Contrast Enhancement Using Bacteria Foraging Optimization

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Abstract— Image enhancement is one of the leading field in which researches are continuously exploring new algorithms and concepts to enhance dull and low intensity images by various methods. Contrast enhancement techniques are used for improving visual quality of low contrast images. Bacteria foraging optimization(BFO) method is one such technique used for contrast enhancement. As histogram equalization (HE) preserves the original brightness, but it fails to bring out details specially in dark regions and produces artifacts and noise due to overstretching of histogram. Thus this paper processes a variant of histogram equalization i.e bacteria foraging optimization technique, which gives more efficient results.

Keywords- *Contrast enhancement, Histogram equalization, Background and Foreground objects, Optimization techniques, BFO.*

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I. INTRODUCTION

Image enhancement is a process involving changing pixel's intensity of an input image so that output image should subjectively look better. The purpose of image enhancement is to improve the perception of information contained in the image for human viewers, or to provide a better input for other automated image processing systems.

In [1], a modified approach of Ostu's Method is proposed to reduce the processing time involved in Ostu's threshold computation by performing multilevel thresholding. There are many image enhancement methods being proposed. Histogram Equalization[2] is widely used global technique that enhances image contrast[3]. The operation of HE is performed by re mapping the grey levels of the image based on the probability distribution of input grey levels. It flattens and stretches the dynamic range of the image's histogram and resulting in overall contrast enhancement. The disadvantage of this method is that it may increase the contrast of background noise while decreasing the usable signal. The classical optimization techniques are useful in finding the optimum solution or unconstraint maxima or minima of continuous and differentiable functions. Yet the study of these classical techniques of optimization form a basis for developing most of the numerical technique that are involved in advanced techniques more suitable for today's practical problem[4]. Thus Bacteria Foraging Optimization(BFO) has been widely accepted as a global optimization algorithm of current interest for distributed optimization and control.

In section II the Histogram Equalization and Bacteria Foraging Optimization is described, the proposed method is explained in section III, results and discussions are presented in section IV. Finally the conclusion is provided in section V.

II. HISTOGRAM EQUALIZATION

Histogram Equalization is a simple and effective image enhancement technique. It is the one of the well-known method for enhancing the contrast of the given image in accordance with the sample distribution. HE distributes pixel values uniformly such that enhanced image have linear cumulative histogram. HE technique is a global operation, hence it doesnot preserves the image brightness. HE has been widely applied when the image needs enhancement, such as medical image processing, radar image processing, texture synthesis and speech recognition. HE usually introduces two types of artifacts into the equalized image mainly overenhancement of the image regions with more frequent grey levels, and the loss of contrast for the image regions with less frequent grey levels. To overcome these drawbacks, several HE based techniques are proposed and are more focused on the preservation of image brightness then the improvement of image contrast Bacterial foraging optimization algorithm (BFOA) has been widely accepted as a global optimization algorithm of current interest for distributed optimization and control. BFOA is inspired by the social foraging behaviour of Escherichia coli. BFOA has already drawn the attention of researchers because of its efficiency in solving real-world optimization problems arising in several application domains. The underlying biology behind the foraging strategy of E.coli is emulated in an extraordinary manner and used as a simple optimization algorithm. During foraging of the real bacteria, locomotion is achieved by a set of tensile flagella. Flagella help an E.coli bacterium to tumble or swim, which are two basic operations performed by a bacterium at the time of foraging. When they rotate the flagella in the clockwise direction, each flagellum pulls on the cell. That results in the moving of flagella independently and finally the bacterium tumbles with lesser number of tumbling whereas in a harmful place it tumbles frequently to find a nutrient gradient. Moving the flagella in the counterclockwise direction helps the bacterium to swim at a very fast rate. In the above-mentioned algorithm the bacteria undergoes chemotaxis, where they like to move towards a nutrient gradient and avoid noxious environment. Generally the bacteria move for a longer distance in a friendly environment. When they get food in sufficient, they are increased in length and in presence of suitable temperature they break in the middle to from an exact replica of itself. This phenomenon inspired Passino to introduce an event of reproduction in BFOA. Due to the occurrence of sudden environmental changes or attack, the chemotactic progress may be destroyed and a group of bacteria may move to some other places or some other may be introduced in the swarm of concern. This constitutes the event of elimination-dispersal in the real bacterial population, where all the bacteria in a region are killed or a group is dispersed into a new part of the environment.

The four prime steps in BFOA are:

i) **Chemotaxis**: This process simulates the movement of an E.coli cell through swimming and tumbling via flagella. Biologically an E.coli bacterium can move in two different ways. It can swim for a period of time in the same direction or it may tumble, and alternate between these two modes of operation for the entire lifetime.

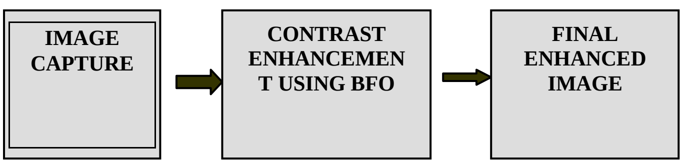
ii) **Swarming**: An interesting group behavior has been observed for several motile species of bacteria including E.coli and S. typhimurium, where intricate and stable spatio-temporal patterns (swarms) are formed in semisolid nutrient medium. A group of E.coli cells arrange themselves in a traveling ring by moving up the nutrient gradient when placed amidst a semisolid matrix with a single nutrient chemo-effecter. The cells when stimulated by a high level of succinate, release an attractant aspertate, which helps them to aggregate into groups and thus move as concentric patterns of swarms with high bacterial density.

iii) **Reproduction:** The least healthy bacteria eventually die while each of the healthier bacteria (those yielding lower value of the objective function) asexually split into two bacteria, which are then placed in the same location. This keeps the swarm size constant.

iv) **Elimination and Dispersal**: Gradual or sudden changes in the local environment where a bacterium population lives may occur due to various reasons e.g. a significant local rise of temperature may kill a group of bacteria that are currently in a region with a high concentration of nutrient gradients. Events can take place in such a fashion that all the bacteria in a region are killed or a group is dispersed into a new location. To simulate this phenomenon in BFOA some bacteria are liquidated at random with a very small probability while the new replacements are randomly initialized over the search space.

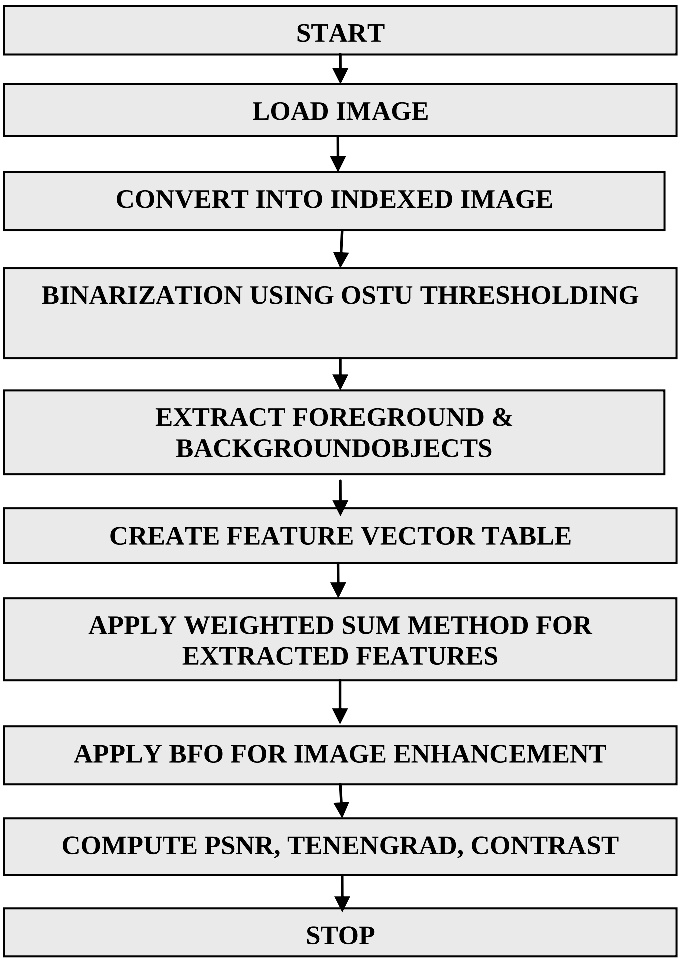
III. PROPOSED METHOD

Thresholds in these algorithms can be selected manually according to a priori knowledge or automatically through image information. The image available is used for contrast enhancement by applying the proposed algorithm. Firstly, we apply Ostu's Method to extract the foreground and background objects of an image and then we apply histogram equalization. Then we create a feature vector table for each object and compute mean, area and distance of object from the centre for each image. The proposed algorithm has been implemented on a set of different images. Bacteria Foreging Optimization Technique has been used to improve the contrast of various images.



Method adopted for Contrast Enhancement

Flowchart for Proposed algorithm



IV. RESULTS AND DISCUSSIONS

The proposed algorithm is tested for various images having the size of 256*256 gray scale images are used for experimentation. The proposed method is compared with the contrast enhancement using histogram equalization. The following images 'saturn.png' , 'hands.jpg' , 'forest.jpg' , 'couple.jpg' , 'robo.tiff' , 'boy.jpg' images are used to verify the performance of the proposed algorithm

To confirm the improvement in contrast , hence, the visual quality of image, a well-known criteria brightness of image , PSNR, tenengrad and contrast are used to compare the results of the proposed method and the conventional methods.

PSNR between two images can be expressed in equation (1):

$$PSNR = 20 \log\left(\frac{L-1}{\sqrt{MSE}}\right) \quad .. \quad (1)$$

Where 'L-1' is the maximum gray level in the image.

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(R_{ij}-I_{ij})^2 \quad (2)$$

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Where R_{ij} is the enhanced image and I_{ij} is the original image and M,N are the dimensions of the images.
The tenengrad of the image is calculated using (3)

$$Gh = \sum_{i=1}^{M} \sum_{j=1}^{N} G_{i,j} \qquad (3)$$

Where

$$G_{i,j} = \sqrt{(G_x{}^2 + G_y{}^2)} \qquad (4)$$

Where 'G_x' is the horizontal gradient of the image and 'G_y' is the vertical gradient of the image.
The contrast in a particular 3*3 window of pixels x1, x2, x3, x4, x5, x6 , x7, x8, x9 where x5 is the pixel to be replaced is calculated based on the joint occurrence of local binary pattern and contrast as

follows:

$$c(x_5) = \left(\frac{1}{n}\right) \sum_{m=1}^{n} x_m - \left(\frac{1}{9-n}\right) \sum_{k=1}^{9-n} x_k$$

Where $x_m > x_5$ for m=1 to n and $x_k < x_5$ for k=1 to (9-n)
The quality measure of the enhanced images shows that the performance of the proposed algorithm gives better results compared to conventional histogram equalization technique. This is shown in table 1:

FIG 1: Boy image

FIG 2: Couple image

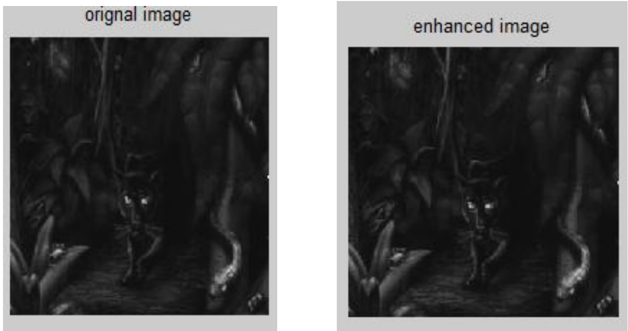

FIG 3: Forest image

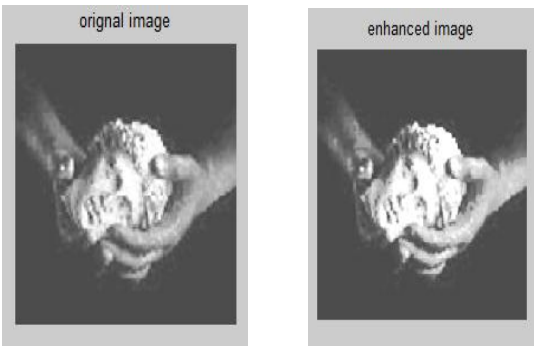

FIG 4: Hands image

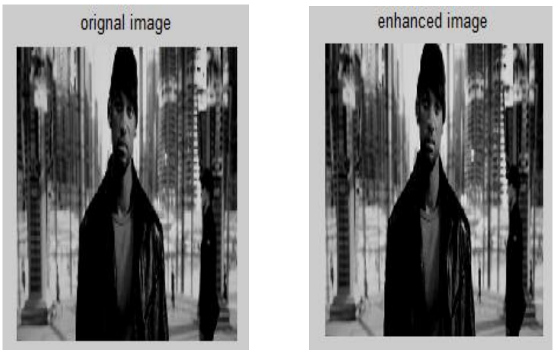

FIG 5: Robo image

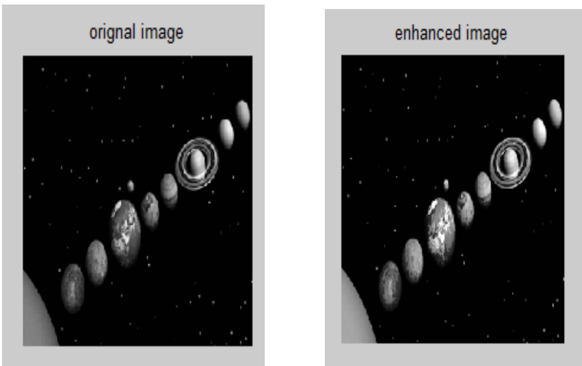

FIG 6: Saturn image

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	Method	Quality Metrics		
		PSNR	TENENGRAD	CONTRAST
Image=hands.png				
	CEHE	32.4353	342229	13.44
	Proposed Algorithm	**54.094**	**301939**	**30.650**
Image=couple.jpg				
	CEHE	28.9848	2307862	19.77
	Proposed Algorithm	**32.248**	**523516**	**58.323**
Image=forest.png				
	CEHE	45.7572	9685286	18.22
	Proposed Algorithm	**80.890**	**247577**	**26.292**
Image =robo.tiff				
	CEHE	28.3523	1338859	17.6545
	Proposed Algorithm	**72.247**	**921319**	**100.64**
Image =boy.jpg				
	CEHE	25.8152	485089	12.7874
	Proposed Algorithm	**60.685**	**271907**	**59.900**
Image=saturn.jpg				
	CEHE	32.4725	197835	5.6733
	Proposed Algorithm	**55.845**	**82581**	**32.363**

V. CONCLUSION

In this paper, an efficient algorithm based on Contrast Enhancement using Bacteria Foreging Optimization technique is implemented. The brightness of the image is preserved using histogram equalization technique. After computing the threshold value the background pixels are replaced by foreground pixels, but the natural appearance of image is preserved. Contrast enhancement using BFO is used for improving the contrast of the images. The experimental result shows that proposed method preserves natural look of the original image and improves the values of various parameters. The proposed method outperforms for many test images.

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VI. BIOGRAPHIES

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