# An Overview of Artificial Bee Colony Algorithm

Suhan YANG[1,a] , Hongwei JIANG[2,b]

[1]Department of information management, Beijing Information Science and Technology University, Beijing, 100192, China

[2]Department of information management, Beijing Information Science and Technology University, Beijing ,100192, China

[a]email: yangsuhan518@163.com, [b]email: jianghongwei@bistu.edu.cn

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**Abstract.** A swarm intelligence algorithm develops rapidly, which has solved many large scale complex problems these years. Artificial bee colony algorithm is a new swarm intelligence algorithm and gets wide attention for its superior performance, such as, strong global convergence, greedy heuristic search feature and quickly problem solution. The biological background is introduced briefly; By comparing bees foraging behavior with problems solution, modeling thought is given; Algorithm model is introduced in detail. Then, research status quo is discussed from two aspects, improvement and application of the algorithm. Also, conclusions are given about artificial bee colony algorithm, and improvement direction and application field are put forward from the weakness analysis of algorithm.

## Introduction

Social creatures such as ants, birds, bees, whose individual structure are very simple, but their behavior are complex through collaborative communication between group, which gets birth to swarm intelligence. Swarm intelligence[1] refers to" simple intelligent body shows the complicated intelligent behavior characteristics through cooperation", which has characteristics of self-organization, distributed control, global information transmission, and highlight the complex behavior emergence phenomenon between individuals collaboration in the group . People begin to pay attention to this phenomenon and study the mechanism behind it, with computer, some researchers try to find regular and simulated a series of new methods solving traditional optimization problems, which make many highly complex optimization problems get perfect solution. Swarm intelligence algorithm is a stochastic optimization algorithm simulating nature biological group behavior. Each individual is seen as a independent agent, we use evolution of the individual or foraging behavior simulates solution search and optimization process, and use individual's ability to adapt to the environment simulates measures of objective function, and use the individual's evolution or foraging process simulates the process of using good feasible solution to replace bad one, thus formed the "*generate and test*" iterative search feature.

Artificial bee colony algorithm is a typical swarm intelligence algorithm with iterative search characteristic. In 1946, German biologist Frisch first deciphered the dance information bees back to hive, and therefore won the Nobel Prize in physiology. In bees group, different social class bees can only finish a single task, but the whole group can complete jobs such as nesting, harvest pollen cooperatively through swing dance, smell and other communication ways [2].Seeley in America was the first come up with the self-organization model, then, Teodorovic in United States put forward the swarm optimization algorithm [3]. Karaboga in Turkey in 2005, put forward a relatively perfect artificial colony algorithm model, he found that solving unrestricted numerical optimization function by artificial bee colony algorithm has better performance than in heuristic algorithm [4]. Artificial colony algorithm has strong global convergence, it uses unemployed bee greedy selecting employed bees to follow, speeding up the iteration of the algorithm, at the same time, it uses scouts helping algorithm to jump out local optimum, increasing the diversity of solution. The advantages

 

of the proposed algorithm are global and local search for each iteration, so the probability of finding the optimal solution increases greatly.

## Artificial Bee Colony Algorithm Principle

### Biological background

In bees group, they live a life similar to the matriarchal clan. There are three types of bees, the queen, worker bees and male bees. The worker bees has the largest number, mainly bears search food source, gather honey, storage honey, etc. After the worker bee gather honey back to nest, it will dance on the honeycomb right a circle and left a circle enclosure the word "*8*". In the linear phase, belly will swing, the direction indicates collection site location, and the average Angle θ indicates the angle of collection site with the sun site; and the distance of the food source depends on the swing time, distance increasing 100 m, bee swing time increasing 75 ms [5]. These two part information are bee dance language. Finding food bees can attract other bees' attention on the hive by swing dance, and other bees will get food source information accurately after seeing 5 ~ 6 times, and chose to fly to food source to gather honey or to find new sources. The whole group always find high quality food source by this information exchange and learning.

### Modeling thought

Artificial bee colony algorithm originates in simulating foraging process of nature bees, thus extracts three elements and three behavior patterns, food source, employed bees and unemployed bees; giving up some food source, recruit, and search new source. Food source is expressed by "*revenue*" for its distance, the quality of honey and so on. The higher the "*revenue*", the better the food source value, Corresponding to the objective function value in the practical problems. Employed bees are related to relevant food source, which would become hire bees taking food source information. Unemployed bees has two kinds, scouts bees search for new source, and follow bees wait and develop the food source by sharing hire bees 'information.

Initially, all bees are scouts looking for food randomly for no prior knowledge. After finding food source, bees are roles exchanged according to "*revenue*" and sorts: When food source revenue rank high, relevant bees become hire bees gathering honey and record related information to recruit; When food source revenue rank in the middle, relevant bees can become follow bees; When food source rank low, bees give up it and become scouts once again searching for new source. Hire bees with high revenue information can recruit many follow bees, but low revenue bees may not recruit one. Hire bees lead follow bees to develop in the neighbor last found source, and sorts with scouts found, choose again the highest first N rank as hire bees. Do the cycle, until meet the end condition.

Bees foraging behavior represents a specific optimization problem, food source represent feasible solution, food source revenue represent the quality of solution of optimization problem. We assume that each hire bee corresponds to a food source. First, developing the feasible solution in the food source neighbor, if find better one, make the good one instead of bad one, that is to find better solution, otherwise unchanged. Then, All hire bees flying back to hive to recruit after finish searching, follow bees choose hire bees taking high revenue information to follow according to probability selection strategy ,and fly to the source to develop, if find better one, change its target, that is to find better solution, otherwise unchanged; If search times reach a certain limit but still do not find better solution around some food source, give up the source, and bees become scouts again, randomly looking for food source, Generates a new feasible solution and begin a new iteration.

### Algorithm model

The candidate set of feasible solution can get a optimal through evolution by artificial bee colony algorithm. Food source scale is setted N, food source $X_i$(i=1,…,N)are vectors of D dimension, which corresponding to one hire bee. F(Xi)is food source revenue, or objective function value. The iteration times is constrained to "Limit" for each source, and max iteration is constrained to $MAX_{pop}$ for whole group.

Step one: generate N feasible solution randomly.

For i=1 to N

do

$X_i^j = X_{min}^j + rand(0,1)(X_{max}^j - X_{min}^j)$; (1) ( j is component of D dimension vector)

Step two: hire bee search good solution in food source neighbor, and calculate the revenue or the fitness value, if new source fitness is higher than old one, replace it. Search new source formula as follows: For i=1 to N

do

$V_i^j = X_i^j + \varphi_i^j(X_i^j - X_k^j)$ ; (2)

(new source fitness is $F(V_i)$,if $F(X_i)$lower than $F(V_i)$, make $V_i$ replace $X_i$, otherwise unchanged.)

Step three: for follow bees, according to the probability of positive correlation to hire bee fitness value, choosing one hire bee to neighborhood search. The probability of food source i is chosen is: $Pi = \frac{F(Xi)}{\sum_{i}^{n} F(Xi)}$ (3)

(The ways follow bees search and select the food source is similar to step 2.)

Step four: for all food source, if search times reach a certain limit but still do not find better solution around some food source, give up the source and generate new source:

For i=1 to N

do

{limit=0;m=0;

If $F(X_m) = F(X_{m-1})$ then m=m+1;

If m = Limit then

{give up the food source, and generate a new source according to formula(1.1); limit=0;}

}

Step five: Judge whether algorithm meets the end conditions, or get maximum iteration limit $MAX_{pop}$. If it is, output the optimal solution, otherwise the algorithm into the next iteration.

**Artificial bee colony algorithm research status quo**

Since 2005 artificial bee colony algorithm was put forward, which receive less attention by academic area a period of time. But after 2010, a large number of academic paper have mushroomed, especially meeting held in Taiyuan discussing swarm intelligence, artificial bee colony algorithm as a special project, received extensive discussion and research [6]. Currently, research on artificial bee colony algorithm mainly divides into two aspects as follows.

**Improvement of algorithm**

In 2007, Karaboga and Basturk wrote an article about artificial bee colony algorithm solving function optimization problems, comparing with genetic algorithm and particle swarm algorithm and evaluates its running effect [7]. Akay and Karaboga research optimal parameter setting by experiments, concluding that the "*Limit*" should be setted to the multiplication of group size and dimension as a best choice[8]. Luo Jun etc introduced chaotic sequence in initial, the diversity of solution was improved greatly[9].Considering assignment problem solution's discreteness, Sun Xiaoya etc presents a improved artificial bee colony algorithm, giving a discrete coding method for the food source position, adopting neighborhood shift to produce a candidate food position, this algorithm can accelerate the convergence process obviously and improved the precision[10].Alatas introduces chaotic mapping mechanism in basic algorithm implementing the adaptive change of parameters ,and involves global search ability and convergence speed[11].Hu ke etc in order to solve traditional ABC algorithm is inclined to fall into local optima,first the improved ABC algorithm was derived from the skills of extrapolation in mathematics to update the new location of ABC. then, a fine-tuning mechanism is introduced and different perturbation factors is discussed. The improved algorithm has better performance in search ability and accuracy[12].Huang Lingling

analysed characteristics of ABC and differential evolution algorithm, and proposed a integrated the advantages hybrid algorithm[13].Chen etc introduced simulated annealing algorithm in the process of hire bees search, improved ABC algorithm's ability to develop solutions[14].Yuan Xiaoyan introduced chaotic operator and reverse learning operator in initialized stage, then, in mining bee search equation introduced the best guide in the individual, and improved the search mechanism of scout bees, making the convergence have improved significantly[15].

**Application of algorithm**

People who propose the artificial bee colony algorithm such as Karaboga etc applied it to multivariate function optimization, integer programming, and traveling salesman problem. Hu zhonghua etc applied the improved algorithm in robot path planning and unmanned aerial vehicle route planning [16].Ozurk etc proposed that applying the hybrid algorithm of ABC and Levenberg-Marquardts to neural network training[17].Singh etc proposed an improvement algorithm solving minimum spanning tree, and verified the superiority of the algorithm to solve such problems[18].Wang Zhigang etc applied the improved algorithm to solve multidimensional knapsack problem. During evolution process, it used greedy algorithm to repair the infeasible solution and rectify feasible solution with insufficient use, showing the effectiveness of the proposed algorithm[19].Liang Huijian etc applied it in image segmentation. Image thresholds are regarded as bees and the fitness function of ABC algorithm is designed by two-dimensional Otsu method. The best threshold is approached in parallel via the division of labor, cooperation and information sharing of employed bees, onlookers and scouts[20].Lu Binbin etc proposed an optimization methodology based on ABC algorithm. The ABC algorithm has advantages in easiness, simple calculation, good optimization performance and strong robustness, thus it can self-rune the parameters of PID controller to improve the system performance[21].Huang Lijun proposed a design of reverse logistics network of waste based on discrete artificial bee colony algorithm, successfully apply ABC algorithm to solve vehicle routing problem and location allocation problem of reverse logistics in closed-loop supply chain logistics network, Expanding the ABC algorithm application in the field of supply chain logistics[22].

**Conclusion**

Artificial bee colony algorithm is a new swarm intelligence algorithm; it has become a wonderful flower in bionic intelligent computing area. The algorithm has strong global convergence, using follow bees choose hire bees to follow according to probability, accelerating the iteration speed, and scouts help algorithm jump out of local optimal solution at the same time, increasing the diversity of solution. The algorithm has characteristics of greedy heuristic search, it can combine the rapidity of problem solving with global optimization and the rationality of the results in the limited time together, through the positive feedback of the precocious convergence searching target to get the optimal solution.

In recent years, artificial bee colony algorithm has received more attention, but improvement and application of algorithm have many problems waiting for research. In improvement aspect: For parameter settings has great influence on the performance of algorithm, how to set reasonable parameters and how to adjust parameters in the process of algorithm worth further study; ABC algorithm is easy to fall into local optimum, so it is necessary to study how to improve the global search ability and enhance the robustness of the algorithm. In application aspect: Recently ABC and improved algorithm has applied in many areas such as multivariate function optimization, image processing, traveling salesman problem, the neural network training and so on. Also, some scholars recently begin focus on artificial bee colony algorithm solving the closed-loop supply chain logistics network optimization problem, trying to expand the application in this area. How to improve the performance and enrich its application field of artificial bee colony algorithm have great practical value.

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