# Contrast Enhancement of Digital Image using Artificial Bee Colony Optimization

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**ABSTRACT**

*Image contrast enhancement is aim to enhance the contrast level of images, which are degraded during acquisition process. In this paper the contrast enhancement of image has been taken as an optimization problem and artificial bee colony (ABC) algorithm has been used here to solve the optimization problem. The work has been done in two phase, in the 1st phase a fitness function has been proposed to evaluate the quality of the enhanced image where as in the 2nd phase is to generate new pixel intensities for the enhanced image from the original input image. Artificial bee colony technique is used to optimized the searching parameter. Experimental analysis has been drawn and the result has been presented to support the proposed method.*

*Keyword:- Contrast Enhancement, Artificial Bee Colony, Optimization*

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## I. INTRODUCTION

Image contrast enhancement techniques have been widely used in many applications of image processing where the subjective quality of images is important for human interpretation. Contrast is an important factor in any subjective evaluation of image quality. Contrast is created by the difference in luminance reflected from two adjacent surfaces. In other words, contrast is the difference in visual properties that makes an object distinguishable from other objects and the background. In visual perception, contrast is determined by the difference in the colour and brightness of the object with other objects. Our visual system is more sensitive to contrast than absolute luminance; therefore, we can perceive the world similarly regardless of the considerable changes in illumination conditions. Many algorithms for accomplishing contrast enhancement have been developed and applied to problems in image processing.

A widely used image enhancement method in the spatial domain is called histogram equalization, which can be further improved by the adaptively modified histogram equalization [1]. The image intensity values can also be adjusted based on various contrast and sharpness measure [2]. In addition, gray transformation function can be also combined with evolutionary algorithms [3-7] to process low-quality images. These evolutionary algorithms are utilized to search for the optimal mapping of the gray levels of the input image into new gray levels, so that the image contrast is enhanced [8].Images are sometimes been acquired under poor illumination. Under this condition, the same uniform region will appears brighter on some areas and darker on others. This undesired situation will leads to several severe problem in computer vision based system. The pixels might be misclassified, leading to wrong segmentation results, and therefore contribute to inaccurate evaluation or analysis from the system. Therefore, it is very crucial to process this type of images first before they are fed into the system. One of the popular methods used to enhance or restore the degraded images by uneven illumination is by using artificial bee colony based technique.

## 2. ARTIFICIAL BEE COLONY ALGORITHM

The ABC algorithm is a swarm-based metaheuristic for solving numerical optimization problems [9]. This metaheuristic is inspired by the intelligent foraging behavior of natural honeybees. The population in an artificial bee colony is subdivided into three subgroups: (i). employed bees; (ii). onlooker bees; and (iii). scout bees. These artificial bees move in a search space and choose food sources, which are possible solutions to the target optimization problem.

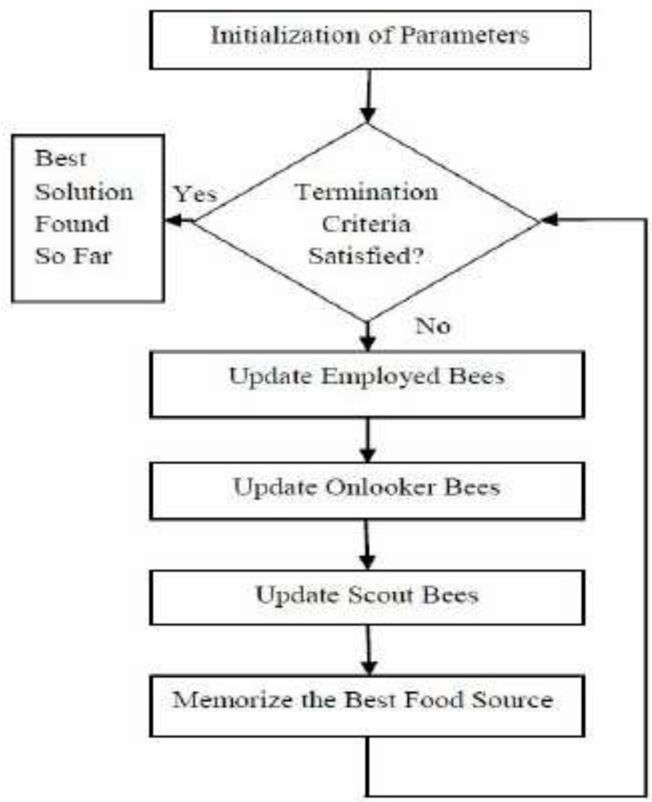


Fig -1: Artificial Bee Colony Optimization Flow Chart

The employed bees are responsible for finding various food sources and sharing the information with the onlooker bees. The food source that yields higher score and higher quality will have a larger chance to be selected by onlooker bees where as food sources with lower marks will have smaller chances to be selected. The food source could also be rejected due to its low quality. In this case, the scout bees will conduct the random search for new food sources. Therefore, in each cycle of searching iteration, three steps are involved:

(i). the employed bees are sent to search the food sources and measure their quality; (ii). the food sources are selected by the onlookers after sharing the information with the employed bees; (iii). the scout bees are sent to search for new possible food sources, if certain food sources are rejected due to low quality.
The aforementioned ABC algorithm is briefly described as below.
Initialization stage: Every solution of the bee colony is initialized, and the fitness of each solution is measured.

Iteratively perform the following steps until the maximum number of iterations is reached or the stop condition is satisfied.
Employed bee stage: A new solution is produced by the employed bee, which randomly moves in the neighbor of its current solution. The new generated solution will replace the old solution, if it yields a better fitness value.
Onlooker bee stage: After all employed bees have completed their works, each onlooker bee probabilistically selects a solution according to its fitness value of the solution.
Scout bee stage: A solution will be abandoned if its fitness value has not been improved for a given number of generations. Then a new solution is re-generated using the initialization method.
The solutions are updated using the greedy criteria, and the best solution and its corresponding fitness value are recorded.

## 3. ABC-BASED IMAGE CONTRAST ENHANCEMENT APPROACH

3.1. Motivation and challenges of using ABC algorithm in image contrast enhancement
The image contrast enhancement optimization problem is regarded as a foraging process of bee colony. The position of a food source denotes a possible solution of this image contrast enhancement problem. The fitness value of a food source represents the quality of the associated solution. The key advantage of the ABC algorithm is that both the global and local searches are carried out in each iteration step, which greatly avoids the local optimal solution; consequently, the probability of finding the optimal solution is increased.

3.2. Proposed image contrast enhancement approach
The ABC algorithm in image contrast enhancement, we need to consider: (i). the design of the transformation function, which will generate new pixel intensities for the enhanced image from the original image; and (ii). the design of the fitness function, which examines the quality of the produced image.

3.3. Transformation function
Image contrast enhancement is conducted in the spatial domain by using a transformation function, which produces a new intensity for each pixel of the original image to generate the enhanced image. Conventional methods use piecewise-linear transformation function have been proposed to deal with low-quality images [10,11].. Given the original image intensity level (denoted as x), this function applies the transformation defined in (1) to generate a new image intensity level (denoted as T(x)). This can be mathematically defined as

$$T(x) = \frac{1}{\int_0^1 t^{\alpha-1}(1-t)^{\beta-1}dt} \times \int_0^x t^{\alpha-1}(1-t)^{\beta-1}dt \quad (1)$$

where t is the variable of integration, α and β are two parameters that are used to adjust the function to obtain larger fitness value in the enhanced image.

3.4. Fitness function
The fitness function is the objective evaluation criterion to automatically measure the quality of the produced image, fitness function is proposed to contain four performance measures: (i). sum of edge intensities; (ii). number of edge pixels; (iii). entropy of the image; and (iv). image contrast.
More specifically, given the original image, the proposed approach will enhance the image to produce a enhanced version of the image (denoted as Ie) according to the following fitness function

$$F(I_e) = \log(\log(S(I_e)))\cdot E(I_e)\cdot H(I_e)\cdot C(I_e), \quad (2)$$

where the detailed mathematical definitions is described as follows.
The first term S (Ie) in the proposed fitness function (2) represents the sum of edge intensities of the image. The enhanced image is desired to have larger value than the original low-contrast image. It can be obtained by first applying the image edge detector (e.g., Canny edge detector [12]), followed by calculating the summation of intensities of edge pixels.
The second term E(Ie) in the proposed fitness function (2) represents the number of edge pixels of the enhanced image. The enhanced image is desired to be sharper, that means it has more edge pixels, than the original low-contrast image. It can be calculated by counting the number of pixels whose intensity value is above a threshold in the Canny edge image.
The third term H(Ie) in the proposed fitness function (2) represents the entropy value of the enhanced image, which is defined as

$$H(I_e) = \sum_{i=0}^{255} h_i \log_2(h_i), \qquad (3)$$

in which ft,- is the probability of occurrence of the i-th intensity value of the image.
The fourth term C(Ie) in the proposed fitness function (2) represents the contrast value of the enhanced image. The enhanced image is desired to yield larger contrast than the original input image. The contrast at a gray-scale image pixel should be expressed as the ratio of the local change and the local average [13]. The contrast of the whole image is evaluated by considering local contrast of non-overlapping image blocks as

$$C(I_e) = \sum_{i=1}^{N_B} C(B_i), \qquad (4)$$

where Bi represents the i-th image block, NB is the total number of image blocks. For each image block, the local band limited contrast value C (Bi) is calculated over all contrast measure at each pixel location (r, c) of the image block Bi as

$$C(B_i) = \sum_{(r,c)\in B_i} C(r,c) = \sum_{(r,c)\in B_i} \frac{I_e(r,c) \otimes F_b}{I_e(r,c) \otimes F_l}, \qquad (5)$$

in which $\otimes$ is the convolution operator, Fb is a band pass filter and Fl is a low pass filter.

## 4. EXPERIMENTAL RESULTS

The proposed approach has been evaluated using simulation software MATLAB. Verities of test image has been take with low contrast and the result has been shown which show the performance of the proposed artificial bee colony optimization technique.

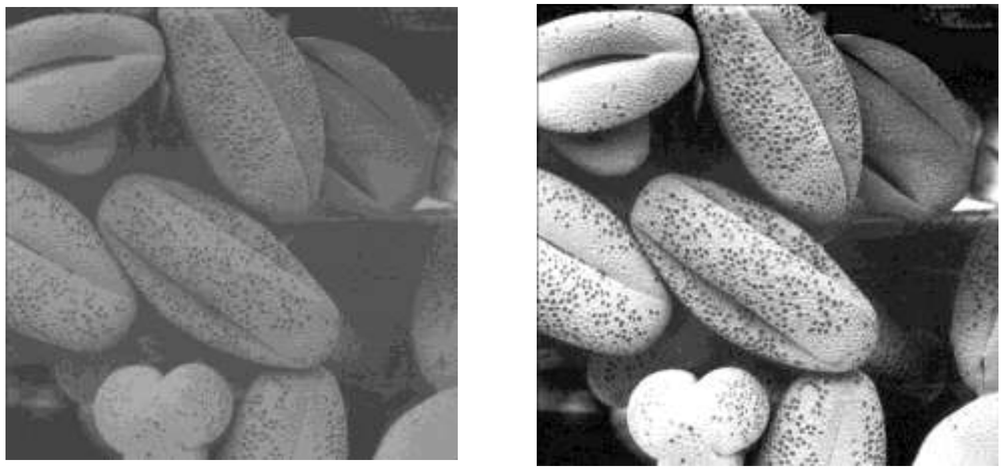

**Fig 2**. (a) Seeds Image of dimension 500x500 (b) Contrast enhanced seed image

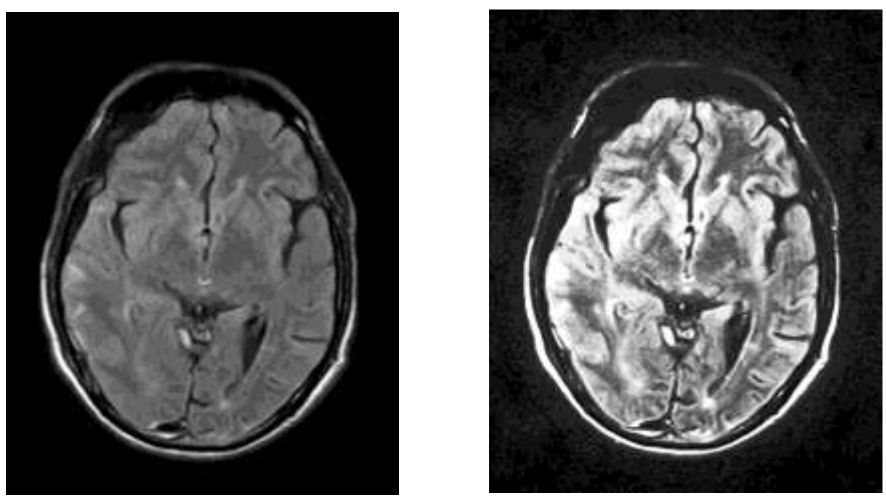

**Fig 3**. (a) Brain MRI Image of dimension 415x510 (b) Contrast enhanced brain image

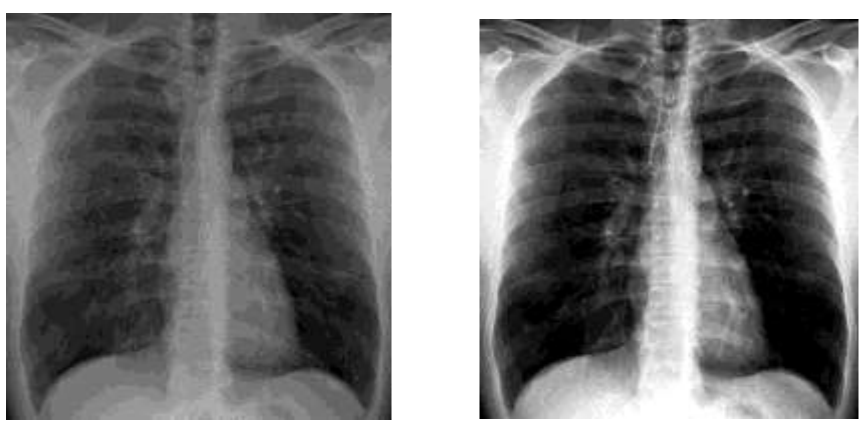

**Fig 4**. (a) Lungs Xray Image of dimension 1850x1950 (b) Contrast enhanced lungs Xray image

**Fig 5**. (a) Leena Image of dimension 365x365 (b) Contrast enhanced Leena image

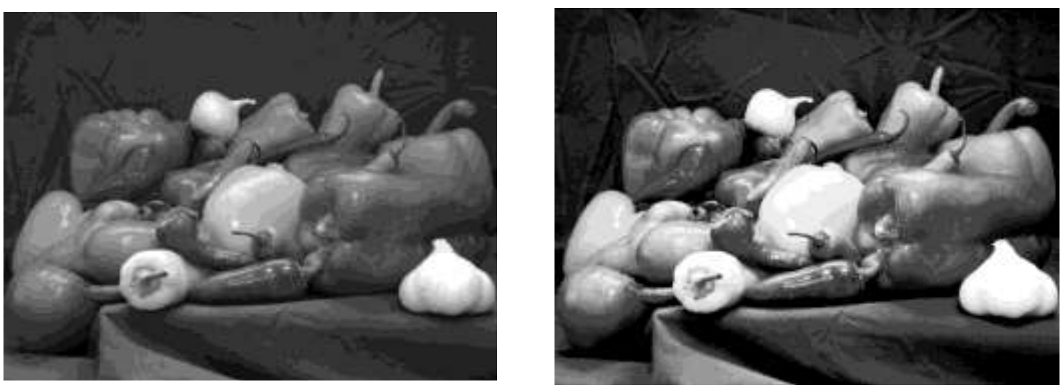

**Fig 6**. (a) Vegetables Image of dimension 512x380 (b) Contrast enhanced vegetable image

## 5. **CONCLUSIONS**

An image contrast enhancement approach has been proposed in this paper by exploiting the ABC algorithm. The proposed approach develops a new objective image contrast fitness function by introducing a new image contrast measure. In addition, the proposed approach utilizes a parametric transformation function for performing image contrast enhancement. This is faster and more efficient than conventional approaches that need to search for optimal image pixel intensities levels. The proposed approach is able to achieve better enhanced images in terms of both visual quality and objective performance measure, as verified in extensive experimental results.

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