NOVEL FOR UNDERWATER IMAGE ENHANCEMENT BY TOTAL VARIATION WITH GRASS HOPPER OPTIMIZATION

Mr. ANIL KUMAR KAUSHAL[1] Ms. ANUDEEP GORAYA [2]
[1, 2] ELECTRONIC AND COMMUNICATION ENGINEERING
RAYAT INSTITUTE OF ENGINEERING AND INFORMATION TECHNOLOGY
INDIA

Abstract- **A novel pre-processing filter is proposed for the process of underwater image restoration. Because of specific transmission properties of light in the water, underwater image suffers from limited range, non-uniform lighting, low contrast, colour diminished, and blur. Today, the methods of pre-processing typically concentrates on non-uniform lighting or colour correction and often require additional knowledge of environment. The algorithm proposed in this paper is an automatic algorithm for pre-processing of underwater images. It reduces underwater perturbations, and improves the quality of image. It is composed of several successive independent processing steps which help in correction of non-uniform illumination, suppresses noise, enhances contrast and adjust colours. Performances of filtering will be assessed using a robust criterion of edge detection. Underwater images suffer from poor visibility conditions because of medium scattering, light distortion, and inhomogeneous illumination. This results in large image stitching techniques to fail when they are applied to underwater images. In this work, a proposed grasshopper base optimization method is used which finds the noise variance and takes the input from total variation method which further reduces the blurriness and noise based on the concept of noise variance. This method is not provided with any kind of static input, it will vary according to image blurriness and noise. The experiment shows a great significance of proposed approach using the parameters of PSNR and MSE. As a result, PSNR improves and MSE gets reduced significantly as compared to existing approaches.**

Keywords- Under water imaging, Grass hopper optimization, spatial domain, frequency domain.

I. INTRODUCTION

In last few years, underwater imaging is an interesting area of research for the researchers. The reason behind this is that underwater images are used in different fields as well as existing systems [1]. This field includes discovery of objects in the water and image analysis to identify the targets submerged in a liquid. This type of research is helpful for the underwater exploration and defence applications. In this type of studies various approaches of image processing is used for image enhancement. Various domain techniques in digital image processing

- Spatial domain: In this technique, we directly deal with the signal or image matrix to produce an output image. The pixel values changes with respect to scene. A direct manipulation of pixels is performed in an image. It is used for smoothing filters, sharpening filters, un-sharp masking and laplacian.
- Frequency domain: Unlike spatial, this technique analyses signal with respect to frequency. The image is transformed to its frequency distribution. The output of this processing is a transformation rather than an image. An inverse transformation is performed to produce an image which, in result, is viewed in spatial domain.
- Time domain: It is continuous, infinite domain. In this the measurement is a function of time. One axis that plots the signal is time while the other is amplitude that gives time-amplitude representation of signal as an output.
- Temporal domain: It is ratio or relative interval between the events which contains information about the distance between events relative to the distance between other events rather than the frequency and sequence.

Image Enhancement: It is a process of enhancing the image quality by manipulating the image such that the resultant image is more suitable than original forgiven application. It makes use of various filters for altering or manipulating images. It can be used for contrast enhancement, increasing/ decreasing intensity pixels as per requirement [3][7].

1.1 Underwater Image Enhancement

It is the process of enhancing image quality underwater by de-noising. Underwater images are categorized by their poor visibility due to the light attenuation inside the water, which results in images with low brightness and low contrast Therefore, processing of such images is needed to improve the quality and to retrieve the information. Major work has been done in Image Color Correction and Image Enhancement to improve the quality of image. Digital image processing is a broad subject who includes the complex mathematical functions and procedures but it is very simple idea for images [1][4][9]. The main aim of DIP is to understand the information, interpret the images. This process is implemented in many areas of science and engineering. Underwater images are affected by illumination, external noise and temperature fluctuations. Visibility restoration is a process which belongs to reduce of removes the deterioration or degradation of images that have occurred due to relative camera motion, mis-focus of camera and atmospheric condition etc. In this part we are discussing on degradation occurred due to bad weather and in Haze weather conditions. Degradation in images also occurred due to scattering of light before reaching the camera due to large amount of suspended particles present in the water [2] [3]. This thing affects the monitoring system and smart transportation system. Scattering is occurred due to basic phenomena like attenuation and air light. Removal of Haze of fog from the image improves the robustness and stability of the visual system. It is a difficult task because fog depends upon unknown scene depth map information. Fog effect is the result of distance between camera and object. Hence removal of fog requires the estimation of air light map or depth map. The current haze removal method can be divided into two categories: (a) image enhancement and (b) image restoration. This method can enhance the contrast of haze image but loses some of the information about image [9].

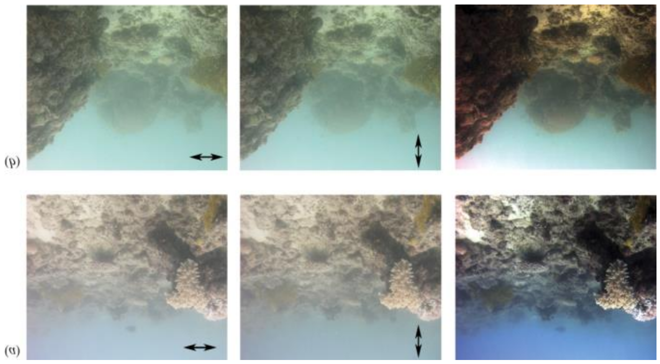

Figure 1: Visibility Restoration

Visibility Restoration Technique for removing haze, fog from the image various techniques are used. Typical techniques of image restoration to the haze are:

1.2 Dark Channel Prior

This techniques is used to estimate the atmospheric light in the dehaze image to get the real result. It is mostly used in non-sky patches, in one color channel have very low intensity at few pixels. The low intensity in the dark channel is predominant because of three components:

- Colorful items or surfaces
- Shadows(shadows of car, buildings etc)
- Dark items or surfaces(dark tree trunk, stone)

While the outdoor images are generally filled with shadows the dark channels of images will undoubtedly be really dark. Because of fog (airlight), a foggy image is brighter than its image without fog. So we are able to dark channel of foggy image may have higher intensity in region with higher fog. So, visually the intensity of dark channel is really a rough estimation of the thickness of fog. In dark channel prior we use pre and post processing steps to get good results. In post processing steps we use soft matting or trilateral filtering etc.

1.3 CLAHE

Contrast limited adaptive histogram equalization short form is CLAHE (Xu, Zhiyuan et al, 2009). CLAHE is used for enhancement of low contrast images. It does not require any predicted weather information for processing of fogged images. Firstly, the image captured by the camera in foggy condition is converted from RGB (red, green and blue) color space is converted to HSV (hue, saturation and value) color space. The images are converted because the human sense colors similarly as HSV represent colors.

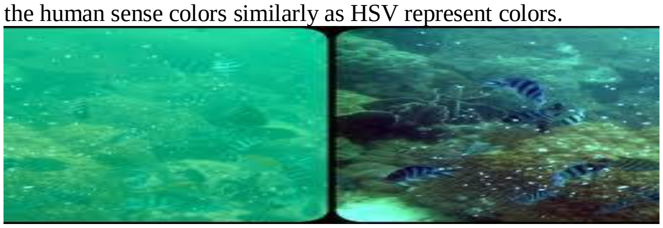

Figure 2: CLAHE Effect

1.4 Bilateral Filtering

Bilateral Filtering is used for the edge smoothening and preserves the edges with non-linear combination of nearby values. This filtering is non-linear, simple and local. Gray levels or colors are combined by the bilateral filter based on both their geometric closeness and their photometric similar, and prefers close values to distant values in both domain and range. Bilateral filter smooth edges towards piecewise constant solutions. Bilateral filter does not provide stronger noise reduction [10, 11]. Figure (3) illustrates the processing of foggy image and establishment of it into original image by using bilateral filter.

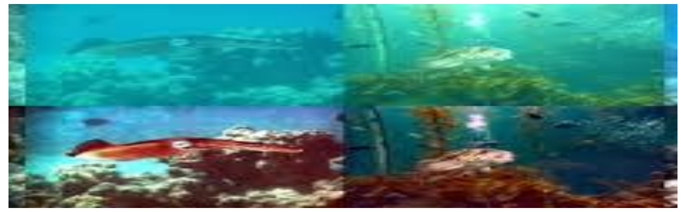

Figure 3: Bilateral Filtering

1.3 MIX-CLAHE

The presented method to enhance underwater images using a mixture Contrast Limited Adaptive Histogram Equalization. The enhancement method effectively improves the visibility of underwater images and produces the lowest MSE and the highest PSNR values. Thus, it has shown that the mix-CLAHE based method is promising for classifying coral reefs especially when visual cues are visible.

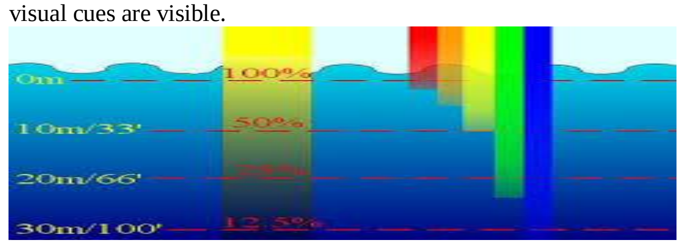

Figure 4: Absorption of light By Water

Figure: 4 shows an illustration about the absorption of light by water. For every 10m increase in depth the brightness of sunlight will drop by half. Nearly all red light is gone by 50% from the surface but blue continues to great depth. That is why most underwater images are dominated by blue-green coloration.

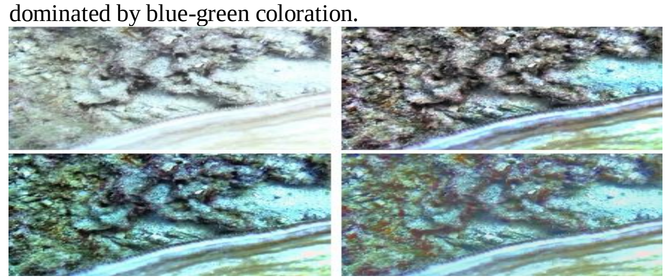

Figure 5: Comparison of CLAHE method on B2

CLAHE-Mix first normalizes the result of CLAHE-RGB. Figure: illustrates the results of CLAHE technique operating on RGB and HSV color models and the result of Mix-CLAHE operating on Image. As can be seen from the figure, when CLAHE operated on RGB color model, it corrupts the human sense of color. A more logical approach is to spread the color values uniformly, leaving the colors themselves (e.g., hues) unchanged. The result from CLAHE-HSV shows that the overall color is more sensible than CLAHE-RGB. However, the overall image is much brighter and looks unnatural to image. Moreover, the unavoidable enhancement of noise in smooth regions is identified. To reduce the undesired artifacts as well as brightness in CLAHE RGB and CLAHE HSV images we introduce a new method which mixes the results of CLAHE-RGB and CLAHE-HSV. The method is called CLAHE-Mix. The aim is to enhance the image contrast and at the same time preserve the natural look of underwater image.

1.6 Trilateral Filtering

This filtering smooth's images without influencing edges, by means of a non-linear combination of nearby image values. In this filter replaces each pixel by weighted averages of its neighbour's pixel. The weight allotted to each neighbor pixel decreases with both the distance in the image plane and the distance on the intensity axis. This filter helps us to get result faster as compare to other. While using trilateral filter we use pre-processing and post processing steps for better results. Histogram stretching is used as post-processing and histogram equalization as a pre-processing.

1.7 Underwater Visibility Estimation & Image Enhancement

The goal of this research is to allow real-time enhancement of underwater images which are naturally lit and degraded due to relatively high turbidity and other visibility reducing phenomena. Enhancement of underwater images requires modelling and estimation of the water absorption and scattering characteristics to remove haze [12]. However it also requires a scene depth map. Many papers use a single image and the dark channel prior in the estimation of a depth map. In our approach, we use stereo images in a two-stage enhancement process to improve overall image quality allowing visibility and range estimation [5] [6].

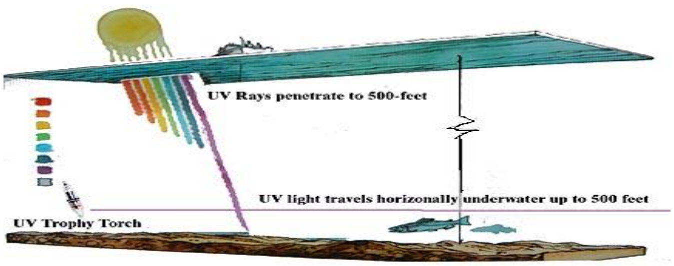

Figure 6: Underwater Light Model

Underwater Light Propagation Modelling Underwater light models generally follow a standard attenuation model [8] to accommodate wavelength attenuation coefficients. In this study the Koschmieder Model was adopted which has been established as a description of the atmospheric effects of weather on the observer. In outdoor clear weather conditions, the radiance from a scene point would reach the observer nearly unaltered. However when imaging underwater the irradiance observed by each pixel of the camera (E) is linear combination of directly transmitted scene object radiance that will be attenuated in the line of sight and scattered ambient light towards the observer as depicted in Figure 1.6. Water splitting is an important reaction that can be used to harvest and store solar energy. In nature, the process produces reactive protons, building up a concentration gradient to power dark reactions which turn CO_2 to organic molecules. In laboratories, a simplified version of the reaction has been conceived to produce O_2 and H_2, the latter promising a solution to problems caused by the combustion of fossil fuels. In a variation, artificial CO_2 reduction can in principle be powered by sunlight to produce solar fuels. Although the detailed chemical mechanisms of these reactions vary, they share the same key features of harvesting solar energy and storing it in chemicals. Essential components necessary to enable the conversion include an antenna to absorb photons and to produce excited electrons, a mechanism to physically move the excited electrons away from the site where they are generated, and an efficient catalyst to drive chemical reactions selectively. Because of the existence of a band gap and the typical band bending formed when in contact with an electrolyte, semiconductors are good candidates for solar water splitting or CO_2 photoreduction. Other appealing aspects of using semiconductors for solar fuel for an underwater image, the radiance of the scene point attenuates exponentially with the propagating distance, according to Beer–Lambert law. The light attenuation in water is caused mainly by absorption and scattering. From red to violet, the wavelength becomes shorter gradually. According to the selective absorption of water, visible light is absorbed at the longest wavelength first. So red light is much easier to be absorbed than shorter wavelengths such as the blue and green. On the other hand, based on Rayleigh scattering theory, scattering intensity is inversely proportional to the fourth power of wavelength, so that shorter wavelengths of violet and blue light will scatter much more than the longer wave-lengths of yellow and especially red light [4].

II. RELATED WORK

Ancuti, Codruta O., et al. [1] in this paper, the author proposed color balance and fusion for under water image enhancement. This method is proposed on single image and not required any additional hardware. In this associate weight maps are used to transfer the edges and color contrast to output image. Artifacts are created in low frequency component of reconstructed images. This method improves the global contrast, edges sharpness and reduced dark regions. Huang, Dongmei, et al. [2] in this paper, the author proposed relative global histogram stretching for water image enhancement approach. This approach consists of two parts that are color correction and contrast correction. In contrast correction method RGB color space is used and redistributes each RGB channel histogram. These dynamic parameters are related to intensity distribution of original image and wavelength attenuation of different color underwater. To reduce the noise from the image bi-lateral filtering is used and enhances the local information of shallow water image. Li, Chongyi, et al. [3] under water image enhancement is done by image color correction method which is based on weakly supervised color transfer. This approach solved the problem of color distortion. In this approach multi-term loss function is used for measure adversial loss, similarity index measure loss, and cycle consistency loss. The results of the proposed approach are better in image enhancement and it improves the performance of vision tasks. Hu, Haofeng, et al. [4] underwater images are degraded by scattering of light and noise in the water. In this work polarization information is used which has efficiency to improve the quality of image in scattering medium. Non-uniform optical field image recovery method is proposed in this paper. This method enhances the quality of image and gives better performance from existing method. Lu, Huimin, et al. [5] The approach proposed in this paper is used to solve the problem of underwater depth map estimation problems that are occurring in low intensity of light. This problem is solved by using deep neural network by depth estimation. The results of the proposed approach outperforms and effective. Ao, Jun, et al. [6] in Underwater images the physical properties of water lead to attenuation of light which travel through water channel. This generates the low contrast and color cast in images. In this paper the author proposed the combination of two approaches that are Adaptive linear stretch method to improve the image quality at low cost at the same time. Threshold id reduced from the histogram by using adaptable threshold. This method reduces the color cast and enhances the image contrast. The computation consumption is low in the proposed method. Han, Min, et al. [7] Underwater imaging is done to explore the underwater image environment. These images are used for microscopic detection, mine detection, telecommunication cables, and underwater vehicles. These images are disrupted by noise, color distortion and scattering of light which causes blurness and greenish tone. Underwater image enhancement is divided into two methods that are image dehazing and image color restoration. This paper presented a detailed survey of the approaches and methods that used in underwater image enhancement and summary on underwater image processing methods. Jain, Rakshit, et al. [8] in this paper the author works on the underwater wireless sensor networks. This network faces some issues like packet loss, battery and propagation delay. The sensor that are deployed in water called mobile and the main challenge in them are data packets. Various protocols are proposed for the reliable and safe data transfer but that are not fully reliable. Robust and efficient Routing protocol is proposed in this paper for static communication between two nodes in UWSN. It assigns the rank to each node for effective communication routing path. This protocol enhanced the packet delivery ratio. Walter, Nishit, et al. [9] in this paper the author works on the underwater wireless sensor networks. The proposed method solves the mobility issue in the nodes present underwater. The author proposed 3 dimensional image enhancement approach named as KRUSH-D. This approach solves the mobility issue and maintains communication network at the same time. It uses Kruskal Algorithm for path selection and Euclidean distance method for distance measurement. This method provides a reliable communication network in underwater. Zhang, Shu, et al. [10] Underwater image enhancement is attractive research area due to the degradation occurred by scattering and absorption of light. In this paper, the author proposed Retinex method which is a combination from retina and cortex. This method uses bi-lateratel and tri-lateral filters for the images. Performance evaluation of the proposed method is done by comparing with existing method. Chang, Cheng-Hao, et al. [11] in this paper, the author design and implement a low-cost guided image filter for underwater image enhancement. This method is based on TSMC and CMOS technology and operates on high power to support full HD image enhancement. It provides high throughput and effective frame rate.

Emberton, et al. [12] underwater image and video dehazing is done by using Haze region segmentation approach. It improves the visibility in images and videos by detecting and segmenting image regions. Illuminant elimination is done by using white balancing approach. This method reduces the color cast and enhances the image contrast. The computation consumption is low in the proposed method. Perez, Javier, et al. [13] the approach proposed in this paper is used to solve the problem of underwater depth map estimation problems that are occurring in low intensity of light. This problem is solved by using deep neural network by depth estimation. The results of the proposed approach outperforms and effective.

III. THE PROPOSED METHOD

3.1 Proposed Methodology

Various steps of proposed methodology are presented below:

Step 1: Input the Image.
Step 2: Pre-processed the image and removes the noise data from it.
Step 3: Apply convolution Process on image.
Step 4: After convolution low dimension matrix is produced.
Step 5: Initialize the grass hopper algorithm.
Step 6: Search local and global best by grass hopper.
Step 7: Check the output is optimized or not if optimized the go to Step 8 otherwise go to step 4.
Step 8: Calculate the total variation.
Step 9: Analyse the PSNR and MSE of the Image.

3.2 Proposed methodology: Flowchart

3.3 Proposed Algorithm

IV. RESULT ANALYSIS

4.1 Result Analysis

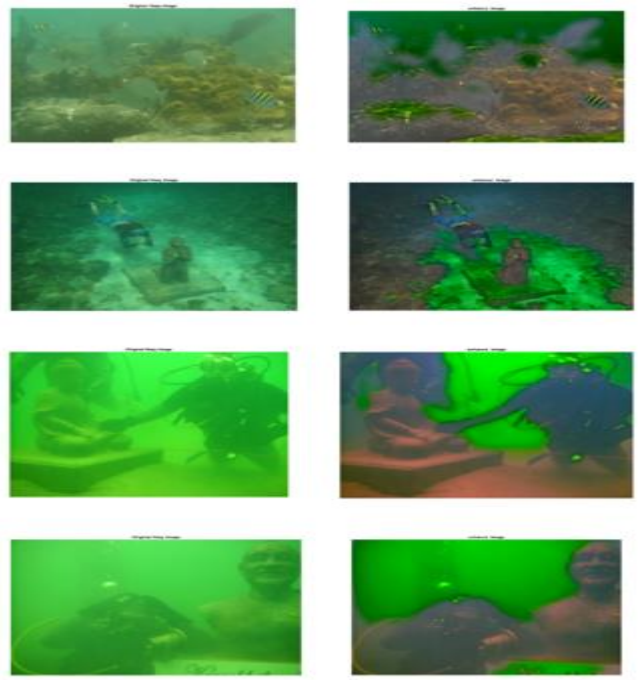

Figure 7: Existing Approach Before and After images

Figure 8: Proposed Approach Before and After images

Table 1 Images based on PSNR/MSE

Image No.	PSNR	MSE
Image 1	39.13	30.45
Image 2	32.13	32.13
Image 3	30.13	50.13
Image 4	26.13	57.23
Image 5	25.25	58.23

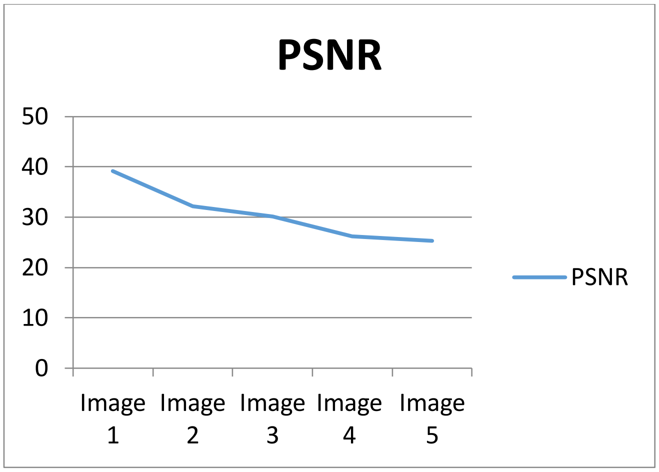

Figure 9: Graph of PSNR of proposed results

Figure 9 depicts the PSNR value of the five images in the proposed approach. In this Image 1 has PSNR value 39.13 which is highest and image 5 has 25.25 which is lowest among the all images which are undergone in this experiment.

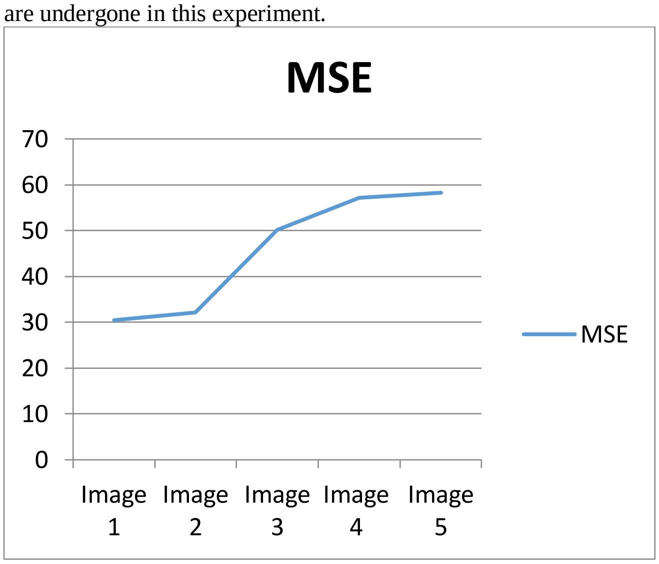

Figure 10: Graph of MSE of proposed results

Figure 10 depicts the MSE value of the five images in the proposed approach. In this Image 5 has MSE value 58.23 which is highest and

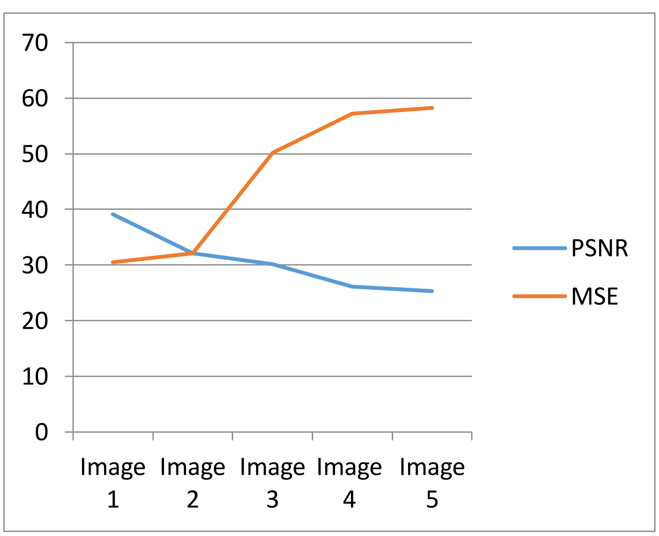

image 1 has 30.45 which is lowest among the all images which are undergone in this experiment.

Figure 11: Graph of PSNR and MSE of proposed method

Figure 11 demonstrate the value of PSNR and MSE of five images in the proposed method. This graph shows two lines in which red line indicates the MSE value of images and blue line indicates the PSNR of the images. The position of lines changes according to the variation in the results.

Table 2 Comparison of existing and proposed results

Image No.	PSNR Existing	PSNR Proposed	MSE Existing	MSE Proposed
Image 1	32.13	39.13	45.13	30.45
Image 2	30.23	32.13	52.23	32.13
Image 3	29.13	30.13	61.23	50.13
Image 4	20.45	26.13	70.45	57.23
Image 5	20.13	25.25	71.65	58.23

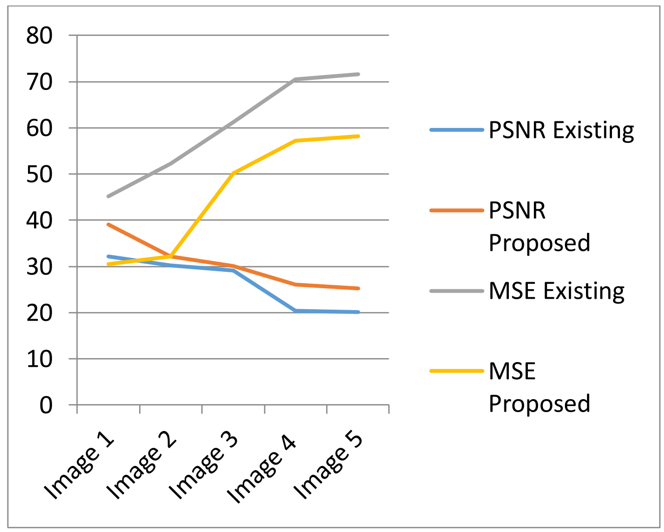

Figure 12 Graph of PSNR and MSE of proposed method and existing method.

Figure 12 depicts the comparison between the PSNR and MSE of the proposed work and existing work. In this blue line shows the existing PSNR, red line shows the PSNR proposed, green line shows the MSE existing and purple line represents the MSE proposed of the images.

IV CONCLUSION

This paper analysis the impact of optimization-based approach over total variation performance and its effect on under water image enhancement. Under water image enhancement depends on blurriness and noise present in image. The proposed approach detects this part in a dynamic way and tries to reduce by total variation approach. The proposed experimental approach is applied over some of the images and it presents the effect on PSNR and MSE values. The results indicate that the PSNR and MSE values of the proposed approach represents a quite significant improvement sd desired by the system.

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