal to Noise Ratio & Mean Square Error calculation for various Images using the lossless Image compression in CCSDS algorithm", 2018, International Journal of Pure and Applied Mathematics, Vol. 119, Issue 12, pp. 14471-14477.

[24] Sara Umme, Akter Morium, "Image Quality Assessment through FSIM, SSIM,MSE and PSNR- A Comparative Study", 2019, Journal of Computer and Communication, Vol.7, Issue 3.

[25] Rajput, B. S. .; Gangele, A. .; Alaria, S. K. .; Raj, A. . Design Simulation and Analysis of Deep Convolutional Neural Network Based Complex Image Classification System. ijfrcsce 2022, 8, 86-91.

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[26] M. Kumar, Pooja & S. K. A. "A Security Approach to Manage a Smart City's Image Data on Cloud," AI-Centric Smart City Ecosystems: Technologies, Design and Implementation (1st ed.), PP: 68-82, (2022). CRC Press. https://doi.org/10.1201/9781003252542.

[27] Dogiwal, Sanwta Ram, Y. S. Shishodia, Abhay Upadhyaya, Hanuman Ram, and Satish Kumar Alaria. "Image Preprocessing Methods in Image Recognition." International Journal of Computers and Distributed Systems 1, no. 3 (2012): 96-99.

[28] Vyas, S., Mukhija, M.K., Alaria, S.K. (2023). An Efficient Approach for Plant Leaf Species Identification Based on SVM and SMO and Performance Improvement. In: Kulkarni, A.J., Mirjalili, S., Udgata, S.K. (eds) Intelligent Systems and Applications. Lecture Notes in Electrical Engineering, vol 959. Springer, Singapore. https://doi.org/10.1007/978-981-19-6581-4_1