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# Application of artificial intelligence algorithms in image processing

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ABSTRACT

As the main media of human communication and understanding of the world, image is one of the important information sources of human intelligence activities. With the development of the times, the demand for image processing technology is increasing day by day. The rapid development of computer technology also provides a platform for the application of image processing. In order to achieve better image processing effect, this paper focuses on the application of artificial intelligence algorithm in image processing. Image segmentation is a technology that decomposes images into regions with different characteristics and extracts useful targets. It can be regarded as a combinatorial optimization problem. It is completely feasible to apply artificial intelligence algorithm to optimization problems. Firstly, this paper introduces the ant colony algorithm in artificial intelligence algorithm, elaborates the basic principle and mathematical model of the ant colony algorithm. Secondly, in order to improve the ability of global search of ant colony algorithm, this paper introduces the crowding degree function of fish into the ant colony algorithm. Finally, the improved ant colony algorithm is used in image segmentation to improve the effect of image segmentation. The simulation results show that it is feasible to use ant colony algorithm in image segmentation. And the optimization improvement of ant colony algorithm is effective. The improved ant colony algorithm applied in image segmentation can significantly improve the segmentation performance.



## 1. Introduction

Image, a medium containing abundant information, is an important source for human beings to obtain and exchange information. Generally speaking, images are photos, graphics, movies, videos, computed tomography (CT), magnetic resonance (MR), remote sensing and even two-dimensional or three-dimensional data [1,2]. However, the image itself sometimes has some drawbacks. To obtain credible information in the image, it is necessary to process the image. The main application fields of image processing include aerospace, land mapping, urban planning, medical research, product anti-counterfeiting, engineering surface damage identification, real-time monitoring, iris recognition and military, cultural, artistic and communications aspects of human life and work.

Image is equivalent to two-dimensional for machine and computer. In order to process image by computer, image must be understood as two-dimensional function, which is sampled and quantified and then processed. Therefore, the process of image digitization is a necessary process for computer to recognize images. Generally speaking, this process can be summarized as: scanning, sampling and quantization. Scanning is the process of traversing the entire image as required. Sampling is the process of discretizing the smallest pixels in the scanning process. Sampling is usually done by photoelectric sensor. The gray value of each pixel is obtained by sampling. The last step of quantization is to convert the gray value sampled into discrete value by using analog-to-digital converter.

After three stages of initiation, development and popularization, image processing has been studied by various disciplines and widely used in various fields. Nowadays, with the rapid development of science and technology, image processing science will make greater progress both in theory and practice.

After the practice and research of image processing, the technology and method of image processing have also been greatly improved. The method of image processing has also been

*Abbreviations:* AI, Artificial Intelligence; ANNs, Artificial Neural Networks; NNs, Neural Networks; ACA, Ant Colony Algorithm; CT, Computed Tomography; MR, Magnetic Resonance.

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improved, from the traditional method to the more and more popular method of artificial intelligence processing. Traditional image processing methods are mainly embodied in digital image acquisition, domain name transformation, image sharpness enhancement, image restoration, data compression storage coding, image gray detection and segmentation recognition.

Traditional image processing technologies mainly focus on image acquisition, transformation, enhancement, restoration, compression coding, segmentation and edge extraction. With the development of information technology, image feature analysis, image registration, image fusion, image classification, image recognition, content-based image retrieval and image digital watermarking have made great progress [3–5]. These image processing technologies reflect human intelligence activities, and imitate, extend and expand human intelligence on the computer. They have intelligent processing functions. Because of the remarkable research and application achievements of artificial intelligence at home and abroad, the application effect of artificial intelligence technology in image processing will be enormous.

Artificial Intelligence [6,7], abbreviated as AI technology. It is a new science rising in the 1950s. It not only studies technology, but also applies related technology to products and develops intelligent products. It is a technical discipline resembling or partly resembling human beings, which is used to help people complete related activities and extend some human intelligence.

Artificial intelligence is a more advanced product in human history. Since human history, people have always tried to seek breakthroughs, breakthroughs in knowledge, breakthroughs in technology, and attempts to use tools or machines to facilitate or even replace people's work, which also promotes the continuous development of human intelligence. Human society from stone tools, iron tools to the later era of machine industry is a good proof.

Artificial intelligence technology is an interdisciplinary subject, which covers a wide range of contents and intersects with philosophies, mathematics, statistics and so on. With its development, various more innovative theories and technologies have emerged. For now, the research and application directions of AI technology are: perception intelligence, thinking intelligence, learning intelligence and behavior intelligence, etc.

First, research and application of expert system. It is the most important part of artificial intelligence, and it breaks through the process of applying theory to practice.

Second, research and application of pattern recognition. When we distinguish a certain object or goal, we need to find the difference between the object and the related things. In addition, we can classify and identify similar and different things, such as apples, all kinds of apples have similarities and differences. Pattern recognition, like human recognition process, uses certain algorithms to classify objects of the target class into a pattern, so as to realize classification and recognition of limited or unrestricted targets.

Third, the research and application of Artificial Neural Networks (ANNs) [8–11]. It is an algorithm based on the principle of animal neural network. It is widely used in various fields and has good application effect.

Fourth, research and application of robotics [12]. This is mainly to study the "human-like" of robots and realize the function of communication between robots and other things. Because of the intelligence of robots, they can be applied in many fields and bring great convenience to life. Nowadays, robots work in many scenarios instead of humans.

Artificial intelligence algorithm is mainly to imitate some laws of nature summarized by people themselves and then transform them into some algorithms to solve some problems. Under the background of the continuous development of computer technology, the application of artificial intelligence algorithm achieves better image processing effect to a certain extent, such as the application of various optimization algorithms in image processing.

Image segmentation is one of the key technologies in digital image processing. Image segmentation is to extract meaningful features from images, such as edges and regions, which is the basis for further image recognition, analysis and understanding. Image segmentation mainly classifies and extracts the useful features in the image, which include the edges and regions of the image, so the image is the most critical technology in digital image processing [13]. As the basis of image recognition, analysis and understanding, many methods of edge extraction and region segmentation have been developed by scholars, such as gray threshold segmentation [14], clustering [15], edge detection [16] and region growth [17]. The premise of these methods is that the target has obvious gray level change compared with the background, but it can only be applied to relatively simple images, but it cannot do anything about ten complex CT images, remote sensing images, sonar images and so on. In order to realize the processing of these complex images, the research of image segmentation must continue, and the application of artificial intelligence algorithm to image segmentation may be a better scheme for complex image segmentation.

As an image segmentation method, which decomposes the image into different regions with different characteristics and extracts useful target technology, it can be regarded as a combination optimization problem. Ant colony algorithm in artificial intelligence algorithm is a formal optimization algorithm, which can get a good image segmentation effect when applied to image segmentation. The contribution of this paper can be expressed as follows:

(1) Introduce ant colony algorithm in artificial intelligence algorithm, elaborate the basic principle and mathematical model of ant colony algorithm;
(2) Focus on improving the ability of ant colony algorithm to find the global optimal solution. In this paper, the crowding degree function of fish swarm is introduced into ant colony algorithm to improve its performance.
(3) The improved ant colony algorithm is used in image segmentation to improve the performance of image segmentation.

## 2. Proposed method

### 2.1. Description of ant colony algorithms

#### 2.1.1. Fundamentals of ant colony algorithms

Ant Colony Algorithms (ACA) [18–20] is a new bionic algorithm. Marco Dorigo, an Italian scholar, explored the principle of ants searching for food by studying the behavior of ants searching for food. That is, under the guidance of pheromones, they find out the best path from ant nest to food, and a bionic intelligent algorithm is specially designed according to such food search mechanism.

Ants are able to communicate information between groups in the process of searching for food. This communication is mainly realized by the substances released during their journey. This communication is also the reason why ants can find the best way out of food. Where the substance is called pheromone. Here, exogenous hormones play two roles: one is that exogenous hormones exist as communication substances between individuals of ants, which can guide the subsequent ants to choose the path, that is, along the path with higher concentration of exogenous hormones. Second, because of the volatilization of exogenous hormones, the longer path and those that have not been traveled for a long time, the concentration of exogenous hormones is getting lower and lower, which has less and less influence on the path selection of ants [21]. Ants can sense exogenous hormones in the process of moving, and guide their own direction. The behavior of searching for food by a large number of ants can be regarded as a positive feedback phenomenon. It can also be said that the higher the concentration of exogenous hormones on a certain path, the greater the probability of subsequent ants choosing that path.

In this paper, a visual legend is used to illustrate the working principle of ant colony system. Point A is expressed as nest and point D is the food source that the ant is going to. Assuming that the ABD path is 9 units long and the ACD path is 18 units long, each ant travels one unit length per unit time, releasing one unit of concentration of exogenous hormones at the same time, regardless of the volatilization of exogenous hormones. Now one ant is assigned to each path, and after nine time units, the situation is shown in Fig. 1 (a).

Fig. 1 (b) is a case of 18 time units. As can be seen from the figure, the ratio of the concentration of exogenous hormones on the ABD pathway to that on the ACD pathway is 2:1. If we are assigning an ant to search for food, the third ant will choose the ABD path according to the concentration of exogenous hormones. If it continues, the ants will eventually abandon the ACD path and choose the ABD path.

As can be seen from Fig. 1, this behavior of searching for food through a large number of ant colonies can be considered as a phenomenon of positive feedback. It can also be said that the higher the concentration of pheromones in a certain path, the greater the probability that later ants will choose the path. Ants communicate between groups through the remaining pheromones, thus finding an optimal path among multiple search paths. The characteristics of the ant colony algorithm can be described as follows [22]:

(1) Ant colony algorithm is a population-based evolutionary algorithm, which uses distributed parallel search.
(2) Each ant can only perceive its local information, but can not directly use the global information.
(3) Indirect communication between ants can be achieved by changing environmental variables.
(4) It has strong self-organization, that is, the complex behavior of groups emerges through the interaction of individuals.
(5) The global search method of ant colony algorithm depends on the probability density of environmental variables, and this uncertainty probability density can make ant colony have a greater probability to find an optimal path.
(6) Parallelism. The ant colony algorithm can search multiple times at the same time when searching for the path. The ant can search for the food path in multiple paths and at the same time, which can improve the cooperation ability of multiple machines. The distributed parallel mode will greatly improve the search efficiency of the ant search food path algorithm.

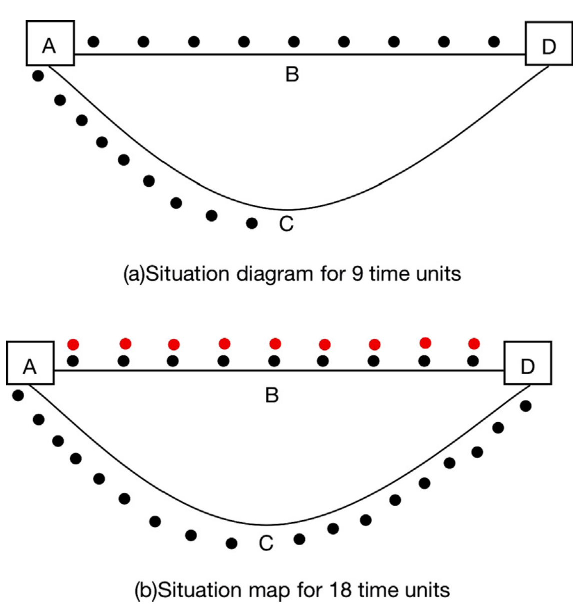


**Fig. 1.** Ant colony algorithm schematic.

### 2.1.2. Search model of ant colony algorithm

In order to better explain the ACA search model, this paper uses the classic TSP problem to describe, firstly because the traveling salesman problem is a very typical combination optimization problem, which is familiar and can verify the feasibility of the algorithm. This description is well known. And can verify the feasibility of the ant colony algorithm; secondly, because the ant colony algorithm is applied, the first time is applied to the TSP problem [23].

The TSP problem is that there is a travel agent who goes to $n$ city, requests to visit only one city at a time, visits all the cities once, the path between the two cities is only once, and finally returns to the shortest path of the departure city.

Assuming that there are $n$ cities, City $i$ can be represented by a pair of real $(x_i, y_i)$ and city $j$ by $(x_j, y_j)$, then $r_{ij}$ is the distance between City $i$ and city $j$. In addition, the number of ants is $m$, $\tau_{ij}(t)$ is the time of the $t$, the number of pheromone concentrations left by ants on the path of cities $i$ and $j$. At the beginning of the search, the pheromone setting of the ants on all paths is the same. Here, the ant chooses the path according to the probability. Here at time $t$, the transition probability $p_{ij}^k(t)$ of the selected path $d_{ij}$ is:

$$p_{ij}^k(t) = \begin{cases} \frac{\tau_{ij}^{\alpha}(t)\eta_{ij}^{\beta}(t)}{\sum_{\gamma \in allowed_k} \tau_{ir}^{\alpha}(t)\eta_{ir}^{\beta}(t)}, & j \in allowed_k \\ 0, & otherwise \end{cases} \tag{1}$$

The pheromone heuristic factor in the formula is expressed by $\alpha$. The parameter variable describes the degree of influence of ants on urban selection in the search process, and emphasizes the role of pheromones. The size of the parameter value represents the probability of ants in selecting the path. Expectation heuristic factor is expressed by $\beta$. The parameter variable describes the important size of Prophet information in ant search process. The heuristic function is denoted by $\eta_{ij}(t)$. The parameter variable describes the expected size from city $i$ to the next city $j$. The expression is $\eta_{ij}(t) = 1/d_{ij}$. $allowed_k$ is at $t$, the ant can choose the next city's collection, which changes dynamically as the ant $k$ travels.

Over time, $\tau_{ij}(t)$ may have two situations: the first is that the amount of pheromone left behind gradually disappears; the second is that there are too many residual pheromones, which drowns out the inspiration information. In order to avoid these two situations, after a traversal visit to all cities, the algorithm needs to update the global pheromone for this traversal. The updated formulas are as follows:

$$\tau_{ij}(t+n) = \rho \cdot \tau_{ij}(t) + \Delta\tau_{ij}(t, t+n) \tag{2}$$

The pheromone volatilization factor is represented by $\rho$. This parameter is to prevent the continual accumulation of pheromones from causing unnecessary trouble for the ants to search for the food path. The general value range of the $\rho$ is defined between the $(1,0)$. $t_{ij}(t+n)$ is the total amount of pheromones on the path from $i$ to $j$ at $t+n$. $\Delta\tau_{ij}(t,t+n)$ represents the increment of pheromones released by ants on paths $i$ to $j$ during $(t,t+n)$. It can be imagined that if the path distance is smaller, the pheromone left by ants will be larger.

Dorigo M, a scholar, gives three different ant colony algorithm models for different ideas of ant colony algorithm in pheromone updating. They are ant-cycle system, ant-density system and ant-quantity system. The main difference between the three systems is the difference in solving $\Delta\tau_{ij}^{k}(t,t+n)$ [24,25].

Under the model of ant week system, the solution of $\Delta\tau_{ij}(t,t+n)$ is as follows:

$$\Delta\tau_{ij}^{k}(t,t+n) = \begin{cases} Q/\quad L_k, \text{If ant k passes through city i and j in this cycle} \\ 0, \qquad \textit{otherwise} \end{cases} \tag{3}$$

where $Q$ is pheromone intensity and $L_k$ is the length of path that ant $k$ takes in the search cycle.

Under the ant-dense system model, $\Delta\tau_{ij}^{k}(t,t+n)$ is solved as:

$$\Delta\tau_{ij}^{k}(t,t+n) = \begin{cases} Q, \ \text{If ant k passes through city i and j in this cycle} \\ 0, \qquad \textit{otherwise} \end{cases} \tag{4}$$

Under the model of ant quantity system, $\Delta\tau_{ij}(t,t+n)$ is solved as:

$$\Delta\tau_{ij}^{k}(t,t+n) = \begin{cases} Q/\quad d_{ij}, \text{If ant k passes through city i and j in this cycle} \\ 0, \qquad \textit{otherwise} \end{cases} \tag{5}$$

where $Q$ denotes pheromone strength, $d_{ij}$ is the distance between city $i$ and city $j$.

The difference of the three ways of pheromone updating is that the former emphasizes the whole information of ant colony, and then adjusts the global pheromone after visiting all the cities, while the latter two formulas need to update the remaining pheromones every time a city is visited.

### 2.2. Improvement of ant colony algorithm

Ant colony algorithm uses pheromone positive feedback mechanism to search the optimal path. At the beginning of the algorithm, pheromones on each path are considered the same. Each ant randomly chooses a path to advance while searching for food, leaving its pheromone while traveling. In this way, in the process of continuous progress, the pheromones on each path begin to change, and the ants behind will generate different probability of forward path selection according to the different levels of pheromones on each path, which further changes the size of pheromones on the path. This mechanism can be seen that the higher the probability of ants choosing the path with the highest pheromone concentration, the higher the probability of ants choosing the path with the highest pheromone concentration. In the continuous cycle, ants will eventually choose the path with the highest pheromone concentration to move forward, so that the path with the highest pheromone concentration is considered the optimal path.

In fish swarm algorithm, artificial fish have three behaviors: foraging, clustering and tailing. The foraging behavior is that the artificial fish search a better state than the current state randomly within the search range; the clustering behavior is that the fish state is better and less crowded within the search range, and the artificial fish gather towards the center of the fish group; the tail-chasing behavior is the further behavior of the artificial fish in the direction of the best partner. The difference between fish swarm algorithm and ant colony algorithm is that the swimming direction of artificial fish should consider not only the optimal state, but also the location crowding. If a location is too crowded, the artificial fish do not move to that location, which can effectively reduce the possibility of all fish gathering near the local solution, so the crowding degree function is applied to the ant colony algorithm.

In this paper, the concept of crowding degree in fish swarm algorithm is used to improve the ant colony algorithm to prevent the premature convergence of the ant colony algorithm in local solution, and effectively increase the ability of the ant colony algorithm to find food globally. The improved process can be expressed as follows:

(1) At the beginning of the algorithm, that is, $t=0$, $m$ ants were randomly placed in $n$ cities, and at first the pheromone sizes of each path were the same, set to $\tau_{ij}(0) = const$ ($const$ is constant).

(2) According to the size of pheromone on the search path, ant$k$determines the predicted direction of transfer. Transfer probability $p_{ij}^{k}(t)$ is expressed as the transfer probability of ant $k$ from city $i$ to $j$ at $t$ time.

(3) After the ant chooses the predicted transfer path according to the transfer probability, the congestion $q_{ij}$ of the route is calculated.

$$q_{ij} = 2\tau_{ij}(t) / \sum_{i \neq j} \tau_{ij}(t) \tag{6}$$

If $q_{ij} < \delta(t)$, it means that the search path is not too crowded. Ants can move from place $i$ to place $j$. Otherwise, it means that the search path is too crowded, and ants need to re-randomly select a search path in other higher pheromone paths to move forward. Where $\delta(t)$ represents the congestion threshold at $t$ time and updates it by pressing down.

$$\delta(t) = 1 - e^{-ct} \tag{7}$$

The threshold change coefficient in equation (7) is expressed by $c$.

(4) After each ant travels through all cities, the pheromone is updated.

(5) Cyclic steps (2) to (4) end the algorithm when all $m$ ants choose the same path or reach the maximum number of cycles set by the cycle.

At the beginning of the algorithm, this paper chooses a congestion threshold close to 0, so that most ants can choose their own path randomly as far as possible, which is conducive to the rapid generation of paths with higher pheromone concentration. When the pheromone concentration of a path is high, if the number of ants is the same, the next ant will not choose the path because of the setting of congestion threshold, but will move randomly in other paths, which effectively avoids all ants gathering at the local solution quickly and enhances the ability of global search. As the number of searches increases, the size of the congestion function is gradually increased, which means that the value of pheromone concentration is more important in this paper. This is because in the later stage of the algorithm, the optimal path has been approached, which needs to improve the speed of fast gathering in the optimal path.

### 2.3. Application of improved ant colony algorithm in image segmentation

#### 2.3.1. Image segmentation feature extraction

An image contains abundant image information, such as target, background, boundary and noise. The goal of image feature extraction is to search the feature quantities which distinguish these information. This feature quantities are very important for the subsequent information classification process.

In addition, the gray value of the pixel is an important feature information to distinguish the target from the background, and the boundary point and the noise point occur in the gray level mutation, which is the gradient of the point changes, which can be said that the gradient is an important feature to distinguish the noise point from the background or the target point. For higher gradient boundary points and noise points, domain features can be used to distinguish them. This feature can be used to distinguish boundary points from noise points, assuming that an image has eight boundary points in $3 \times 3$ neighborhoods with similar gray values within the region, and noise points are generally less than four. The method of extracting domain features is to compare the gray difference between the current pixel and the neighborhood pixel with the set gray difference threshold. The number of neighborhood pixels less than the threshold is the domain feature we need to extract.

Through the above description, this paper uses three-dimensional feature vectors of gray value, gradient and neighborhood to distinguish the pixels of target, background, boundary and noise.

#### *2.3.2. Application of improved ant colony algorithm in image segmentation*

Through the description and improvement of ant colony algorithm in this paper, we can know that ants are randomly distributed when they first walk. In this paper, every pixel in an image is regarded as an ant. Assuming the size of the image is $m \times n$, each ant needs to calculate the distance and path selection probability with other $m \times n - 1$ants. This means that the search process needs multiple cycles to complete the pixel clustering, which leads to the problem of long search time and too much computation. In order to solve this problem, according to the characteristics of image segmentation, a guiding process is added to the initial clustering center, which reduces the randomness of the ant's advance. In this paper, the similarity between the ant and the clustering center is taken as the guiding function.

Image content is generally targeted, background, boundary and noise, etc. The purpose of image segmentation is to aggregate different feature pixels into these categories. By analyzing the characteristics of the image, we can find out the features of gray scale, gradient and neighborhood corresponding to these contents as the initial clustering center, which can make ants calculate the distance and probability directly with the clustering center, reduce a large number of irrelevant calculations, and thus accelerate the clustering process. Next, the initial clustering center and the setting process of the bootstrap function are given.

(1) Initial cluster center grayscale calculation

The frequency of different gray level pixels is reflected by the gray level histogram of the image, which represents the result of gray level clustering to a large extent. Based on the gray histogram of the image, $n$ peak points of the gray histogram are selected as the gray features of the clustering center, and the number of the initial clustering centers is determined by the $n$. In this way, a large number of cyclic computation among all pixels can be transformed into a comparison between pixels and a few peak points, which leads ants to go directly to the cluster center, reduces the search process and greatly reduces the amount of computation. The first eigenvector $V$ of $C$ can be determined.

(2) Gradient calculation of initial clustering center

The gradient of background and target internal pixels is generally smaller, while the gradient of boundary points and noise points is larger. At the same time, the number of background and target internal pixels is the majority, and the number of noise points is much smaller than that of boundary points. Therefore, according to the gray histogram and gradient image of the original image, in the determined $n$clustering centers, if the number of pixels corresponding to the gray features of some clustering centers is much larger than that of others, the clustering center is most likely to set the gradient feature of the clustering center to zero within the background or target. For other clustering centers, the mean value of the column with the maximum gradient of the gradient graph is taken as the gradient value.

(3) Initial cluster center neighborhood feature calculation

Corresponding to the previous step, according to the neighborhood characteristics of different kinds of pixels in the image, the clustering center with zero gradient is set to 8 and the clustering center with high gradient value. If the number of pixels corresponding to gray features is large, the clustering center may be a boundary, and the neighborhood feature is set to 6. If the number of pixels corresponding to gray features is small, the clustering center may be noise, and the neighborhood feature is set to 3.

In this way, the selected initial clustering center is expressed as $C_j(V;G;Ne)$. $j = 1, 2, \cdots, n$ roughly represents the characteristics of various kinds.

The guide function, which reflects the similarity between pixels and cluster centers, can be represented by formula (8):

$$\mu_{ij} = \frac{r}{\sqrt{\sum_{k=1}^{m} p_k (X_{ik} - C_{jk})^2}} \tag{8}$$

The cluster radius in formula (8) is expressed by the variable $r$. The size of the value indicates the value of the guiding function, and the probability of selecting the cluster center is further expressed.

## 3. Experiments

In order to achieve better image processing effect, this paper is committed to introducing artificial intelligence algorithm into image processing. Based on the characteristics of image segmentation, this paper studies the feasibility and advantages of using ant colony algorithm in image segmentation. In addition, in order to improve the ability of global search of ant colony algorithm, this paper applies the concept of crowding degree of fish swarm to ant colony algorithm. In the early stage of the algorithm, a smaller threshold is set so that the ants can choose the path as autonomously as possible and increase the possibility of global search. In the later stage of the algorithm, the threshold is raised so that the ants can quickly gather on the path with the best concentration. The process of applying improved ant colony algorithm in image segmentation is shown in Fig. 2.

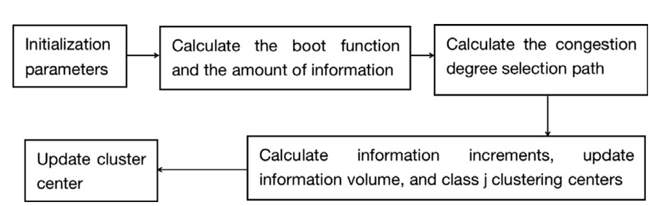


**Fig. 2.** Procedures of improved ant colony algorithm for image segmentation.

In addition, in order to analyze the effect of image segmentation more quantitatively, (MSN) is used as the evaluation parameter of the image. and the error rate formula is expressed as follows:

$$MSN = \frac{N_u + N_o}{N_r} \times 100\% \quad (9)$$

where $N_u$ is a number of points belonging to a certain class but not classified into this class, $N_o$ is a number of points that do not belong to this category but are misclassified into this category, the actual total number of points for this class is represented as $N_r$.

## 4. Discussion

This paper uses TSP30 problem as an example to verify the effect of the ant colony algorithm improvement, in which the parameters are set as follows: $m = 16$, $Q = 100$, $NC_{\max} = 100$, $\alpha = 1$, $\beta = 5$, $\rho = 0.5$. Fig. 3 shows the evolutionary curve before and after the improved algorithm. From Fig. 3, it can be seen that without the improvement of ant colony algorithm, the algorithm will fall into local solution when the number of iterations is 40, thus stagnating the algorithm's continued search for the optimal path. When the ant colony algorithm is improved, the change of the optimal path is stopped only when the number of iterations reaches 70, and the cost value is obviously reduced. This shows that the improvement of the ant colony algorithm effectively improves the problem that the algorithm falls into local solution, and has a certain improvement of the ability of global optimization.

In addition, according to the number of different cities, this paper gives a comparison of the results before and after the improvement of ant colony algorithm in the aspect of path opti-

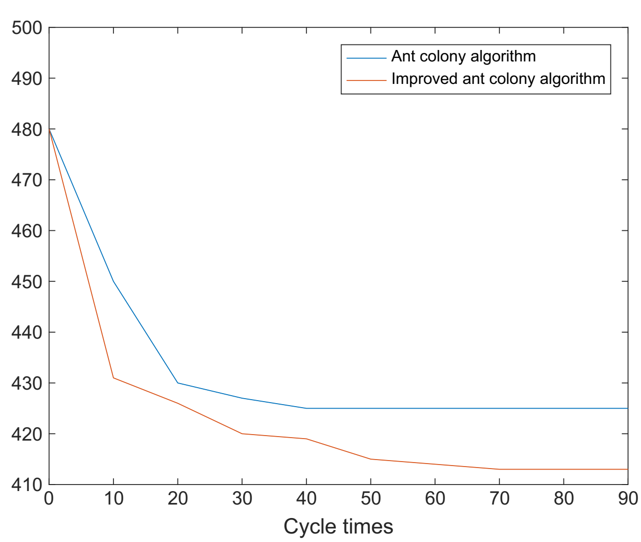


**Fig. 3.** Evolution curves of ant colony algorithm before and after improvement.

**Table 1**
Comparison of results of path optimization before and after ant colony algorithm improvement.

| City number | Ant colony algorithm before improvement | | Improved ant colony algorithm | |
|---|---|---|---|---|
| | Average number of iterations | Optimal solution | Average number of iterations | Optimal solution |
| 10 | 120 | 2.93 | 99 | 2.61 |
| 30 | 609 | 427.28 | 541 | 412.83 |
| 50 | 987 | 441.73 | 707 | 422.36 |
| 70 | 1506 | 567.45 | 885 | 537.52 |

**Fig. 4.** Original image.

**Fig. 5.** Grayscale processing.

**Fig. 6.** Image segmentation based on ant colony algorithm.

mization, as shown in Table 1. From the table, we can see that the improvement of ant colony algorithm can effectively reduce the average number of iterations, and the solution accuracy has been greatly improved.

After validating the effectiveness of the improved ant colony algorithm, this paper applies the ant colony algorithm to image segmentation. Before segmentation, the image needs to be preprocessed. In this paper, classical Lenna image is used, as shown in Fig. 4.

Image segmentation is mainly based on the gray value of the image, so the first step is to gray the image, the result is shown in Fig. 5. As you can see from Fig. 5, the gray processing of the image effectively reduces the three-dimensional image to two-dimensional image, but the basic information of the image is preserved, and does not affect the contour of the image.

Fig. 6 shows the image segmentation based on ant colony algorithm. From the graph, we can see that the effect of using ant colony algorithm is not too good, the image segmentation has a certain ambiguity, and the target is not outstanding.

The result of image segmentation using improved ant colony algorithm is shown in Fig. 7. From the graph, we can find that the target of image segmentation is clear. Comparing with Fig. 6, we can find that the improved ant colony algorithm can effectively improve the image segmentation effect.

In order to reflect the performance of image segmentation in this paper, the traditional Otsu method is used as a comparison to illustrate the effect of using ant colony algorithm in image segmentation in this paper. The performance comparison is shown in Table 2, and the histogram is drawn as shown in Fig. 8. Combining Table 2 and Fig. 8, it can be found that the error rate of image segmentation using ant colony algorithm is 9.64% better than that based on Otsu method. After improving the ant colony algorithm, the error rate of image segmentation is increased by 5.74% on the original basis.

**Fig. 7.** Image segmentation based on improved ant colony algorithm.

**Table 2**
Comparative analysis of image segmentation performance of different methods.

| Methods | *MSN*(%) |
|---|---|
| Otsu method | 20.17 |
| Ant colony algorithm | 10.53 |
| Improvement of ant colony algorithms | 4.79 |

## 5. Conclusions

With the development of the times, the demand for image processing technology is increasing. The application of artificial intelligence algorithm in image processing can achieve better image processing effect. Based on this background, the image segmentation in this paper is implemented by ant colony algorithm. This is because image segmentation is a combination optimization problem, and ant colony algorithm has a good application in optimization solution, which theoretically shows that the idea of this paper is feasible. After the introduction of ant colony algorithm and the introduction of fish crowding function, this paper effectively solves the problem that ant colony algorithm falls into local solution prematurely and stops searching for the optimal path. Then the improved ant colony algorithm is used to improve the image segmentation effect. Through simulation analysis, it is shown that the improvement of ant colony algorithm can reduce iteration times and search accuracy. Secondly, compared with the traditional image segmentation method, it shows that the proposed method has better segmentation results. It also shows that the application of ant colony algorithm in artificial intelligence method to image segmentation is feasible and has good segmentation performance.

## Conflict of interest

There is no conflict of interest.

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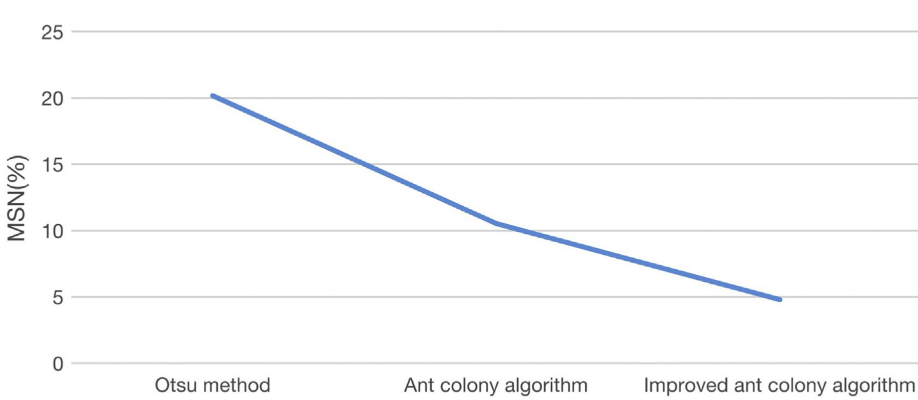


**Fig. 8.** Comparisons of image segmentation performance between different methods.

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