Araştırma Makalesi   *Research Article*

Modified Region Growing Method For Image Segmentation Using Ant Lion Optimization Algorithm

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Abstract

Image segmentation is a significant step in image processing that applies to various fields. These fields include machine vision, object detection, astronomy, biometric recognition systems (face, fingerprint, plate, and eye), medical imaging, video surveillance, and many other image-based technologies. Efficient image segmentation is one of the most important tasks and critical roles in automatic image processing. Especially in engineering studies, finding the most suitable solutions for problems is one of the important research topics. Bio-inspired algorithms such as Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Artificial Bee Colony (ABC), and Bat Algorithm (BAT), etc. are used to find the optimal solutions in search spaces and Ant Lion Optimization (ALO) is one of these algorithms. In recent years, bio-inspired algorithms are used to optimize the segmentation parameters of the images. This research proposes a modified region growing (RG) image segmentation approach using bio-inspired ALO. Region growing (RG) has three main problems as the selection of the right seeds, the number of seeds, and the region growing strategy. Therefore, ALO was used to solve seed selection problems in RG. In this study, firstly, the median filter was applied to the inputs to improve the quality of the images. Subsequently, the region growing segmentation was carried out using optimal seed points obtained from the ALO. For obtaining the optimal seeds, ALO was used to solve the limitations of RG during the segmentation process. The success of the proposed approach was tested using some images taken from the BSDS300 (Berkeley) dataset. The experimental results show that the proposed method segments almost all the images.

Keywords: Region growing, Seed point selection, Image Segmentation, pre-processing, Ant Lion Optimization.

Karınca Aslanı Optimizasyon Algoritması Kullanarak Görüntü Segmentasyonu İçin Modifiye Edilmiş Bölge Genişletme Yöntemi

Öz

Görüntü bölütleme, çeşitli alanlar için geçerli olan görüntü işlemenin önemli bir adımıdır. Bu alanlar arasında makine görmesi, nesne algılama, astronomi, biyometrik tanıma sistemleri (yüz, parmak izi, plaka ve göz), tıbbi görüntüleme, video izleme ve diğer birçok görüntü tabanlı teknoloji bulunmaktadır. Etkili görüntü bölütleme, otomatik görüntü işlemede en önemli işlemlerden ve kritik rollerden biridir. Özellikle mühendislik çalışmalarında, problemlerde en uygun çözümleri bulmak önemli araştırma konularından biridir. Arama alanlarında en uygun çözümleri bulmak için Parçacık Sürü Optimizasyonu (PSO), Karınca Algoritması (KA), Yapay Arı Kolonisi (ABC) ve Yarasa Algoritması (YA) gibi biyo-esinlenmiş algoritmalar kullanılır ve Karınca Aslan Optimizasyonu (KAO) bu algoritmalardan biridir. Son yıllarda, görüntülerin bölütleme parametrelerini optimize etmek için biyo-esinlenmiş algoritmalar kullanılmaktadır. Bu araştırma, biyo-esinlenmiş KAO kullanarak, geliştirilmiş bir bölge büyütme (BB) görüntü bölütleme yaklaşımı önermektedir. Bölge büyütme doğru tohum seçimi, tohum sayısı ve bölge yetiştirme stratejisi olmak üzere üç ana sorunu vardır. Bu nedenle RG'deki doğru tohum probleminin seçiminde KAO kullanılmıştır. Bu çalışmada öncelikle görüntülerin kalitesini artırmak için,

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giriş görüntülerine ortanca filtresi uygulanmıştır. Daha sonra KAO'dan elde edilen optimum tohum noktaları kullanılarak bölge büyütme ile bölütleme işlemi gerçekleştirilmiştir. Optimal tohumları elde etmek için, bölütleme sırasında BB'nin sınırlamalarını çözmek için KAO kullanılmıştır. Önerilen yaklaşımın başarısı, BSDS300 (Berkeley) veri setinden alınan bazı görüntüler kullanılarak test edilmiştir. Deneysel sonuçlar, önerilen yöntemin neredeyse tüm görüntüleri bölütlere ayırdığını göstermektedir.

Anahtar Kelimeler: Bölge büyütme, tohum seçimi, görüntü bölütleme, önişleme, Karınca Aslan Optimizasyonu

1. Introduction

In an image, some properties of similar pixels in a certain region such as density, color, texture are similar. Similarly, adjacent regions containing pixels of different properties may be substantially different from each other. The main goal of image segmentation is to divide a picture into more understandable and easy-to-analyze sub-parts [1]. Image segmentation is a process of dividing up digital images into multiple subsegments and it became an important research area of today's image processing technology [2]. Segmentation is a critical step of image processing that increases usefulness while reducing the complexity of the data. The reason for doing segmentation is to make it easier to process an image, speeding up subsequent processings [3]. There a lot of application of image segmentation including machine vision, biometrics, medical imaging, face recognition, fingerprint recognition, control of traffic Systems, satellite imagery, video surveillance and etc.

Many different algorithms and systems have been produced for image segmentation. However, since the success of the segmentation process depends on the applied area and problem, there is no definite answer for the image segmentation problem. These process often need to be combined with domain knowledge to effectively solve the segmentation problem [3]. The basic objective of this research is to introduce a modified region-based image segmentation technique using Region Growing (RG) based on Ant Lion Optimization algorithm (ALO). The rest of the study is arranged as follows. The related works were discussed in Section 2, the material and method was described in section 3. Proposed method was given in Section 4 while section 5 presents the experimental result of the study. And the final section is presented with conclusions and recommendations.

2. Related Work

The history of image segmentation dates back to the earliest 1970s where the first works on single image segmentation are from the early '70s[1]. For example, Brice and Fennema (1970) propose a segmentation algorithm for blocks world pictures. Since that time many image segmentation procedures have been invented by scholar and researchers, anyhow the most frequently and generally utilized segmentation methods incorporate Region-based, edge-based, fuzzy-based theory, artificial neural network, and threshold-based segmentation [2]. In the last years, countless studies have been executed in the area of the image segmentation process. Nowadays, there are thousands of algorithms that do the partitioning process, which is quite different from each other, but there is still no specific algorithm that applies to all kinds of digital images that fulfill every purpose [3, 4]. Many image segmentation procedures have been created by scholar and researchers. But generally image segmentation are categorized as similarity-based (region-based and tress holding) and discontinuity-based (edge) [5]. The main idea of this section is to review the studies related to this study and the mechanisms used in previous studies. Merzougui et al. [6] Suggested a segmentation technique dependent on region growing(RG) and metaheuristic algorithms (EA). Before division, the quantity of classes is dictated by the standard of maximum entropy. The joined RG and EA comprise of choosing among the entirety of the potential segments the ideal parcel by expanding a measure for validating division. Jeevakala et al. [7] proposed a changed region growing division technique that precisely segments the cochlear nerve area. The portioned locale is estimated and assessed utilizing the long distance across, short measurement, and cross-sectional field. Reddy et al.[8] Proposed another algorithm dependent on the RG, where brain tumor MRI pictures are utilized to test the success of the technique. Chondro et al. [9] proposed a computer-assisted region segmentation for plain chest radiographs that included enhancing avant-garde contrast-enhancing obscurity of the lung areas. Charifi et al. [10] studied the seeded region growing (SRG) algorithm in 2 different color spaces as RGB and HSV. The implemented method were investigated for 3 different cases as utomated seed selection based on color and area features, region growth using Euclidean distance and overcome the over-segmentation. RG is used to distinguish breast masses in [11], the study used RG was enhanced where the underlying seed pixels and thresholds are ideally created utilizing a multitude of swarm optimization strategy known as Dragon Fly(DF) Optimization. The texture highlights are extricated utilizing GLCM and GLRLM strategies from the partitioned pictures and took care of into a Feed-Forward Neural Network (FFNN) programmed to utilize a backpropagation algorithm which orders the pictures as benign and malignant. Bruntha et al.[12] Presented a viable RG methodology for the early discovery of lung disease utilizing registered tomography. At first, the Gaussian filter (GF) was utilized for pre-processing to expel clamor. For portioning lung parenchyma, a versatile power thresholding technique was utilized. Baghi et al. [13] Presented another technique dependent on the RG and Spectral Cluster (SC) for the division of synthetic aperture radar pictures. In the proposed technique first RG is applied to the SAR pictures so as to discover the boundary and afterward segmentation is finished utilizing SC strategy. Duman & Erdem. [14], utilized the RG division to distinguish whether the pixels are a piece of the edges or the textures. Malarvel et al. [15] Presented a new segmentation scheme based on RG method without implication of preprocessing techniques in the input image. Happ et al. [16] presents another method for distributed RG picture segmentation dependent on the MapReduce model (the most used programming models to process a tremendous volume of data in the cloud). Zhongming & Jun. [17] proposed a strategy for infrared image segmentation dependent on wavelet transform (WT) modulus maxima and the RG. Elmorsy et al.[18] presented another segmentation algorithm according to the size choice RG for extraction of liver from CT images. The preprocessing of the algorithm includes 3 steps as thresholding, region growing, and size selection morphological operations. Singh & Gupta [19] proposed a basic and simple methodology for the location of dangerous tissues in the mammogram. The identification stage

is trailed by the division of the tumor area in a mammogram picture. X. Li et al.[20] Presented a new method of segmentation for high-level resolution remote sensing pictures using traditional region growing (RG).

Wu & Guo [21] proposed an image segmentation method using the Markov random field (MRF) model and the RG for sonar image segmentation. Zhang et al. [22] proposed a RG named as bi-directional growing segmentation algorithm for medical images. At first, a pixel from the background was selected as the initial seed. Lu et al. [23] Utilized Quasi-Monte Carlo strategy to improve conventional RG technique, the improved procedure upgrades the proficiency of choosing the right seed focuses and the improved RG rules better suits the liver division. Seeded RG (SRG) in view of PSO is presented in [24]. The strategy could be considered as one of the methodologies which present another support of PSO for image segmentation.

Optimization can be described as a cycle of finding the best cases to increase the efficiency, output, performance and profit while reducing cost and resource consumption [25]. Metaheuristic algorithms are often called as bio-inspired and nowadays they are widely used to find optimal parameters. There are several MA algorithms such as genetic algorithms (GA) [27], Simulated Annealing (SA) [28], Differential Evolution (DE) [29], Ant Colony Optimization (ACO) [30-32], Particle Swarm Optimization (PSO) [33], Harmony Search (HS) [34, 35], Bat Algorithm (BA) [36], Evolutionary Programming (EP) [37] and others. Some of the new algorithms proposed in recent years are Grey Wolf Optimizer (GWO)[38], Artificial Bee Colony (ABC) [39] , Firefly Algorithm (FA) [40], Cuckoo Search (CS) [41], Gravitational Search Algorithm (GSA) [42], Cuckoo Optimization Algorithm (COA) [43], Charged System Search (CSS) [44], Ray Optimization (RO) [45], Colliding Bodies Optimization (CBO) [46], Hybrid Particle Swallow Swarm Optimization (HPSSO) [47], Democratic Particle Swarm Optimization (DPSO) [48], Dolphin Echolocation (DE) [49], Chaotic Swarming of Particles (CSP) [50], Whale Optimization (WO) [51] and Ant Lion Optimizer (ALO) [52]. Optimization algorithms scan for the global ideal in a pursuit space by making at least one random answers for a given issue [52]. This is known as the arrangement of candidate solutions. The arrangement of candidates is then improved iteratively until the fulfillment of an ending condition. The improvement can be considered as finding a more exact estimation of the global optimal than the underlying arbitrary guesses. With this procedure, Evolutionary Algorithms (EA) are considered with improvements in points such as issue and determination independence, nearby optima evasion, and straightforwardness. Many of these algorithms for example, Firefly Algorithm (FA) [53], GA [54], PSO [24], ABC [55], ALO [56], GWO [57, 58], ACO [59] and others have been implemented in image segmentation. Among them, in the study using ALO, Mostafa et al. [56] proposed a methodology for liver segmentation based on ALO.

3. Material and Method

3.1. Pre-processing

One of the basic preprocessing steps in the image processing is filtering. Filtering is a basic method used to highlight the features or improve the quality of the image [60]. Some basic operations such as edge detection, image enhancement, sharpening and straightening in image processing are performed using some filtering operations. Filters help visual interpretation of images and can be used for facilitating subsequent digital processing steps [60]. Median filter (MF) was used in this study. The MF is a basic nonlinear filter that is used to remove noise from an image. The MF first sorts all the pixel values in ascending order list and then calculates the pixel value as the center by taking the value in the middle of the list. There are two main advantages to using the median filter. The first is that it is easy to apply. The second is that it may be used to remove different types of noise [60].

3.2. Region growing

Region growing (RG) is a pixel-based approach of image segmentation where intensity, texture, color and other image features are considered for dividing the pixels into regions. RG depends on the initial pixel named as "seed", which decides whether adjacent pixels should be added to it's region or not. At first, a seed pixel is selected. Then, the neighboring pixels that meet the growing criteria according to the determined features are gathered around the seed and the region is enlarged. The growing for that region is halted when none of the neighboring pixels satisfy the determined growing criteria, and another pixel is selected as the new seed and new growing is made around that seed. This process continues till entire pixels in the picture belong to a region. In the RG segmentation method, the selection of seeds and thresholds plays a notable role in the segmentation. The procedure of the RG algorithm is performing in the following steps:

Step_1. The n number of seed pixels are selected as $p_1, p_2, \ldots \ldots, p_n$. Also, the n number of regions according to these seed pixels are determined as $C_1, C_2, \ldots \ldots \ldots, C_n$.

Step_2. Calculate the difference between the seed point p_i and the pixel value of neighboring points. If the distinct is smaller than the defined threshold value (criterion), the adjacent point can be classified as C_i region, where i = 1, 2,…, n.

Step_3. Recalculate the boundary of C_i and the mean values of all pixels in C_i region is recomputed as new $p_i(s)$ respectively.

Step_4. Repeat the Steps 2 and 3 till whole pixels in the image have been assigned to a suitable region.

RG has three main problems: The first problem that is the selection of the right seeds, is the most difficult problem of the growing method. The second problem is the number of seeds that should be used because different number of seed points give different segmentation results. And the last problem is the different results obtained by the different strategies (top-to-down or bottom-to-up) that region growing uses to perform segmentation. Apart from these main problems, not only for region growing but also for other

segmentation techniques, is the effect of noise on images. For this reason, researchers are trying to solve these problems and propose segmentation algorithms that give good results in noisy images.

3.3. Antlion algorithm

Ant Lions are a category of insects under the family Myrmeleontidae of the class Neuroptera, which incorporates Dobsonflies and Lacewings [62]. The name "ant lion" is called the hunter larvae which eat ants and similar insect species. These hunters hide under the ground or in the self-made pits of sand and wait for predatory insects to fall into their trap. When a prey is trapped, they consume it immediately. The Ant Lion Optimization (ALO) method inspired and modeled mathematically by the hunting procedure of ant lions larvae was proposed by researcher Mirjalili in 2015 [52].

The ALO impersonates the communication among ant lions and the ants in the snare. In the algorithm model, ants are permitted to move for food in the inquiry space and subterranean insect lions hunt the ants utilizing the snares.. There are *n* number of ants and ant lions in ALO. The position of ants is spared and used matrices for ants and ant lions during an improvement in the algorithm are given in Eq (1).

$$M_{ant} = \begin{bmatrix} A_{1,1} & A_{1,2} \cdots\cdots\cdots\cdots & A_{1,d} \\ A_{2,1} & A_{2,2} \cdots\cdots\cdots\cdots & A_{2,d} \\ \vdots & \vdots & \vdots \\ A_{n,1} & A_{n,2} \cdots\cdots\cdots\cdots & A_{n,d} \end{bmatrix}$$

It ought to be noticed that ants are like particles in PSO or individuals attributes in genetic algorithm. The location of an insect alludes to the boundaries for a specific solution. Fitness (objective/cost) function matrices have been considered to store the location of entire ants or antlions throughout the optimization. The matrices denoted the fitness (objective) function during optimization are given in Eq (2).

$$M_{OA} = \begin{bmatrix} f([A_{11},A_{12},\ldots\ldots,A_{1d}]) \\ f([A_{21},A_{22},\ldots\ldots,A_{2d}]) \\ \ldots\ldots\ldots\ldots \\ f([A_{n1},A_{n2},\ldots\ldots,A_{nd}]) \end{bmatrix} \qquad M_{OAL} = \begin{bmatrix} f([AL_{11},AL_{12},\ldots\ldots,AL_{1d}]) \\ f([AL_{21},AL_{22},\ldots\ldots,AL_{2d}]) \\ \ldots\ldots\ldots\ldots \\ f([AL_{n1},AL_{n2},\ldots\ldots,AL_{nd}]) \end{bmatrix} \qquad (2)$$

There are five steps in ALO given as follows:

Random Walks (RW) of ants: Ants renew their positions with the RW at every step of optimization as presented in Eq **(3)**.

$$x(t) = \pi r$$
$$X(t) = [0, \text{cumsum}(2r(t_1) - 1), \text{cumsum}(2r(t_2) - 1), \ldots\ldots\ldots \text{cumsum}(2r(t_n) - 1) \qquad (3)$$

Where *cumsum* stands for the cumulative sum, *n* is the maximum number of iteration, *t* shows the step of the RW which represents the iteration process, and $r(t)$ is for stochastic function described as Eq (4). In Eq (4), *rand* is a random number generated with uniform distribution in the interval of [0,1].

$$r(t) = \begin{cases} 1 & if\ rand > 0.5 \\ 0 & if\ rand \leq 0.5 \end{cases} \qquad (4)$$

The RW of ants are totally founded on the Eq. (4). Ants renew their positions with the RW at each progression of optimization. Since each search space has a limit or scope, regardless of how Eq. (4) can't be legitimately utilized for refreshing the situation of ants. So as to keep the arbitrary strolls inside the search space, they are standardized utilizing the accompanying (min-max standardization) equation given in Eq (5).

$$X_i^t = \frac{(X_i^t - a_i) \times (d_i - c_i^t)}{(d_i^t - a_i)} + c_i \qquad (5)$$

Where a_i is the minimum of Random Walk of ith variable, d_i is the maximum of Random Walk in i^{th} variable, c_i^t is the minimum of ith variable at t^{th} iteration, and d_i^t indicates the maximum of ith variable at t^{th} iteration.

Building trap: So as to display the ant lions' hunting ability, the roulette wheel is utilized. In every iteration, ants are presumed to be caught in just one chose ant lion. During the process of the optimization, a roulette wheel that gives high opportunities to the fitter ant lions is used for picking ant lions.

Sliding ants in the direction of ant lion: Until this point, ant lions can set up traps relative to their fitness and ants move randomly. Notwithstanding, ant lions shoot sands outwards the middle of the snare once they understand that an ant is in the net. This behavior slides down the ant that is attempting to get away. For scientifically demonstrating this behavior, the span of ants' RW hyper-circle is diminished adaptively as given in Eq (6) and (7).

$$c^t = \frac{C^t}{I} \qquad (6)$$

$$d^t = \frac{d^t}{I} \qquad (7)$$

Here I is a ratio, c^t is the minimum of all variables at t^{th} iteration, and d^t indicates the vector including the maximum of all variables at t^{th} iteration.

Catching prey and re-constructing the pit: In ALO, getting prey happens when ants fall into the trap then the ant lion pulls the ant inside the sand and eats it soon. After that, the ant lion upgrades its position according to Eq (8) to increase the chance of catching new prey.

$$Antlion_j^t = Ant_i^t \quad if \left(f(Ant_i^t) > f\left(Antlion_j^t\right) \right) \qquad (8)$$

Where t shows the current iteration, $Antlion_j^t$ shows the position of selected j^{th} antlion at t^{th} iteration, and Ant_i^t indicates the position of ith ant at t^{th} iteration.

Elitism: Elitism is a significant attribute of evolutionary algorithms that permits them to keep up the best solution(s) got at any phase of the iteration. In ALO, the best ant lion obtained in every iteration is maintained and considered as an elite. So, it is accepted that each ant randomly walks around a selected ant lion by the roulette wheel and the elite. The new positions of the ants are updated as given in Eq (9).

$$Ant_i^t = \frac{(R_A^t - R_E^t)}{2} \qquad (9)$$

Where R_A^t is the random walk around the antlion selected by the roulette wheel at t^{th} iteration, R_E^t is the random walk around the elite at t^{th} iteration, and Ant_i^t indicates the position of ith ant at t^{th} iteration.

4. Proposed Method

RG has three main problems as the selection of right seeds, the number of seeds, and the RG strategy and here, ALO was used to selection of right seeds problem. The ALO algorithm takes the total number of ants, ant lion and iterations as primary input parameters and provides the elite (best) seed solution as output. The flowchart in Fig.1 shows the segmentation steps of the suggested method.
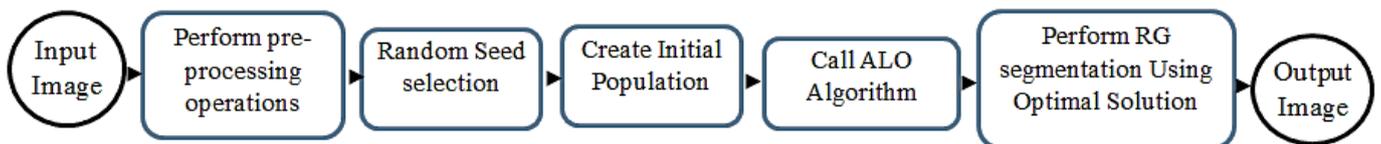

Fig 1. Steps of the proposed method

As seen in the Fig.1, the proposed method consists of five main steps. The first step is to apply preprocessing to input images. In the study, median filter was applied to the images as preprocessing for removing the noise. The second step is selection of random seed points. The selection of seed points is an important part of the RG because the algorithm's performance depends on the selection of the first seeds. Choosing the right seed points gives the better image segmentation results. At the beginning, RG starts with putting *n* numbers of initial seeds in the image to be segmented. Then, at each stage, adjacent pixels are added to these central seeds according to the addition criteria, and the regions grow. The random selection of initial seeds is selected reliant on the following three criteria:

- The seed pixel should have powerful correlation with its neighbors.

- For segment, at least one seed should be selected to create it.
- Seeds for various areas must be detached.

There is no global strategy utilized in choosing the initial seed points, it relies upon the nature of the issue. However, there are two significant strategies considered while choosing the initial seeds: First, if targets should be recognized utilizing infrared images, the most brilliant pixel (s) of the image(s) are chosen. Second, in situations where there is no prior information, the histogram is calculated and the gray level values relating to the strongest peaks are chosen as the initial seed points. In this study, the second option was used to choose the initial seed point. The histogram of the images was determined and the gray level values corresponding to the strongest peaks were considered as the first seed points.

After selection of the initial seeds, segments were formed by measuring the distance between seeds and neighboring pixels. In the study, the euclidean distance formula was used to measure the distance between seed point and its neighbor pixels. The euclidean distance among two points as p and q is described as the square root of the summation of the squares of the differences between the corresponding coordinates of the points. The 2D euclidean distance (ED) between 2 points (a_x, a_y) and (b_x, b_y) is formulated as in Eq (10).

$$d(a,b) = \sqrt{(b_x - a_x)^2 + (b_y - a_y)^2} \qquad (10)$$

The third step in the algorithm is to create an initial population of ALO. In this step, it is created the first random population by specifying the number of searches agents, lower and upper bound variables. Search agents determine the number of antlions and ants. Thirty search agents were used in the study.

The fourth step is to apply ALO to optimize seeds to perform region growing segmentation. ALO takes the maximum iteration number, the number of search agents, and the upper and lower boundaries of the search area of the image pixels as inputs. While the maximum iteration number represents the number of loops, the number of search agents describes the numbers of ant lions and ants and the upper and lower boundaries of the search area of the image define the minimum and maximum limits of the image size. In this study, 10 maximum iterations and 30 search agents (antlion and ants) were used.

5. Result Analysis

The experimental result of the proposed approach is given in this section. The proposed algorithm was tested using the BSDS300 dataset [63]. This dataset contains 300 real images, 200 for training images, and 100 for test images. The size of these images is 481x321 or 321x481 pixels. In the study, MATLAB was used. The project was run on a computer with Intel (R) Core ™ i3-2370m CPU @ 2.40GHZ processor and 4 GB RAM.

The results of this method are compared with the results of PSO segmented images given in [24]. The segmentation results proposed by Mirghasemi and his friends contains some limitations. Due to the noise in the images, some regions are not segmented effectively. The results of the method proposed by Mirghasemi et al are shown in Fig.2.

Fig 2. The example segmentation result from [24]

As seen in Fig.3, the results of the proposed model are moderately better than the outcome of the PSO-based multi-seed region growing strategy in the literatüre [24]. The proposed approach impeccably segmented the image by identifying and gathering pixels that share qualities, for example, shading, texture, or grayscale.

Fig 3. The example result of the proposed model using ALO

6. Conclusion

Image segmentation is a basic issue in image processing, pattern recognition (PR), and artificial intelligence (AI). The essential and significant key advance in computer vision innovation is image segmentation, which is likewise a significant piece of computer vision. Best image processing result is quite difficult without appropriate segmentation, so image segmentation is a significant image understanding method in various fields throughout everyday life and it is broadly utilized in numerous different areas. In this study, a new region-based image segmentation method has been introduced by using region growing based on Antlion Optimization (ALO). The ALO algorithm was utilized to optimize and choose correct seed pixels for region growing. Experimental results show that the suggested method gives good segmentation results.

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