AUTOMATIC IMAGE ENHANCEMENT USING EVOLUTIONARY ALGORITHM

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Report submitted for the partial fulfillment of the requirements for the degree of Bachelor of Technology in **Information Technology**

Submitted by

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Place: RCCIIT, Kolkata

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Approval

This is to certify that the project report entitled "Automatic image enhancement using evolutionary algorithm" prepared under my supervision by Anindita Chatterjee, University Roll No. : 11700214013, Prannoy Dhar, University Roll No. : 11700214050, Anish Chakraborty, University Roll No.:11700214014, be accepted in partial fulfillment for the degree of Bachelor of Technology in Information Technology.

It is to be understood that by this approval, the undersigned does not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn thereof, but approves the report only for the purpose for which it has been submitted.

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Name & Designation of the HOD Name & Designation of Internal Guide

INTRODUCTION

Image enhancement is applied to improve the overall visual quality of an image—to smooth or sharpen the image features such as edges for better visual interpretation or better subsequent digital image analysis. It is applied to many types of images, such as medical images, digital photography, and remotely sensed imagery.

- It is the sub areas of image processing.
- Image enhancement widely used in computer graphics.

The visual appearance of an image may be significantly improved by emphasizing its high frequency contents to enhance the edge and detail information in it. Advanced image enhancement software also supports many filters for altering images in various ways. Programs specialized for image enhancement are sometimes called *image editors*. Image enhancement is applied in every field where images are ought to be understood and analyzed. Image enhancement algorithms offer a wide variety of approaches for modifying images to achieve visually acceptable images. Enhancement will improve the clarity of the original image by removing the noise. so that it will be more easier to analyze any image. The aim is just to enhance the properties of original image for the better output. The main purpose of image enhancement is to modify various image attributes to make the original image more suitable for any given task and for a specific observer. For this to achieve we can modify one or more attributes of the particular image.

PROBLEM DEFINITION

The enhancement alters the visual impact that the image has on the interpreter in a fashion to improve the information content. Image enhancements improve the perceptibility of objects in the scene by enhancing the brightness difference between objects and their backgrounds. The enhancement alters the visual impact that the image has on the interpreter in a fashion that improves the information content. The greatest difficulty in image enhancement is quantifying the criterion for enhancement and therefore a large number of image enhancement techniques are empirical and require interactive procedures to obtain satisfactory results. In this project we will try to enhance the image automatically by an evolutionary algorithm without any human intervention.
Enhancement of image becomes a difficult and challenging task due to various perturbations present in those images.

- In this project we have proposed a novel method to enhance an image without human intervention.
- By summing up various mathematical enhancement functions a combined enhancement function is being created.
- Here we have used bat algorithm as an evolutionary algorithm depending on the image statistics.
- The performance of the proposed method is found to be superior than that of the state-of-the-art methods for image enhancement on standard data set.

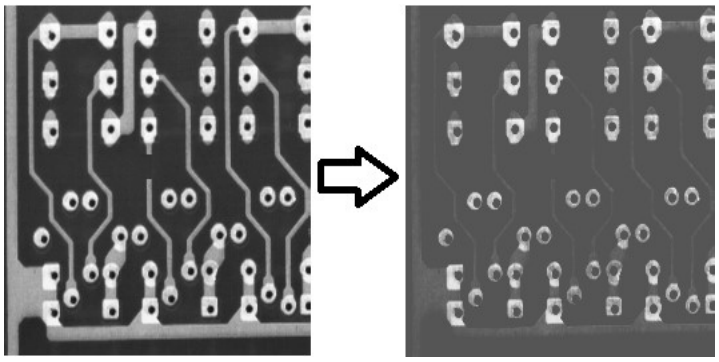


Fig1: (a) Original Image (b) Enhanced Image

(Enhancement Of Image)

LITERATURE SURVEY

In the literature, a limited number of methods are proposed to enhance images.

B. D. Ghimire et al.[1] proposed a method in which the image enhancement was applied only on the V (luminance value) component of the HSV colour image and H and S component were kept unchanged to prevent the degradation of colour balance between HSV components. A.A.Rivera et al.[2] proposed a content-aware algorithm that enhances dark images, sharpens edges, reveals details in textured regions, and preserves the smoothness of flat regions. S. K. Pal et al.[3] proposed a method where, Genetic algorithms represent a class of highly parallel adaptive search processes for solving a wide range of optimization and machine learning problems. X. Yang et al.[4] proposed Bat algorithm (BA) is a bio-inspired algorithm developed to be very efficient and provided a timely review of the bat algorithm and its new variants. M.Jamil et al. [5] extended the bat algorithm with a good combination of L´evy flights and subtle variations of loudness and pulse emission rates. They tested the IBA versus over 70 different test functions and proved to be very efficient. A. A. . Belousov et al.[6] proposed an algorithm applying wavelets and evolutionary algorithms to automatic image enhancement which are effective methods of multidimensional optimization, allow quick selection of optimal values of transformation parameters, using objective optimization criterion. S. Gowda et al. [7] discussed about the significance of image pre processing in medical image processing. Consider the case of breast cancer detection, it was found that there are various schemes of optimization techniques which is either training based or leads to recursive iterations leading to computationally complex process. Hence, the proposed system implements a new optimization technique called Image Enhancement using Bio-inspired Algorithms. P. Bidwai et al.[8] proposed an algorithm to compare two image enhancement algorithms i.e. Hybrid Binarisation and Histogram Equalization method. By analysis made by visual appearance on the enhanced images can conclude that hybrid Binarisation method outperforms the histogram equalization algorithm. Results show that Hybrid Binarisation method performs better than Histogram Equalization both in visual perception and image metrics values. M. Tuba et al.[9] proposed a new meta-heuristic search algorithm, called cuckoo search (CS), based on

cuckoo bird's behaviour to train BP in achieving fast convergence rate and to avoid local minima problem. The performance of the proposed Cuckoo Search Back-Propagation (CSBP) is compared with artificial bee colony using BP algorithm, and other hybrid variants. Specifically OR and XOR datasets are used. The simulation results show that the computational efficiency of BP training process is highly enhanced when coupled with the proposed hybrid method. K. Hasikin et al.[10] proposed a new enhancement technique using the fuzzy set theory for low contrast and non uniform illumination images. A new parameter called the contrast factor which will provide information on the difference among the gray-level values in the local neighbourhood is proposed. The contrast factor is measured by both local and global information to ensure that the fine details of the degraded image are enhanced. A. Kaur et al.[11] proposed global graylevels image contrast enhancement technique using particle swarm optimization (PSO) so as to best fit the demands of the human interpreter. S. Khunger et al. [12] proposed an embedded system application where image enhancement techniques are adopted for bringing online corrections to the images captured by autonomous underwater vehicles that get blurred due to shadows generated. M.C.Lee et al. [13] proposed application of DEA based automatic image enhancement technique to achieve improvement in the image captured by the camera sensor in mobile devices. Subjective test shows the usefulness of the DEA based approach proposed. J. Oh et. al. [14] presented a new morphology-based homomorphic filtering technique for feature enhancement in medical images. This method is based on decomposing an image into morphological subbands. By using the morphological subbands, homomorphic filtering is performed. DE is used to find an optimal gain and structuring element for each and every subbands. Results showed that proposed filter improved the contrast of the features in medical images. C. Munteanu et al.[15] proposed a real-coded GA is used with a subjective evolution criterion to globally adapt the gray-level intensity transformation in the image. C. Munteanu et al.[16] a real-coded GA is used with intensity transformation function to local and global enhancement of the image. All the methods described above did not consider the texture property of an image As a result the performance of the methods are still below the expectation. So, this is our motivation for finding a better solution.

In this paper we propose a novel method for automatic image enhancement without using human intervention. The method is based on combining the enhancement function which creates a combined enhancement function. Then the combined function passes through an evolutionary algorithm , here we have used bat algorithm in order to get an optimized solution.

SRS (SOFTWARE REQUIREMENT SPECIFICATION)

HARDWARE REQUIREMENTS	
RAM	4GB
MINIMUM SPACE REQUIRED	10 GB

Table1. (Hardware Requirements Table)

SOFTWARE REQUIREMENTS	
Operating Platform	WINDOWS 10/10PRO
Internet Connection	1MBps
Tools	MATLAB 2017a
Operating System Type	64 bit

Table2. (Software Requirements Table)

PlANNING

SERIAL NO.	TASK	RESOURCE	DATE
1	Project Selection	None	August,2017
2	Project Assignment	Project Related Papers	August,2017
3	Project Initialization	Related Research Papers, Development Tools(MATLAB)	August,2017
4	Project Development	Do	September,2017
5	Partial Validation of development	Matlab, Developed Algorithm	October,2017
6	Presentation Day	MS Powerpoint	October,2017
7	Continuation of previous work	MATLAB, Previous Developed Algorithm, Sample images from databases	October,2017
8	Project Synopsis	MATLAB, Related Papers	November,2017
9	Synopsis Presentation	MS Powerpoint	November,2017
10	Testing	Matlab,image databases,Developed Algorithm	January,2018
11	Refinements	Do	February,2018
12	Results and Analysis	Do	March,2018

DESIGN

The purpose of image enhancement is to improve the picture quality, more specifically. The process of evaluation of the quality of an image (picture) is subjective, which makes the definition of a well-processed image an illusive standard for comparison of algorithm performance. To make this task objective it is necessary to define some mapping functions which will be used for image enhancement operation and combine those mathematical functions then pass the combined function by bat algorithm in order to get an optimized result.

I. BAG OF ENHANCEMENT FUNCTION

The purpose of image enhancement is to improve the picture quality, more specifically, to improve the quality for visual judgment and/or machine understanding. It is to be noted that the process of evaluation of the quality of an image (picture) is subjective, which makes the definition of a well-processed image an illusive standard for comparison of algorithm performance. To make this task objective it is necessary to define an objective function which will provide a quantitative measure for enhancement quality. The mapping function (f1) depicted in Figure 2(a) increases the contrast within the darker area of the image, while the application of a function (f3) as in Figure 2(c) will produce effects exactly opposite to that of Figure 2(a). The function (f2) shown in Figure 2(b) will result in stretching middle range gray levels and the function (f4) in Figure 2(d) will drastically compress the middle range values, and at the same time it will stretch the gray levels of the upper and lower ends. The mathematical forms of the above mentioned mapping functions are given below:

$$f_1(x) = \frac{Ax^2}{1+x^2} \qquad (1)$$

where par_1 *and A are positive constants*

$$f_2(x) = [1+(\frac{x - x_{min}}{par6})^{par7}]^{-1} \qquad (2)$$

where x_{max} *and* x_{min} *are the maximum and miniimum gray levels in the image*

$$f_3(x) = par2[G(x)]^2 + par3x + par4 \quad (3)$$

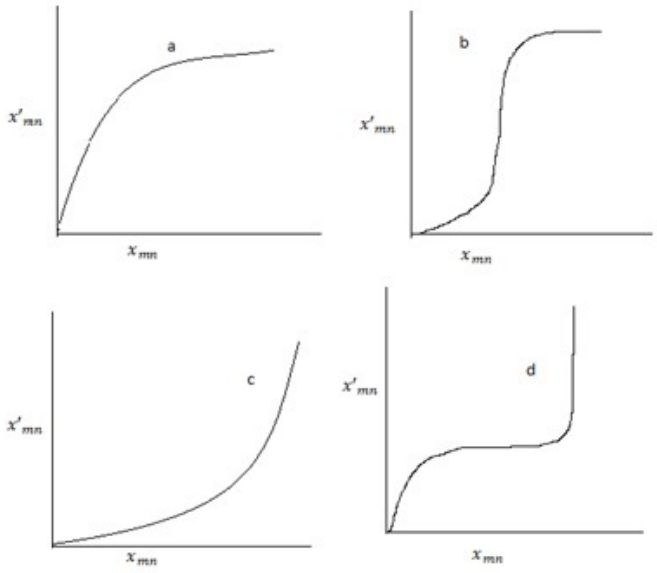
where $G(x) = x\text{-}par_5$ *for* $x > par_5$,

$= 0$ *otherwise* ,

$x_{min} < par_5, < x_{max}$

$$f_4(x) = [\frac{1}{x_{max}} * (x_{max} - par6\left\{\left(\frac{x_{max}}{x} + par8\right) - 1\right\}^{-par7}] \quad (4)$$

where par_6 *and* par_7 *are positive constants and* par_8 *is the value of f(x) for x=0*



x_{mn} =pixel intensity

X'_{mn} =transformed pixel intensity

Fig2. (Graphical Representation of mathematical functions)

All these functions perform contrast enhancement of an image .Since we do not know the exact function which will be suited for a given image, it seems appealing and convenient to use one general functional form which will yield the four functions mentioned above as special cases and possibly others. As an illustration one may consider a convex combination of these four functions

f(x)=par_9 f1(x) +par_{10} f2(x) +par_{11} f3(x)+ par_{12}f4(x) [combining 1,2,3,4]

Here, the parameters (par_9 , par_{10}, par_{11}, par_{12}) are to be chosen according to the importance (suitability) of a function for a given image .

The range of the parameters of the different enhancement functions:

Parameters	Range
p_1- p_4 & p_8- p_{12}	[0-1]
p_5 & p_6	$(gray_{min}, gray_{max})$
p_7	[1,3]

Table3. (Range of parameters)

In our application, the domains of the different parameters are given below, where $gray_{min}$ and $gray_{max}$ are the minimum and maximum value of the gray-level dynamic range.

2. BAT ALGORITHM

Yang [4] proposed bat algorithm by simulation the behavior of bat when it finds the food. It takes into account the major advantages of particle swarm optimization and simulated annealing.

Three main rules are used for executing the bat algorithm:

1) Echolocation is used by all bats to measure distance. The bats are able to differentiate between food/prey and background barriers. In the echolocation system, high frequency is emitted by a bat and it is followed by listening to returning echoes. The distance and location of the prey are decided by the differences between the emitted frequencies and the echoed frequencies.

2) Bats move randomly with velocity at a position. It has a fixed frequency and varying wavelength. It also has a loudness to search for prey. They can adaptively alter the wavelength of their emitted pulses and also alter the rate of pulse emission based on the closeness of the target.

3) Though the loudness varies in many ways, here the basic assumption is that the loudness changes from a large (positive) to a minimum constant value.

Main steps of the algorithm are given below

1) Initialization;
   Repeat

2) Generating the new solutions;
3) Local searching for minimizing the effect of local optima;
4) Generating new solution with the random fly;
5) Getting the current best solution until termination criteria are met.

The Bat algorithm is a metaheuristic algorithm for global optimization. It was inspired by the echolocation behavior of **microbats**, with varying pulse rates of emission and

loudness. Each bat is associated with a velocity v_i^t and a location x_i^t, at iteration t, in a d-dimensional search or solution space. Among all the bats, there exists a current best solution x_*. Therefore, the above three rules can be translated into the updating equations for x_i^t and velocities v_i^t :

$$f_i = f_{min} + (f_{max} - f_{min})\beta$$

$$x_i^t = x_i^{t-1} + v_i^t$$

$$v_i^t = v_i^{t-1} + (x_i^{t-1} - x_*)fi$$

where $\beta \in [0, 1]$ is a random vector drawn from a uniform distribution.

In order to provide an effective mechanism to control the exploration and exploitation and switch to exploitation stage when necessary, we have to vary the loudness $A_i$and the rate r_i of pulse emission during the iterations. Since the loudness usually decreases once a bat has found its prey, while the rate of pulse emission increases, the loudness can be chosen as any value of convenience, between A_{min} and A_{max}, assuming $A_{min} = 0$ means that a bat has just found the prey and temporarily stop emitting any sound. With these assumptions, we have

$$A_i^{t+1} = \alpha A_i^t \qquad r_i^{t+1} = r = r_i^0 [1 - exp(-\gamma t)]$$

where α and γ are constants. In essence, here α is similar to the cooling factor of a cooling schedule in simulated annealing. For any $0 < \alpha < 1$ and $\gamma > 0$, we have

$$A_i^t \to 0 \quad r_i^t \to r_i^0 \quad as \quad t \to \infty$$

PROPOSED FUNCTION GENERATION AS A CONSTRAINT OPTIMIZATION PROBLEM

In the previous section, we have seen that it is logical to determine the enhancement function for an image adaptively from a bag of enhancement functions. For constraint optimization using an evolutionary algorithm we have to find out the ki , i ∈ [1 14] in such a way that if should satisfy the parameter constraints. For any evolutionary algorithm, an evaluation function required which has to be maximized or minimized to get the optimal solution. In the proposed method we use the index of fuzziness as an evaluation function. The index of fuzziness γ represents the amount of fuzziness present in an image. Since in an image the boundary can not be crisply defined. It is feasible to transform it into a fuzzy plane and measure its fuzziness. More, the fuzziness is reduced more it will be better. So the objective of the evolutionary function will be to reduce the index of fuzziness. It is defined as

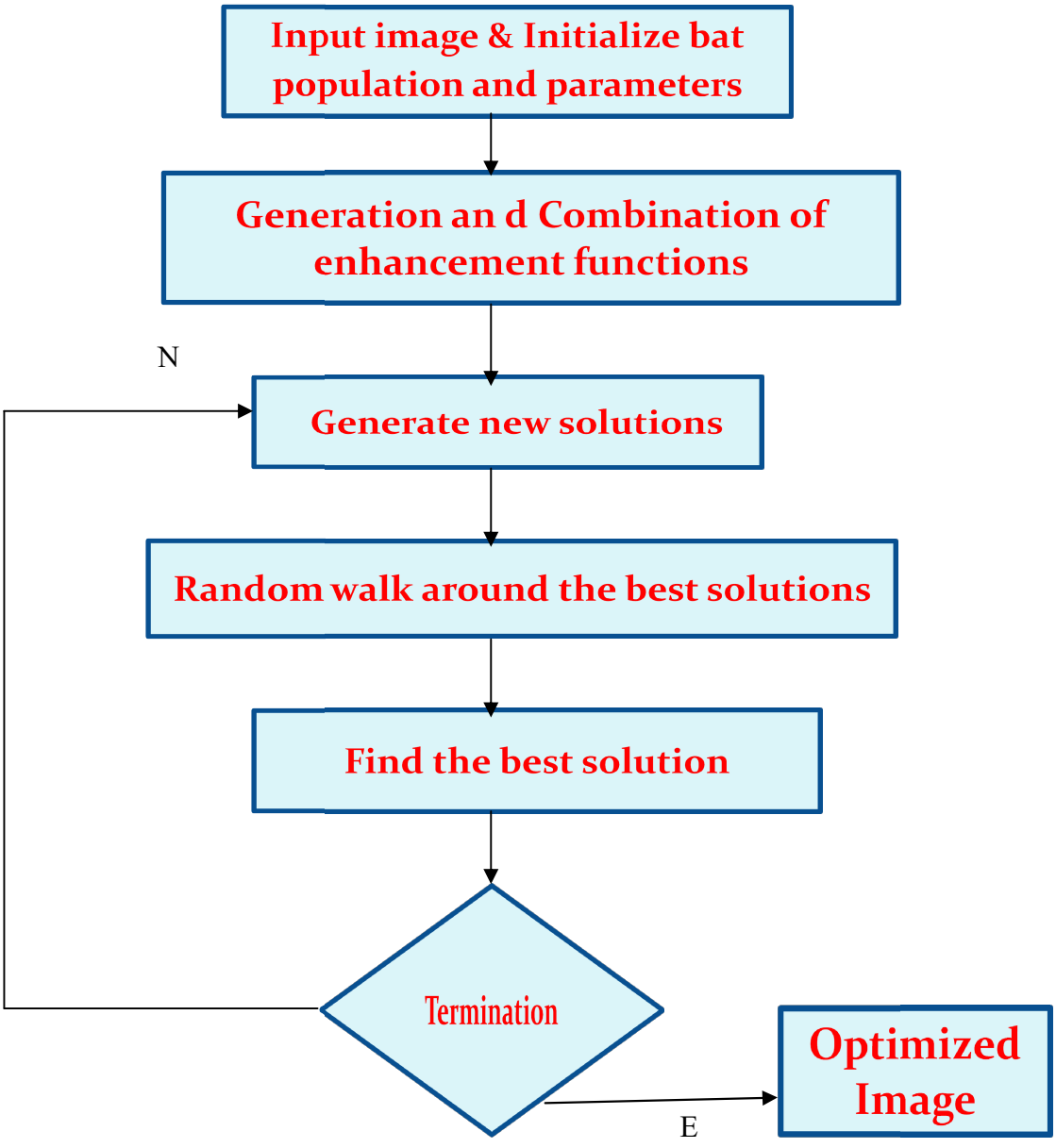
$$\gamma(X) = \frac{2}{\sqrt{MN}}\left[\sum_m \sum_n (\mu_X(x_{mn}) - \mu_{\bar{X}}(x_{mn})\right]$$

In the proposed method the image X of dimensions M × N is transformed into a fuzzy plane using an S function. The membership value is given by

$$\mu(x_{mn}) = \left[1 + \frac{(x_{max} - x_{mn})}{F_d}\right]^{-F_e}$$

where F_d and F_e are the fuzzifiers. The correct estimation of the parameters will result in the minimum index of fuzziness and an optimal enhanced image will be generated. So, the evaluation function is used as the fitness function, where the evolutionary algorithm will try to find out the minimum value of it.

PROPOSED METHOD



Proposed algorithm for efficient approach for generation of enhancement function for an NDT image using Bat algorithm:

Input: Image of dimensions $M \times N$
Output: The enhanced NDT image

Initialisation:The population of b bats are initialized i.e the set of position vectors $b_i = [k_1, k_2..., k_{14}]_i$ with random positions. With the population, the frequency f_i, the velocity v_i, the loudness A_i and pulse emission rate r_i where $i = 1, 2, .., b$ are also initialized. The maximum number of iterations is M1 and iteration number $iter = 0$.

1: **repeat**
2: **for** each of the bat b_i in the current population **do**
3: Update f_i, v_i and p_i with the help of b^* (Eq9, Eq10 and Eq11)to make new solution i.e the new parameter vector.
4: **if** $(rand > r_i)$ **then**
5: pick a local solution in the neighborhood of the best solution. Here $rand$ represents random variable;
6: **end if**
7: Fly randomly to generate a new solution b_{inew}(Eq12);
8: Generate the enhancement functionsf_1, f_2, f_3 and f_4 (Eq 1,Eq 2,Eq 3,Eq 5)using the parameters and combine them to generate f(Eq 6)
9: Transform the NDT image into a fuzzy plane (Eq8 and evaluate the fitting function index of fuzziness(Eq 7);
10: **if** $(rand < A_i$ and $\gamma(b_{inew}) < \gamma(b^*))$ **then**
11: The solution is updated as as $b_i = b_{inew}$ with increase of r_i and the decrease of A_i;
12: **end if**
13: **end for**
14: $iter = iter + 1$;
15: Choose the current best solution b^* with minimum index of fuzziness among the bats in the current population;
16: **until** $iter = M1$ or fitting function remains unchanged
17: Return optimized parameters $b_i = [k_1, k_2, ..., k_{14}]$.
18: Generate the enhanced NDT image.

Where $v_i^t$and b_i^t are the velocity and position of the ith bat at an iteration t. The frequency of the bat is represented by f_i . At first, each bat is randomly assigned a frequency f which is taken uniformly from $[f_{min}\ f_{max}]$. The $\beta \in [0\ 1]$ is a random value

taken from a distribution which is uniform. Here b^* is the current global best location (solution). The best location is found after comparing all the solutions among all the bats. After choosing a solution from the current best solutions, a new solution for each bat is locally generated based on a random walk according to the equation:

$b_{new} = b_{old} + \eta A^t$

Where $\eta \in [-1\ 1]$ is a random number generated from Gaussian distribution. η is the step size to generate new location (i.e new solution). The At represents the average loudness of all the best solutions at the current time step. The bold is calculated . The loudness A_i and pulse rate emission r_i are updated at each iteration t in the Bat algorithm. The loudness decreases and the corresponding pulse emission increases when the bat founds the prey. The loudness A_i and the rate of pulse emission ri generate according to the following equations.

$$A_i^{t+1} = \alpha A_i^t \qquad r_i^{t+1} = r = r_i^0 [1 - exp(-\gamma t)]$$

Where α and γ are constants and $0 < \alpha < 1$, $\gamma > 0$.

$$A_i^t \to 0 \quad r_i^t \to r_i^0 \quad as \quad t \to \infty$$

The loudness and emission rate are updated only when the new solution is obtained. That means the bats move towards the optimal solution.

PROPOSED ENHANCEMENT FUNCTION GENERATION USING BAT ALGORITHM

For generating the function the initial bat population b=50 and total number of iterations=40. The constraints of the parameters are given as $0 \leq k1, k3, k4 \leq 2$, $x_{min} \leq$ k2, $k7 \leq x_{max}, 1 \leq k5, k6, k8, k9, k10 \leq 3$ and $0 < ki < 1$ where $i = 11, 12, 13, 14$. For each bat in a population the positions are generated and best solution i.e the best combinations of the enhancement functions from the set of bags are found out using index of fuzziness. The algorithm for generating the function is shown in algorithm1

RESULTS AND DISCUSSION

In this section, we tested the proposed method on the images from Mehmetsezgin dataset. The dataset contains different images like eddy current of a rivet region, the thermal image of GFRP composite material, defective tile image, defective cloth image, defective PCB image, degraded document image etc. The size of the images varies from 200 × 200 to 500 × 500.We have taken some differential enhancement functions which forms together combined enhancement function. By passing that combined function on bat algorithm gives certain parameter values, those parameter values judiciously enhance the non destructive images that we have taken as original image, which produces optimized image.

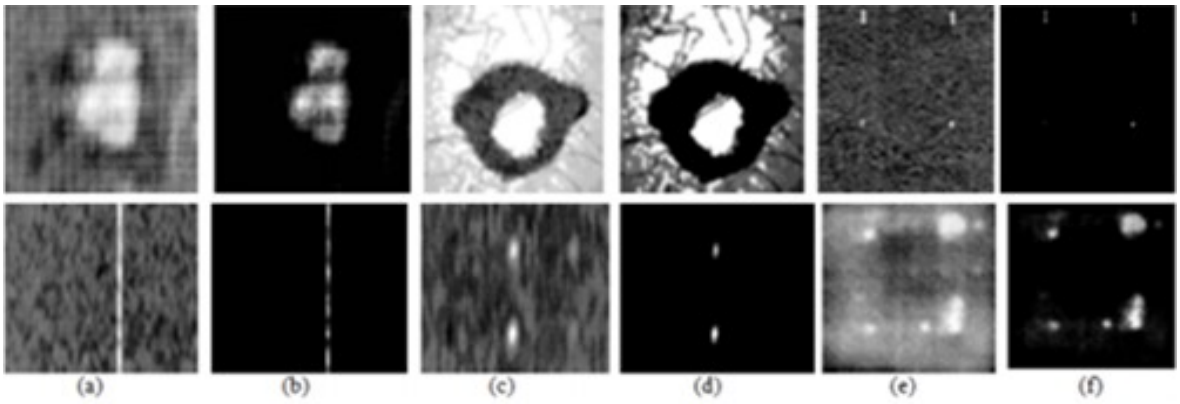


Fig3. Column (a),(c),(e) represents the original test image,(b),(d),(f) show the enhanced image by the proposed image

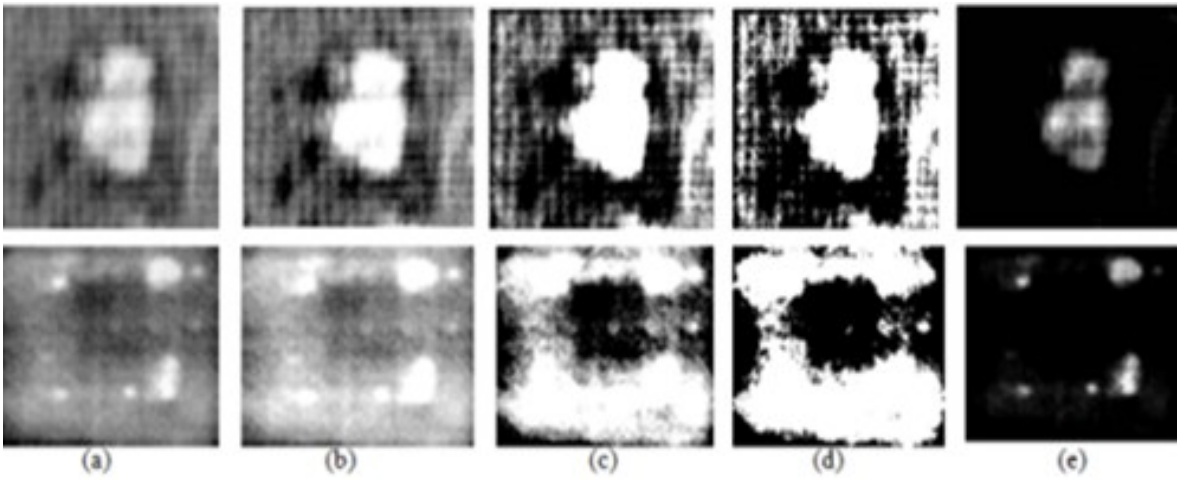
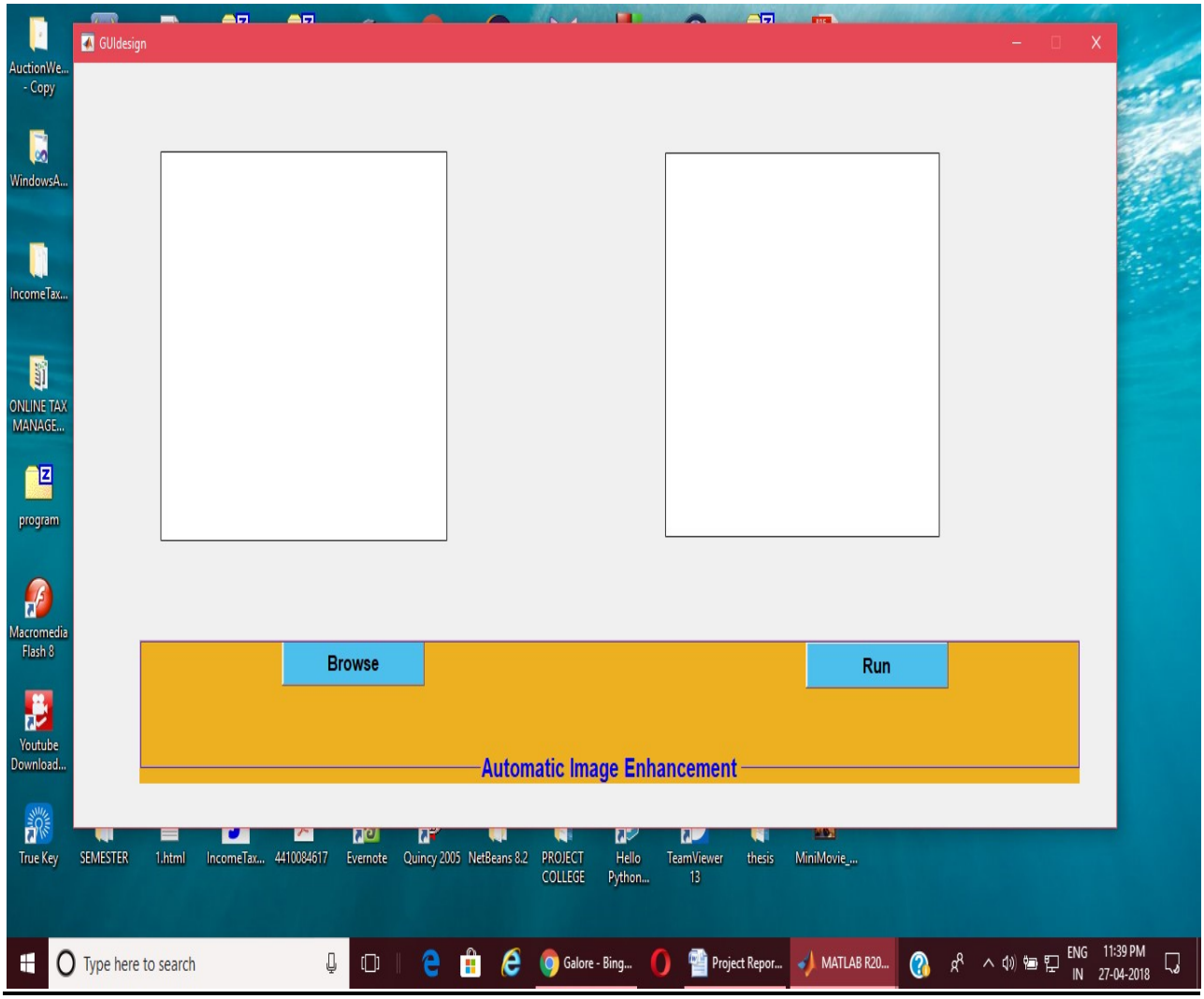


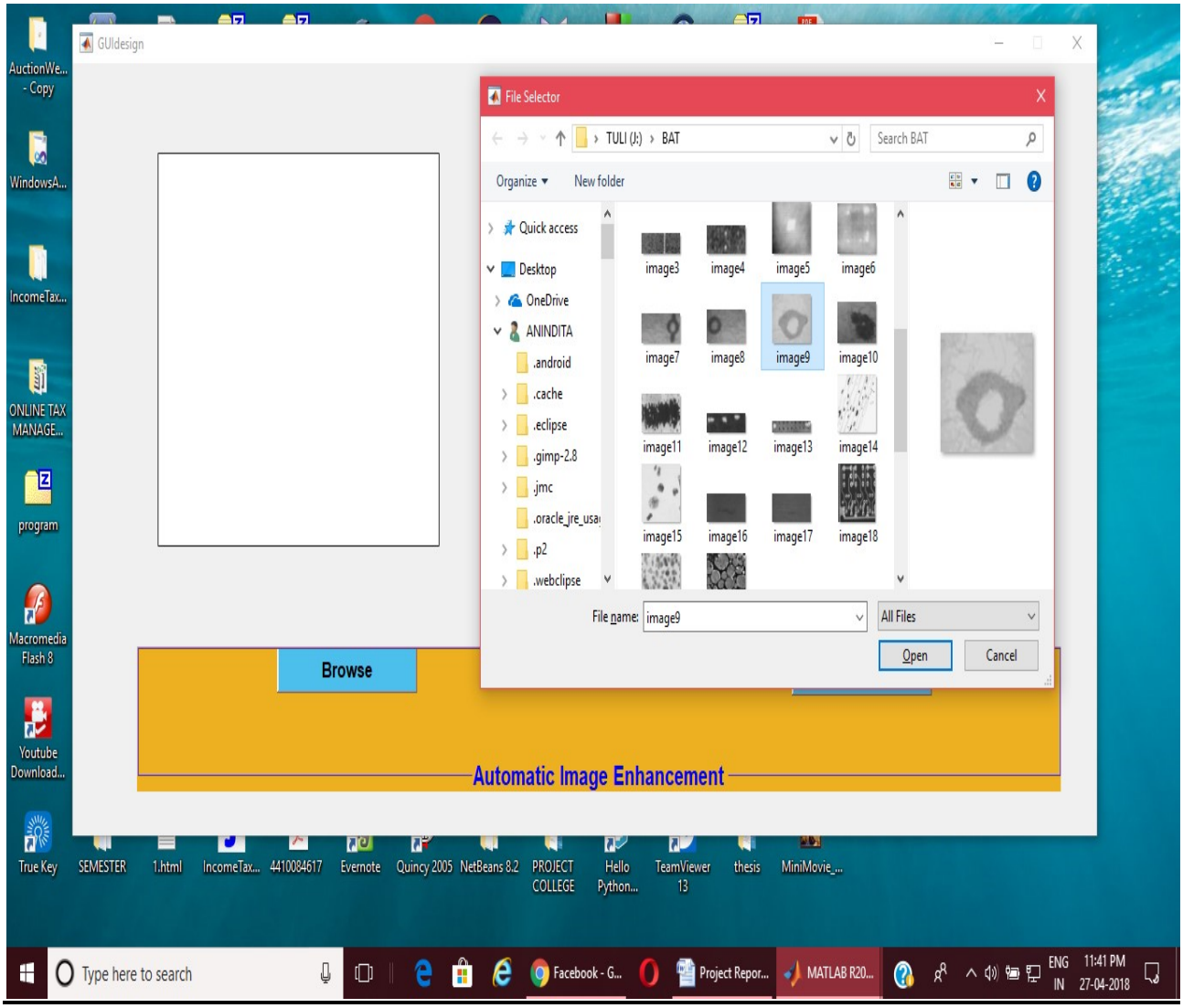
Fig4.Comparison with the different methods (a) original test image (b) Results by Singh et al.,(c)Results by Lim et al.,(d)Results by Lu et al.,(e)Results by the proposed the method

- **SCREENSHOTS**

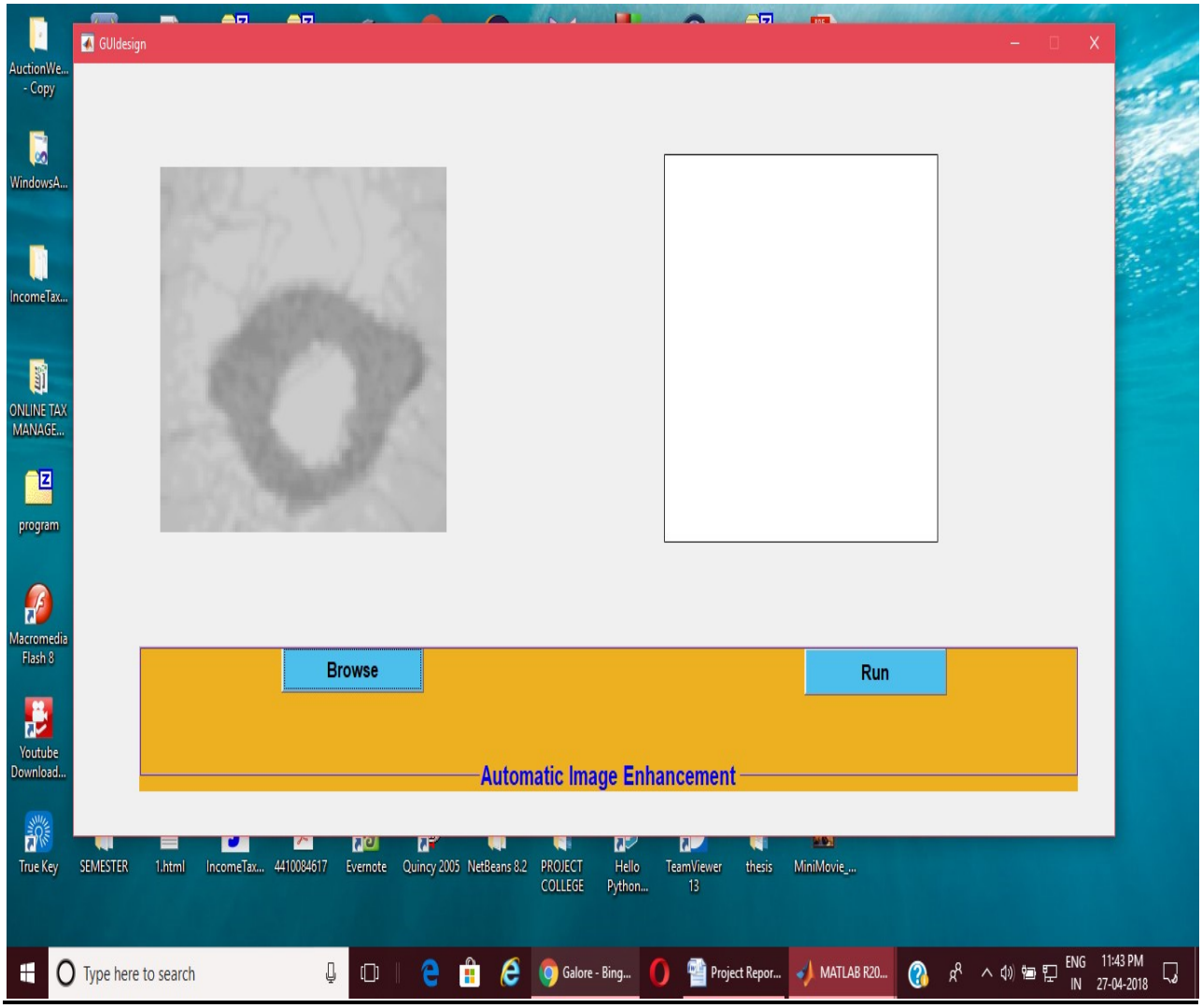
1.The basic view of the GUI



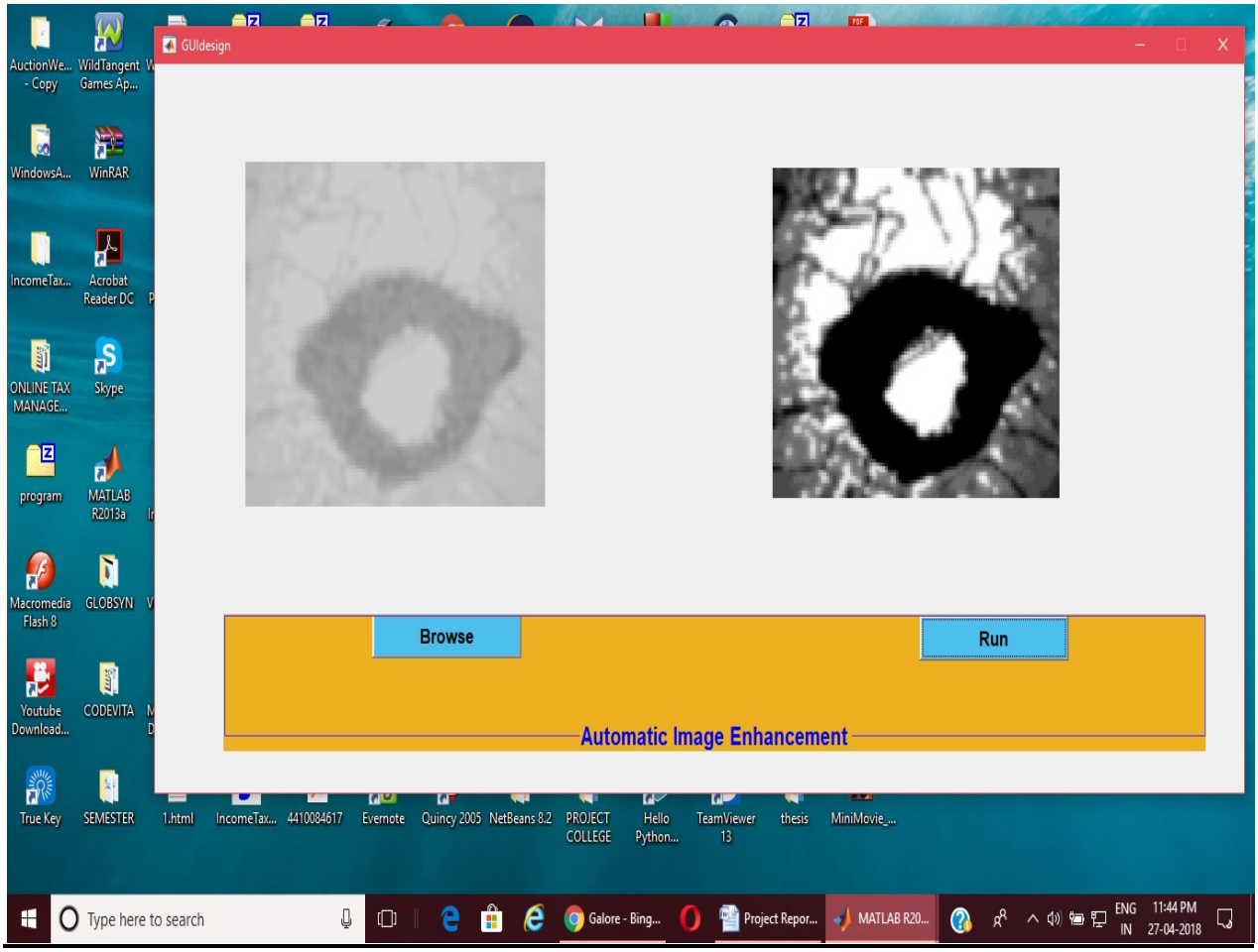
2.Click the browse button for selecting the test image



3.After the selection of the image the window will display the test image



4.Click the run button to run the test image then the window will display the optimized image



CONCLUSION AND FUTURE SCOPE

We have proposed a method to enhance a non destructive image which have some noise. The method uses the combination enhancement function which is passed through bat algorithm. The proposed method judiciously chooses the appropriate noisy area of an image. Likely many meta heuristic algorithms, bat algorithm has the advantage of simplicity and flexibility. BA is easy to implement, and such a simple algorithm can be very flexible to solve a wide range of problems. Here we have used mathematical enhancement functions using bat algorithm which will produce an optimized image without any human intervention. The method performed better than the state-of-the-art methods. The proposed method shows the efficiency to bring out detail that is hidden in an image or to increase contrast in a low contrast image. So, it gives a new direction of research. With suitable modification in the current method, it can be extended for the recognition of the non destructive images, which is being currently investigated.

- We propose a method to enhance the images. The method efficiently combines a bag of enhancement functions to generate an efficient enhancement function.

- The function is generated adaptively depending on the image statistics. To speed up the process the evolutionary Bat algorithm is used. The method does not require any external expert to enhance the image.

- The method performed better than that of the state-of-the-art methods on the standard dataset of images.

- The methods can be efficiently used in industries.

Current research is going on to so that it can be executed in the real-time environment.

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