Underwater and Seawater Image Enhancement using GA with BPDFHE Algorithm

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Abstract— In this research, presented an underwater and a seawater image enhancement (IE) making use of genetic algorithm (GA) with brightness preserving dynamic fuzzy histogram equalization (BPDFHE) algorithm. The main issue in IE underwater images is that non-uniform illumination, low-contrast, blur effect because of turbulence in the flow of water. In underwater images, it effects the scattering of light from several particles of different sizes, low intensity because of low visibility conditions, Suspended movement particles. The experimental effect is carried out on peak signal Noise Ratio (PSNR), Entropy. This algorithm is compared with three algorithms, namely histogram equalization (HE), CLAHE-HF[1], HF method. The proposed algorithm shows that better performance as compared to other algorithms.

Key words: GA, CLAHE, HF, HE, BPDFHE, PSNR, Entropy

I. Introduction

It is observed that lesser amount of research work has been done in the field of image processing of underwater images compared with the other branches of image processing. image enhancement is clearly bettering the image best with none lack of understanding. An enhancement is done to improve certain features of an image for the purpose of some specific application. For this, various types of image enhancement algorithms are also employed. Enhancement techniques are application specific and accordingly, for a particular application, certain features that are needed to be focussed are enhanced. When images are acquired in normal condition, various types of noises like Gaussian, Rayleigh, gamma, exponential, white and speckle noises may come into the image [1].

Underwater vision is an fundamental obstacle in ocean engineering. Images in the atmosphere suffer from medium scattering and light distortion, leading to the low contrast and visibility of images which is same as the underwater images. However, there are some different characters of the underwater images. First of all, shooting images underwater is intricate, as a result of the attenuation caused by using gentle that is mirrored from a surface, and is deflected and scattered by using particles. Meanwhile absorption substantially reduces the light energy. The random attenuation of the light is the major motive of the haze appearance whilst the absorption of light make the underwater image is specific from the atmosphere hazing pictures because the brightness distribution is entirely modified. The objects at a distance of greater than 10 meters are practically indistinguishable due to the fact the colours are faded as a result of the characteristic wavelengths are cut consistent with the water depth [2].

The underwater image enhancement used GA to evolve a relation between input and output gray levels, thereby enhancing the contrast of the image. The depth of spatial edges integrated in the image is used as health function.

The fuzzy set theory is employed to deal with the uncertainties in the form of imprecise boundaries and intensities. The bright and dark pixels are hard to be interpreted and may simplest be qualitatively perceived by using human reasoning. Therefore, the fuzzy set theory is selected to be incorporated with the enhancement algorithm since it empowers a machine to mimic human reasoning. The fuzzy image enhancement differs from the other enhancement process in which the pixels are not directly modified in the spatial domain. However, in the fuzzy image enhancement, the pixels in the spatial domain are converted to fuzzy domain using membership function and transformation of membership function is done to enhance the image. It involves three stages which includes image fuzzification process, modification of membership function and defuzzification process.[3]

In addition to the FHE techniques, a tone mapping approach has also been embedded in modification of image histogram. The tone mapping operator successfully increase image contrast and produced high quality images as reported in [4].

II. Underwater Image Enhancement Model

The light propagation model is slightly extraordinary in underwater environment. Within the underwater optical imaging model, absorption plays an foremost position in picture degrading. Furthermore, unlike scattering, the absorption coefficient is specific for each colour channel, being the perfect for crimson and lowest for blue in seawater.[5]

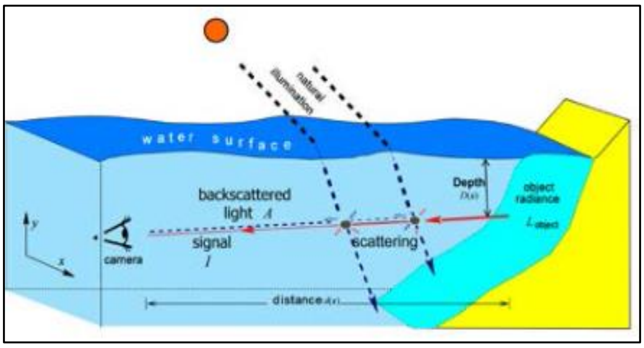

Fig. 1: Underwater optical imaging model.

III. Genetic Algorithm

GA employs the principles of natural selection to find solutions to optimization and search problems. It allows a population of many individuals to evolve towards a better solution such that they maximize the "fitness". GA thus helps in finding the optimal value from the solution space. GA begins by generating a finite population of individuals encoded as chromosomes. Fitness of each chromosome is evaluated to select individuals (usually a fixed percentage of fittest individuals) that survive and produce new individuals in the next generation. Genetic operators and mutation, are employed to produce new individuals in the subsequent generations. Fitness is again evaluated for the next generation and the process is continued until the termination condition (usually the maximum number of generations) is reached. The fittest individual then will yield the optimal value. The mutation operator on the other hand, alters the genes in the chromosomes and ensures that the GA does not get stuck at the local minima and searches the entire solution space.[6]

IV. FUZZY LOGIC

Fuzzy image processing contains fuzzy sets that are the collection of all techniques that have an understanding of, characterize and method the pictures, their segments and aspects. It has a human like reasoning ability. If image features are interpreted as linguistic variable then fuzzy if-then rules are used to segment the image.[7]

A. Fuzzy Histogram Computation

Fuzzy facts is ready to handle the inexactness of gray worth and produces a gentle histogram. Fuzzy histogram[8] is a series of real numbers h(i), i Є {0,1,…,l-1} where h(i) is the frequency of rate of gray levels that are around i. through in view that the gray values I(x, y) as a fuzzy number the FH $I(x, y)$ will also be computed as

$$h(i) \leftarrow h(i) + \sum_{x}\sum_{y} \mu 1(x, y) \ , k \in [a, b]$$

Where $\mu 1(x, y)i$ a Triangular fuzzy membership function is will also be outline as

$$\mu 1(x, y)i = \max\left(0, 1 - \frac{|l(x, y) - i|}{4}\right)$$

[a,b] is the support of triangular membership function.

V. LITERATURE SURVEY

[9] In this paper, presented a novel shallow water imaging model to compensate for the attenuation discrepancy along the propagation path and mighty underwater scene enhancement scheme. The recovered pictures are characterized via a decreased noised stage, better publicity of the dark areas, and expanded international contrast the place the finest small print and edges are inprove greatly.

[10] This paper proposed BPDFHE utilising triangular membership function which is the modified method of HE. It uses fuzzy data of digital images for his or her illustration and processing in the fuzzy discipline which permits the technique to handle the approximation of grey level values in a better method for higher presentation. This algorithm enhances picture contrast as good as conserves the brightness very good. Some pictures should not available to outstanding value, so proposed Fuzzy algorithm can be utilized for image enhancement to improve the excellent of the picture.

[11] This efficient approach consists of image enhancement, extracting region of curiosity using active Contour model, extracting spatial points from segmented picture, train these feature vectors and classify the test picture by way of FIS. This proposed method performance is compared with one of the most efficient and popular existing method Support Vector Machine and shows better accuracy of 94.12%

[12] On this paper, it addressed the challenging quandary of underwater stereo image enhancement. A new underwater imaging model is proposed and it can better describe the degradation of underwater images including color distortion and contrast attenuation. Additionally, a novel statement that the depth of the water part inside the picture is almost always contributed through the scattering gentle can be proposed. Coupling the proposed mannequin and prior together, the parameters of scattering mild can be estimated.

[13]The image is processed by fuzzy enhancement with repeated use of non-linear transformation. Finally, the fuzzy membership worth is modified with inverse operation, and the picture's greater gray value is received. The outcome display that the multiplied algorithm simply overcomes the shortcomings of the P-K algorithm and retains the age information of the low gray worth within the picture. Hence the multiplied algorithm in this paper is strong.

[14] GA are more and more being explored in many areas of image evaluation to clear up complex optimization problems. This paper gives a quick overview of the canonical GA and it additionally experiences the duties of image pre-processing. The major challenge of machine vision is to increase picture great with admire to get a required image per-ception. The gas had been adopted to achieve better outcome, rapid processing instances and extra specialised functions. This paper introduces quite a lot of techniques centered on GA to get picture with excellent and natural contrast.

[15] This paper presents a new method utilising intuitionistic fuzzy set idea for medical IE. The method produces an intuitionistic fuzzy image utilising Sugeno sort fuzzy complement and the parameter in intuitionistic fuzzy picture is optimized utilising intuitionistic fuzzy entropy. Experimental results on several low contrasted medical images show that the proposed method produces better enhanced image as compared to the existing fuzzy and intuitionistic fuzzy methods.

VI. PROPOSED WORK

This algorithm presented an underwater and seawater IE using GA and BPDFHE method. In this process, firstly take a low contrast input image. Change the size of an input image with 512X512 dimensions. Convert the color image into gray image for further processing. Apply GA to optimize the image matrix for enhancement based on best fitness value. Apply BPDFHE for calculating histogram value on the basis of Fuzzy membership function. It estimates the local maxima points.

A. Proposed Algorithm

1) Read underwater Image is indicated as I and resize the image with 512*512 dimension
2) Then the dimensions of the image are set

$$[r, c, ch] = size(I)$$

Where r,c is the row and column of underwater image and ch is the number of measurement

1) Resetting the populace of possible solutions.

2) Calculation of an evaluation i.e. fitness function that performs the position of the atmosphere, rating answer in positions of their 'fitness'.
3) Definition of genetic operators (selection and mutation) that alter the composition of children for the period of replica.
4) Establishing values for the parameters (population measurement, possibilities of applying genetic operators) that the genetic algorithm makes use of .The genetic algorithm takes in following strictures.
5) Compute Fuzzy histogram using Eqn:

$$h(\beta) \leftarrow h(\beta) + \sum_{m}\sum_{n} \varepsilon_{F'(x,y),\beta}$$

Where (x, y) pixel location for an image is for $F(x, y)$, F as a fuzzy number $F'(x, y)$ $\varepsilon_{F'(x,y),\beta}$ denote fuzzy membership function defined as in eqn with constant α, F is set as a sequence of real numbers $h(\beta)$, $\beta \in \{0,1 \dots L-1\}$, $h(\beta)$ is the frequency of occurrence of gray levels

$$\varepsilon_{F'(x,y),\beta} = max\left(0.1 - \frac{|F(m,n) - \beta|}{\alpha}\right)$$

6) Find the local maxima of an image using formula:

$$\beta_{max} = \beta \forall\, \dot{h}(\beta+1) \times \dot{h}(\beta-1) < 0, \ddot{h}(\beta) < 0$$

Where, $\dot{h}(\beta)$denote I order derivative and $\ddot{h}(\beta)$ as a II order derivative of the F, $h(\beta)$ at position. It is computed through the 'central difference operator' (CDF) and 'II order CDF' as

$$\dot{h}(\beta) = \frac{\partial h(\beta)}{\partial(\beta)} = \frac{h(\beta+1) + h(\beta-1)}{2}$$

$$\ddot{h}(\beta) = \frac{\partial^2 h(\beta)}{\partial \beta^2} = h(\beta+1) - 2h(\beta) + h(\beta-1)$$

7) Obtain the partitions of the fuzzy histogram using local maxima points.
8) Determine the output dynamic range for ith partition is defined in prior step:

$$Range_i = \frac{(L-1) \times (HIG_i - LOW_i) \times log_{10}P_i}{\sum_{m=1}^{j+1}(HIG_m - LOW_m) \times log_{10}P_m}$$

Where $HIG_i and LOW_i$ signify the maximum and minimum intensity values of the i^{th} input sub-histogram. P_i is the total number of pixels contained in that divider. Thus given the output dynamic range of all the sub-histograms smallest gray level (*Start*) and largest gray level (*Stop*) in each partition can be defined as

$$Start_i = \sum_{m=1}^{i-1} Range_i + 1$$

$$Stop_i = \sum_{m=1}^{i} Range_i$$

The exceptions are present at the two extremities, where $Start_i Stop_i$ = Fmin $Range_i$ and $Start_i$ $Stop_i$= Fmin $Range_i$.

9) After that previous step, equalize the histogram of fuzzy values.
10) Finally, enhance the brightness of an image with normalization using this formula:

$$Final = \frac{\mu_F}{\mu_{F'}} F'$$

Where G let the mean intensity levels for F and F'

B. Pseudo code of GA:

1) start on with a randomly generated population of N chromosomes, the location N is the dimension of populace, l – size of chromosome x.
2) Calculate the fitness price of operate φ(x) of each and every chromosome x in the populace.
3) Repeat except off springs are created:
   – Probabilistically indicate a pair of genetic material from present people by value of fitness function.
   – Create an offspring y_i by crossover and transformation operatives, where i = 1, 2, …,N.
4) Exchange recent populace with a new created one.
5) Go to stage 2.

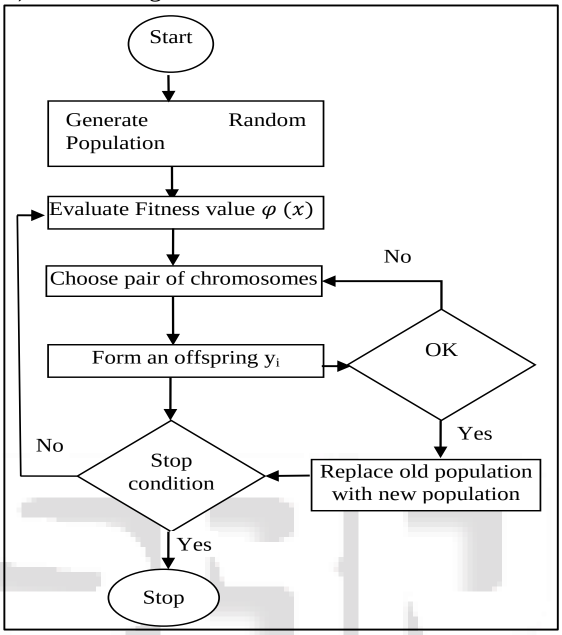

Fig. 2: Flow chart of GA Optimization

VII. PERFORMANCE ANALYSIS

The experimental analysis is used underwater and seawater images for performance evaluation. It takes color images for evaluation. It estimates the value of PSNR and Entropy using below formulas. The algorithm is designed on MATLABR12 using Image Processing toolbox.

A. Calculate MSE among the input image and enhanced image.

$$MSE = \frac{1}{M * N}||y - s^{\wedge}||^2 = \frac{1}{MN}\sum_{i=1}^{MN}(y - s)^2$$

Where M, N is size of input image, y is original input image and s is enhanced image

B. Calculate PSNR between the input image and enhanced image.

$$PSNR = 10 \times log10 \frac{maxValue(size(y))}{sqrt(mean(mean(MSE)))}$$

Where y is the input image, MSE is mean contrast

C. Calculate entropy of an image:

$$E = -\sum_{i=0}^{N-1} p(xi)\, logp(xi)$$

Where E: Entropy
N: Maximum gray level value
p(xi): Probability of incidence of xi

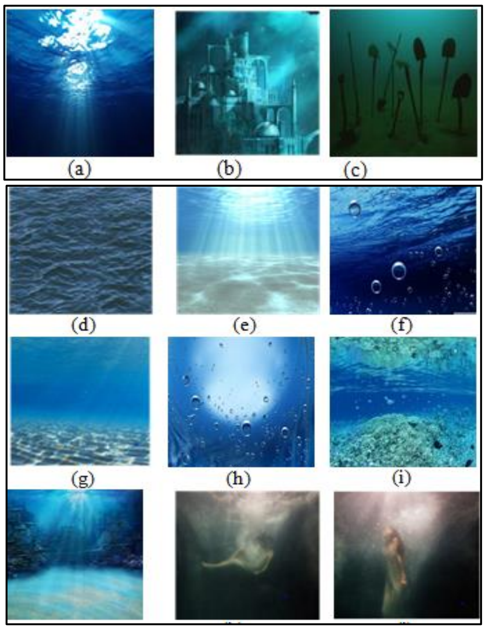

Fig. 3: Experimental Dataset

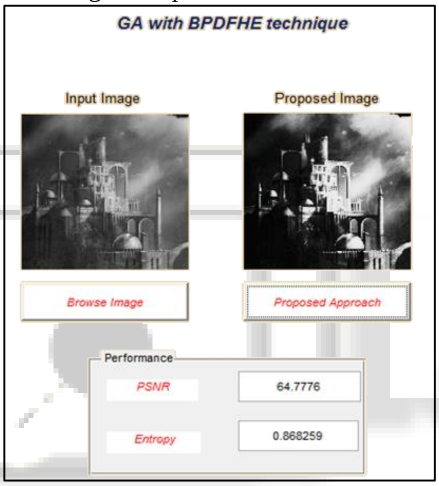

Fig. 4: GUI of Proposed System

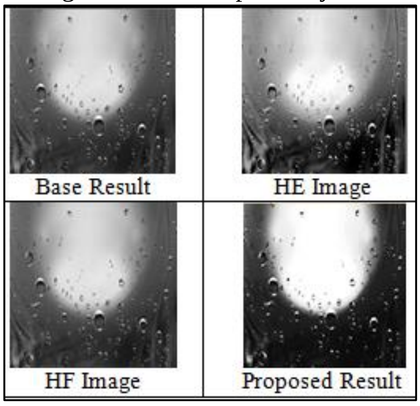

Fig. 5: Image (H) Result Using Base, He, Hf and Proposed System

Image	Base PSNR	HE PSNR	Homomorphic PSNR	Proposed PSNR
(a)	47.6414	12.5781	47.6302	58.4219
(b)	47.6177	14.0641	47.5807	63.9971
(c)	47.7879	8.95431	47.6488	69.862
(d)	47.702	10.6018	47.5865	68.4629
(e)	47.5656	11.7607	47.4828	67.6808
(f)	47.7039	10.5909	47.6726	61.0441
(g)	47.6258	12.8431	47.5509	66.1663
(h)	47.5691	20.9326	47.5444	63.2382
(i)	47.5917	14.996	47.5511	63.9583
(j)	47.6019	17.8602	47.5666	63.5735
(k)	47.6889	11.8719	47.6352	61.3461
(l)	47.6871	13.4988	47.6331	62.6601

Table 1: PSNR Comparison between Proposed and Previous Method

Image	Proposed Entropy
(a)	0.9994
(b)	0.8590
(c)	0.86917
(d)	0.9952
(e)	0.9897
(f)	0.9472
(g)	0.5352
(h)	0.9622
(i)	0.9508
(j)	0.9964
(k)	0.9907
(l)	0.9734

Table 2: Entropy Calculation using Proposed System

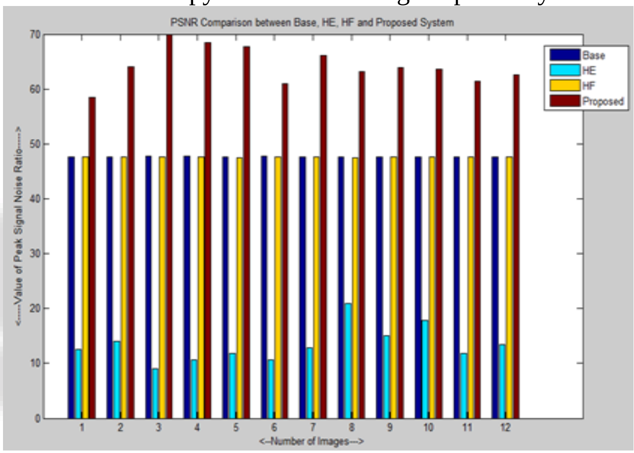

Fig. 6: PSNR Comparison between Proposed and Previous Approach

In this Graph1, shows the PSNR result using Base, HE, HF method and Proposed system. The proposed system bar shows that good presentation as mached to other algorithms. PSNR is estimating for quality measure of an image.

VIII. CONCLUSION

The hybrid approach for underwater IE using GA and BPDFHE. This method gives better PSNR in underwater and seawater images where the issue of low illumination and low down contrast are major issues. It can develop the images over blurry, stormy conditions. Also, this study can be implemented for surface tension, turbulent motion of the sea water. This proposed can be extended in future for sea water images, satellite pictures with the other optimization algorithm.

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