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Underwater Image Enhancement using HOG and SIFT Method

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Abstract*: Capturing underwater images can be considered as form of art and collecting data of underwater environment which plays major role in the field of marine biology research, marine zoology and ecology study. It also plays a significant role in scientific missions such as analyzing marine life species, taking census of population and monitoring underwater biological environment. Underwater imaging also offers many other attractions such as aquatic plants and animals, different types and species of fishes, shipwrecks, coral reef and beautiful landscapes. But the captured images lack contrast and are hazy due to absorption and scattering. Thus the quality of the image gets deteriorated. The degraded underwater images can be enhanced using different methods. This research work proposed the white balancing technique and image blending process to improve the degraded images. The image blending can be done using the methods of feature matching. The features can be matched using HOG and SIFT methods. The proposed technique is implemented in MATLAB and results are analyzed in the terms of PSNR and MSE.

Index Terms*: HOG, Image Fusion, MSE, PSNR, SIFT, Underwater images.

I. INTRODUCTION

For the past few years, the introduction of the digital cameras have led to the craze of colored images and it has now become a necessity as the objects or the information in them is useful because of its clarity, color contrast and good appearance. But when we talk about the underwater images, the images which are captured underwater or clicked underwater lack the color contrast, its appearance is foggy or misty, objects appear blurred and overall image have haziness in them [1]. The reason behind its distorted color and contrast degradation is absorption and scattering of light. As the person goes deep inside the water to capture the image there is no source of light, the colors starts getting absorbed as the color with the longest wavelength is absorbed first and similarly for other colors as per wavelength spectrum. This results in the poor visibility and gives a degraded image. Another reason of image deterioration is scattering of light that occurs due to random deviation of the light rays which are on the way back to the lens of camera and due to flash used in clicking the picture that is an artificial light which gets reflected back after hitting the particles of water.

Thus both the factors become a major reason of underwater image degradation which lacks contrast and color combinations are distorted in them making their appearance blurry and dull [2]. As underwater images plays an important role in marine biology research, archeology, scientific missions like monitoring the aquatic life including plants and animals, underwater biological and ecological system. To preserve the marine life as few species of aquatic animals and plants are getting extinct, underwater imaging is a main source of capturing and recording the data [3]. So these underwater images or aquatic images needs to be enhanced, restored and needs improvement to acquire the useful information from them. In such cases the digital image processing has made a huge contribution in the correction of digital images which are degraded or has poor visibility using different image processing techniques [4, 5] such as image acquisition, image fusion [4], image preprocessing, morphological operations [6, 7] and many others which are less expensive and also time consuming. This research work presents the approach in which underwater images can be enhanced and preserved using white balancing technique and image fusion with HOG (histogram of oriented gradients) and SIFT (scale invariant feature transform) based methods of digital image processing. HOG method is basically the method used for object detection and a feature descriptor using computer vision and image processing. SIFT method is feature description algorithm used to detect and locate the features in image for its improvement in computer vision. Our approach used this method to extract the important objects and features in the image. The approach works in the two steps strategy, first one is the white balancing of the image which will use the gray world algorithm to enhance the contrast of the image and then the input image which is white balanced will provide two input images. The first input image is gamma corrected and second input image is sharpened. Then both the inputs are blended together as single input image on which further HOG and SIFT methods are applied to extract the features with clear and sharp fine edges. The image with better color contrast, sharpened features, preserved edges and haze-free images are obtained in the output. Our technique have given the best possible results. In the below given Fig. 1 the simple block diagram of underwater enhancement technique is shown. The technique used in this paper is implemented in the MATLAB and the results analyzed in the terms of PSNR (peak signal to noise ratio) and MSE (mean square error).

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Further the paper is presented in another two sections. In the second section, literature survey is presented and in third section the research methodology is explained of the proposed technique.

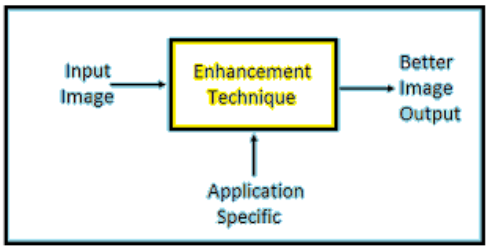

Fig. 1 Underwater image enhancement process block diagram.

II. LITERATURE REVIEW

Codruta O. Ancuti, et.al presented an efficient approach for the image enhancement. These images were taken in underwater condition and dishonored because of the average dispersion and amalgamation. The proposed approach was considered an individual picture mechanism and did not need particular hardware or information about the underwater situations or sight arrangement. The proposed technique was developed on the amalgamation of two descriptions [8]. These images were taken from a shade salaried and white-balanced description of the genuine tainted picture in a direct manner. The fusion of two pictures and their connected mass maps were described for the promotion of edges transferring and shade difference to the yield picture. A multistage fusion plan was adopted for avoiding the creation of objects in the low frequency mechanism of the rebuild picture by the sharp weight map changeover. Various widespread qualitative and quantitative assessments revealed that obtained improved descriptions and videos were differentiated through exposedness of the dim areas, enhanced inclusive difference, and boundaries unevenness. The corroboration also proved that the proposed algorithm was sensibly autonomous of the camera surroundings, and improved the correctness of numerous picture dispensation operations just like picture sectioning and input end corresponding. Amjad Khan, et.al utilized the wavelet-based fusion approach for the enhancement of hazy underwater descriptions by means of shade and dissimilarity. Because of some effects of the underwater medium, the pictures taken in water were misty. The balanced element directed these effects and led to the amalgamation and dispersion of brightness throughout the picture configuration procedure [9]. The underwater standard was not found gracious for information imaging and caused low distinction and faded shade concerns. Thus, the imaging data must be enhanced before auxiliary dispensation during any picture based investigation and scrutiny commotion. The openly obtainable misty underwater descriptions were improved and investigated in a qualitative manner along with several state of the art techniques. The capable outcomes were demonstrated by the quantitative research of picture attribute. The subjective outcomes depicted that the projected technique enhanced the eminence of the misty underwater descriptions. The perceptible study indicated that picture eminence was preserved as well. as future work, a inclusive proportional research will be executed on the basis of state of the art processes for perceptible scrutiny in association with the projected technique. Atif Anwer, et.al presented the particulars and recital of a graphical consumer boundary constructed for Kinect v2. The GUI was considered a modified execution of the Kinect synthesis structure and incorporated underwater camera assessment, noise sieving, flight correction time period [10]. The refraction alteration sifts were built for the adaptation of Kinect Fusion for 3D scene renovation in an underwater surroundings. In the presented work, particulars of the client boundary and the consequence of different sub-functions and supplementary alteration filters on the presentation of Kinect Fusion reconstruction were described as well. The presentation study confirmed that the sight renewal outline rate could be enhanced from the existing 10-15 frames per second to even 20+ fps. The reimbursements of multi-threaded coding were gathered and perhaps even faster if GPU calculations such as CUDA were utilized. The proposed approach utilized a commercial time of flight camera like Microsoft Kinect v2 which was practicable for near-real time deepness measurement in underwater surroundings. Ritu Singh, et.al executed a fusion technique on the basis of solitary foggy picture for strengthen the superiority of tainted underwater descriptions [11]. It was identified that a high-quality selection of keys and heaviness procedures were necessary for the improvement of the misty underwater picture's clarity. The efficiency of the improvement process was upgraded with the help of a strapping synthesis method that incorporated necessary characteristics from every picture. The tested outcomes demonstrated that the projected underwater demisting technique always produced satisfactory and enhanced results for all the analysis descriptions. The proposed approach also provided dehazy descriptions with reinstated excellence. As future work, this research study can be extended for the enhancement of underwater images with a development in calculation complication. Ahmad Shahrizan Abdul Ghani, et.al proposed an improved approach for disparity and visibility enhancement for deep sea underwater picture. This approach was particularly utilized for underwater robot [12]. The projected approach used a hybrid technique of improved backdrop sieving and wavelet fusion techniques (EBFWF) [13]. The freshness of this approach was laid in its method and ability of the projected technique for minimizing the negative underwater consequences like blue and green shade sheds, low difference, and low clarity in contrast with supplementary state-of-the-art schemes. Therefore the proposed approach improved the contrast and clarity of underwater picture. The main objective of this approach was the attainment of an improved stage for entity recognition and acknowledgment procedures. The tested outcomes demonstrated that the projected EBFWF approach was proved more efficient and important for the enhancement of the entire underwater picture excellence. The obtained pictures were processed with the help of projected technique. This approach could also be used for discovery and acknowledgment for the extraction of supplementary precious data.

III. RESEARCH METHODOLOGY

This research work is related to underwater image enhancement using the methods of white balancing and image fusion.

The white balancing can be done using the low frequency components equalization and SIFT algorithm is applied for the feature matching for the image fusion. To improve image contrast, PCIQ and UCIQE the technique of Hog transformation can be applied alongside with the SIFT algorithm. The phases of the proposed method are explained below:-

A. Input image

The input image is taken as input as shown in the Fig. 2 which needs to enhanced in terms of contrast and color adjustments. The image contains haze in it which needs to be removed. The input image is a blur image and have foggy appearance in which objects are not clear and needs improvement to obtain the useful information out of it with its enhanced version. The image enhancement is done in two phases. First phase includes white balancing technique and second phase includes image fusion with HOG and SIFT methods.

Fig. 2 Underwater input image

B. White Balancing

In the first phase, the white balancing technique is used which will remove the red artifacts or loss of color caused due to the absorption in underwater. As we go down deep

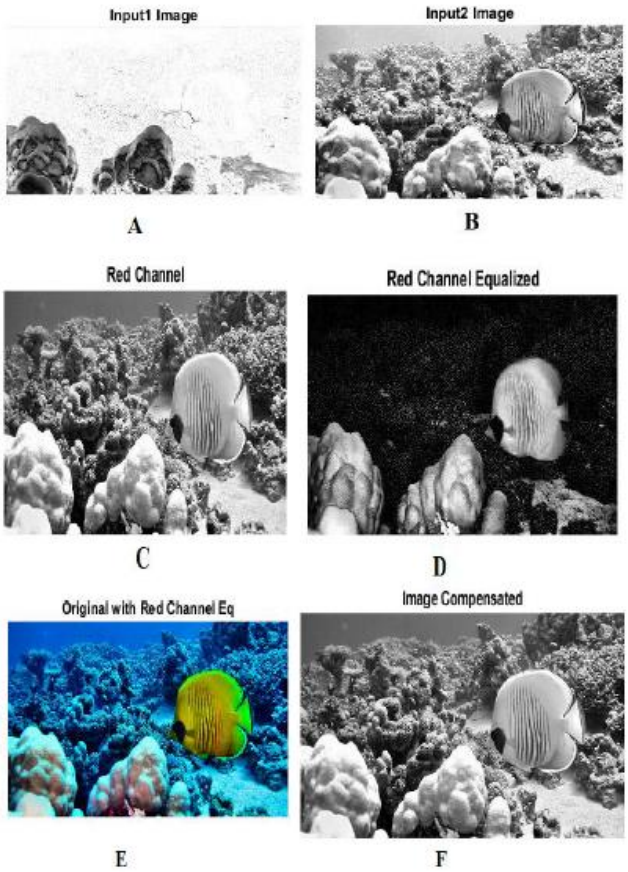

Fig. 3 The white balancing approach in the proposed methodology.

(A) First input image. (B) Second input image. (C) Red Channel in the image. (D) Red Channel equalized image. (E) Original image with red channel equalized. (F) Image Compensated.

in the water the color with longest wavelength will get absorbed first and will have noticeable loss of that color. So red having the longest wavelength will get absorbed first and similarly followed by other colors. The low frequency components of the input image are calculated. The low frequency components are the red components which are equalized with equalization method. In this step the Gray world algorithm (GWA) will be used for white balancing approach. After applying this approach the red artifacts will be corrected and color will be balanced. The lost information of image can be recovered using this approach. Also in the region where aquatic plants are found more often in high concentration or where water is cloudy or opaque blue color also have chance of getting attenuated and blue color loss may occur in the images which can also be corrected by gray world algorithm as it is best method to enhance the image and restore the color contrast in the images. After obtaining the color contrast in the images is not enough so we will extract the sharper edges and other features in the third phase that is image fusion. The white balancing approach is explained in the Fig. 3 as shown.

C. Image Fusion

In the second phase, the process of blending takes place with the feature matching. As shown in the Fig. 4, in this phase, the HOG (histogram of oriented gradients) transformation and SIFT (scale invariant feature transform) methods are applied for the feature matching and object detection in the images. Both the methods are used in feature describing of the images. The SIFT algorithm is applied to locate the local features and describe them so that the image gets enhanced well.

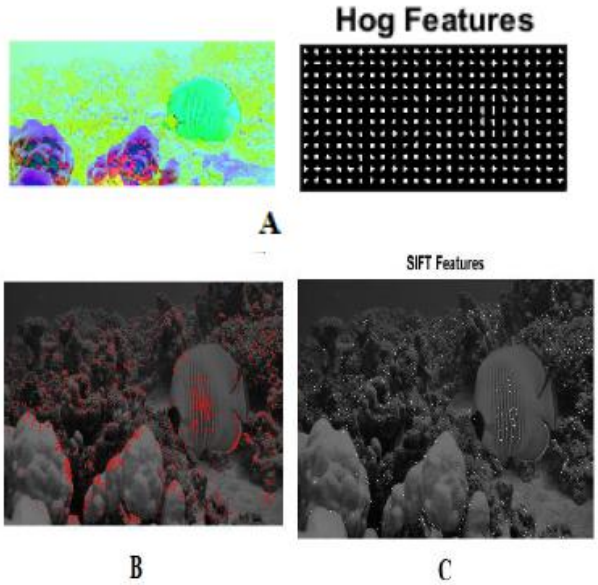

Fig. 4 Image fusion process. (A) HOG Transformation. (B) Extracted features marked. (C) SIFT method applied on the image.

The white balanced image which gives us two inputs, the first input image is gamma corrected that increases its global contrast and second input is sharpened. Both the inputs are blended together.

When the blending process get completed, the final enhanced image get created which will be of good quality. In this HOG filtering is used in which a filter is present that is the combination of both range and domain filtering and hence denote the combined filter as it computes the filter output at a pixel as a weighted average of neighboring pixels and also it smoothens the image while preserving edges. Due to this property, it has been widely used in noise reduction, HDR compression and multi-scale detail abstraction. Bilateral filtering makes a nonlinear combination of similar pixel values and it filters the image using range and domain filter. For domain filtering, values chosen show the desired amount of combination of pixels, while the range filtering chooses values based on the desired amount of low pass filtering. HOG filter can eliminate the noise point and keep the characters of edges. Therefore this filter is a proper method to solve the halation problem.

The flowchart for proposed methodology is given below in the Fig. 5 showing the steps for enhancement of the underwater images.

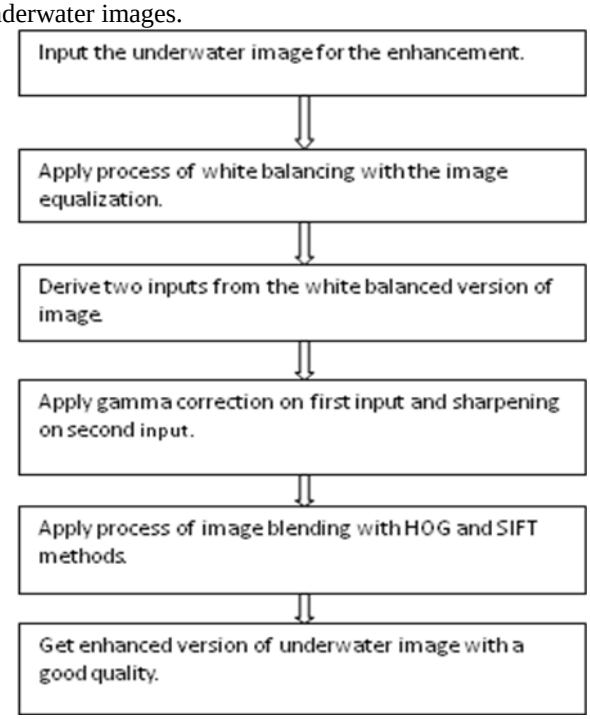

Fig. 5 Flowchart for proposed methodology

IV. RESULT AND DISCUSSION

The proposed approach enhances the underwater captured image which can be seen in the final output image obtained. The lack of color contrast and haziness present in the image is improved as shown in the Fig. 6. The proposed methodology is implemented in MATLAB. The HOG transformation and SIFT method is applied for the underwater image fusion which used their feature matching and object locating properties to recognize the objects and locate them making the image look brighter, clear and visible. The overall contrast of the image is increased and the desired result is obtained in the terms of the PSNR and MSE. The performance of the method used to enhance the images have given the result with increased PSNR value and decreased MSE values. The final results obtained are discussed further with the help of graph and in the tabular form and also compared with the previous approach.

Fig.6 Final output underwater image after applying HOG and SIFT method with better color contrast and good quality.

As shown in Fig. 7, the graphical representation of PSNR analysis of proposed algorithm is compared to the existing algorithm. Thus it is analyzed that proposed approach gives the better performance.

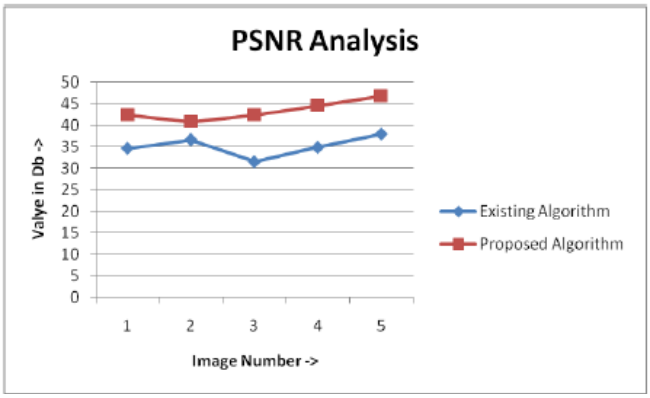

Fig. 7 PSNR analysis

Table. I PSNR analysis

Image Number	Existing Algorithm	Proposed Algorithm
1	35	42
2	37	40
3	32	43
4	35	45
5	39	46

In the Table. I the values for peak signal to noise ratio is obtained for each image that has undergone the process of the implemented method and give better results from the previous algorithm. The above obtained values gives the clear difference between the performance of the previous approach and the proposed one. The parameter PSNR is used to measure the quality of reconstructed images or the enhanced images. And using this approach the PSNR value have increased for each image. Comparison of MSE analysis for proposed and previous approach is represented in the graphical form as shown in the Fig. 8. The result obtained in the terms of MSE describes the squared error between the original image and the enhanced image which is used to check the quality of an image. The mean square error value of the proposed algorithm decreases and the error rate is also decreased which gives the good performance. Hence, obtaining the improved result.

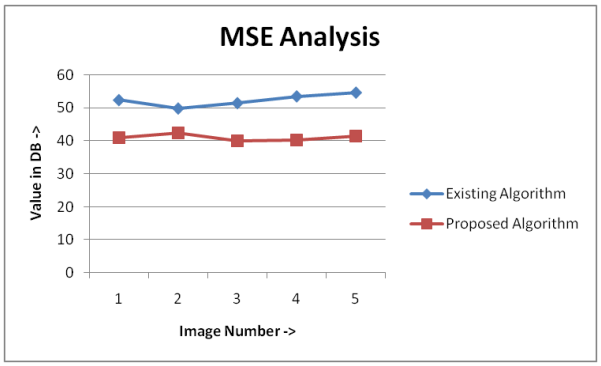

Fig. 8 MSE analysis

In the Table. II the values for MSE of existing and the proposed algorithm are analyzed and compared in the tabular form for each image. The MSE is the error between the original image and the enhanced image which needs to be decreased as the image contains the information which is required and after its enhancement it should be retained along with the important components in it. By this approach we are able to get the required information which was lost due to the factors of lights that are absorption and scattering. Thus obtaining the better version of the original image.

Table. II MSE analysis

Image Number	Existing Algorithm	Proposed Algorithm
1	52	41
2	50	43
3	51	40
4	53	40
5	55	42

Finally the desired results are obtained in the terms of PSNR and MSE that are both used as error metrics to check the quality and performance of the image enhancement methods. This approach is able to achieve overall good performance in the terms of error metrics used to measure the image's quality as well as its ability to retain the lost information providing it a better version with adjusted color contrast, improving its background, making the object look more clearer, brighter with the sharpened edges and making them haze-free.

V. CONCLUSION

The underwater images lack color contrast and appear dull or misty due to factors of light that is absorption and scattering. Due to which the quality of an image also gets degrade and objects in the images are unrecognizable. The images need to be enhanced and improved which can give us the better version of the original image captured underwater which can be done using image processing techniques. As implemented in our approach the white balancing technique and image fusion with HOG and SIFT methods are used to obtain the image with its better version. First input image using white balancing will remove the red color loss occurred due to the absorption of the colors underwater and will improve the color contrast and adjust the colors of the image. The white balanced image will give two inputs out of which first input is gamma corrected and second one is sharpened. Both the inputs are fused together and give the fused single output image. The HOG and SIFT methods are used to extract the features and objects in the image. The HOG method is used to detect the objects and SIFT algorithm is applied to locate the features in the image. Thus the proposed method gives improved result in the terms of PSNR and MSE. As the peak signal to noise ratio of the implemented method increased and the mean square error gets decreased thus increasing the overall performance of the method up to 5 to 8 percent.

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