ISSN 2348 – 8034
Impact Factor- 3.155

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

A NOVEL APPROACH FOR IMAGE ENHANCEMENT USING PSO

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ABSTRACT

Histogram Equalization enhances the image contrast very effectively butits impact on poor quality images are not equally good. HE may causes unnatural look of such type of images due to over enhancement. This paper proposed a novel approach for image/contrast enhancement using Particle Swarm Optimization with selection of specific parameters. Dynamic Histogram Equalization is applied on the input image first than Particle Swarm Optimization is imposed on resultant image. This method is compared with the other approaches like DHE, CLAHE and CLAHE with PSO and found very effectives.

Keywords- *Image Enhancement, Histogram Equalization, Computational Intelligence, PSO, etc.*

I. INTRODUCTION

Vision is the most important feature related to the human senses and images play an important role in human perception. Despite, human vision can only cover visual bands of the electromagnetic spectrum, whereas machine vision covers the whole of the electromagnetic range from gamma to radio waves such as X-ray images in medicine and gamma-ray images taken by satellites [5]. Thus, image computing encompasses wide and various domains of applications [1-3].Image enhancement is the way to collect information from the digital image that is not visible but present in the image. And we can also remove some unnecessary artifacts that are being present in the image due to several reasons, may be the inappropriate setting of the image capturing devices or the medium in which we are capturing images. By image enhancement we can easily manipulate the images and enhance the noise, their contrast, preserve the brightness level and get a processed image that can be used as an input to several digital image processing applications. Image enhancement paradigm is classified mainly into two categories based on pixel manipulations and the Fourier transform based methods that are also known as spatial domain and frequency domain methods respectively. Spatial domain techniques are mainly focus upon the manipulation on the image pixels and sub categorized in three types of approaches: gray scale transformation or point processing, histogram processing and mask processing. In point processing may methods are followed like image negation, contrast modification or contrast stretching, gray level slicing with or without background, logarithmic transform, power law transform and bit plane slicing. In histogram processing the methods are histogram equalization, histogram specification, image averaging and image subtraction [4, 6, 7]. And in mask processing the neighborhood matrix is used for image smoothing and image sharpening or it could be said that it is the filtering phase. In this paper we are mainly focused on the contrast improving methods. In spatial domain methods contrast manipulation can be done through stretching the gray levels of an image using histogram processing. In context of contrast enhancement in spatial domain the contrast stretching approach is not much appreciable when compared to histogram equalization. But unfortunately both the methods give some unnatural artifacts and these methods do not work well in preserving the image brightness. Therefore, here is a need to go through various existing histogram equalization methods like: bi-histogram equalization and multi histogram equalization methods. So from the previous analysis we can go through dynamic histogram equalization and contrast limited adaptive histogram equalization because these methods work well in gray scale and mammographic images. In both of these methods DHE gives better result than the CLAHE methods and it is also able to preserve the mean brightness of the images. Many authors try to enhance the image contrast using hybrid methods with some computational approaches [12, 13, 16, and 17] but there was some natural artifacts due to which the hidden information of the images are not properly visible. We are trying to remove such artifacts and enhance the contrast by our proposed method so that these images could be applied to other real time applications like biometric analysis, robotics, machine intelligence, pattern recognition etc.

II. HISTOGRAM EQUALIZATION

Histogram Equalization is a technique of image processing for the contrast adjustment using the concept of image's histogram. The methodology is mainly used for the increase of the global contrast of images. By providing the adjustment to the images the intensity factor of images improves and so is their contrast [10, 11]. The methodology allows increase of the lower or pixels with low intensity.

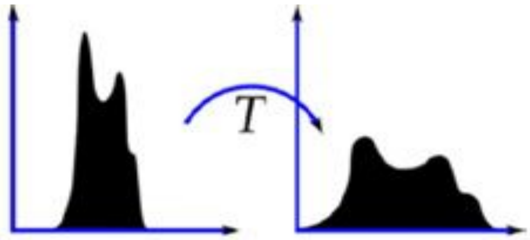

Fig2.1: Spreading the Intensity Values

Let us consider a digital image having gray level intensities in the range from [0, L-1], now on the basis of the gray level intensities of the image Probability distribution function can be computed using:

$$P(r_k) = \frac{n_k}{N}$$

Where, k=0, 1, 2…L-1 and r_k is the kth gray level and n_k is the total number of pixels in the image with gray level r_k. Also Cumulative Distribution function can be computed using:

$$C(r_k) = \sum_{i=0}^{i=k} P(r_i)$$

Where, k=0,1 ….L-1 and $0 \leq C(r_k) \leq 1$.

2.1: Proposed Methodology: - The proposed methodology implemented here for the contrast enhancement of dark images is a hybrid combinatorial method of Dynamic Histogram Equalization optimized by the Particle Swarm optimization Technique.

a). Dynamic Histogram Equalization:- Dynamic Histogram Equalization is a bi-histogram equalization method. DHE was essentially popularized in 2007 by Wadud *et al.* [8], to eliminate the influence of higher histogram components on lower histogram components in the image histogram and to regulate the amount of spreading of gray levels for objective enhancement of the image appearance by using local minima separation of histogram. DHE displays continuous and better enhancement of the image than the traditional paradigm. Withal, the DHE oversight the mean brightness perpetuation and influences to intensity saturation artifacts [9]. DHE technique has overcome the drawbacks of histogram equalization and has shown a better brightness preserving and contrast enhancement than HE. DHE reinforces the image beyond making any destruction in image particulars. However, if user is not satisfied, may control the extent of enhancement by adjusting only one parameter. Besides, DHE is transparent and computationally adequate which makes it easy to implement and can be operated in real time systems. DHE separates the histogram depends on local minima. Formally, it implements a one-dimensional smoothing filter on the histogram to dispose meaningless minima. Then it makes sub-histograms taking the portion of histogram that falls between two local minima. And HE is applied on each of the sub-histogram.

b). PSO algorithm:-PSO is a global optimization approach, and was firstly discussed in 1995 by Dr. James Kennedy and Dr. Russell Eberhart [14]. This method was inspired by social behaviors of animals and biological populations. In fact, it is a simulation of a simplified social model like bird flocking and fish schooling. PSO was originally an optimization method for continuous nonlinear functions, i.e., the search space is continuous and decision variables are encoded into real numbers.Some advantages of PSO in comparison to other heuristic search algorithms such as GA are ease of its implementation, its fewer parameters for adjustment, its fewer operators and high rate of its convergence. PSO has been utilized in many areas that uses the soft-computing approaches, such as training neural networks, optimizing power systems, fuzzy control system, robotics, radio and antenna design and computer games. PSO algorithm is a multi-agent parallel search technique which maintains a swarm of particles and each particle represents a potential solution in the swarm. In this algorithm particles fly through a multidimensional search space where each particle is adjusting its position according to its own experience and that of neighbors. Particle Swarm Optimization (PSO) is also used for maintaining the variety of swarm [15]. Basic PSO has been designed in two steps, i.e., randomly initializing a population and iteratively updating velocities and positions. The particle position is updated by equation (2.1)-

$$\mathbf{X_1(t+1) = X_1(t) + V_1(t+1)} \quad (2.1)$$

And the particle velocity is calculated be the equation (2.2)-

$$\mathbf{V_1(t+1) = wV_1(t) + C_1r_1(X_{Pbest} - X_1(t)) + C_2r_2(X_{Gbest} - X_1(t))} \quad (2.2)$$

Where 'i' is the particle index't' is discrete time index, $V_i$is velocity of the i^{th} particle, $X_i$is position of i^{th} particle, X_{Pbest} is best position found by i^{th} particle, X_{Gbest} is best position found by swarm, r_1 and r_2 are the random numbers on the interval [0, 1] applied to i^{th} particle, C_1 and C_2Acceleration coefficient such that $C_1 + C_2 >= 4$.

The steps required to implement PSO are given as -

1. For each particle initialize particle
2. Repeat for each particle
a). Calculate fitness value
b). If the fitness value is greater than best Pbest in history, set current value as the new Pbest.
3. Choose the particle with the best fitness value of swarm as the Gbest.
4. For each particle
a).Update particle velocity according to equation (2.2)
b).Update particle position according to equation (2.1)
5. until stopping criteria.

Fig 2.2: Pseudo code for PSO algorithm

2.2. Function used:-The fitness function used in Particle swarm optimization is given by [11] [12]-

$$\text{Fitness}(P) = \log(\log(E(I(P)) * \frac{N_{edgels}(I(P))}{M \times N} * H(I(P)) \qquad (2.3)$$

The parameters used in the fitness function are given in the table 2.2-

Table 2.2: Fitness function terminology

Parameters	Summary
Fitness(P)	Fitness function for the optimization of PSO
I(P)	Original Image I
E(I(P))	Intensity of the edges detected
N_edgels	No. of edges pixels detected using Sobel Edge detector.
M	No. of pixels rows
N	No. of Pixles Columns

And the cumulative sum is calculated by equation (4.4)-

$$\text{CumSum} = \frac{\text{Image\_Histogram}}{M \times N} \qquad (2.4)$$

2.3. Proposed Algorithm: - The proposed algorithms implemented here for the contrast enhancement of dark images consist of the following steps that are shown in table 2.3.

Table 2.3: Steps of the proposed algorithm

Steps	Action
Step 1	Take an input Dark Image whose contrast needs to be enhanced.
Step 2	If the dark image is colored then convert the image into gray level.
Step 3	Apply DHE to the image and get enhanced image.
Step 4	Compute the histogram of the enhanced image.
Step 5	Calculate the cumulative sum of the histogram image using equation (4.4).
Step 6	Calculate the average frequency of pixels whose cumulative value is above 0.75.
Step 7	Again Compute the New CDF (Cumulative Distribution function) to obtain some enhanced image.
Step 8	Initialize the PSO parameters including Swarm Size, maximum Iterations, inertia, correction factor,

	fitness value.
Step 9	For each particle initialized or contains on the PSO
Step 10	Compute the fitness value of the particles using equation (4.3).
Step 11	Choose particle with the best fitness value of all particles.
Step 12	For each of the particle
Step 13	Compute the particle velocity using equation (4.2).
Step 14	Now update the particle position using equation (4.1).
Step 15	Repeat till maximum iterations.

In the proposed method weinitialize the parameters for PSO when it is applied to the resultant image (DHE image). The swarm size is 64, the number of iteration is 50, inertia weight is 1.0, acceleration coefficient C_1 and C_2 both are equal to 2.0, and random numbers r_1 and r_2 both lies between [0 1].The flow diagram for the proposed algorithm is shown by the figure 2.3.

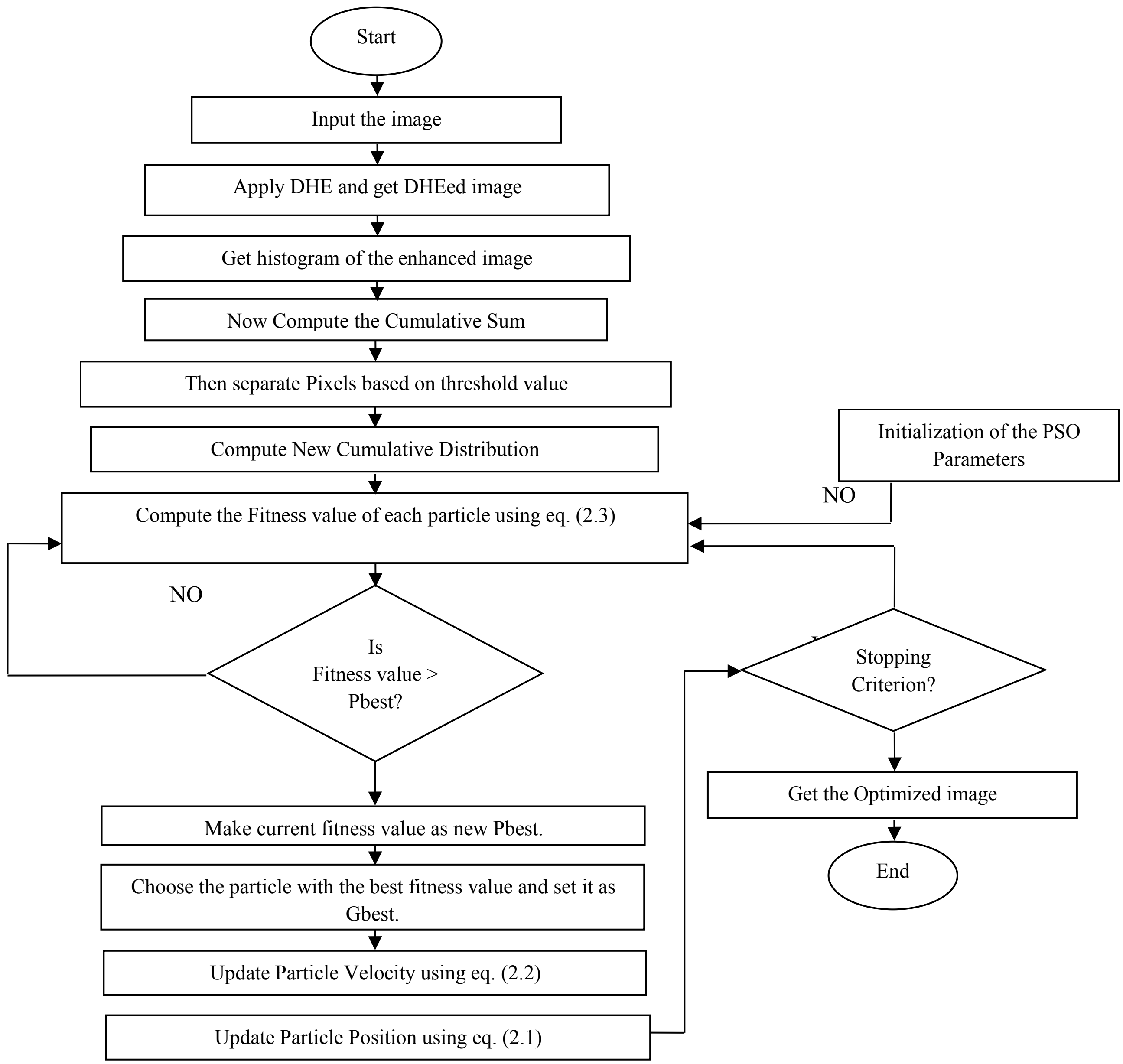

Fig 2.3: Flow diagram for the proposed algorithm

ISSN 2348 – 8034
Impact Factor- 3.155

III. RESULT & DISCUSSION

Table 3.1: Peak signal to noise ratio

Images	HE	DHE	CLAHE	DHE + PSO	CLAHE + PSO
Building	15.12	22.51	20.64	**27.06**	25.24
Tower	13.50	14.92	21.32	20.48	**25.32**
House	10.80	19.75	15.34	**28.17**	22.36
Tire	10.39	26.89	17.38	**35.21**	24.82
Fog_1	16.08	15.66	18.15	19.17	**23.62**
Rain_4	21.14	33.14	14.12	**38.78**	18.71
Pirate	18.71	21.74	17.71	**28.02**	22.62
Beach	9.26	16.31	13.54	**24.57**	20.84

Table 3.2: Normal absolute error

Images	HE	DHE	CLAHE	DHE + PSO	CLAHE + PSO
Building	0.28	0.09	0.12	**0.09**	0.12
Tower	0.27	0.25	0.10	0.25	**0.10**
House	0.88	**0.16**	0.51	0.19	0.52
Tire	1.18	0.13	0.48	**0.11**	0.41
Fog_1	0.27	0.30	0.18	0.30	**0.18**
Rain_4	0.15	0.07	0.34	**0.05**	0.35
Pirate	0.20	0.16	0.22	**0.16**	0.23
Beach	1.58	0.47	0.88	**0.47**	0.88

Images	HE	DHE	CLAHE	DHE+ PSO	CLAHE + PSO
Building	**0.98**	0.93	0.94	0.93	0.94
Tower	1.19	1.43	1.00	1.43	**1.00**
House	0.27	0.63	0.45	**0.63**	0.45
Tire	0.36	0.81	0.62	**0.81**	0.73
Fog_1	0.77	0.57	**0.91**	0.57	0.90
Rain_4	0.82	1.01	0.79	**1.01**	0.79
Pirate	0.72	1.03	0.75	**1.03**	0.75
Beach	0.17	0.39	0.31	**0.39**	0.31

Table 3.3: Structural Content

To find out the quality of the resultant image some statistical parameters are used such as PSNR (peak signal to noise ratio), NAE (normal absolute error) and SC (structural content) [18-20]. Our method is compared with existing methods like: HE, DHE, CLAHE, and CLAHE with PSO and the enhanced result for two images out of eight images are shown by the figure 3.1 and 3.3.The PSNR, NAE and SC values for eight images are shown in table 3.1, 3.2 and 3.3 respectively.

The better values of PSNR, NAE and SC are highlighted in gray shade in the following tables. As we know greater the PSNR the image visual quality will also be better. As lower the error rate, the image will be better and for SC the value nearby1gives better result. Thus, our proposed method has better PSNR value, NAE value and SC value compare to the other existing techniques.

(a) **(b)** **(c)**

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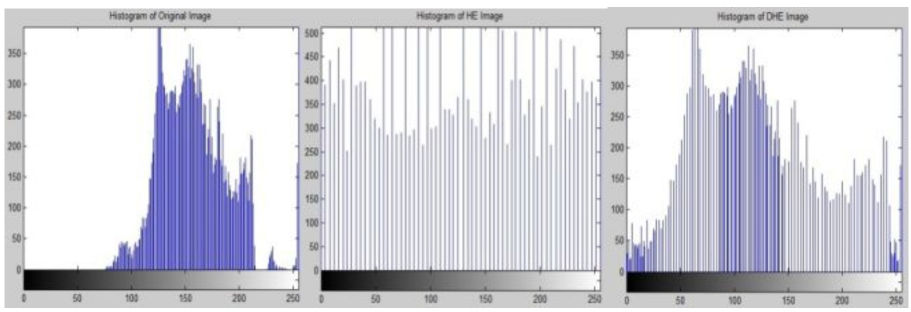
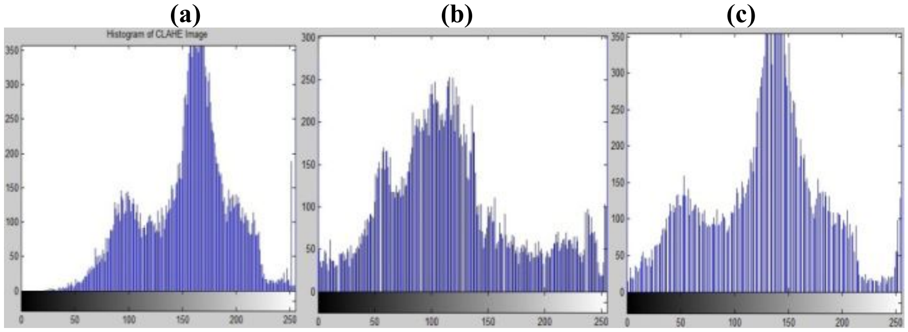
Impact Factor- 3.155

(d) (e) (f)

Fig 3.1- Enhancement result for Tower image: (a) Original image, (b) Enhanced image using HE, (c) Enhanced image using DHE, (d) Enhanced image using CLAHE, (e) Enhanced image using DHE with PSO and (f) Enhanced image using CLAHE with PSO.



(a) (b) (c)



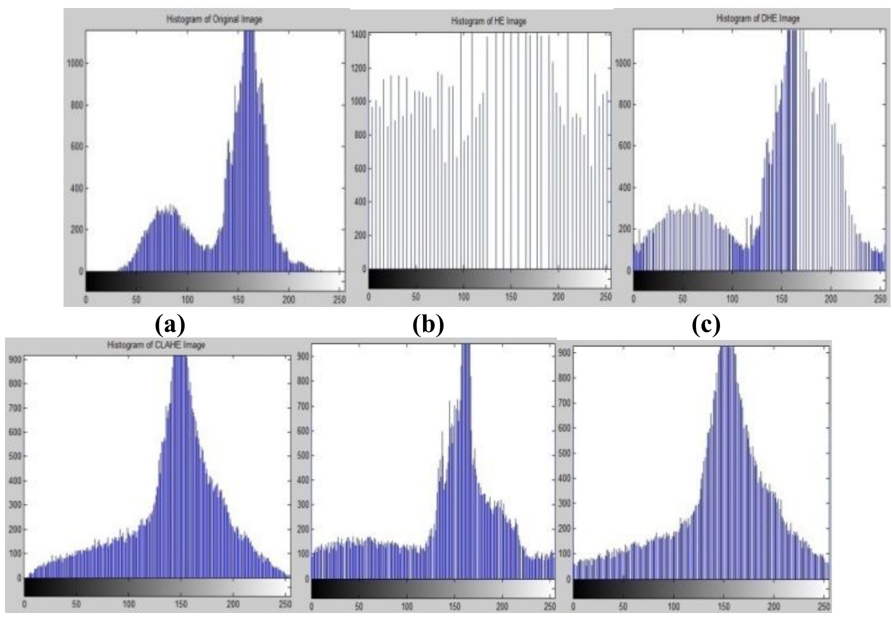
(d) (e) (f)

Fig 3.2- Illustration of Histogram for Image Tower: (a) Histogram for Original image, (b) Histogram for image using HE, (c) Histogram for image using DHE, (d) Histogram for image using CLAHE, (e) Histogram for image using DHE with PSO and (f) Histogram for image using CLAHE with PSO.

(a) (b) (c)

(d) (e) (f)

Fig 3.3- - Enhancement result for Building image: (a) Original image, (b) Enhanced image using HE, (c) Enhanced image using DHE, (d) Enhanced image using CLAHE, (e) Enhanced image using DHE with PSO and (f) Enhanced image using CLAHE with PSO.



(a) (b) (c)

(d) (e) (f)

Fig 3.4- Illustration of Histogram for Image Building: (a) Histogram for Original image, (b) Histogram for image using HE, (c) Histogram for image using DHE, (d) Histogram for image using CLAHE, (e) Histogram for image using DHE with PSO and (f) Histogram for image using CLAHE with PSO.

In the fig: 3.1 and 3.3 the enhancement result for image tower and building are shown: input image, image using HE, image using DHE, image using CLAHE image, image using DHE with PSO and image usingCLAHE with PSO are illustrated. In the fig: 3.2 and 3.4 the corresponding Histogram for image tower and building are shown: histogram for input image, histogram for image using HE, histogram for image using DHE, histogram for image using CLAHE image, histogram for image using DHE with PSO and histogram for image using CLAHE with PSO are illustrated. The graphical representation of PSNR and NAE values is shown in figure 3.5 and 3.6 respectively.

From the table and the graph we could easily say that our method has better PSNR values than the other methods, it has lower error rate than the other methods and it has better structural content to the original image than other methods. Regarding to the image contrast HE method gives the higher contrast than these methods in many cases but it having a main disadvantage is that it causes unnatural artifacts that degrade the image information and the image visual quality. Therefore our proposed method is the second best in the contrast measure and also having better PSNR, SC and NAE value that makes our resultant image visually better than HE and other methods.

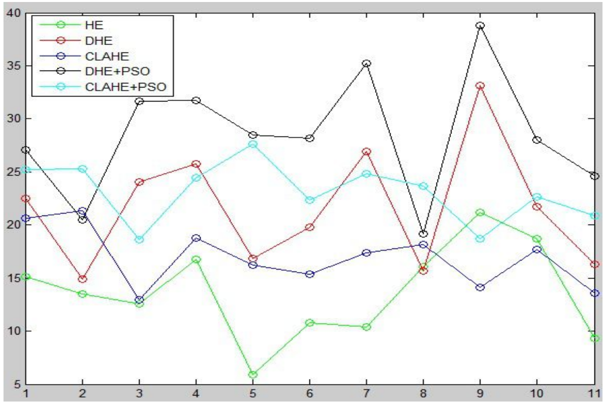


Fig 3.5: PSNR graph of different methods

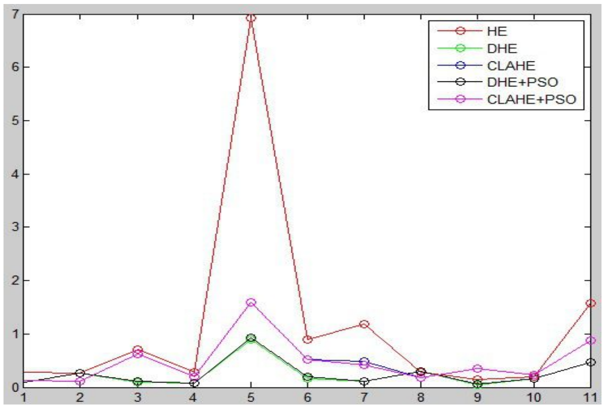


Fig 3.6: NAE graph of different methods

IV. CONCLUSION

In this paper, a novel approach to image contrastEnhancement using PSO is implemented byspecifying a suitable fitness function proportional to thenumber and intensity of the edge pixels and to the image entropy. The objective of the algorithm is tomaximize the total number of edgels to visualize more details in the images. The proposed method is tested on various images and their result are tabulated and compared with other HE methods like DHE, CLAHE and CLAHE with PSO. Therefore, from the obtained results it is clear that our proposed method is better than the other methods. In form of PSNR our method has greater values than the other methods. And for NAE our method has lesser values than the other HE methods.In future, the proposed PSO method may be extended as: fine tuning of thePSO parameters to reduce the number of particles, or to reduce the number of iterations.

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