Under water image enhancement by convolution using hybridization of gravitational search with genetic algorithm with Total variation

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Abstract-In this thesis work a novel image enhancement approach is formulated which enhanced the Grey Wolf Optimization algorithm with genetic algorithm by finding color cast using Total Variation method and then removing the color cast by optimizing the correction method using Grey wolf optimization (GWO_GA). The quality of underwater images is improved by using proposed approach which finds the intensity of color cast instead of assuming it. Computed results have enhanced visual details, contrast and color performance. In experiment five different images are used and show the results on two parameters PSNR which represent the quality of image and MSE represents the difference between original and enhanced image. These parameters compare on total variation method (existing) Total variation with grey wolf optimization (GWO_GA).

Keywords—*GWO,under water imaging:dhazing:optimization.*

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. 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 defense 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.

A. 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.

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. 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. 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].

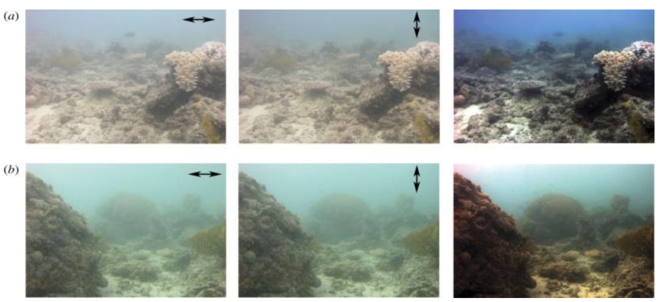


Fig.1: Visibility Restoration

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

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:

a) Colorful items or surfaces
b) Shadows(shadows of car, buildings etc)
c) 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 (air-light), 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 et

B. CLAHE

Contrast limited adaptive histogram equalization short form is CLAHE (Xu, Zhiyuan et al, 2009). CLAHEis 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.

Fig.2: CLAHE Effect

C. 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. Figure (1.3) illustrates the processing of foggy image and establishment of it into original image by using bilateral filter.

Fig.3: Bilateral Filtering

D.MIX-CLAHE:

This 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.

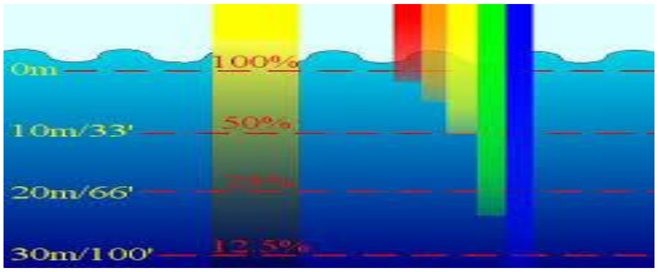


Fig.4: Absorption of light By Water

Fig.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.

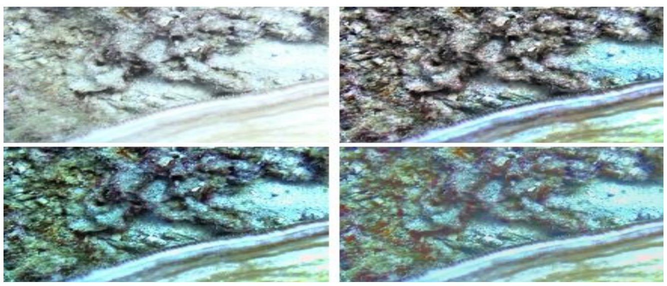


Fig.5: Comparison of CLAHE method on B2

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.

E. 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 alloted 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.

F. 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. 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.

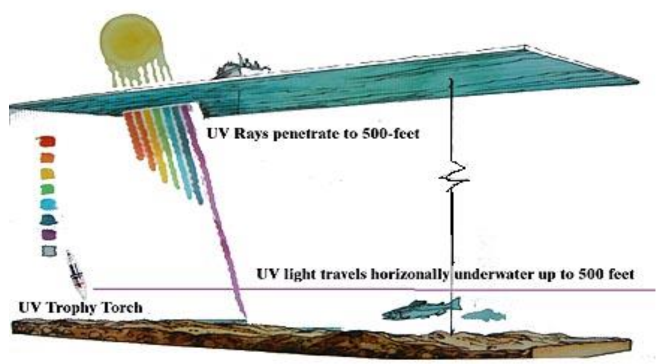


Fig.6: Underwater Light Model

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 Fig.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 CO2 photo reduction. 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].

G. Underwater Degradation

A major difficulty to process underwater images comes from light attenuation. Light attenuation limits the visibility distance, at about twenty meters in clear water and five meters or less in turbid water. The light attenuation process is caused by the absorption (which removes light energy) and scattering (which changes the direction of light path). Absorption and scattering effects are due to the water itself and to other components such as dissolved organic matter or small observable floating particles. Dealing with this difficulty, underwater imaging faces to many problems. First the rapid attenuation of light requires attaching a light source to the vehicle providing the necessary lighting. Unfortunately, artificial lights tend to illuminate the scene in a non-uniform fashion producing a bright spot in the center of the image and poorly illuminated area surrounding.Then the distance between the camera and the scene usually induced prominent blue or green color (the wavelength corresponding to the red color disappears in only few meters). Then, the floating particles highly variable in kind and concentration, increase absorption and scattering effects: they blur image features (forward scattering), modify colors and produce bright artifacts known as “marine snow. At last the non-stability of the underwater

vehicle affects once again image contrast. Our preprocessing filter has been assessed on natural underwater images with and without additional synthetic underwater degradations as proposed in. Underwater perturbations we added are typical perturbations observed and they have been tested with varying degrees of severity. We simulate blur and unequal illumination using Jaffe and McGlamery’s model, Gaussian and particles noise as additive contributions to the images and finally reduced color range by histogram operation.

II. IMAGE ENHANCEMENT: HISTOGRAM EQUALIZATION

A general framework based on histogram equalization for image contrast enhancement is presented in many literatures [1-3]. In this framework, contrast enhancement is posed as an optimization problem that minimizes a cost function. They introduced specifically designed penalty terms, the contrast enhancement level can be adjusted; white or black stretching, noise robustness and mean-brightness preservation may easily be incorporated into the optimization. Analytic solutions for some important criteria are presented along with a low-complexity algorithm for contrast enhancement was presented, and its performance was demonstrated against a recently proposed method. These frameworks [6] employs carefully designed penalty terms to adjust the various aspects of contrast enhancement. Hence, the contrast of the image/video can be improved without introducing visual artefacts that decrease the visual quality of an image and cause it to have an unnatural look [2].

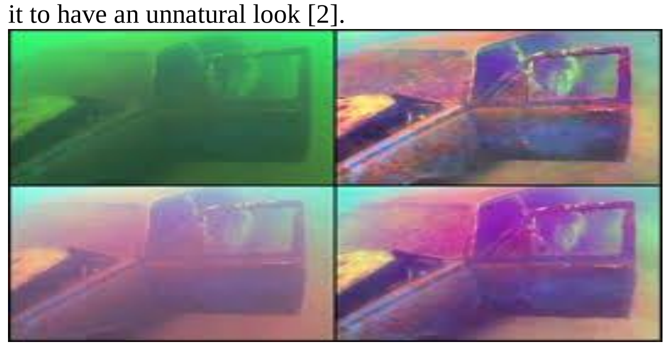


Fig.7: Histogram equalization

It is found that image enhancement is one of the most important issues in low-level image processing. In some algorithm basically enhancement methods were classified into two classes: global and local methods. In such work the multi-peak generalized histogram equalization is proposed. [2] The global HE is improved by using multi-peak histogram equalization combined with local information. These enhancement methods are based either on local information or on global information. Such approach used both local and global information to enhance image. This method adopts the traits of existing methods. It also makes the degree of the enhancement completely controllable.

III. RELATED WORK

Chang, Cheng-Hao, et al. [1] 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. [2] 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. [3] 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. Wang, Yafei, et al. [4] Underwater image enhancement is done by using wavelet decomposition. In frequency domain fusion based strategy is applied. This fusion process gives two inputs that are color corrected and contrast enhanced images which are extracted from the original underwater image. These images are divided into low and high frequency component by wavelet operator. Average weight is given to the low frequency for fusion and high frequency component by Multi-scale fusion process. Rajendran, Rahul, et al. [5] 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. Peng, Yan-Tsung et al. [6] underwater image restoration is done on image blurriness and light absorption. In this paper, the author proposed depth estimation method for this work. Images are restored and enhanced by using Image Formation Model. It also estimates the maximum intensity of prior and dark channel prior. The depth of underwater scenes is estimated accurately by this method. Zhu, Yue, et al. [7] Image segmentation of underwater images is done in this paper by using co-saliency and local statistical active contour model. Co-saliency is detected by using cluster-based algorithm; it highlights the silent region of the image. Segmentation of the image is done by using region-based level set method. The proposed method of segmentation provides efficiency and quality of underwater images. Ghani, et al. [8] introduced a technique for contrast and visibility improvement in underwater images. Basically it is an integrated approach of enhanced background filtering and wavelet fusion methods. This approach minimizes the negative effects of color cast and low cast. It also improves the visibility and contrast of the image. It provides an effective way for detection and recognition process. Before removing the low frequency background image is sharpened it minimizes the noise from the image. Histograms are mapped to reduce the gap between inferior and dominant color channels after this wavelet fusion is applied. The result of the proposed is more effective and improves the image quality. Erat, Ozan, et al. [9] in this paper, the author works on the contrast enhancement for underwater images in maritime border protection. This type of method is used to capture the unlawful materials. It is mainly used to detect the capsized boat in the water. This method reduces the color cast and enhances the image contrast. The computation consumption is low in the proposed method. It provides high throughput and effective frame rate. Qiao, Xi, et al. [10] 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. Wang, Yi et al. [11] in this paper, the author proposed a novel underwater image restoration method which is based on prior called adaptive attenuation-curve prior. This prior is based on the statistical distribution of pixel value. Pixels of the image are divided into clusters in RGB space. Power function is used to assign value to each cluster. Saturated constraints are used to reduce the noise and adjust three color channels.

IV. THE PROPOSED METHOD

A. Proposed Methodology

Step 1: Input the Image.

Step 2: Preprocessed 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 gravitational search algorithm.

Step 6: Search local and global best by genetic algorithm.

Step 7: Check the output is optimized or not if optimized the go to
otherwise go to step 4.

Step 8: Calculate the total variation.

Step 9: Analyze the PSNR and MSE of the Image.

B. Proposed methodology: Flowchart

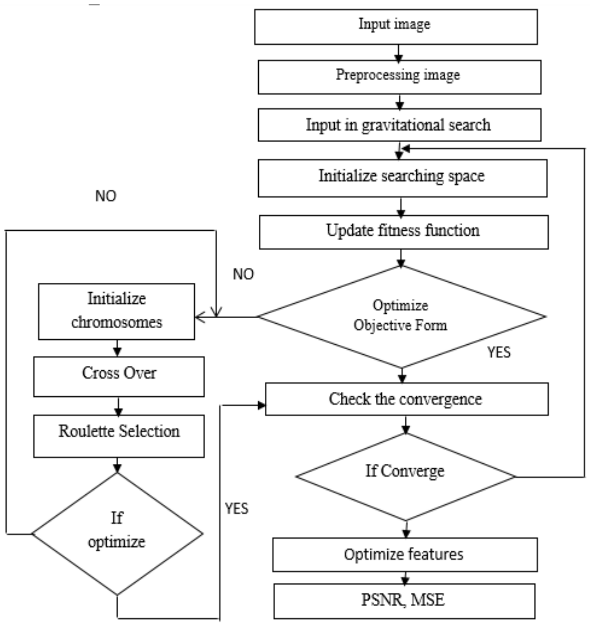


Fig.8: Proposed Flowchart

B. Proposed methodology: Algorithm

Gravitational Search: G.S algorithm is based on the law of gravity and the notion of mass interactions. This algorithm is based on the theory of Newtonian physics and collections of masses are searcher agents. The position of these masses corresponds the solution of problem and its masses are determined by using fitness function. The best solution in this algorithm is mass with heavier mass.

Genetic Algorithm: Genetic algorithm is a meta-heuristic algorithm which is used to solve the optimization problems in computing and artificial intelligence. It provides the optimized solution by using the concept of selection and evolution. Genetic algorithms are able to solve the complex problems and provide reasonable solution onthem. This algorithm is differing from the existing algorithms due to following reasons:-

1) Genetic algorithm generates a population of point where as classical algorithm generates only single point in each iteration.
2) Deterministic computation is used to select the next point in classical algorithms but genetic algorithm used random number generator to select the next population.

Genetic Algorithm works in the five stages that are following.

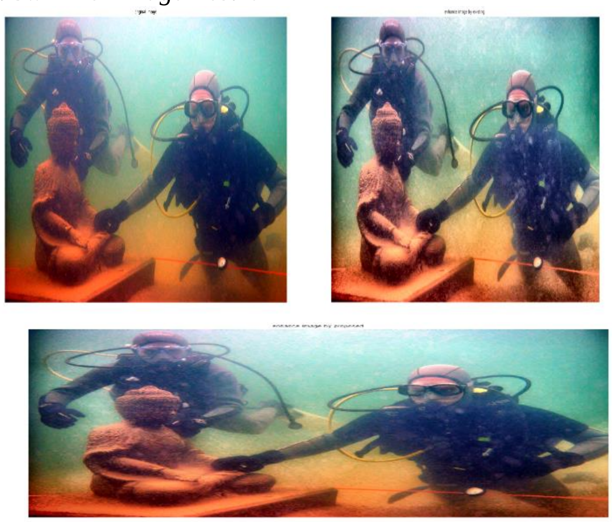
a) Initial Population: It is a set of individuals which is basically solutions of the given problem and called as population.
b) Fitness Function: In this phase fitness of each chromosome or solution is evaluated in the population set.
c) Selection: Two parent chromosomes are selected in this phase on the basis of their fitness.
d) Crossover: In this phase new population is created by this process called children. If this process is not occurred then offspring's are copy of parents
e) Mutation: In this phase the mutation probability mutate new offspring at each position of chromosome.

ALGORITHM
Step 1: Input the image. **Step 2:** Convert the image into gray scale image. **Step 3:** Find the effective block from the image. **Step 4:** Mix the block with blurred image. **Step 5:** *Initialize the GSA algorithm.* I. Setting the values of gravitational constant G_0, a,Ɛ and the iteration counter t. II. Initial population is generated randomly which consist of N agents and position of each agent defined by : $X_i(t) = \left(x_i^1(t), x_i^2(t), \dots\dots.. x_i^n(t)\right)$.......... (1) $i = 1, 2, 3$........., N. III. Repeat the step until don't match with stop criteria. IV. All agents in the population are evaluated and according to this best and worst are assigned. V. When agent j acts on agent i with force at a specific time (t) the calculation of force is done by following : $F_{ij}^d(t) = G(t)\frac{M_{pi}(t) \times M_{aj}(t)}{R_{ij}(t)+ \in}(x_j^d(t) - x_i^d(t))$ $M_{a,j} = gravitational\ mass\ of\ agent\ j$ $M_{pi} = passive\ mass\ of\ agent$ $G(t) = Gravitational\ constant\ at\ time\ t$ VI. Calculate the total force acting on agent i: $F_i^d(t) = \sum_{j \in K\ best\ j \neq i} r\ and\ jF_{ij}^d(t)$ K is the biggest set of first k agent with the best fitness value and biggest mass. VII. Calculate the inertial mass $M_i(t) = \frac{fit_{i-}\ worst\ (t)}{best\ (t) - worst\ (t)}$ **Step6:** Check the output is optimized or not if yes then check convergence otherwise go to step 7. **Step7:** Initialize the *Genetic algorithm* and perform the crossover and roulette selection. **Step8:** Check the output is optimized or not if optimized then converge otherwise iterate the G.A process again until it does not give the optimized algorithm. **Step9:** Analyze the PSNR and MSE.

V. RESULT ANALYSIS

This analysis [Fig.9, 10] shows the result of the proposed and existing method and gives a graphical representation of the result and also compares them all.

A. Swimmer Image Result



B. Image 2 Result

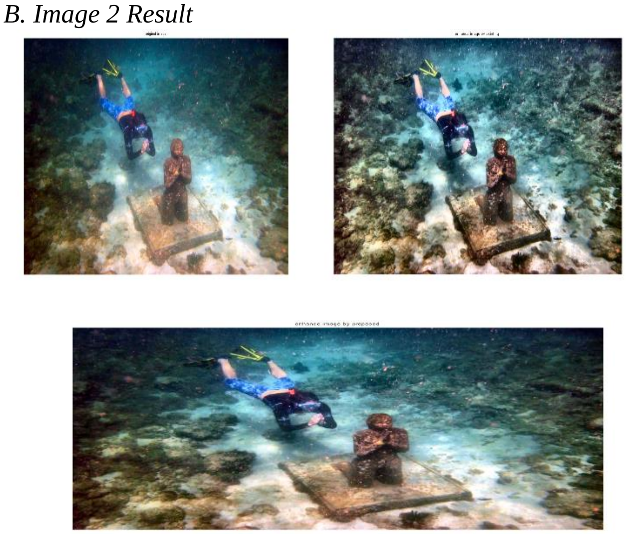


Table.1 Previous Results

Images	**PSNR**	**MSE**
Fish Image	30.13	25.23
Swimmer Image	40.23	22.34
Image 3	22.23	30.13
Image 4	20.64	33.67
Image 5	6.28	50.23

Above given Table.1 contains the values of PSNR (Peak Signal to Noise Ratio) and MSE (Mean Squared Error) of five images that are Fish Image, Swimmer Image, Image 3, Image 4 and Image 5.

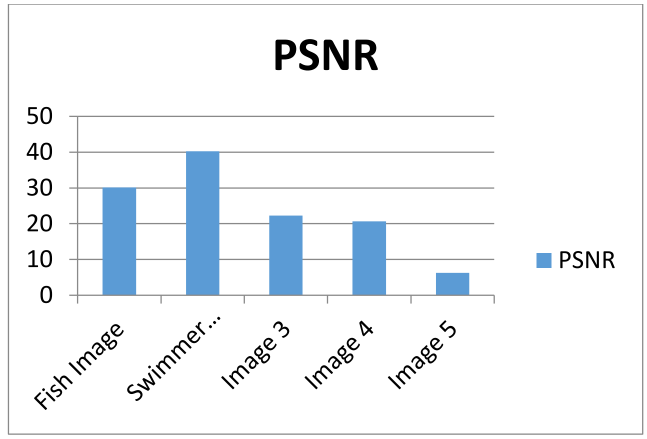


Fig.11: PSNR of 5 Images

Fig.11 depicts the values of PSNR (Peak Signal to Noise Ratio) (Mean Squared Error) of five images that are Fish Image, Swimmer Image, Image 3, Image 4 and Image 5 in the graphical form the maximum value of the PSNR is on Swimmer Image and Minimum value is on Image 5.

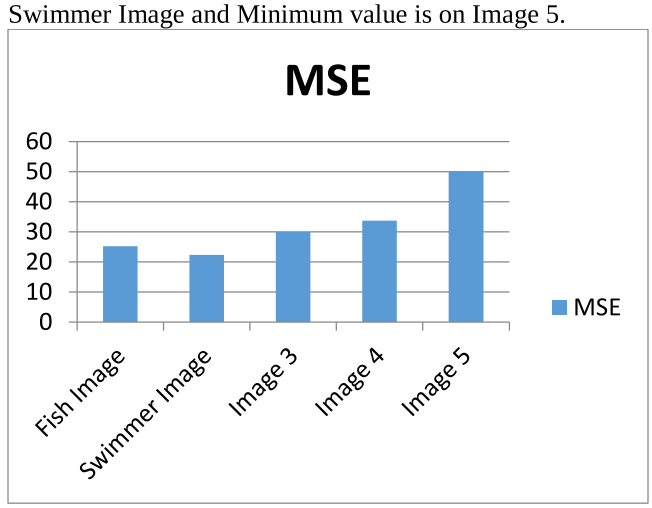


Fig.12: MSE of 5 Images

Fig.12 represents the MSE (Mean Squared Error) of five images that are Fish Image, Swimmer Image, Image 3, Image 4 and Image 5 in the graphical form the maximum value of the MSE is on Image 5 and Minimum value is on Swimmer Image.

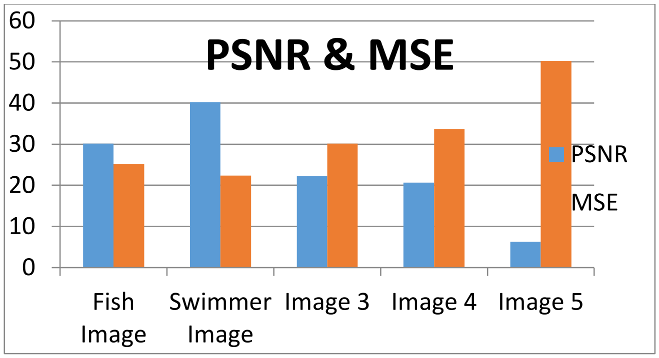


Fig.13: PSNR and MSE of 5 Images

Fig.13 represents the PSNR and MSE of the proposed and existing methods. The figure shows the results on the five images and that are Fish Image, Swimmer Image, Image 3, Image 4 and Image 5. Blue Line represents the PSNR of the images and Red line represents the MSE of the images.

Table.2 Proposed Results with Grey wolf Optimization

Images	PSNR	MSE
Fish Image	35.62	27.13
Swimmer Image	51.23	20.23
Image 3	26.13	21.23
Image 4	18.64	30.16
Image 5	15.24	42.13

Above given Table.2 contains the values of PSNR (Peak Signal to Noise Ratio) and MSE (Mean Squared Error) of five images that are Fish Image, Swimmer Image, Image 3, Image 4 and Image 5.

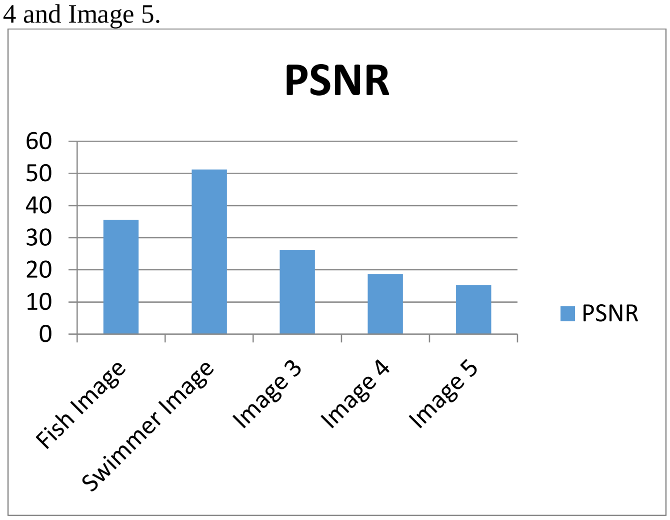


Fig.14: PSNR of 5 Imageson proposed method

Fig.14 depicts the values of PSNR (Peak Signal to Noise Ratio) in the graphical form the maximum value of the PSNR is on Swimmer Image and Minimum value is on Image 5.

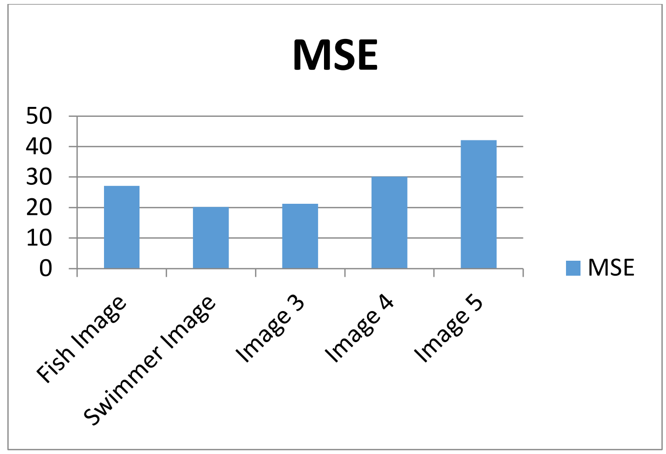


Fig.15: MSE of 5 Images on proposed method on proposed method

Fig.15 represents the MSE (Mean Squared Error) of five images that are Fish Image, Swimmer Image, Image 3, Image 4 and Image 5 in the graphical form the maximum value of the MSE is on Image 5 and Minimum value is on Swimmer Image.

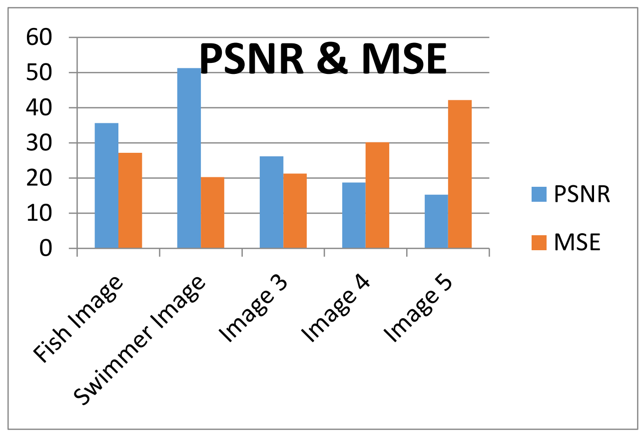


Fig.16: PSNR and MSE of 5 Images on proposed method

Fig.16 represents the PSNR and MSE of the proposed and existing method s. The figure shows the results on the five images and that are Fish Image, Swimmer Image, Image 3, Image 4 and Image 5. Blue Line represents the PSNR of the images and Red line represents the MSE of the images.

Table.3 Comparison of Existing and Proposed Method

Images	PSNR Existing	MSE Existing	PSNR Proposed	MSE Proposed
Fish Image	30.13	25.23	35.62	27.13
Swimmer Image	40.23	22.34	51.23	20.23

Image 3	22.23	30.13	26.13	21.23
Image 4	20.64	33.67	18.64	30.16
Image 5	6.28	50.23	15.24	42.13

Above given Table.3 contains the values of PSNR (Peak Signal to Noise Ratio) and MSE (Mean Squared Error) of five images that are Fish Image, Swimmer Image, Image 3, Image 4 and Image 5.

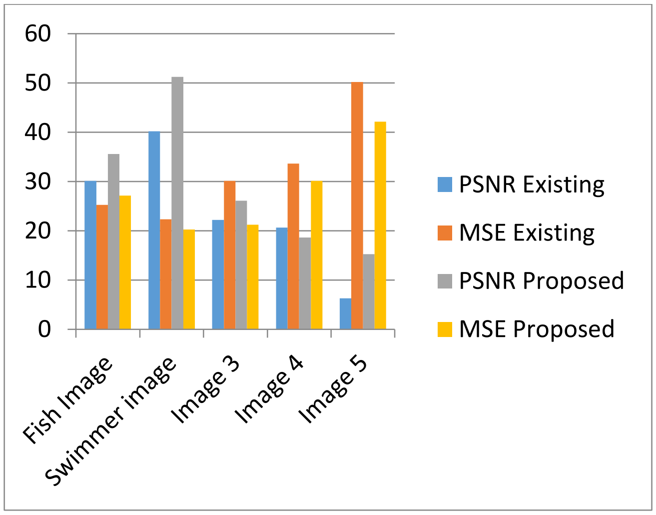


Fig.17: Comparison graphs of Proposed and Existing PSNR &MSE

Fig.17 depicts the values of PSNR (Peak Signal to Noise Ratio) and MSE (Mean Squared Error) of five images that are Fish Image, Swimmer Image, Image 3, Image 4 and Image 5. It shows the changes in the values in proposed and existing method according to image and variation in the results.

VI. CONCLUSION

Then SIFT is used to find and match features between images and a single homography per image was used to perform alignment. In the next step, a graph cuts-based seam cutting method in the image gradient domain is used to find the optimal cut between two images in order to reduce visible seams in the overlapped regions. While producing an image with no overlaps using seam cutting, we use linear blending to reduce colour discontinuities that may still exist. A novel idea proposed in this method is to use colour normalization to transform images into the same colour space to make the stitching result even more “seamless”

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