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Adaptive Fuzzy Based Image Enhancement Techniques with Histogram

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ABSTRACT

Image Enhancement works an important aspect in digital image managing programs for both human and computer viewpoint. The major problem that improves in image improvement is quantifying the way of improvement thus needs interesting techniques to acquire satisfied results. The overall objective of this proposed work is to evaluate the performance of existing image enhancement techniques like Histogram equalization, adaptive histogram equalization and Fuzzy image enhancement technique. It has been found that the value of contrast parameter 'K' in fuzzy method was taken statically as 128. To overcome this, to make contrast dynamic a new optimized fuzzy method have been proposed. Here different optimization techniques Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO) and Artificial Bee Colony (ABC) have been used to optimize the contrast and the technique with best optimized contrast value is selected. The proposed technique is designed and implemented in MATLAB using image processing toolbox.

Keywords : Contrast Enhancement, Color Image, Optimization Techniques, Fuzzy Method

I. INTRODUCTION

Computer vision system enhancement is the method for improving the quality of image. It is relatively simple, that is modifying the image from light to dark or to enlarge or reduce contrast. The goal of image enhancement is to improve the quality of image in order to get more suitable results for a specific application than the original image. Contrast enhancement not only improves the visual quality of an image but also enhances image features for further processing. Contrast enhancement methods traditionally based on either spatial or Transform domain techniques. In case of spatial domain method, different procedures are directly applied on image pixels. On other hand transform domain works on modifying the frequency transform of an image. However, transformation for image into two dimensional is very time consuming task even with fast transformation which makes it less appropriate for real time processing.

II. METHODS AND MATERIAL

1. Image Enhancement Techniques

Image Enhancement : Image Enhancement is essentially a simplest and attractive area of digital image processing. Image enhancement is method used to enhance the overall superiority of the corrupted images can be attained by using enhancement mechanisms .So that the human eye can effortlessly detect the key features of the pictures. It is used to eliminate the inappropriate artifacts from the pictures like noise or brighten the photograph and it simply to identify main features and then it looks improved. It is an individual area of digital image processing. To create a graphic display further helpful to visualize and examination, it recover the photograph features such as edges or boundaries. It enlarges the dynamic range of collected features. It does not increase the inbuilt content of data.

Contrast Enhancement : It increases the Visibility and the full quality of an image by not referring to the incorrect noticeable façade or non-appropriate artifacts. The international evaluation enhancement methods generally increase the luminance for shiny pixel and thereby decreasing the luminance for the black pixel. So by not losing the highly effective range stress, the group dependent evaluation enhancement is pleased to get evaluation for image enhancement. The actual life programs of automated evaluation enhancement methods are numerous and include different areas such as the medical image, geophysical prospecting, seismic finding, astronomy, camera and video managing, aerial and sea image, receptors and instrumentation, optics, and tracking. The most heard over technique is the histogram equalization technique being based on the considered information that a continually assigned grayscale histogram thus includes the best noticeable evaluation.

2. Contrast Enhancement Techniques

✓ Histogram Equalization

Histogram equalization accomplishes this by effectively growing out the most regular strength concepts. The strategy is useful in pictures with credentials moments and foregrounds that are both bright or both black. In particular, the strategy can cause to better views of navicular bone framework in x-ray pictures, and to better details in pictures that are over or under-exposed. A key benefit of the strategy is that it is a pretty simple strategy and an invertible owner. So hypothetically, if the histogram equalization function is known, then the exclusive histogram can be recovered. The calculations are not computationally extreme. A disadvantage of the strategy is that it is irregular. It may improve the evaluation of credentials interference, while decreasing the useful sign. In healthcare picture where spatial relationship is more important than focus of sign (such as breaking DNA pieces of quantized length), the small sign to interference rate usually results noticeable identification. Histogram equalization often produces wrong results in photographs; however it is very useful for healthcare pictures like x-ray pictures etc.., often the same type of pictures to which one would apply wrong color.

✓ Adaptive Histogram Equalization

Versatile histogram equalization (AHE) is a pc picture managing strategy used to improve evaluation in pictures. It differs from common histogram equalization in the respect that the flexible strategy decides several histograms, each corresponding to a exclusive area of the picture, and uses them to redistribute the lightness concepts of the picture. It is therefore appropriate for helping the local evaluation. However, AHE will over amplify interference in relatively homogeneous places of an picture. A edition of flexible histogram equalization known as evaluation limited flexible histogram equalization (CLAHE) prevents this by decreasing the enhancing.

✓ Fuzzy Image Enhancement Technique

Fuzzy-logic is being effectively utilized in different places of picture managing. Recently, uncertain based techniques for picture enhancement have been developed with better efficiency com-pared to traditional and other innovative techniques like GLG. Unclear picture managing includes mainly three stages: picture fuzzification, adjustment of consideration concepts, and, if necessary, picture defuzzification. The main power of uncertain picture managing is in the middle step (modification of consideration values). After the picture data are customized from gray-level industry to the uncertain consideration industry (fuzzification), appropriate uncertain techniques change the consideration concepts. This can be a uncertain clustering, a uncertain rule-based strategy, a uncertain development strategy and so on. In uncertain based picture enhancement techniques histogram is used as the basis for uncertain modeling of pictures. Two major efforts in the field of picture enhancement using the uncertain framework have been established in the past few years. In Fuzzy method for gray image enhancement and smoothing two merits have been considered. First approach is IF…. THEN ELSE rules for image enhancement, in this to enhance the pixels some directive fuzzy rules same as human-like reasoning are given and these rules are generated from the neighborhood pixel of the image. The second method relates to a rule-based smoothing. Here, on the basis of neighborhood compatibility different filter classes are devised.

Further, for color images Enhancement three 2-D histograms (RG, GB, BR) technique is used and for color image enhancement using LHS color model [2] equalization method is used. In the fuzzy approach membership functions are used to structure fuzzy sets for utilizing the gray tone or color intensity property of the pixel. The image is taken as an array of fuzzy singletons whose membership value indicates the degree of some image property in the range [0-1]. For Gary scale images, different fuzzy membership functions improves the speed and quality of the enhancement and for color images histograms method are used which measure the quality of the enhancement on the basis of entropy[3].

In human visual system RGB color model for Histogram equalization is not feasible to use since it effects the original color composition of the image which produces color artifacts. For that reason RGB color image is converted to HSV (Hue, Saturation, and Intensity) where hue is the color content, saturation is bright light used to reduce the color content and V is the intensity of the color content. The H and S get preserved while V that is the intensity of the color is changing. Firstly to model the V , a Global type membership function is used which is suitable for under exposed images only and for over exposed and under plus over exposed images a global intensification operator (GINT) method[4] is used which stretch the contrast of V globally which changes the value of intensity parameter. For automatic image enhancement parameters of GINT on the basis of fuzzy entropy is calculated. For the enhancement of low contrast color images a Fast and efficient Fuzzy logic algorithm with histogram equalization is used. In digital image processing Histogram equalization (HE) method is simples [13] most effective technique but it has some limitation that it does not preserve the brightness and original look of images. To overcome this problem several Bi- and Multi-histogram equalization methods have been proposed. From which the Bi-HE methods significantly enhance the contrast and can preserve the brightness as well, but the natural look of the image get destroyed. To maintain the natural look of image, Multi-HE methods are proposed, in which the proposed method the histogram of an input image is decomposed into multiple segments and at each segment HE is applied independently [20].

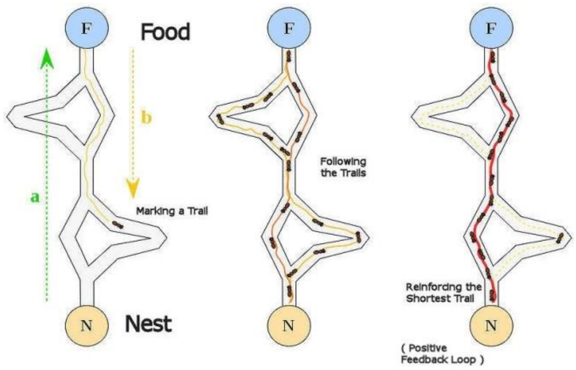
It uses two parameters M and K, where M is the average intensity and K is the contrast intensification parameter. Only V parameter is stretched under the control of M and K. The value of control parameter M can be calculated form average histogram value. The value for K can be calculated on the basis of stretching required. From the experimental analysis, the value K is fixed as 128, which gives better results for the low contrast and low bright color images. The effectiveness of histogram and fuzzy based image enhancement method on various kinds of images like underwater, remote sensing images has been evaluated using MSE and PSNR parameter. The result has shown the effectiveness of the fuzzy based enhancement over the existing techniques [21]. In this paper we have extended this fuzzy approach [20] and changed the value of contrast value “K” dynamically using different optimization methods.

3. Optimization Techniques

In optimization numerical function plays an important role for optimizing the objective function. The famous approach of Artificial Intelligence (AI) is Computational Intelligence (CI). Optimization is used to handle the complex problems and to find the best solution out of the solution space. For optimizing the numerical functions optimization algorithms can be categorized into two category that is evolutionary computing and meta heuristic methods. Various Optimization techniques like Ant Colony Optimization [6] (ACO), Particle Swarm Optimization [9] (PSO), and Artificial Bee Colony algorithm [8] (ABC).

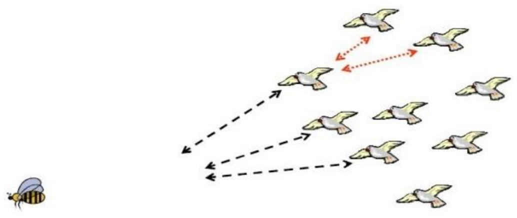
Ant Colony Optimization

A graph representation based technique has been applied successfully to solve various hard combinatorial optimization problems. The main motive of ACO is to model the problem as to search minimum cost path in a graph. In this artificial ants walk through specific graph and find the good paths. In ACO ants working is parallel. First Ant finds a route between n nest (N) and Food source (F) and laid a Pheromone trail (τ). If the food is found, ant returns to nest laying down pheromone trail. Other ants randomly follow one of the path and lay pheromone trail



Particle Swarm Optimization

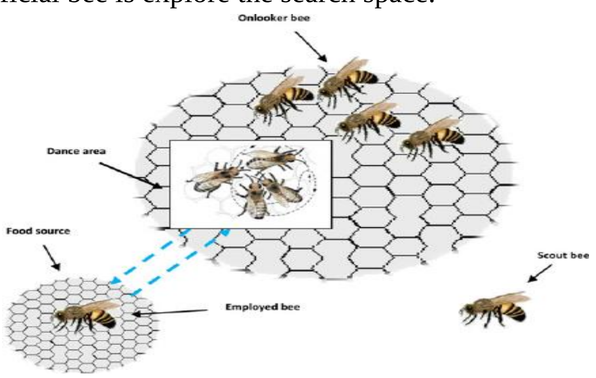
PSO provides the solutions to numerical and qualitative problems which is developed from swarm intelligence and is based on the research of bird by fish flock movement behaviour.



In these in the birds either scattered or fly together as to find the food. Among all there is always a bird that can smell a food resource.

Artificial Bee Colony

The bottom-up approach which behaves partially alike, and partially differently from bee colonies in nature. Artificial bees are the agents, which solves complex combinatorial optimization problem. Here every artificial bee computes one solution to the problem. There are two phases of algorithm forward pass and backward pass. Initially in each forward pass, every artificial bee is explore the search space.



From predefined number of moves it constructs or improves the Solution and also forms a new solution. After obtaining the new partial solution, the bees again go to the nest and move the next phase that is backward pass. In this all artificial bees share information about their solutions. In nature, bees perform a dancing ceremony, and signalled other bees about the quantity of food they have collected and the distance of the area to the nest.

III. LITERATURE SURVEY

Sundaram, M., K.Ramar , N.Arumugam, and G.Prabin. [25] presented a Modified Contrast Limited Adaptive Histogram Equalization. Histogram equalization is a highly effective and simple technique for contrast enhancement. The traditional Histogram equalization usually results in excessive contrast enhancement due to insufficient control on the amount of enhancement. The Histogram Modified Contrast Limited Adaptive Histogram Equalization adjusts the total amount of contrast enhancement, which often supplies the resultant image a strong contrast and brings the area details for more relevant interpretation. It incorporates both Histogram modifications becoming an optimization technique and Contrast Limited Adaptive Histogram Equalization. This technique is tested for Mias mammogram images. The performance of this method has been determined using the parameter like Enhancement Measure. From the subjective and quantitative measures it's interesting this proposed technique provided better contrast enhancement with preserving the area information of the mammogram image. **Ehsani and Seyed P.[29]** proposed an adaptive and iterative Histogram matching algorithm for chromosome contrast enhancement especially in banding patterns. The reference Histogram, with which the initial image must be matched, is done based on some processes on the very first image Histogram. Usage of raw information in the Histogram of initial image can lead to more dependency to the input image and acquiring better contrast improvement. Moreover, the iteration procedure results in a gradual contrast enhancement and getting the most effective result. The iteration steps may differ greatly regarding the image characteristics and Histogram. To have the ability to measure the performance of the proposed algorithm in comparison with existing image enhancement techniques, Constant Gain Transform and Local Standard Deviation Adaptive Contrast Enhancement , a quantitative measurement, the contrast improvement ratio, is utilized. The experimental results indicated that the proposed method showed the most effective results as it pertains to the CIR measure and, along with in visual perception. **Jha and Rajib Kumar [28]** proposed a nonlinear non-dynamic stochastic resonance-based technique for enhancement of dark and low contrast images. A low contrast image is treated as a sub-threshold signal and noise-enhanced signal processing is positioned on improve its contrast. The proposed technique uniquely utilizes addition of external noise to neutralize the effectation of internal noise of a low contrast image. Random noise is added repeatedly to a graphic and is successively hard-thresholded followed closely by overall averaging. By varying the noise intensities, noise induced resonance is obtained at particular optimum noise intensity. Performance of the proposed technique has been investigated for four types of noise distributions - gaussian, uniform, poisson and gamma. Quantitative evaluation of the performances has been done in terms of contrast enhancement factor, color enhancement and perceptual quality measure. Comparison with other existing spatial domain techniques demonstrates the proposed technique gives remarkable enhancement while ascertaining good perceptual quality. **Lee and Eunsung[23]** presented a contrast enhancement approach predicated on dominant brightness level analysis and adaptive intensity transformation for remote sensing images. The proposed algorithm computes brightness-adaptive intensity transfer functions utilising the low-frequency luminance component in the wavelet domain and transforms intensity values based on the transfer function. More specifically, they first performed discrete wavelet transform on the input images and then decompose the LL sub band into low-, middle-, and high-intensity layers using the log-average luminance. Intensity transfer functions were adaptively estimated utilising the knee transfer function and the gamma adjustment function on the cornerstone of the dominant brightness level of each and every layer. Following the intensity transformation, the resulting enhanced image is obtained utilising the inverse DWT. Although various Histogram equalization approaches have now been proposed in the literature, they often degrade the entire image quality by exhibiting saturation artifacts in both low- and high-intensity regions. The proposed algorithm overcame this matter utilising the adaptive intensity transfer function. The experimental results demonstrate that the proposed algorithm enhances the entire contrast and visibility of local details a lot better than existing techniques. The proposed method can effectively enhance any low-contrast images acquired with a satellite camera and may also be well suited for other various imaging devices such as for instance consumer digital camera models, photorealistic 3-D reconstruction systems, and computational cameras. **SChouhan and Rajlaxmi [26]** proposed an energetic stochastic resonance based technique in spatial domain for the enhancement of dark- and low-contrast images. Stochastic resonance phenomenon in that the performance of something could be improved by addition of noise. DSR is applied in a iterative fashion by correlating the bistable system parameters of a double-well potential with the intensity values of a low-contrast image. Optimum output is ensured by adaptive computation of performance metrics - relative contrast enhancement factor, perceptual quality measures and colour enhancement factor. When compared with the existing enhancement techniques such as for instance as an example adaptive Histogram equalisation, gamma correction, single-scale retinex, multi-scale retinex, modified high-pass filtering, edge-preserving multi-scale decomposition and automatic controls of popular imaging tools, the proposed technique gives significant performance in terms of contrast and colour enhancement along with perceptual quality. Comparison with a spatial domain SR-based technique was already illustrated. **Nercessian and Shahan C.[24]** presented a multi-scale image enhancement algorithm dedicated to a whole new parametric contrast measure. The parametric contrast measure incorporates not only the luminance masking characteristic, but additionally the contrast masking characteristic of the human visual system. The formulation of the contrast measure could be adapted for every multi-resolution decomposition scheme to be able to yield new human visual system-inspired multi-scale transforms. In this information, it's exemplified utilising the Laplacian pyramid, discrete wavelet transform, stationary wavelet transform, and dual-tree complex Wavelet transform. Consequently, the proposed enhancement procedure is developed. The features of the proposed method included the integration of both the luminance and contrast masking phenomena; the extension of non-linear mapping schemes to human visual system inspired multi-scale contrast coefficients; the extension of human visual system-based image enhancement approaches to the stationary and dual-tree complex wavelet transforms, and an instantaneous approach to adjusting overall brightness; and achieving dynamic range compression for image enhancement in the direct multi-scale enhancement framework. Experimental results demonstrated the ability of the proposed algorithm to attain simultaneous local and global enhancements.

IV. PROPOSED METHODOLOGY

The principle objective of the proposed algorithm is to supply better results than existing algorithms to improve the visibility of the digital images. In proposed method Input image is RGB image is converted into HSV. For calculating the value of intensification factor K different optimization techniques have been applied with fuzzy image enhancement. Further H and S are concatenated to V and obtained HSV is converted to RGB.

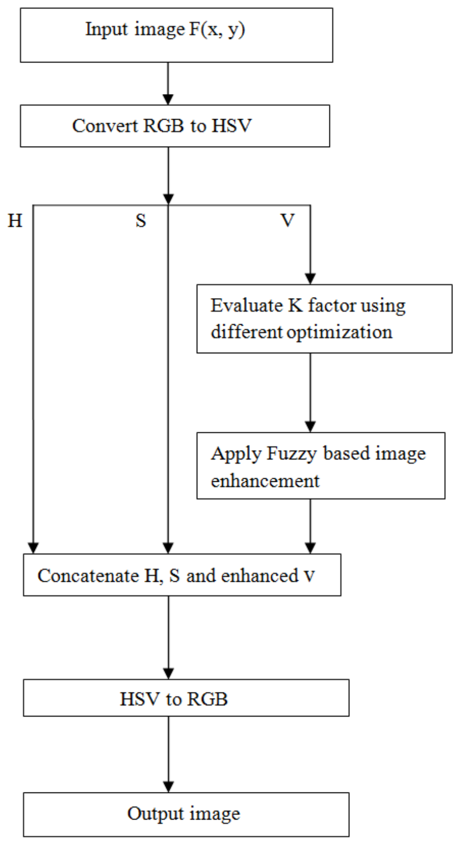


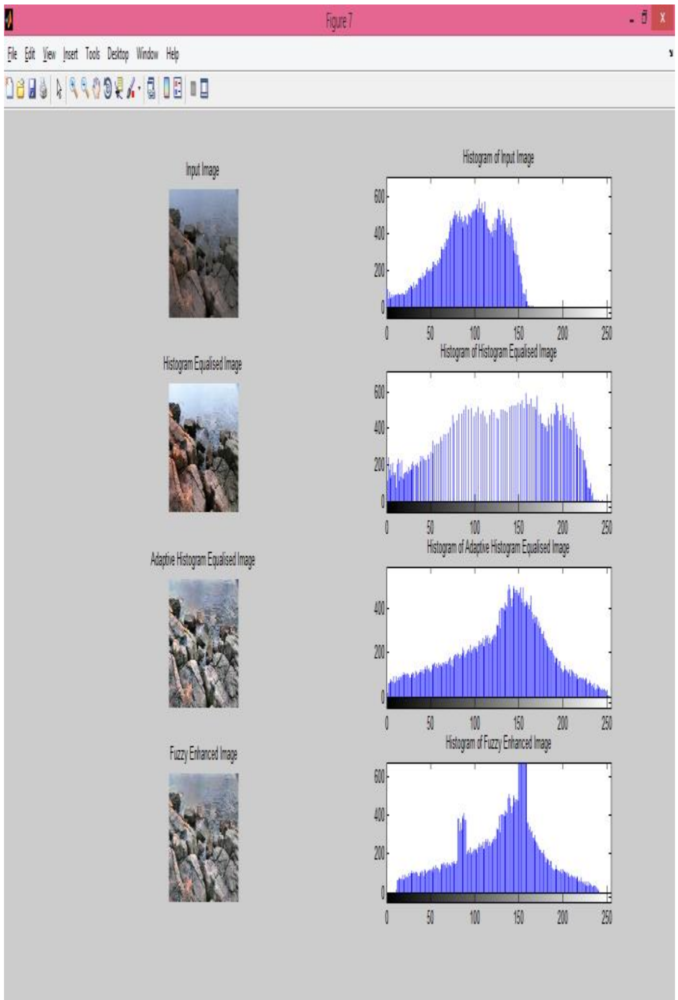
Figure 1. Flowchart describes working of enhanced fuzzy

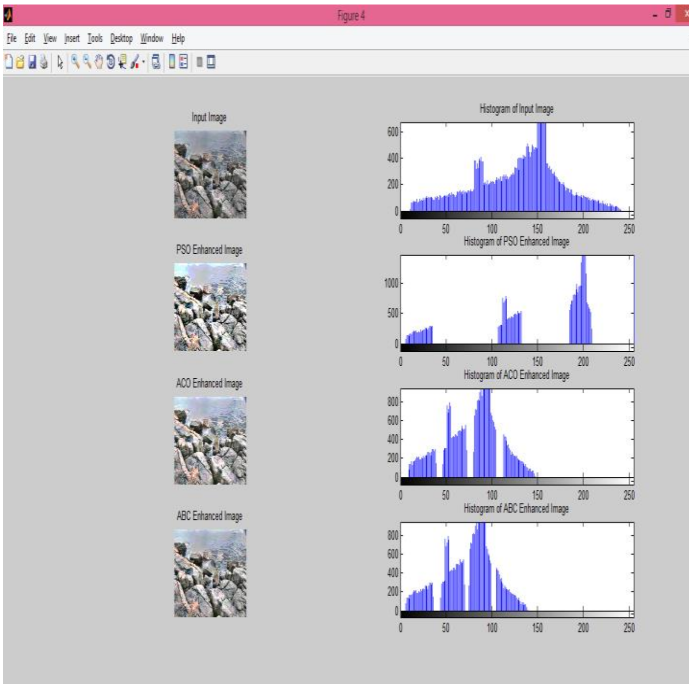
V. RESULTS AND DISCUSSION

In this Experiment 3 images with low contrast and brightness have been taken and to analyze the performance of the fuzzy method various qualitative performance measures have been used.

✓ **Comparsion of various Contrast Enhancement Techniques**

Here, the basic techniques of contrast enhancements namely Histogram equalization, adaptive Histogram equalization, Fuzzy enhancement (K=128) and Fuzzy method with optimized value of K have been compared.





✓ **Performance Evaluation**

Performance Evaluation table shows the analysis of optimization technique using different parameters that is MSE, PSNR, SSIM, and execution time. The average values of parameters on conventional and new techniques have been calculated to analyze the performance.

Mean Square Error (MSE)

Mean Square Error in image processing measures the average of squares of errors. In above equation *R* and *C* represent the number of rows and columns in the input images with index *i* and *j* respectively. *f(i,j)* represents the original image at location *(i, j)* and *f'(i,j)* represents the degraded image at location *(i,j)*.

$$\mathrm{MSE} = \frac{1}{RC}\sum_{i=1}^{R}\sum_{j=1}^{C}(f(i,j) - f'(i,j))^2 \ldots\ldots\ldots (1)$$

Table 1 shows the MSE value obtained after applying different enhancement techniques on different images. Here the minimum value of MSE is obtained by PSO optimization technique and it shows the better results as compared to conventional, ACO and ABC.

Table 1. MSE Values

MSE						
IMAGES	HE	AHE	FUZZY	ACO	PSO	ABC
IMG1	11.07	14.8	7.86	16.8	14.6	12.9
IMG2	8.07	12.5	6.89	18.9	12.9	21.9
IMG3	7.69	9.06	5.98	24.8	17.8	20.9
AVERAGE	8.94	12.12	6.91	20.16	15.1	18.52

Peak Signal to Noise Ratio (PSNR)

PSNR refers to the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the quality of image. Higher value of PSNR indicates that the reconstruction is of higher quality.

$$\mathrm{PSNR} = 10.\log_{10}\left(\frac{\mathrm{MAX}_I^2}{\mathrm{MSE}}\right) = 20.\log_{10}(\mathrm{MAX}_I) - 10.\log_{10}(\mathrm{MSE}) \ldots\ldots\ldots (2)$$

Table 2 shows the PSNR value obtained after applying different enhancement techniques on different images. From the table values it is evident that the value obtained by PSO optimization technique is higher as compared to conventional, ACO and ABC.

Table 2. PSNR Values

PSNR						
IMAGES	HE	AHE	FUZZY	ACO	PSO	ABC
IMG1	21.67	29.84	39.79	35.70	46.77	32.91
IMG2	25.80	26.53	42.41	32.82	40.89	39.82
IMG3	27.90	27.93	33.09	31.66	37.89	35.86
AVERAGE	25.12	28.10	38.43	33.39	41.85	36.19

Structural Similarity Index Measure (SSIM)

A new approach proposed to overcome this problem which provide solutions which are independent of visibility conditions and threshold problems. Main aim to extract structural information from image. Structural Similarity Index Matrix (SSIM) separate out the three parameter such as luminance, contrast and structure which are independent of each other and are highly structured. If consider two non negative images x and y where x is original discrete signal and y is distorted discrete signal, then

$$\mathrm{SSIM}(x,y) = [l(x,y)^{\alpha}].[c(x,y)^{\beta}].[s(x,y)^{r}] \ldots\ldots (3)$$

Table 3 shows the results of SSIM value obtained after applying different enhancement techniques on different images. It is vivid from the average analysis that the value obtained by PSO optimization technique is higher as compared to conventional, ACO and ABC

Table 3. SSIM Values

SSIM						
IMAGES	HE	AHE	FUZZY	ACO	PSO	ABC
IMG1	0.507	0.553	0.986	0.969	0.978	0.978
IMG2	0.735	0.789	0.979	0.989	0.999	0.997
IMG3	0.454	0.699	0.965	0.995	0.996	0.994
AVERAGE	0.565	0.680	0.976	0.984	0.991	0.989

Execution time

It is the time taken by the algorithm to process the image.

Table 4 shows the Execution time taken by different enhancement techniques on different images.

From the table values, it is evident that the value obtained by PSO enhanced is faster as compared to conventional, ACO and ABC.

Table 4. Execution Time values

EXECUTION TIME						
IMAGES	HE	AHE	FUZZY	ACO	PSO	ABC
IMG1	0.597	0.889	0.102	4.670	3.930	5.244
IMG2	0.873	0.570	0.064	5.098	4.890	3.455
IMG3	0.813	0.789	0.070	4.567	3.916	4.567
AVERAGE	0.761	0.749	0.078	4.778	4.244	4.422

- ✓ **Application of Contrast Enhancement**

Medical Imaging: Different pictures are of different low quality and low evaluation makes itself challenging to identify and find out the details. Thus, the pictures has to get down on a procedure known as image improvement which contains an collecting or collecting of methods that raise for helping the noticeable part of an image.

Camera and Movie Processing: Movie improvement is the most general and tough elements in video research. Its aim of video improvement is to enhance the appearance of it and for providing a good convert presentation for future computerized video managing, as of examining and partition of pictures. There are various applications where video is needed, prepared and used, such as tracking, basic identification verification, guests, privileges methods, private or army video managing.

Contrast Enhancement for Visual Imaging: In this one refer that the evaluation improvement is done here by showing the dual-interfering-source as called phased array technique. In-phase and out-of-phase sources assess an interference-like style, which declines the background signals. The perturbation being designed by little things allows for improved identification knowing.

Contrast Enhancement on under water images: Underwater field is the medical areas of research for the researchers. These under water Vehicles and Managed Vehicles are usually decided to catch the details as of marine mines and of coral reefs of coral reefs, sewer lines and telecommunications cables taken by the marine environment. These are usually recognized by the insufficient exposure they form due to light is significantly attenuated as it goes.

VI. CONCLUSION

The fuzzy based image enhancement approach has the ability to boost the contrast in digital images in efficient manner by utilizing the Histogram based fuzzy image enhancement algorithm. The overall objective of this work is to evaluate the effectiveness of Histogram and fuzzy based image enhancement for various kinds of images. The fuzzy and Histogram based enhancement has been designed and implemented in MATLAB using image processing toolbox. Firstly, the results obtained show that the effectiveness of the fuzzy based enhancement over other conventional basic methods. It has been found that the value of contrast intensity 'K' in fuzzy method has been taken as static as 128. In order to overcome this, To make contrast dynamic been introduced a modified approach. Here different optimization techniques ACO, PSO and ABC have been used to optimize the contrast. It is concluded that the different optimization techniques (ACO, PSO and ABC) have shown optimized values for contrast parameter 'K'. From optimistic values it is clear that there is a difference between the values obtained from different techniques however, from quality measures it has been analyzed that the value obtained by PSO technique is more efficient than ACO and ABC.

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