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A Hybrid Image Segmentation Method Using Firefly And Artificial Bee Colony Algorithms For Color Images

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Abstract
In Image segmentation, optimization problems have been efficiently solved by two notable swarm intelligence algorithms, Firefly Algorithm (FA) and Artificial Bee Colony (ABC). The proposed methodology presents a hybrid approach for image segmentation by integrating both the Firefly and Artificial Bee Colony (HFAABC) Algorithm is proposed for solving optimization problems. This proposed algorithm, FA investigates the search space globally to locate favorable regions of convergence and ABC is employed to perform local search. To segment the color images using by Fuzzy C-Means (FCM) method. The extracted objects are optimally selected by means of Hybrid Firefly and artificial bee colony (HFAABC). The implementation result shows the efficiency of proposed segmentation method in segmenting the images. The experimental results demonstrate the effectiveness of the proposed HFAABC algorithm and showed that it overtakes other algorithms in terms of performance measures, such as Peak Signal-to-Noise Ratio (PSNR) and Accuracy.

Keywords: Firefly Algorithm, Artificial Bee Colony, HFAABC, segmentation, optimization problems.

I Introduction

Image processing is a collection of several processes applied to an image for improvement or extraction of some curious information. It is one of the fast and growing technologies. Image watermarking, image filtering, image classification and image segmentation are the main operations performed in this field [1]. These operations require continual improvement. Currently, artificial intelligence (AI) is an emergent field that aims to handle the imitation of human intelligence to computers. AI methods are considered as essential in technology, contributing in looking for solutions to many interesting problems that different applications in computer science face [2].

Bio-inspired procedures are well-known techniques of artificial intelligence in solving problematic and combinatorial optimization problems [3]. They are population-based methods stimulated by behavior in animals. Bio-inspired algorithms are capable to escape the local optimum and discover the global optimum due to their exploitation aspects. The bio-inspired algorithms are combined with image segmentation methods with the aim to find the optimal parameters essential in the segmentation methods such as finding the centers in the C-means clustering segmentation technique [4]. Finding the parameters is a complex problem that requires forceful optimization techniques such as the bio-inspired algorithms.

Color image segmentation is a method of assigning pixels of given image to segments which share similar color. Pixels from a segment should be similar color wise and pixels from different segments should be distinct [10]. The problem of color image segmentation is one of the most difficult problems in computer vision. There exist several algorithms for this specific problem, nevertheless none of them work well for all categories of images. Images of real world are very dissimilar in colors, shapes and noise [14]. Generally before choosing an algorithm for color image segmentation, area knowledge is used to assess the type of algorithm needed for particular set of images.

The goal of color image segmentation research is to find an universal algorithm that would not require domain knowledge prior use and would provide good results for all kinds of images. Color image segmentation is a significant part of numerous computer vision problems, including pattern recognition. It is a step performed before pattern recognition, so if the color segmentation is poor, the pattern recognition stage will fail. The Fuzzy C-Means method is used to segment the color images

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with intention to develop a mutual method for various types of images. This paper is organized as follows. Section II introduces related work. In section III proposed methodology are described. In section IV the overviews the computational experiments and achieved results section V contains conclusions and plans for further research.

II Related Work

Numerous image segmentation methods were presented in the last few years. Ozturk, Hancer et. al., discussed an image segmentation method based on an improved k-means algorithm by artificial bee colony optimization [13]. It included a novel fitness function that used both, inter and intra-class variance as well as the quantization error that describes the general quality of a clustering algorithm. Based on the Davies–Bouldin Index and the XB Index, that is used to regulate the eminence of segmentation, the artificial bee colony algorithm was finding clusters.

Ahmed A. Ewees et. al., suggested the multi-level thresholding approach is used to segment the image and is considered as a preprocessing step in many applications [2]. A new hybrid algorithm for multi-level segmentation was proposed both of the Artificial Bee Colony and Sine-Cosine algorithms. This proposed algorithm is called ABCSCA, is applied to segment images and it utilizes Otsu's function as the objective function. The ABCSCA algorithm can be applied to difficult color image segmentation problems Since, this problem requires determining the threshold at different dimensions.

G. Hemalatha et. al., discussed the Discrete Feature Segmentation (DFS) method is used for extracting the attributes connected to a medical image [8]. For inventing the contrast of an image, the general Histogram equalization method is utilized that enlarges the dynamic range of intensity. For classifying the diseases in medical image, the prime emphasis is on the Fuzzy C-Means (FCM) algorithm. The various medical images are studied depend on upon the combination of DFS and FCM methods. This complex process as it involves detecting and removing the affected part of the image comprising abnormal tissues which are later being used for analysis.

V.Sheshathri et.al., developed the IPSO method to evolve background elimination by searching the optimized threshold form the available feasible thresholds which is a variance based approach of segmentation [14]. However, segmentation method still has some difficulties in accurately segment the object with complex background images.

The optimal centroids for fuzzy clustering were determined by the adaptive chemical reaction optimization algorithm [4]. Asanambigai et.al., suggested the segmentation method was used for medical images and the goal is to detect abnormal regions in brain, abdomen and eye images. Anter, et.al., recommended crow search optimization algorithm combined with fuzzy k-means clustering for segmentation of color images [3]. It has been tested that the crow search optimization improved the quality of the solutions obtained by the k-means algorithm and that was successful for crop rows detection.

Medical image segmentation with particle swarm optimization hybridized by fuzzy k-means and kernelized fuzzy k-means algorithm was proposed by Venkatesan et. al., suggested brain MRI images and the average intra cluster distance, computation time and Davies-Bouldin Index were tested as quality measures [16]. This hybridized method had faster convergence and were less sensitive to the noise in assessment with other existing methods.

Lahbib khrissi et.al., Proposed a new image segmentation method that relies on the optimization of segmentation by cuckoo search [9]. CSA has a global optimization capability and hybrid method of FCM with CSA will compared to traditional FCM clustering. FCM is the most widely used clustering algorithm in classification problems, especially in image segmentation because it is efficient and simple. However, FCM has the limitation of being sensitive to prior values and often falls into local optima. This approach requires the knowledge of the number of classes and it relies on the Euclidean distance to measure the similarity between an observation and the center of a class which makes it usable only to detect spherical classes.

III Proposed Methodology

The proposed methodology presents a hybrid approach for image segmentation by integrating both the Firefly and Artificial Bee Colony (HFAABC) Algorithm is proposed for solving optimization problems. This method introduces a weighted median filter to remove the noise. Then improve the contrast using CLAHE histogram equalization method. This proposed

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algorithm, FA investigates the search space globally to locate favorable regions of convergence and ABC is employed to perform local search. Finally, the FCM algorithm can be used to segment the object and the background. It proves that the HFAABC method is an effective segmentation method based on the experiments for color images.

3.1 Preprocessing

In preprocessing method using weighted median filter to remove noise. After that the resultant image will be applied CLAHE method for purpose of histogram equalization, which is very useful method to enhance the images.

3.2 Weighted Median Filter

The Weighted Median Filter is to remove high frequency component noise from color Image without disturbing the edges. The weighted median filter is a variation of the median filter that incorporates spatial information of the pixels when computing the median value. A weighted median filter is executed as follows:

$$W(x, y) = \text{median}\{w1 \times x1 \ldots wn \times wn\} \quad \ldots(1)$$

x1…..xn are the intensity values inside a window centered at (x, y) and w×n denotes replication of x, w times.

3.3 Contrast Limited Adaptive Histogram Equalization (CLAHE) Method

Histogram Equalization first, the input image is taken which is necessary to be enhanced. From this image the number of regions in the vertical and horizontal direction and number of the bins finds in a dynamic range in a histogram. The histogram is normalized in the range of 0 to 1 and finds the clip limit for the image. Further, the image is padded. The Histogram is prepared for each of the image in the region with the help of the bin count and clip limit and converted into a transformation function known as a mapping. A cluster of four of these mapping is made with them overlapping on each other. Afterward, a single pixel of the image is selected and the mappings are applied on it. The output of these mappings is interpolated to give the resulting image. [8] This CLAHE method assistances to bring the high contrast of the image under a certain limit by enhancing the low contrast regions.

3.4 Firefly Algorithm

Swarm intelligence optimization algorithms are being used heavily in information technology applications. Firefly algorithm has been used in various applications and proved to very accurate and efficient [1]. But to tackle wide area of problems the firefly algorithm should be modified and improved. This algorithm was developed in which the behavior and flashing pattern of the fireflies formed its basis.
Assumptions for firefly algorithm are as follows:

1. Every firefly is neither male nor female i.e. a firefly is attracted to every other firefly.
2. Brightness is the key factor in attractiveness. Between two firefly searches agents the less bright one will be attracted towards the brighter one. As the distance increases light intensity decreases which in turn decreases the brightness.
3. The firefly will move randomly when there is no brighter firefly near it.

The firefly algorithm contains two important steps: light intensity variation and calculating the attractiveness. For proposed approach that the attractiveness is calculated from the brightness of the firefly and the brightness in turn is defined by the objective function. The light intensity *I(r)* varies with distance 'r' monotonically and exponentially, is given by:

$$I = I_0 e^{-\gamma r} \quad \ldots(2)$$

Where I_0 is defined as the initial light intensity and γ is defined as the light absorption coefficient. The firefly attractiveness β is:

$$\beta = \beta_0 e^{-\gamma r^2} \quad \ldots(3)$$

Where the distance between the two fireflies is denoted by 'r' and β define their attractiveness at r=0. The Cartesian distance between two fireflies is given as follows:

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$$r_{ij} = ||x_i - x_j||_2 = \sqrt{\sum_{k=1}^{d}(x_{i,k} - x_{j,k})^2} \quad \ldots(4)$$

Where x_i and x_j is the position of the I and J firefly. During firefly processing the less bright firefly (i) move towards the brighter firefly(j). The movement is given by:

$$x_i = x_i + \beta = \beta_0 e^{-\gamma r^2}\left(x_j - x_i\right) + \alpha\varepsilon_i \quad \ldots(5)$$

The basic step of the firefly algorithm is the initialization of the firefly population in the algorithm. Its size determines the number of solutions. Then each firefly's light intensity is used to evaluate its fitness. Distance taken between fireflies is called the Cartesian distance. Light intensity and absorption coefficient are used to define the attractiveness function.

3.5 Artificial Bee Colony Algorithm

Artificial Bee Colony (ABC) is an optimization algorithm inspired by the behavior of real honey bees colony [2]. It consists of three collections. The first one is employed bees. This collection searches for new food sources and the information about this phase is transferred to the second collection (onlooker bees). The onlooker bees use this information to choose a food source. The third collection (scout bees) searches randomly for a food source. The ABC algorithm generates a random population of N solutions that describes the employed bee $x_i \in R^d$, $i = 1, 2, \ldots, N$. The new solution v_i is generated based on x_i as follows:

$$v_{ij} = x_{ij} + \varphi_{ij}(x_{ij} - x_{kj}), \qquad k = int(rand * N), j = 1, \ldots, d \quad \ldots(6)$$

where xk is a neighbor employed bee of x_i, $\varphi_{ij} \in [-1, 1]$ and it is created in a random manner.
The objective functions for Fx_i and Fv_i are computed for xi and v_i respectively; then, if $Fx_i \leq Fv_i$, the solution x_i is removed from the memory of the first collection and v_i is added. The objective function Fx_i which is obtained from employed bees is transferred to the onlooker bees. Thereafter, the roulette wheel selection method is used to determine the x_i that has a higher probability of having the objective function (P_i), which is calculated as:

$$P_i = \frac{fit_i}{\sum_{i=1}^{N} fit_i}, \qquad fit_i = \begin{cases} \frac{1}{1+Fx_i} & if\ \ Fx_i > 0 \\ 1 + abs(Fx_i) & otherwise \end{cases} \quad \ldots(7)$$

Each one of the onlooker bees updates its solution via the same process used by the employed bees. The onlooker bee tests both the new and old solutions to decide whether the old solution is removed from the memory or not. If there is no difference in the solutions after a particular number of repetitions, these solutions are discarded; then the scout bee group explores a new solution to update x_i as:

$$x_{ij} = x_j^{min} + (x_j^{max} - x_j^{min}) \times \delta \quad \ldots(8)$$

Where x_{ij} is an optimized parameter for the i^{th} is employed bee, x_j^{min} and x_j^{max} are the lower and upper bounds for x_{ij} respectively, and δ is a random number. After a new solution x_{ij} is generated, it becomes an employed bee.

3.6 Fuzzy C-Means Method

The best solution obtained from the ABC process is taken for the FCM operation [3]. The FCM is a clustering technique that allows a single pixel to belong to two or more clusters. FCM clustering is the modified version of the K-means clustering. Clustering is the process to classify the image in such a way that same group of data is in one group and at the same time different group of data having separation. In the FCM data elements can belong to two or more clusters based on the degree of belongingness. Fuzzy c means algorithm is partitioning the dataset $\{x_k\}_{k=1}^{N}$ into c number of clusters based on the following objective function in Eq. (9).

$$J_m = \sum_{i=1}^{C}\sum_{k=1}^{N} u_{ik}^{p}||x_k - v_i||^2 \quad \ldots(9)$$

Where, p indicates the real number, which denotes the quantity controlling of the fuzziness of the resultant group, u_{ik}^{p} is the membership of the data point x_k belongs to the cluster i and is the x_k pixel of the image which satisfying $\sum_{i=1}^{C} u_{ik}$=1and v_i is the centroid of the cluster. From the above Eq. (9), where c is the total number of clusters and N denotes the number of data points. The FCM makes the partitioning by iteratively updating the membership values and the cluster centroids. The membership value of each data point to the every centroid also derived after each time updating of centroids that is done by the Eq. (10).

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$$u_{ik} = \frac{1}{\sum_{j=1}^{C}(\frac{||x_k - v_i||^2}{||x_k - v_j||^2})^{1/p-1}} \quad \ldots(10)$$

The cluster centroids are updated based on the distance between the data point to the cluster centroid which is done by the Eq.(11).

$$v_k = \frac{\sum_{k=1}^{N} x_k U_{ik}^p}{\sum_{k=1}^{N} U_{ik}^p} \quad \ldots(11)$$

The objective function performs the calculation to measure the weighted sum of results between the cluster center and data presents in the fuzzy clusters. FCM provides better segmentation results for the images, which does not have any noise.

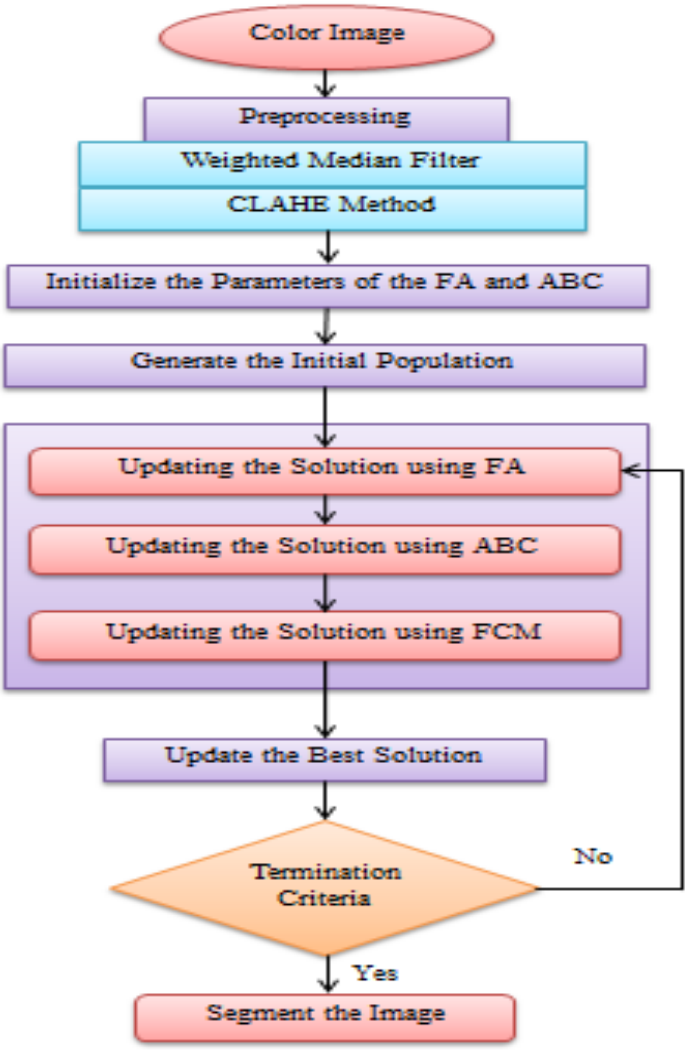

Figure 1. Block Diagram of Proposed Methodology

IV EXPERIMENTS AND RESULTS

The experiments use a variety of sample color images. The input color images have different types of dimensions. The proposed HFAABC method is tested for different parameters. The experiment is implemented through Matlab R2013a. Its results outperformed the compared algorithms in terms of the Peak Signal to Noise Ratio (PSNR) and Accuracy measures.

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4.1 Peak Signal to Noise Ratio (PSNR)

The PSNR is calculated based on color texture based image segmentation by using the Eq.12. The PSNR range between [0, 1), the higher is better.

$$PSNR(I,S) = \frac{10log10s^2}{MSE(I,S)} \quad \ldots(12)$$

In above equation, s is the maximum fluctuation in the input image data type i.e. 255.

Mean Square Error (MSE) is calculated pixel-by pixel by adding up the squared difference of all the pixels and dividing by the total pixel count. MSE of the segmented image can be calculated by using the Eq. 13.

$$MSE(I,S) = \frac{(\Sigma_{i=0}\Sigma_{j=0}[I(i,j)-S(i,j)]^2)}{MN} \quad \ldots(13)$$

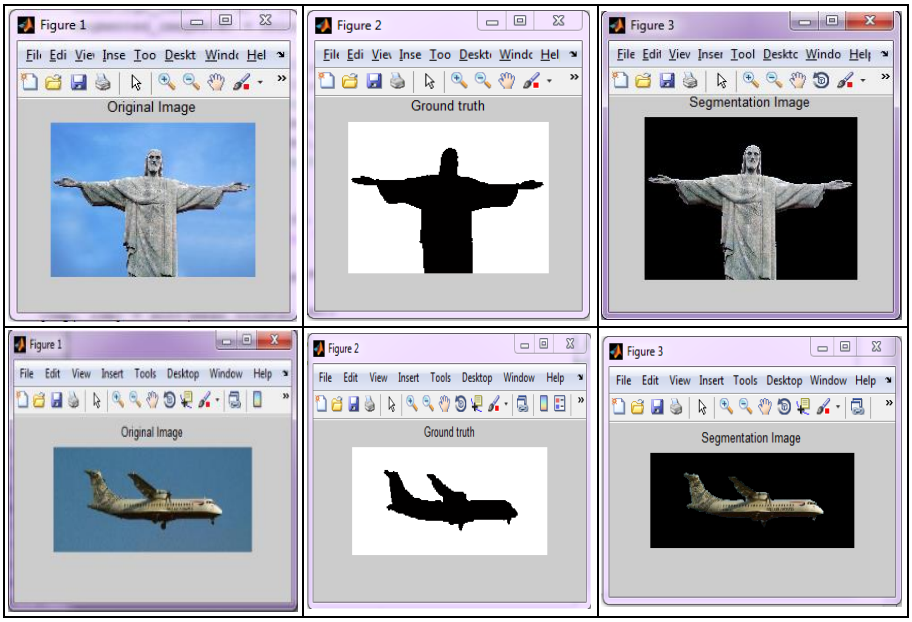
Here M and N are the number of rows and columns in input images, whereas I and S are the original and segmented image.

4.2. Accuracy

The segmentation accuracy is usually used to test the image segmentation accuracy of the algorithm, through which the performance of the algorithm can be displayed. The Segmentation accuracy number of correctly segmented pixels Total number of pixels $0 \leq SA \leq 1$. The corresponding accuracy value for the segmentations. 4240

$$\text{Accuracy} = \frac{Number\ of\ correctly\ segmented\ pixels}{Total\ number\ of\ Pixels}\ 0 \leq SA \leq 1 \quad \ldots(15)$$

The Figure 2, column 1 shows the original image, column 2 shows the ground truth images, column 3 shows the segmented image of the proposed method of HFAABC. In Table 1, shows PSNR and Accuracy values are compared with existing methods of DFS-FCM and ABC-SCA and the proposed method of HFAABC produces good result.



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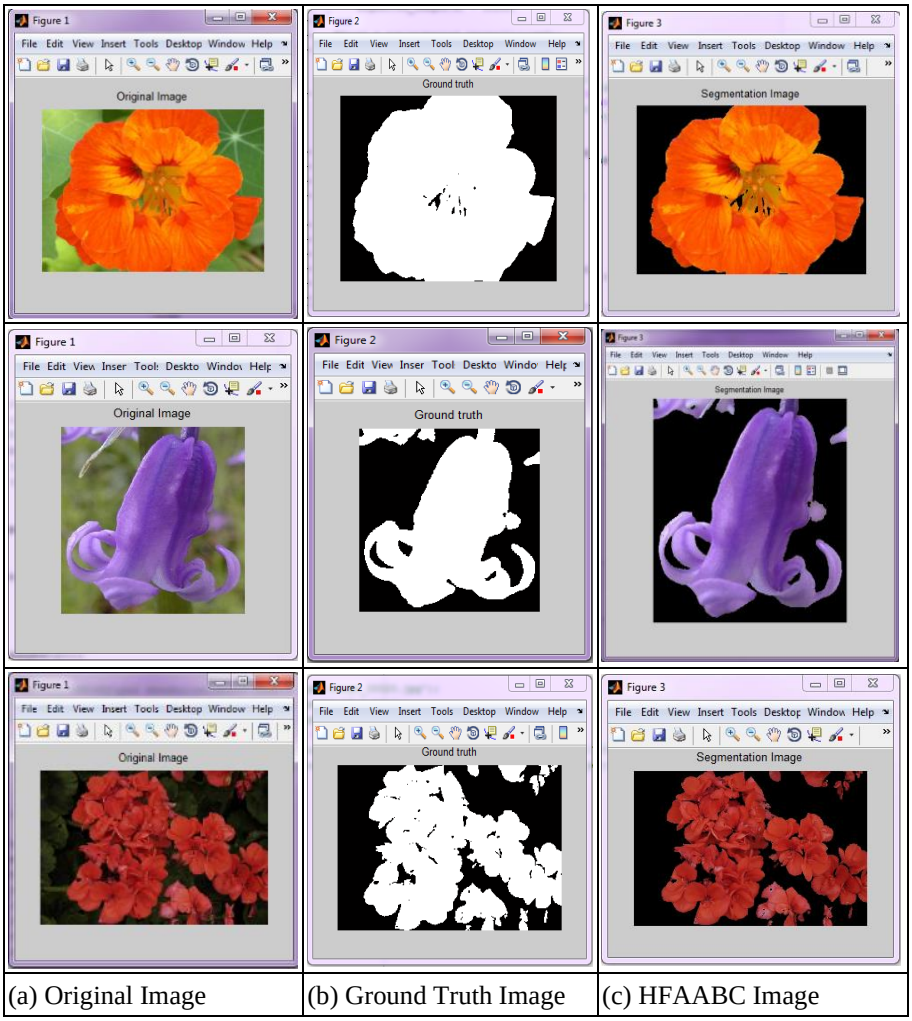

(a) Original Image | (b) Ground Truth Image | (c) HFAABC Image

Figure 2. Segmented Images using HFAABC Algorithm

Table 1. Comparison of Accuracy for Color Images

Images/ Methods	**Existing Methods**		**Proposed Method**
	DFS-FCM	**ABC-SCA**	**HFAABC**
Image 1	90.22	93.55	98.99
Image 2	88.25	91.25	97.23
Image 3	90.98	93.49	98.23
Image 4	90.56	92.33	98.46
Image 5	90.41	92.67	98.33

Table 2. Comparison of PSNR Values for Color Images

Images/ Methods	**Existing Methods**		**Proposed Method**
	DFS-FCM	**ABC-SCA**	**HFAABC**

Image 1	20.8822	22.9448	27.9842
Image 2	18.2288	19.8647	26.8927
Image 3	19.3379	21.5627	27.2299
Image 4	20.9856	21.4598	27.8786
Image 5	20.4759	21.2891	27.3486

V Conclusion

This paper presents a method of the color image segmentation based on the HFAABC algorithms. This method introduces a weighted median filter to remove the noise. Then improve the contrast using CLAHE histogram equalization method. The number of clustering centers can be determined by the number of points of a color quantization histogram. Subsequently the separation of the object and background of the image, FCM clustering is useful to the object and background. The best solution can be attained by the proposed method. The segmentation image obtained by the experiment that the segmentation accuracy of the proposed HFAABC method is produce better results other existing methods of DFS-FCM and ABC-SCA. In addition, the process of object and background separation and the algorithm can be further improved. The proposed method for image segmentation can be used in the future to solve different problems and applications in terms of image processing such as analyzing the image structure, visualization, computer-aided diagnostics, computer vision, image classification, and object detection. In all applications, the quality of images is a very important issue in image segmentation.

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