INTL JOURNAL OF ELECTRONICS AND TELECOMMUNICATIONS, 2022, VOL. 68, NO. 4, PP. 875-880
Manuscript received October 19, 2022; revised November 2022. DOI: 10.24425/ijet.2022.143897

An Enhanced Approach for Image Edge Detection Using Histogram Equalization (BBHE) and Bacterial Foraging Optimization (BFO)

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***Abstract*—The Edge detection is a customarily task. Edge detection is the main task to perform as it gives clear information about the images. It is a tremendous device in photograph processing gadgets and computer imaginative and prescient. Previous research has been done on moving window approach and genetic algorithms. In this research paper new technique, Bacterial Foraging Optimization (BFO) is applied which is galvanized through the social foraging conduct of Escherichia coli (E.coli). The Bacterial Foraging Optimization (BFO) has been practice by analysts for clarifying real world optimization problems arising in different areas of engineering and application domains, due to its efficiency. The Brightness preserving bi-histogram equalization (BHEE) is another technique that is used for edge enhancement. The BFO is applied on the low level characteristics on the images to find the pixels of natural images and the values of F-measures, recall(r) and precision (p) are calculated and compared with the previous technique. The enhancement technique i.e. BBHE is carried out to improve the information about the pictures.**

***Keywords*—edge detection; bacterial foraging optimization; BBHE; images processing; graphics**

I. Introduction

THE Edge detection is defined as the sudden changes of discontinuities in an image. Detection of edges done as the most of the information about the shape of the images are enclosed in the edges [1]. Step by step detection of the edges is done as in the first step detection is done using filters and then by enhancing the areas of an image will increase the sharpness of the image and the image become more clear. It is the important in the image processing and understanding. Low-level features [2] are different from the high level features. Low level characteristics are used as to build the high level characteristics. Low level features are important for edge detection as they are usually suitable for real time applications. Corner detection and region detection(blob detection) and also scale-invariant feature transform are the low level features. The numbers of the excessive level functions like high level features are quality assessment, color quality, brightness [3].

Bacterial foraging optimization (BFO) is recommended by Kevin passion in 2002. This optimization technique is nature inspired optimization algorithm. It is an evolutionary algorithm which estimates the better results and the better fitness value after every iteration [5]. The moving bacteria represent the movement of pixels in an image which helps to detect the edges in the images. The bacterial foraging strategy of E.Coli is explained by performing four steps. The steps are chemotaxis, swarming, reproduction, elimination and dispersal [6]. The chemotaxis process replicates the flow of E.coli bacterium in two ways that are tumbling and swimming. If the movement of bacteria finds the pixel i.e. accurate value of the pixel then it continues swimming in the same direction and if it is not able to find the pixel then it tumble i.e. it changes the path and start moving again to find the pixel.

In the reproduction process, the fitness of the bacteria is calculated after each chemotaxis step. The health (fitness) is calculated in the way that the bacteria with least fitness value die and the other half with great fitness value survive. The other half of which continue to exist splits into and these two are positioned on the same area. As on this way, population of the bacteria remains consistent. The chemotaxis performs the searching of the pixels in an image and reproduction speeds up the concurrence of search parameter. Sometimes due to unexpected changes in the local environment the bacteria also got trapped in local environment as summing it to be best part of fitness position surrounding patch. So to avoid this problem have the probability Ped (probability of elimination and dispersal) [7]. Edges in a image can be detected using different several approaches [1]–[2].There are many approaches which focus on the values or output which are evaluated using differentiation. It is an approach which automatically detects edges with sub-pixel accuracy.[3], [4], statistics [5], mathematical morphology[6], [7]. Some more approaches for this are machine learning (ML) which is also analogous to computational statics [8], phase congruency and local energy [9], [10], multi resolution [11], a local feature's combination [12], and optimization strategies which are established on frequency models also called as phase congruency and the groups of pixels [13].The above approaches are generally connected with some of the preprocessing techniques like Gaussian filtering [14], [15]. Many methods were reported for higher quality of an image consisting of local contrast stretching [16], [17], graphical representation such as histogram equalization [18], [19], [20], contrast limited adaptive histogram equalization (CLAHE) [21], Bi histogram equalization (BHE) [22] which are spatial domains and DWT [23], [24], DCT [25] are commonly used compressed domain methods.

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II. BBHE AND BFO APPROACH TECHNIQUES FOR EDGE DETECTION

Brightness preserving bi-histogram technique (BBHE) is applied to get enhanced images and also to get the desired information about the images. BBHE enhance the quality of images. Bacterial Foraging Optimization (BFO) detects the edges as in this paper, the bacteria represents location of the pixels. The movement of bacteria helps to find the edges in the images. Firstly, the edge detectors are evolved. Firstly, the whole image is traversed and BBHE is imposed on the whole image and then that enhanced image is given as input to detect the edge detectors and to find the pixels. After finding the pixels, the movement of bacteria will find the detected edges in the image and hence the edge detected image will be obtained.

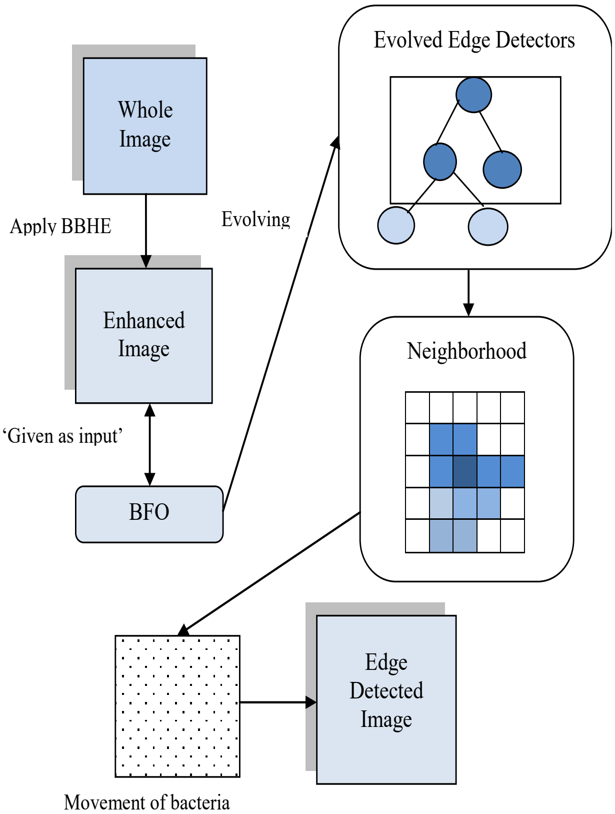


Fig.1. Process to find the detected edges by using BBHE and BFO

III. OPTIMIZATION MODELS FOR EDGE DETECTION

A. BBHE

The BBHE method is used to enhance the brightness of the images which helps to detect the edges accurately in the images. This strategy improves the data in the images and gives the improved 'input' for other image processing strategies. It improves the quality of picture in terms of contrast. The flowchart of methodology for BBHE is given in Fig. 2.

The BBHE method separated the image into two parts as I_(L) and I_H based on mean brightness as threshold [26], [27]. Let M is the mean brightness of input image (I) i.e. in sub image as given below:

$$I = I_L \cup I_H \quad (1)$$

where, $I_L = \{I(g,h)|I(g,h) \leq M, I(G,H) \in I\}$
and $I_H = \{I(g,h)|I(g,h) > M, I(G,H) \in I\}$

Then probability density function of the main image is considered for I_L and I_H as:

$$P_L(I_K) = \frac{n_l^k}{n_l}, \text{ where k=0, 1, 2.....m} \quad (2)$$

$$P_H(I_K) = \frac{n_h^k}{n_h}, \text{ where k=m+1, M+2.....N} \quad (3)$$

Where n_L^K *and* n_H^K are the K^{th} grey level for image one and image two respectively in sub-images and $n_L n_H$ are the total number of grey levels in I_L *and* I_H sub-images, whereas N is the gray levels and It is represented as N=$n_L + n_H$ and CDF is represents the Cumulative Density Function; CDF_L *and* CDF_H are calculated by using equations (4) and equation (5) respectively.

$$CDF_L = \sum_{k=1}^{m} P_L(I_K) \quad (4)$$

$$CDF_H = \sum_{k=m+1}^{N} P_H(I_K \quad (5)$$

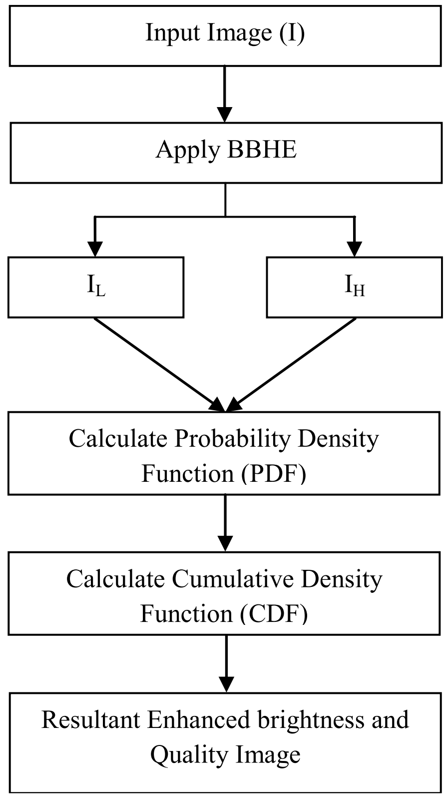


Fig.2. Process to find the detected edges by using BBHE

B. BFO

Second technique used is this paper is BFO (Bacterial Foraging Optimization) which helps to find the edges in the images by implementing main four steps that are elimination, dispersal, chemotaxis, swarming. In this edges of enhanced image will be observed and improved using bacterial foraging optimization algorithm i.e BFO. For detecting the edges, edge detection technique s applied on the selected image so after taking an enhanced image as 'INPUT' the edges of the selected image are selected. After detecting edges, the results are analyzed. It is analyzed whether the edges are detected properly or not. Then the earlier applied technique for edge detection is improved using BFO optimization algorithm. Employing optimization algorithm will enhance the quality of detected edges. After applying optimization algorithm, population is generated. This population is generated for getting better optimized results. The BFO algorithm will traverse in the whole search space of an image. It will traverse the area in the [X:1] i.e it will traverse complete row one column and so on. The edges of the image are selected according to the generated population using optimization algorithm. After generating population and then finding the edges of the image, the fitness value is calculated. After all these calculations, the algorithm finds the edges of the selected image. Finally, an edge selected image is obtained after applying BFO as shown in Fig. 3.

Algorithm:

- Select an enhanced image which should be given as the input to detect edges.
- The edges will be detected only in the given Search Space (p) i.e. in this paper p=2.
- The bacteria will traverse in the given search space to find the edges.
- The bacteria will move in [X:1] direction as first it traverse complete row one column and so on.
- Initialize the values Nc, Nr, Ned and P.
- The number of chemotactic steps are taken as Nc=4.
- The number of reproduction steps are taken as Nr=4.
- The number of elimination dispersal elements are taken as Ned=2.
- The probability that every bacteria will be dispersed or eliminate will be taken as 0.25.
- After traversing the whole image, the bacteria will find the edges and finally the edge selected image is obtained.

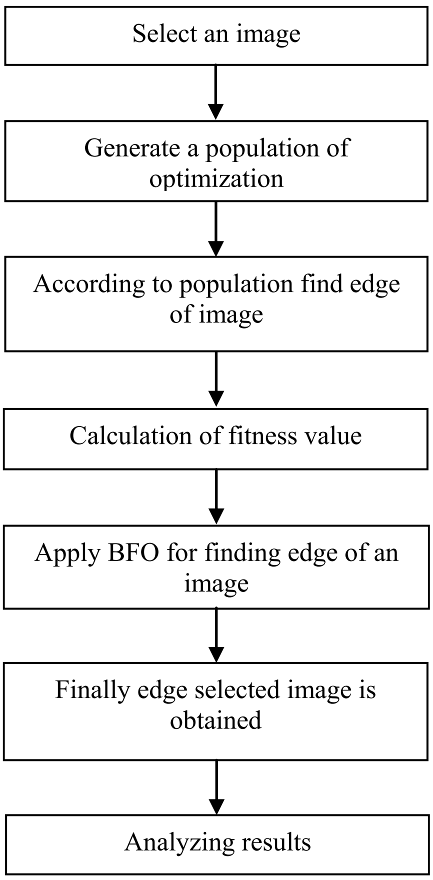


Fig.3. Flowchart of methodology for BFO

1) Fitness Function (F)

Fitness function is used to calculate the fitness value as represents in equation (6), whereas α is a weighting factor whose value lies between 0 and 1 and in this paper value of alpha is taken as 0.5 as at this point the edges are detected properly as shown in Fig. 4. The values are calculated at each point and it shows that after 0.5 the slope of graph lowers and at 0.5 the edges are detected accurately. Here, r is recall(r) which is described as the pixels count on the edges correctly detected as a proportion to the total number of pixels on the edges. P is the precision (p) which is described as a count of pixels on edges correctly detected divided by proportion of total number of pixels detected as the edges [28].

$$F = \frac{r*p}{\alpha*r+(1-\alpha)*p} \quad (6)$$

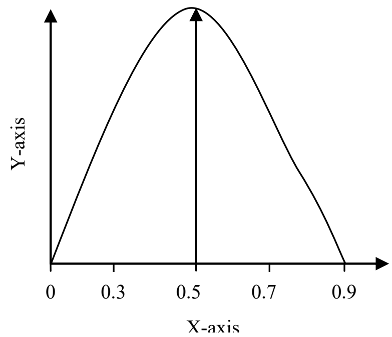


Fig.4. Graph showing value of alpha=0.5

2) Correlation ratio function (F_{cr})

The Correlation ratio function (F_{cr}) is represents by equation (7), which is based on correlation ratio measures. μ_0 and μ_1 are the outputs o_i from the non-edge and edge points and μ is the means of all outputs o_i, N_0 and N_1 are the number of the non-edge points and edge points, set of pixels(X), Th(μ_0, μ_1) are used to indicate the edge points and non-edge points. If c=0, then it indicates non-edge points and if c=1, then it indicates the edge points [29].

$$F_{cr} = \frac{1}{2}\sqrt{\frac{\sum_{c=0}^{1} N_c(\mu_c-\mu)^2}{\sum_{i\epsilon X}(o_{i-\mu})^2}} + \frac{Th(\mu_0,\mu_1)}{2} \quad (7)$$

$$Th(\mu_1\mu_2) = \begin{cases} 1 & if\ \mu_0 \le 0\ and\ \mu_1 > 0 \\ 0 & otherwise \end{cases}$$

3) Parameter Used

In BFO to analyze the result and to find the detected edges some parameters are assumed. The assumed parameters are such as P (Search space dimension), S (Bacteria's count), Nc (chemotactic steps Count), N_{re} (reproduction steps count), N_{ed} (number of elimination dispersal element count) and S_r (count of bacteria reproduction/splits).

4) Confusion Matrix

The confusion matrix is created which evaluates the value of recall and precision by calculating the values of TP (true positive), FP (false positive), FN (false negative), TN (true negative). After that, the non-edge and edge points of each image will be evaluated and then the value of Recall and Precision is calculated.

$$\text{Recall} = \frac{TP}{TP+FN} \quad (8)$$

$$\text{Precision} = \frac{TP}{TP+FP} \quad (9)$$

IV. RESULT AND DISCUSSIONS

A. Research Layout

Dataset of the Image: The dataset of the images is Berekely Segmentation Dataset (BSD) [30].This dataset is famous for facet detection and picture segmentation.BSD mainly includes the herbal photos which can be of length 128*128 count of pixels with floor truth value finished. The reason behind selecting this photograph dataset is the snap shots are observed by means of combining from ten to five human observations so that the edges inside the photo should be detected successfully and properly judgment ought to be done. Some pictures are selected in random way to get desired results.

Parameter Setting: In BFO to analyze the result and to find the detected edges some parameters are used. According to that the values are assigned so that the accurate edges that should be detected. The parameters and values used in BFO Algorithm are shown in Table I.

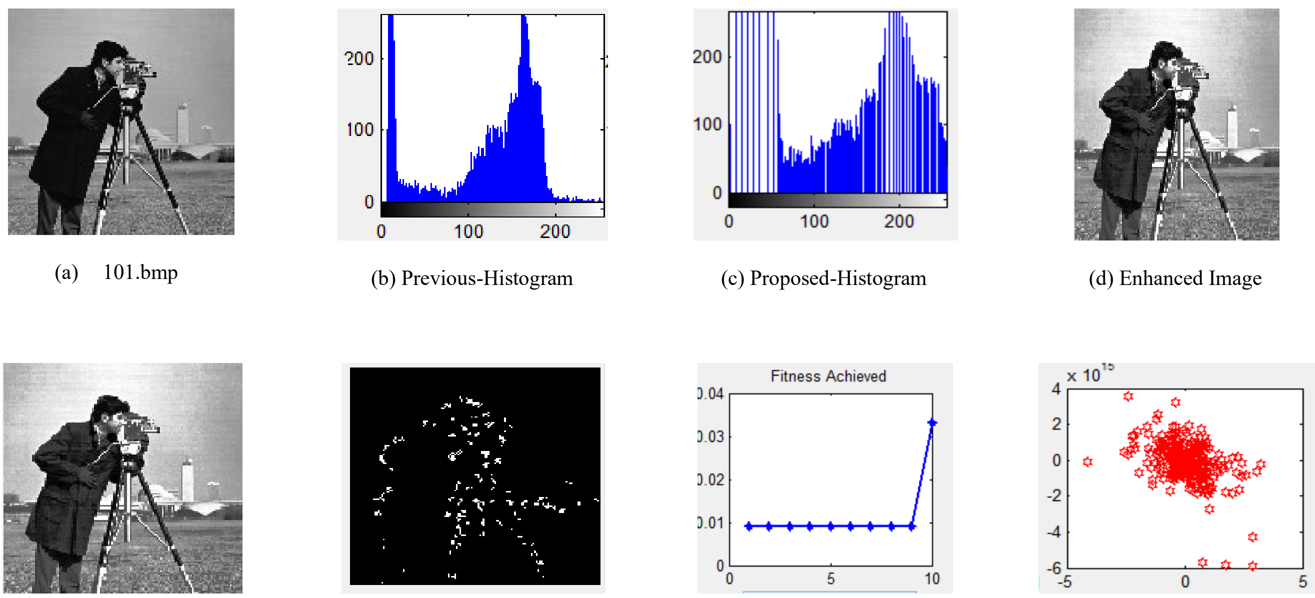
TABLE I
PARAMETERS AND VALUES USED IN BFO ALGORITHM

Parameters	Symbol	Values
Search space dimension	P	2
Bacteria's Count	S	Size (X,1)
Chemo tactic Steps Count	Nc	10
Length of Swim	Ns	4
Reproduction Steps count	Nre	4
Elimination-Dispersal Elements count	Ned	2
Count of Bacteria Reproductions (Splits) /Generation	Sr	s/2
Eliminated bacteria probability	Ped	0.25

B. Proposed and Previous Histograms

In this research article, evaluations of two images are performed which are taken from the dataset of 100 images. The proposed-histogram and previous-histogram are shown in Fig. 5, Fig. 6 for image id-101 and image id-102 respectively. The comparison between the previous technique and new technique is also shown in tabular form. Here the image is represented as image number as first image id is 101, second image id is 102 and so on.

For image id 101, the results are shown in Fig. 5



(a) 101.bmp (b) Previous-Histogram (c) Proposed-Histogram (d) Enhanced Image

(e) BFO Input (f) BFO Optimized Image (g) Graph showing fitness Value (h) Movement of bacteria To find edges

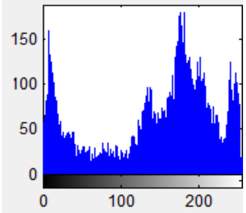
Fig. 5: Results of Image id -101

TABLE II
CONFUSION MATRIX OF DIFFERENT IMAGES

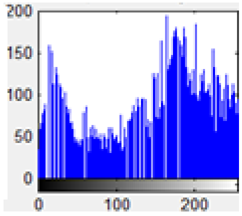
Image id	BFO Optimized Image	Actual Positive	Actual Negative
101	Predicted +ive	TP (181)	FP (39)
	Predicted -ive	FN (39)	TN (16197)
102	Predicted +ive	TP (181)	FP (29)
	Predicted -ive	FN (19)	TN (16222)
103	Predicted +ive	TP (181)	FP (7)
	Predicted -ive	FN (10)	TN (16210)
104	Predicted +ive	TP (181)	FP (9)
	Predicted -ive	FN (9)	TN (16164)
105	Predicted +ive	TP (181)	FP (7)
	Predicted -ive	FN (8)	TN (16210)

For image id 102, the results are shown in Fig. 6

(a) 101.bmp



(b) Previous-Histogram

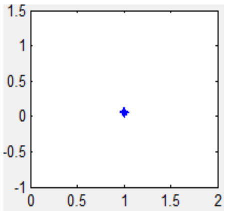


(c) Proposed-Histogram

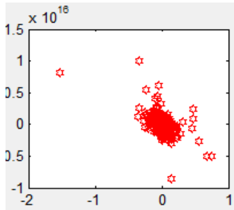
(d) Enhanced Image

(e) BFO Input

(f) BFO Optimized Image



(g) Graph showing fitness Value



(h) Movement of bacteria To find edges

Fig. 6: Results of Image id -102

The confusion matrix calculate the true positive (TP), false negative (FN), false positive (FP), true negative (TN) values to detect the edges in the image as shown in Table II.
The values of Recall (r) and Precession (p) are calculated using confusion matrix as given in equation (10) and equation (11) respectively. The values of recall and precision for various image ids are given in Table III and its graphical representation are shown in Fig. 7.

TABLE III
RECALL AND PRECISION OF DIFFERENT IMAGES

Image id	Recall Value	Precision Value
101	0.9583	0.9679
102	0.89604	1.1173
103	0.97312	0.96348
104	0.8146	0.8227
105	1.0402	0.9532

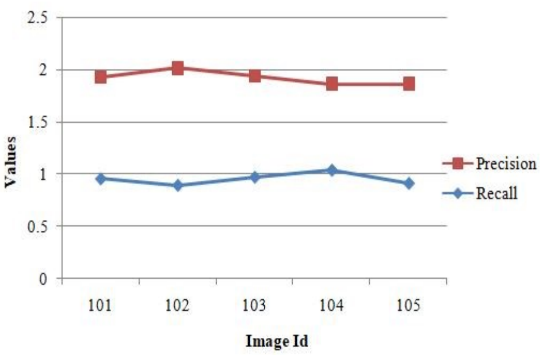


Fig.7. Graphical Representation of Recall and Precision Values

Now, the value of fitness function (F) of different images with respect to BFO value is shown in Table IV and the graphical representation of these values is also shown in Fig. 8.

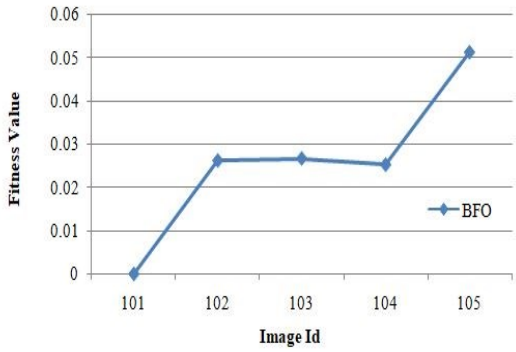


Fig.8. Graphical Representation of Recall and Precision Values

CONCLUSION

After analyzing the result of first and second technique i.e. BBHE (Brightness Preserving Bi-Histogram Technique) and BFO (Bacterial Foraging Optimization) concluded that the images after performing BBHE gives the better result for further image edge detection techniques. Enhancement is performed to enhance the great of the pictures and for the better perception to the humans. BFO detects the edges accurately and gives the fine detected edges. The one limitation of the technique BFO is when the loop size increases it takes the more time to complete the process means loop size is directly proportion to the time. After calculating results and comparing value it conclude that BFO also detect edges more accurately and enhancement technique also gives the more bright images and clear information about edges to be detected.

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