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Design and Modelling of Underwater Image Enhancement using Improved Computing Techniques

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Abstract

The underwater studies and facilities are usually inspected visually by divers manually. This strategy has disadvantages which are very evident: it is hazardous, expensive, and time-consuming and yet often does not provide a complete evaluation. The solution to avoid these issues is using sonar sensors or using cameras to capture the underwater imagery. Design of camera systems has to be robust enough to deal with waves, turbulence of water and also it has to be waterproof to avoid damage to its sensors. Such design issues have been taken care of with modern technology. But using the camera for underwater apps includes several technology-related difficulties such as camera system design, suitable lighting specifications and computer vision improvement methods. Flash light is used for compensating for the light absorbed by water medium. But such measure leads to artifacts in the images like uneven illumination, bubble effect etc . Thus, The most suitable solution to this is pre-processing the captured images with certain image processing algorithms to get a clear picture of the underwater scenery. This work show that how underwater images are formed and the issues associated with underwater images which need to be addressed while processing them.

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1. INTRODUCTION

Oceans encompass a significant portion of the surface of our world, and these water resources control how healthy our planet is. An essential component of marine research is the study of underwater flora and fauna [1]. Geo-referential surveying [5] of the ocean floor is required for underwater surveys that are used in scientific fields including archaeology [2], geology [3], underwater environmental assessment [4], and the construction of long-distance gas pipelines and communication linkages across continents. Prospecting for historic shipwrecks is another aspect of ocean exploration [6]. Thus, the science of underwater optical imaging has emerged as both an important and difficult field of study.

Marine researchers employed sonar-based technology frequently in the past to find shallow water species, wrecks, etc. Selective filtering is required because the noise and clarity problems in the pictures produced by the Sonar imaging system [7] [8] [9] are severe. Although it provides long-range visibility and effective target identification, the short-range resolution is only moderate [10]. It made things more difficult because of the surrounding noise, particularly in the sonar sub-band. Optical imaging systems have begun to gain traction since some imaging applications require excellent resolution at closer ranges. Despite having a high resolution, optical imaging still has drawbacks because of how images develop and degrade in an underwater environment.

Numerous attempts have been made to increase the clarity of underwater images using traditional haze removal methods [25]. The failure of traditional approaches is attributed to the multiplicative process that creates an image picture, making linear enhancement undesirable [26]. The lack of ground truth and reference photos is the main barrier to underwater image processing. We focus on algorithm-based haze removal of the single underwater hazy image since we lack the capacity to take several underwater photographs of the same subject [27], gated range illumination [28], or the availability of polarization cameras to record images [29]. The traditional methods of picture enhancement have been changed to fit underwater imaging [30] [31] [32]. These techniques are independent of underwater scenario physical modeling.

For creating the depth map, restoration techniques are based on statistical priors. Since the problem is poorly posed in such prior-based methods, we make certain statistical assumptions in advance. The main drawback of these techniques is that dehazing becomes challenging when a part of the picture component mimics the whiteness of the image. The selection of the ambient light value and the filter to be used to enhance the transmission map using edge-preserving smoothing filters is the second significant issue with these statistical prior based methods. In the material that follows, we'll examine a few cutting-edge prior-based algorithms.

The current methods for underwater picture enhancement and restoration, as stated above, often have one or more of the following drawbacks:

- Because using many filters in succession results in distorted output, it is necessary to provide a workable solution to this problem.
- Some of the currently used techniques fall short in their ability to dehaze photos with greater turbidity levels.
- Some methods don't greatly enhance the overall contrast.
- A few techniques, excessive color saturation, and unrealistic outcome.
- The state-of-the-art algorithms have not properly tapped into image segmentation based on non-uniform distribution of haze.
- There are several issues with computation of depth maps based on the dark channel without adjusting it to the underwater context.
- Certain techniques need knowledge of undersea variability. These approaches need periodic parameter adjustments depending on the results of experiments.

The research aims to achieve the following goals:

- To design and implement an algorithm that does not demand any underwater scene parameters beforehand.
- To address the problem of poor visibility on account of wavelength dependency of color transmission in the underwater scenario.
- To investigate the use of a suitable filter to overcome the problem of non- uniform illumination and contrast enhancement by addressing the issue of scattering of light.
- To investigate the possibility of incorporating existing color correction technique to deal with the problem of the underwater unwanted color cast.
- To evaluate the effectiveness of the proposed algorithms on underwater images and compare it with the state of the art methods.

2. LITERATURE REVIEW

Bazeille et al. proposed YUV color space based turbid underwater picture improvement utilizing a frequency domain filtering technique was suggested. One luma (Y) and two chrominance (UV) components are used to form the YUV color model. The method is made up of many separate algorithms. Using filtering based on spectral analysis, repeating wave patterns are eliminated in the first stage. Wavelet noise reduction is used after homomorphic filtering to address the issue of uneven illumination. The final image has to be rounded off while keeping the edge details. Applying anisotropic filtering achieves this. Furthermore, contrast stretching improves the image's intensity. The picture is then changed back to RGB color space, and then color normalization is applied. The output, however, is warped in terms of color accuracy in the final image.

Iqbal et al. introduced an ICM model in which the underwater picture is dynamically stretched over the whole range in RGB color space, and then contrast stretching is applied to the resulting image for the I and S components in hue intensity saturation (HIS) color space. This approach is straightforward and efficient and works best for underwater pictures with little haze. The von Kries hypothesis was used to change the red and green channels in the RGB color space, and the Unsupervised Color Model (UCM) technique was then used to adjust the contrast. The main drawback of this method is the production of significant levels of picture noise that damage the pixels in the final image and uneven augmentation that results in areas with dark regions. These regions show less information in the underlying photos. Another issue with this method is that the photos after processing still have blue-green lighting. Ghani and Isa identified this issue and found a solution by merely expanding the blue and red color channels of the murky underwater image.

Naim et.al, using a 3D rotational approach to change the underlying picture pixel distribution, reported a PDSCC technique for improving underwater image contrast. The 3D rotating matrix approach is extended by this technique. In order to fix the white reference point of a color image and make sure it is achromatic, the authors essentially use a shifting procedure on the distribution of pixels in the color image. The strategy, however, falls short of greatly enhancing the overall contrast. This system's reliance on traditional color estimate techniques like the Gray World and White Patch algorithms is another flaw. Authors in their study publication have applied the algorithms for some underwater photographs, despite the fact that they were not especially created for underwater scenarios.

Ghani et al., proposed To get over the drawbacks of ICM and UCM, devised yet another technique based on the DIRS approach. This algorithm uses a two-step process, contrast and color correction using a modified Von Kries theory, followed by global stretching of the histogram. After splitting the stretched histogram into two components, Rayleigh distribution-based histogram stretching is used. After that, an average rule is used to blend the two photos once more. The hue saturation value (HSV) color model is used to further process the resulting image.

He et al., proposed To eliminate haze from a single input picture, suggested a straightforward yet efficient image prior called a dark channel prior (DCP). The previous dark channel contains statistics of clear outdoor photos. Its foundation is the crucial finding that the majority of local patches in outdoor haze-free photos contain a few pixels with very low intensity in at least one color channel. One may directly determine the haze thickness and recover a haze-free image by using this prior in conjunction with the haze imaging model. This approach may not work if the hazy imaging model is not physically sound, as the authors have noted. However, in other circumstances, it may not be customary for the involved channels to transmit, necessitating the use of a different strategy. Many studies have used this technique to improve underwater images by calculating a rough distance map, new priors, blurriness, adaptive restoration, etc.

Chiang and Chen's WCID is an extension of the DCP approach for improving underwater image quality. The estimation parameter of the brightness for underwater photographs was changed by the authors after it was confirmed that there are specific distinctions between atmospheric images and underwater images. In order to determine the amount of artificial illumination utilized, the author divides the image into the foreground and background. The color loss is then compensated for employing energy ratios dependent on the object to camera distance. For the related water body, it makes use of predetermined scattering characteristics. However, these values fluctuate due to structure, time, and other variables, which results in insufficient haze removal and restricts its applicability for common underwater applications

Yang et al., To estimate the depth map of the picture, this approach uses the median filter rather than the soft matting procedure. Additionally, a color correcting technique is used to improve the color contrast in the underwater image. The outcomes of the experiments demonstrate how well the suggested method may improve underwater images while taking less time to execute. Additionally, this approach uses less computational resources and works well for real-time underwater navigation and surveillance. Since this technique uses DCP to create the transmission map, it encounters the same challenges as depth-based prior. Using the degree of picture blur and light absorption in an underwater environment, the DCP-based approaches' constraint of establishing an accurate transmission map is solved

3. PROPOSED METHODOLOGY

As shown in Fig. 3.1, the suggested WCID algorithm moves in the opposite direction to the underwater image generation route previously mentioned. First, take into account any potential impact and existence of the artificial light source. Next, eliminate the color fading and light scattering that happened as the signal traveled from the item to the camera. Finally, adjust the energy loss by obtaining a more accurate depth estimate for each point inside a picture to make up for the differences in wavelength attenuation for traveling through the water depth to the top of the image.

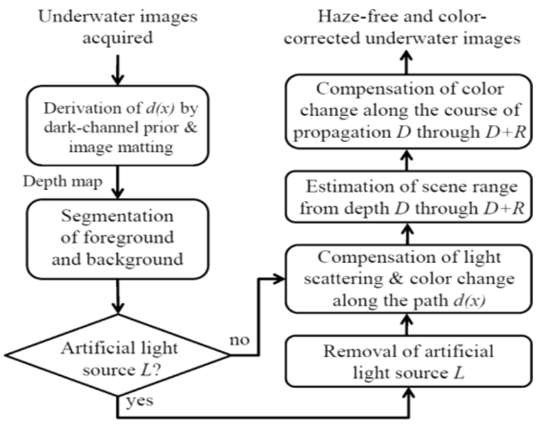


Figure 4.3: Flowchart of the WCID Algorithm Proposed

Improved Fusion Model for Underwater Image Enhancement

The underwater environment is home to numerous unique attractions, including fish and marine life, breathtaking scenery, and mystery shipwrecks. In addition to underwater photography, underwater imaging has generated significant interest in a variety of scientific and technological fields [1], including the study of marine biology [6] and archaeology [7], the inspection of underwater cables and infrastructure [2] and the detection of man-made objects [4]. In contrast to regular photographs, underwater photos have low visibility caused by the propagated light's attenuation, mostly because of absorption and scattering effects. Light energy is significantly reduced by absorption, whereas light propagation direction is altered by scattering. They cause a hazy appearance and a reduction in contrast. Overview of the method: a white-balanced version of the single input is used to create two pictures, which are then combined using a (typical) multiscale fusion technique. The uniqueness of our method rests in the pipeline that is suggested, as well as in the formulation of a white-balancing algorithm that is appropriate for our underwater improvement issue. creating mist on faraway things. Practically, in typical sea water photos, things farther away than 10 meters are nearly imperceptible, and the colors are faded because the wavelengths that make up the colors are reduced in accordance with the depth of the water. Many attempts have been made to improve the visibility of such damaged photographs. Traditional boosting methods like gamma correction and histogram equalization appear to be severely constrained for this purpose because the degradation of underwater pictures is caused by the combination of multiplicative and additive processes [8]. The issue has been addressed by customized acquisition procedures employing multiple pictures [9], specialist hardware [10], or polarization filters [11] in the earlier works that are reviewed in Section II.B. Despite their impressive successes, these tactics have a number of drawbacks that limit their potential to be used in real-world situations. In contrast, this work presents a revolutionary method for removing haze from underwater photographs using just one picture taken with a regular camera. Above method draws on the fusion of many inputs, but it derives the two inputs to merge by sharpening and adjusting the contrast of a single original input picture that has been white-balanced. The goal of the white balancing stage is to eliminate the color cast brought on by underwater light dispersion, resulting in a more realistic look of the underwater photographs. An artifact-free blending is produced by the fusion process' multi-scale implementation. The remainder of the writing is organized as follows. We offer comparisons of our white-balancing and fusion-based underwater dehazing systems' qualitative and quantitative evaluations, along with some findings concerning their applicability to solve typical computer vision issues such picture segmentation and feature matching.

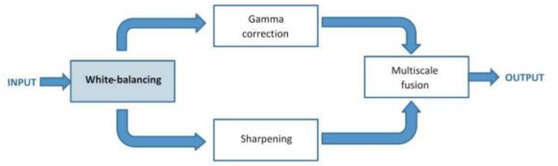


Figure 3.2: Block Diagram of Image Enhancement Using Fusion Method

Figure 3.3 shows how our two-step picture enhancement method, which combines image fusion and white balancing, enhances underwater photographs without explicitly inverting the optical model. In our method, image fusion is thought to improve the edges and features of the scene and to offset the loss of contrast produced by backscattering. White balancing tries to compensate for the color cast created by the selective absorption of colors with depth.

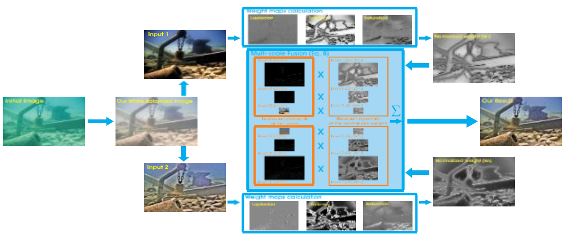


Figure 3.3: Proposed Methodology

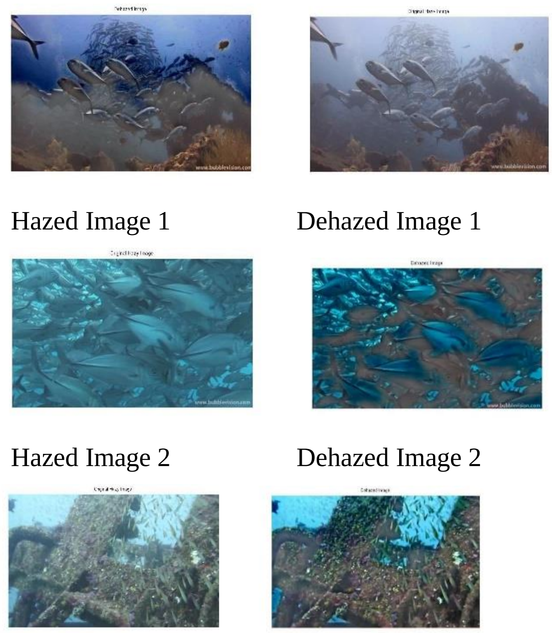
The possible artifacts caused by the weight maps' abrupt transitions are reduced by individually using a fusion method at each scale level. The human visual system, which is particularly sensitive to abrupt transitions appearing in smooth picture patterns but considerably less sensitive to variations/artifacts happening on edges and textures, is what drives multi-scale fusion (masking phenomenon). The multiscale process may, interestingly, be represented by a computationally effective and aesthetically pleasing single-scale approach, according to new research. When complexity is a problem, this single scale approximation should obviously be promoted because it also makes the multi resolution process a spatially confined method.

4. RESULT ANALYSIS

We compare those methods with our suggested white-balancing strategy in Fig. 4.1. The perceptual CI ELab color space, where L is the luminance, an is the color on a green-red scale, and b is the color on a blue-yellow scale, is a better representation of color differences. By using methods like CIE76 and CIE94, which essentially calculate the Euclidean distance between any two colors in CI ELab, one may approximate the relative perceptual differences between them. CIEDE2000 is a more intricate yet accurate color difference measure that addresses the perceived uniformity problem of CIE76 and CIE94. CIEDE2000 produces values between [0,100], with lower values denoting minor color changes and values less than 1 denoting differences that are visually invisible.

Underwater Dehazing Evaluation

The suggested method was tested using actual underwater photos and films from diverse collections of amateur and professional photographers that were taken with different cameras and equipment. Keep in mind that we only analyze 8-bit data formats, therefore our validation applies to typical entry-level cameras.



Hazed Image 1 Dehazed Image 1

Hazed Image 2 Dehazed Image 2

Hazed Image 3 Dehazed Image 3

Figure 4.1: Dehazing by Proposed Algorithm

The outcomes of numerous recent (underwater) dehazing techniques are shown in Fig. 4.2 for 10 underwater photos. The corresponding quantitative evaluation using the three most recent measures, PCQI, UCIQE, and UIQM. The UCIQE and UIQM measures are specifically designed for evaluating underwater images, while PCQI is a general-purpose image contrast statistic. While UIQM covers three crucial underwater image quality criteria: colorfulness, sharpness, and contrast, UCIQE was created expressly to quantify the nonuniform color cast, blurring, and poor contrast that characterize underwater photos.As can be observed, the new method outperforms our prior method in terms of both contrast and color augmentation.

To round up our visual evaluation, Fig. 4.3 contrasts our work with the three most current methods developed by Lu et al. [31],

Figure 4.2: Relative Comparison of Proposed Algorithm

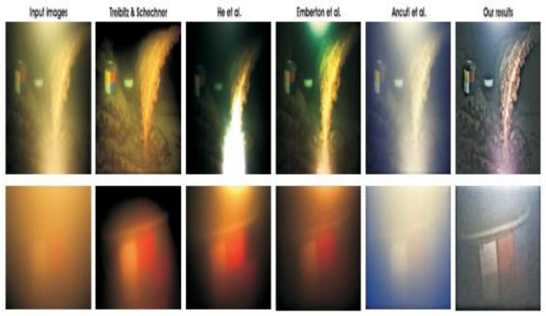
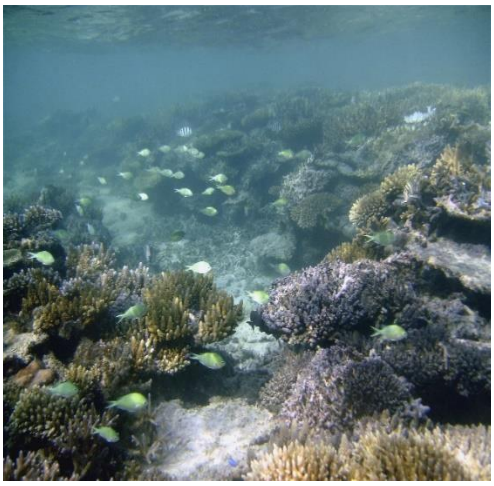


Figure 4.3: Dehazing Comparison by Proposed Algorithm

Figure 5.3 examines the extreme situations in which photographs captured in turbid water seem yellowish as a result of a substantial attenuation of the blue channel. Red attenuation compensation for these photos seems insufficient. Intriguingly, we see that adding the blue component to the color correction considerably enhances the augmented photos.

Figure 4.4: Sample Image-1 for Analysis

Figure 4.5: Sample Image-2 for Analysis



(a)

(b)

Figure 4.6: Sample Image- 3 and 4 for Analysis

Overall, we draw the conclusion that our method typically produces acceptable perceptual quality, with notable improvement of the global contrast, the color, and the fine details of the picture structure. The two primary drawbacks are I color restoration is not always possible, and (ii) some haze is still present, especially in areas of the picture that are far from the camera. Those restrictions are quite modest, especially in light of earlier works.Performance Evaluation Parameters for Input Image l Input Methods are listed in Table 5.1.

Table 4.1

Performance Evaluation Parameters for Input Image l

Input	Methods	PSNR	MSE
Image 1	AHE	15.12	199.8
	CLARE	9.77	6840
	Gamma	25.84	172.512
	DCP	28.62	99.15
	Proposed	58.64	0.023

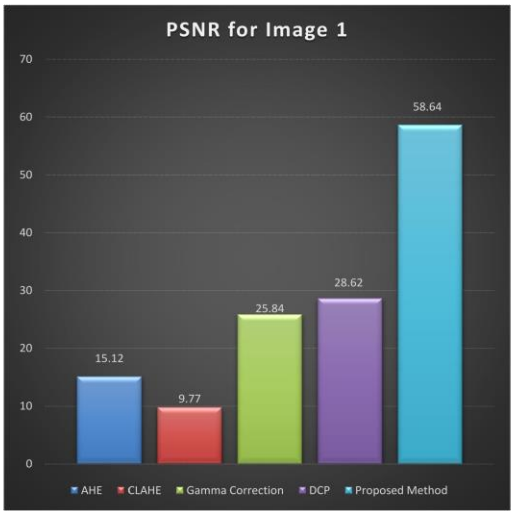


Figure 4.7: Performance Evaluation Chart for Input Image l

In order to separate pictures into distinct and similar sections based on certain properties, segmentation is used (e.g. texture, color). In this study, we use the geodesic active contours approach known as the G AC ++ segmentation algorithm (variation PDE). It demonstrates that when segmentation is performed to photos that have been processed using our method, the results are more consistent. One of the core functions of many computer vision programs is the matching of local feature points. We calculate key points using the SIFT operator, and we compare the matching and computing procedures for a pair of underwater photographs to the equivalent pair of images improved by our technique. In both instances, we apply the original SIFT implementation in the exact same manner. The encouraging results shown in Fig show that our strategy considerably enhances the frequency of matched pairs of important spots by boosting the global contrast and the local characteristics in underwater photos.

5. CONCLUSION AND FUTURE SCOPE

Conclusion

This study's major goal was to investigate the necessity for improving the method of underwater picture enhancement by combining WCID with wavelet processing. The quality of underwater photos may be increased in terms of contrast, brightness, and visibility in low resolution images by utilizing image enhancement techniques, according to the literature already in print. The contrast adjustment, color modification, and edge concentration are amplified in this work using a developed approach termed WCID in addition to the wavelet discrete transform. The DWT method is used to effectively segment the pictures taken underwater. By removing the hazing effect brought on by color dispersion, the WCID algorithm successfully maintains the higher image quality. MATLAB was used as a simulation tool to carry out the simulation study. It is evident from the output pictures that the suggested system manages the colour caste mechanism better than other traditional image enhancement approaches including AHE, CLAHE, Gamma Correction, and DCP. It was also mentioned that the wavelet transformation represented the signals with a high degree of sparsity. Three important elements were evaluated using the suggested enhancement technique: color correction, contrast enhancement, and improvement of the PSNR (peak signal-to-noise ratio) and MSE (mean squared error) values. We've provided a different method for enhancing underwater recordings and photos. The single original image is all that is needed for our method, which is based on the fusion concept. In our experiments, we've demonstrated that our method can accurately improve a wide range of underwater photographs (shot with various cameras, at various depths, and under various lighting circumstances), recovering key fading edges and features. Additionally, for the first time, we show the value and applicability of the suggested picture enhancement method for a number of difficult underwater computer vision applications.

Future Scope

The WCID and the wavelet transformation approach are employed in the suggested study for this paper. To produce better and more precise results, this approach may be applied to ongoing studies in the deep ocean. This planned effort may be expanded to include the identification of locations that have been underwater for years owing to natural causes.

The study plans to use improved deep learning-based image enhancement techniques as part of ongoing research and aims to take into account a variety of advanced performance metrics for assessing the efficiency of the image enhancement technique.

The goal of this research's future work is to combine a variety of additional approaches to improve underwater image quality. Future research will concentrate on expanding the dehazed portion of the algorithm to enhance underwater video quality and make it relevant to other industries like medicine and remote sensing.

REFERENCES

[1.] O. Pizarro and H. Singh, "Towards large area mosaicing for underwater scientific applications," IEEE Journal of Oceanic Engineering, vol. 28, no. 4, pp. 651-672, 2003.

[2.] R. Eustice, H. Singh, J. J. Leonard and M. R. Walter, "Visually mapping the RMS Titanic: Conservative covariance estimates for slam information filters," The International Journal of Robotics Research, vol. 25, no. 12, pp. 1223-1242, 2006.

[3.] J. Escartin, R. Garcia, O. Delaunoy, J. Ferrer, N. Gracias, A. Elibol, X. Cufi, L. Neumann, D. J. Fornari, S. E. Humphris and J. Renard, "Globally alligned photomosaic of the lucky strike hydrothermal vent field," Geochemistry, Geophysics and Geosystems, 9 December 2008.

[4.] A. C. Gleason, D. Lirman, D. Williams, N. Gracias , B. E. Gintert, H. Madjidi, R. Pamela, B. G. Chris, S. Negahdaripour, M. Miller and P. Kramer, "Documenting hurricane impacts on coral reefs using two dimensional video-mosaic technology," Marine Ecology, vol. 28, no. 2, pp. 254-258, 2007.

[5.] Z. Zhu, E. Riseman, A. Hanson and H. Schultz, "An efficient method for geo-referenced video mosaicing for environmental modelling," Machine Vision and Applications, vol. 16, no. 4, pp. 203-216, 2005.

[6.] P. Drap, D. Scaradozzi, P. Gambogi and F. Gauch, "Underwater photogrammetry for archaeology- The venus project framework," in GRAPP, 2008.

[7.] P. Gervenka and C. Moustier, "Post-processing and corrections of bathymetry derived from sidescan sonar systems: Application with SeaMARC II," IEEE Journal of Oceanic Engineering, vol. 19, no. 4, pp. 619-629, 1994.

[8.] D. R. Yoerger, M. Jakuba, A. M. Bradley and B. Bingham, "Techniques for deep sea near bottom survey using an autonomous underwater vehicle," Journal of Robotics Research, vol. 26, no. 1, pp. 41-54, 2007.

[9.] E. Anderson, "Analysis of sonar and underwater camera images," Thesis of Chalmers University of Technology, Sweden, 2010.

[10.] D. M. Kocak, F. R. Dalglcish, F. M. Caimi and Y. Y. Schechner, "A focus on recent developments and trends in underwater imaging," Marine Technology Society Journal, vol. 42, no. 1, pp. 52-67, 2008

[11.] N. Robertson-Brown, Underwater photography: Art and techniques, Wiltshire: The Crowood Press Limited, 2014

[12.] J. R. Zaneveld and W. Pegau, "Robust underwater visibility parameter," Optics Express, vol. 11, no. 23, pp. 2997-3009, 2003

[13.] R. Schettini and S. Corchs, "Underwater image processing: State of the art of restoration and image enhancement methods," EURASIP

Journal of Advances in Signal Prrocessing, vol. 2010, no. 1, pp. 1-14, 2010.
[14.] E. Trucco and A. T. Olmos-Antillon, "Self-tuning underwater image restoration," IEEE Journal of Oceanic Engineering, vol. 31, no. 2, pp. 511-519, 2006.
[15.] J. S. Jaffe, "Computer modelling and the design of optimal underwater imaging systems," IEEE Journal of Oceanic Engineering, vol. 15, no. 2, pp. 101-111, 1990.
[16.] T. C. Aysun and E. Sarp, "Visual enhancement of underwater images using empirical mode decomposition," Expert Systems with Applications, vol. 39, no. 1, pp. 800-805, 2012.
[17.] D. Akkanayak, T. Treibitz, T. Shlesinger, R. Tamir, Y. Loya and D. Iluz, "What is the space of attenuation coefficients in underwater computer vision?," in In Proceedings of IEEE Conference in Computer Vision and Pattern Recognition, 2016.
[18.] G. Bianco, M. Muzzupappa, F. Bruno, R. Garcia and L. Neumann, "A new color correction method for underwater imaging," in Underwater 3D Recording and Modelling, Piano di Sorrento, Italy, 2015.
[19.] L. Abril, T. Mendez and G. Dudek, "Color correction of underwater images for aquatic robot inspection," in LNCS, 2005, pp. 60-73.
[20.] E. O. Hulburt, "Optics of distilled and natural water," Journal of the Optical Society of America, vol. 35, pp. 689-705, 1945.
[21.] E. J. McCartney, Optics of atmosphere: scattering by molecules and particles, New York: John Wiley and Sons, 1976, pp. 23-32.
[22.] B. L. McGlamery, "A computer model for underwater camera systems," in Proceedings of SPIE Ocean Optics, 1979
[23.] S. Q. Duntley, "Light in the sea," Journal of the Optical Society of America, vol. 53, no. 2, pp. 214-233, 1963.
[24.] W. W. Hou, "A simple underwater imaging model," Optics Letters, vol. 34, no. 17, pp. 2688-2690, 2009.
[25.] H. Lu, Y. Li, Y. Zhang, M. Chen, S. Serikawa and H. Kim, "Underwater optical image processing: A comprehensive review," Mobile Network applications, Springer, vol. 2010, pp. 1-14, 2017.
[26.] C. Ancuti, C. Ancuti, T. Haber and P. Bekaert, "Enhancing underwater images and videos by fusion," in Proceedings of IEEE Conference on Computer Vision and Pattern Recognition, Providence, RI, USA , 2012.
[27.] S. G. Narasimhan and S. K. Nayar, "Contrast restoration of weather degraded images," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 25, no. 6, pp. 713-724, 2003.
[28.] D. M. He and G. L. Seet, "Divergent beam lidar imaging in turbid water," Optics and Lasers in Engineering, vol. 41, no. 1, pp. 217-231, 2004.
[29.] Y. Schechner and Y. Averbuch, "Regularized image recovery in scattering media," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 29, no. 9, pp. 1655-1660, 2007.
[30.] R. Garcia, T. Nicosevici and X. Cufi, "On the way to solve lighting problems in underwater imaging," in Proceedings of the MTS/IEEE Oceans Conference, 2002.
[31.] A. Rizzi, C. Gatta and D. Marini, "A new algorithm for unsupervised global and local color correction," Pattern Recognition Letters, vol. 24, no. 11, pp. 1663-1677, 2003.
[32.] M. Chambah, A. Renouf, D. Semani, A. Courtellemont and A. Rizzi, "Underwater color constancy: Enhancement of automatic live fish recognition," in Color Imaging IX: Processing, Hardcopy, and Applications, San Jose, California, United States, 2004.
[33.] S. Bazeille, I. Quidu, L. Jaulin and J. P. Malkasse, "Automatic underwater image processing," in Proceedings of the Caracterisation Du Milieu Marin, 2006.
[34.] K. Iqbal, A. Salam, R. Osman, M. Azam and T. A. Zawawi, "Underwater image enhancement using an integrated colour model," IAENG International Journal of Computer Science, vol. 34, no. 2, pp. 239-244, 2007.
[35.] K. Iqbal, M. Odetayo, A. James, R. A. Salam and A. Z. Talib, "Enhancing the low quality images using unsupervised color correction methods," in IEEE International Conference on Systems Man and Cybernetics, Istanbul, 2010.
[36.] A. S. Ghani and N. A. Isa, "Underwater image quality enhancement through integrated color model with Rayleigh distribution," Appllied Soft Computing, vol. 27, pp. 332-344, 2015.
[37.] M. N. Naim and N. A. Isa, "Pixel distribution shifting color correction for digital color images.," Applied Soft Computing, vol. 12, no. 9, pp. 2948- 2962, 2012.
[38.] A. Ghani and N. Isa, "Underwater image quality enhancement through composition of dual-intensity images and Rayleigh stetching," SprigerPlus, vol. 3, no. 757, pp. 1-14, 2014.
[39.] H. Lu, Y. Li, S. Nakashima, H. Kim and S. Serikawa, "Underwater image super-resolution by descattering and fusion.," IEEE Access: Special section on emotion aware mobile computing, vol. 5, pp. 670-679, 2017.
[40.] X. Fu, P. Zhuang, Y. Huang, Y. Liao, X. P. Zhang and X. Ding, "A retinex-based enhancing approach for single underwater

image," in IEEE International Conference on Image Processing (ICIP), Paris, 2014.

[41.] A. N. Ponce-Hinestroza, L. A. Torres-Méndez and P. Drews, "A statistical learning approach for underwater color restoration with adaptive training based on visual attention," in OCEANS 2016 MTS/IEEE , Monterey, 2016.

[42.] K. He, J. Sun and X. Tang, "Single image haze removal using dark channel prior," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 32, no. 12, pp. 2341-2353, 2011.

[43.] N. Carlevaris-Bianco, A. Mohan and R. M. Eustice, "Initial results in underwater single image dehazing," in IEEE International Conference on Oceans, 2010.

[44.] Y. T. Peng, X. Zhao and P. C. Cosman, "Single underwater image enhancement using depth estimation based on blurriness," in IEEE International Conference on Image Processing (ICIP), Quebec City, 2015.

[45.] J. K. Guo, C. C. Sung and H. H. Chang, "Improving visibility and fidelity of underwater images using an adaptive restoration algorithm," in IEEE OCEANS, Taipei, 2014

[46.] 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.

[47.] S. K. A, "A New Palm Print Recognition Approach by Using PCA & Gabor Filter", *International Journal on Future Revolution in Computer Science & Communication Engineering*, Vol-4, Issue-4 *(2018)*, 38–45.