# Edge detection of images using artificial bee colony algorithm

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***Abstract –*** Digital image pre-processing is of great importance today due to the development of technology in several areas, the most important of which are medical and military. Edge detection is one of the most important and popular pre-processing techniques because it has many benefits in removing unimportant information and extracting accurate and important information in images. It is considered as the sudden change in intensity between adjacent pixels. To date, edge detection of images complicated by noise or lack of data is still under development. For this, many algorithms and methods have been used, and an attempt is made to improve them by combining them with other methods and algorithms to improve the detection of image edges. In our research, we touched on the artificial bee colony algorithm (ABC), considered one of the optimization algorithms, as it is one of the most used methods for finding the optimal solution and has widespread in the fields of optimization. This algorithm mimics the foraging behavior of bees. We have provided some articles on ways to use this algorithm to detect the edges of digital images and show the advantages and disadvantages of each method.

*Keywords – Edge Detection; Artificial Bee Colony Algorithm; Digital Image Processing; Canny; Sobel; Hybrid Filters*

## I. INTRODUCTION

In the last decade and due to the development of technology, image processing has become a necessary step in most scientific, research, and even practical fields, and an indispensable work in advanced image processing and computer vision. It has been used in the military and civil industries, robotics, agriculture, oil exploration, medical sciences, security, satellite images, remote sensing applications, and many other fields [1].

Edge detection is one of the techniques that are widely used in the field of image analysis. In order to detect edges, some factors must be considered, such as noise, image brightness, and angles. The edges' detection depends on the density value's intensity and its abrupt changes. Edges are detected based on the difference in the grey level, with different types of edges (Line edge, Ramp edge, and Roof edge) [2].

Images are of great importance, as they contain much information. Image pre-processing, such as segmentation, feature extraction, pattern recognition, and edge detection, helps extract this information and interpret its content.

However, detecting the edges in the image is difficult, as there are many complex images, and detecting them takes much work. Extracting the edges from the image that does not contain continuous curves or contains missing parts is a difficult task. Therefore, image edge detection is still under development by researchers to try to find ways to process complex images [3].

Many edge detection operators have been used, such as Canny, Roberts, Sobel, Prewitt, and many more. These methods did not work for complex images, as the quality was poor and needed improvement.

The improvement process aims to obtain better results than previous results in the current

circumstances. Still, the improvement process becomes more difficult with time due to the rapid technological development that the world is going through. For this, optimization algorithms were developed, like the genetic algorithm, the ant algorithm, and many algorithms that were classified as (metaheuristics), depending on the principles of random distribution [1]

In this paper, we will review some of the artificial bee algorithm techniques used to detect the edges of digital images and compare the results obtained.

This paper is organized as follows. Section 2 describes the artificial bee colony algorithm and the behavior of real honeybees. In Section 3, we review previous work of the bee algorithm in edge detection. In Section 4, review the results.

## II. ARTIFICIAL BEE COLONY ALGORITHM

The bee algorithm was proposed by Karaboga in 2005 and is inspired by the natural behavior of bees in searching for food sources, used to optimize real parameters.

Each solution is considered a food source in the bee colony, and the amount of nectar for each food source determines the best solutions. There are three different types of bees:[4]

- Worker bees: their job is to search around the current food source.
- Spectator bees: The worker bees wait in the dance area to obtain information about the food sources discovered by the worker bees and then go to these sources for more information.
- Scout bees: their job is randomly search for new food sources in the problem area.

The artificial colony consists of two halves. The first half consists of worker bees, and the second half of spectator bees. Each food source has one artificial bee, meaning that the number of food sources equals the number of worker or spectator bees. The function of the worker bees is to search for solutions and then return to the dancing area. It provides information to the spectator bees who are there dancing. It turns into scout bees and searches for a new solution in the problem area. The spectator bees choose the best food sources according to the dance [5]

The bee algorithm is an iterative process similar to other population algorithms, and it works according to the following steps:

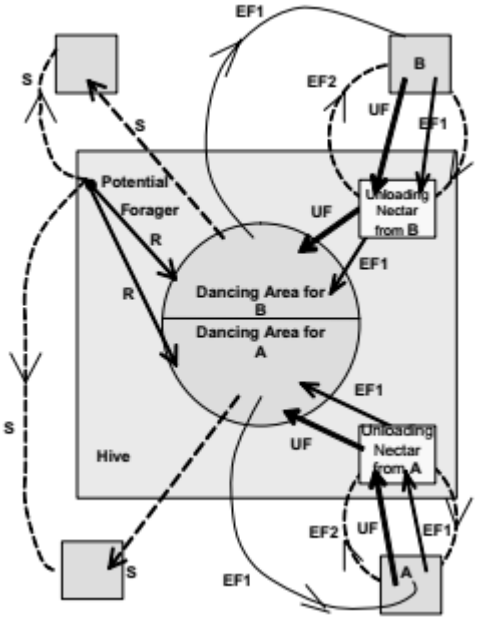


Figure 1. Nectar-foraging behaviors of honeybees

### A. *Initialization population*

The population is initialized randomly with initial solutions, with the number of SN (the number of worker bees or the number of solutions) and with dimensions n (food sources), according to the following equation:

$$x_{i,j} = x_{min,j} + rand(0,1)(x_{max,j} - x_{min,j}) \quad (1)$$

where $i = 1,2,\dots,SN; j = 1,2,\dots,n.$

### B. *worker bee phase*

Such bee generates a new food source using the following equation:

$$v_{i,j} = x_{i,j} + \emptyset_{i,j}\left(x_{i,j} - x_{k,j}\right) \quad (2)$$

Where $k \in (1,2,\dots,SN)$; and must be different from $i$; $\emptyset_{i,j}$ is a random number in the range [1,1]

### C. ONLOOKER BEE PHASE

after the worker bees have finished generating the new food sources, these solutions are evaluated by the amount of nectar they contain through probability. The selection system depends on the roulette wheel, stochastic universal sampling, and other methods.

In the bee algorithm, roulette wheels are used according to the following equation:

$$p_i = f_i \Big/ \sum_{j=1}^{SN} f_i$$

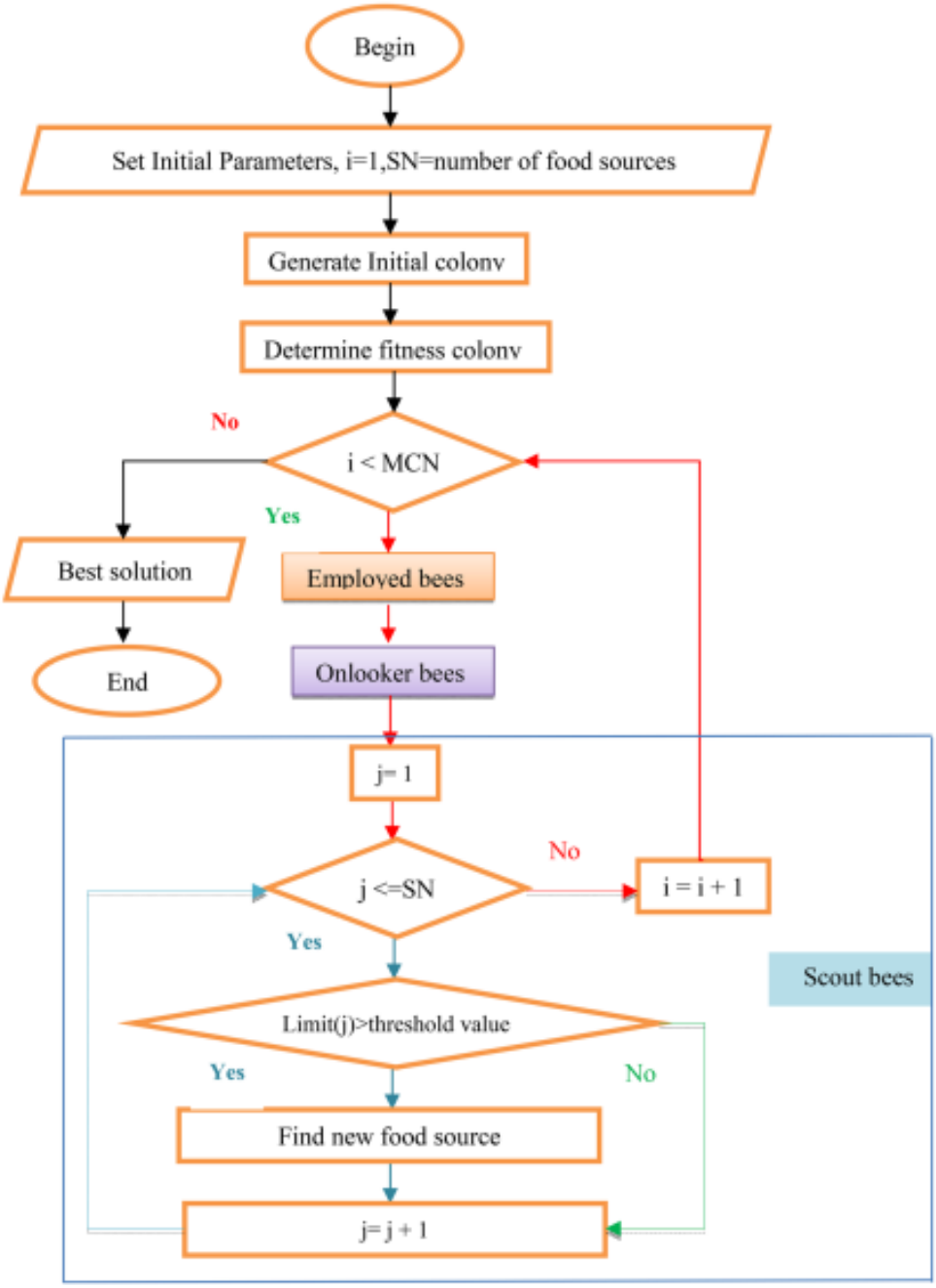


Figure 2. Flowchart of artificial bee colony algorithm work

Where fi is the fitness value of solution i.

All food sources are evaluated, and a food source is selected based on the probability values. After selecting the food source, a new food source is generated using the work phase eq (1). The new solution is evaluated with the old solution through the amount of nectar. If the amount of nectar in the new value is greater or equal to the old value, the values are replaced with the new value.

### *D.* SCOUT BEE PHASE

There is a certain limit to the number of times the food source is repeated. At this stage, the food sources are examined. When the food source exceeds the specified limit, the food source is abandoned, and the bee becomes a scout bee. A new food source is randomly generated, according to equation (2). The flowchart of the ABC algorithm is given in Fig. 2.

## III. RELATED WORK

Since its development in 2005, the artificial bee colony ABC has attracted the attention of many researchers due to its powerful properties. As a result, it has been used in much research on various scientific aspects. This section will briefly review some uses of the artificial bee colony in detecting image edges.

Elif Deniz Yelmenoğlu, Nurdan Akhan Baykan[1], the bee algorithm was used in order to obtain information from aerial photographs, and the law determined the size of the bee colony, that is, each image has its colony size, and the fitness value depends on the gray values in the image.

Colin of Elif Deniz Yigitbasi and Nurdan Akhan Baykan [6] explored the edges of the grayscale images by the bee colony algorithm without using any other method, such as the mask or the derivative.

They modified the bee colony algorithm to suit the images. They determined the colony's size depending on the image's dimensions and set the boundary value of the probability so that if the probability is smaller, the value of the failure counter will increase. If it is larger, the values of the neighbors of the pixel are checked, and if they are greater than the boundary value and the source probability values have abandoned the source, the neighbor becomes the new source.

Determine the number of neighbors to 8 and determine the threshold value based on the standard deviation. The results were after applying this method to five grayscale images of different sizes taken from the Internet and after comparing them with the results of Canny, Roberts, and Sobel methods for the same images. They concluded that the bee algorithm could detect edges without relying on the mask or derivative methods.

Mourad Moussa, Wissal Guedri, and Ali Douik [7] applied the otsu method with the bee colony algorithm on the color image. The objective was to improve the time segmentation quality and compare it with the Ant Colony optimization algorithm (ACO). They divided the work into five stages. The first stage is image pre-processing, the second stage is color space conversions, and the third stage is thresholding using the bee colony algorithm. The fourth stage is image segmentation using a classification algorithm and edge detection.

In the bee colony algorithm stage, the bees were encoded from three integers between 0-255 to divide the image into a k homogeneous. The bee colony algorithm was combined with otsu in order to determine the optimal boundary values for each color space by which pixels will be classified in the filtering phase relative to the boundary values.

The results were good compared to the ant algorithm (ACO) and canny algorithm, as it was in Lab color space that was not very accurate, but in YCbCr space, the results were better than the previous ones, while the results for HSL were the worst among them.

While Anan Banharnsakun [3] implemented ABC to find the optimal coefficient values for the image edge filter and then improve the threshold value, where the algorithm's input is two images, one is the original image. The other is an edge image for the same image. It trains using the bee algorithm to get the best filter when it finishes training. This filter is applied to another image to extract the edges. Then this image moves to the stage of extracting the optimal threshold to improve the contrast between the categories by using it within the fitness function of the bee algorithm.

The results compared to other algorithms inspired by nature were much better as the

algorithm was able to detect angles and slopes in the image in addition to detecting complex edges.

Om Prakash Verma, Neetu Agrawal, and Siddharth Sharma [8] used the bee colony algorithm with an improved derivative technique. In the beginning, an improved derivative technique is used to calculate the value of the fit function and extract the edge pixels. Then the bee colony algorithm is then used to find the most suitable pixels to be considered edge pixels.

The qualitative and quantitative analysis method was used to extract the results and compare them with other edge detection methods, whereas the qualitative analysis was compared with the canny methods. The results were better, as the edge thickness was less than the edge thickness in the canny. As for the quantitative analysis, they used the entropy measure and Pratt's figure of merit (PFM).

In the research of Yi Liu and Shengqing Tang [9], the bee colony algorithm was used to study the effect of parameters on the detection of global points for the edges of the grayscale image with dimensions 256 x 256 pixels. A data structure was created from bees containing four values: profitability, search times, profitability percentage, and pixel location. The differences in parameters were studied—accurate detection of edges.

He concluded, after several experiments, that the size of working bees about the size of bees has a significant impact on the accuracy of the image. The larger it is, the more noise, so the ratio of working bees to the size of bees is equal to 0.4, which is the best ratio to obtain good accuracy, and also that spectator bees and scout bees contain accurate and important information.

In work by Tirimula Rao Benala and Sree Durga Jampala[10], the bee algorithm was used to generate hybrid smoothing filters to improve the edges of the image and compare it with the genetic algorithm in terms of performance and stability of linear and nonlinear filters.

In the beginning, the image pixels were divided into two groups (a foreground group and a background group) through the k-means algorithm. The median of each block was calculated, and each pixel was assigned to one of the two groups. Moreover, choosing the required group, and at the end of each session, the best individual is chosen through the fitness value.

The hybrid filter was used in all stages of the bee algorithm to obtain the best values, including the stages of fitness assessment and recruitment of bees to the selected neighbors.

In the paper by Dr.Kamalam Balasubramani, Madhura, Pavithra, and Ramya..V.Kulkarni [11], the focus is on texture in MR images to extract and classify suspicious areas in the brain. The FPA algorithm has replaced the search process in the bee algorithm.

The bee algorithm was used by Yuxin Liu and Xianmin Ma [12] to detect fires in the mine conveyor belt by integrating it in several ways.

Otsu was used in the fitness function and considered as the segmentation optimization, and canny was used in the last stage for edge extraction.

In Yimin Deng and Haibin Duan's paper[13], Edges of combat aircraft are detected, and information is extracted from the edge of the object in salient areas to identify targets in complex environmental conditions using the synthetic bee colony algorithm.

In Selçuk Aslan's research[14], two methods were presented for discovering circles in the image using the bee algorithm. The first method depends on the best solutions obtained and the solutions at the end of the algorithm. In contrast, the second method depends on the first method and the solutions abandoned in the worker bee stage.

## IV. CONCLUSION

This research presents studies on edge detection using the bee algorithm, explains its working method, and presents its advantages and disadvantages.

Table 1. Summary of presented methods.

| Reference | Methods | Data | Advantages | Disadvantage |
|---|---|---|---|---|
| [1] | ABC | RADIUS/DARPA-IU Fort Hood | the algorithm is adaptable by setting a different bee colony size for each image | The number of iterations is very large, up to 50,000 |
| [6] | ABC | http://marathon.csee.usf.edu/edge/ | did not use masks or methods in work | needs up to 2,500 cycles of repetition for the small image size |
| [7] | ABC and Otsu | Berkeley (BSDS500), 3D medical data-set "Drive", Oxford-17 | The algorithm works on color images in the YCbCr color space | It does not work on color-spaced LAB and HSL images |
| [3] | ABC | -------- | Detect corners and slopes in the image as well as detect complex edges | Functions in the algorithm are evaluated twice per cycle, while in other algorithms once. |
| [8] | ABC and improved derivative technique | Lena, cameraman, pillsetc, coins, and trees images | complex edge detection and low iterations | Edge thickness due to bee buildup on edges |
| [9] | ABC | Lena, cameraman images | Determining the appropriate number of bees to perform the edge detection process | Several touches on limit and fitness values |
| [10] | hybridized smoothening filters by ABC | -------- | Good resolution and better image improvement than the results of the smoothing filters using the genetic algorithm. | It takes too long to process and compute time O (n2), O (n) for GA |
| [11] | ABC with FPA | --------- | Improve classification accuracy and improve timing. | Test the algorithm on MR images only |
| [12] | 2D-Dimensional Otsu, Canny edge detection, and Artificial Bee Colony algorithm | Lena, cameraman images | less computation and high efficiency | Using too many methods may lead to errors |
| [13] | saliency-based visual attention and artificial bee colony (ABC) algorithm | ------- | Accurate edge detection in a complex, noisy environment | Some information is lost in the image |
| [14] | ABC | ------- | Circles are detected in the actual image. | Images must be cropped to 250 x 250. This method works for an image that contains a circle in different locations. |

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