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Novel model of particle swarm optimization for data mining based on improved ant colony algorithm

Chunxia Wang

Department of Computer and Information Technology, Shangqiu Normal University, Shangqiu, China

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ABSTRACT

The biggest characteristic of the particle swarm algorithm is simple, easy to understand, and has a few parameters, easy to implement. This paper mainly introduces the basic thought of ant colony algorithm, and the improved algorithm according to the actual need. Ant colony algorithm will search behavior of ants to can improve the quality of solution and convergence speed near the optimal solution, thus improving algorithm performance. The paper present novel model of Particle swarm optimization for data mining based on improved ant colony algorithm. Experimental results show that the improved ant colony algorithm can effectively improve the efficiency of data mining in particle swarm.

Keywords: Ant colony algorithm, Particle swarm optimization, Data mining.

INTRODUCTION

ACA originated in ant colony foraging behavior. S.Goss "Shuangqiao" experiments that ants will always choose from the food source short branch ants communicate via pheromones to the transmission of information, shortcut the pheromone of ant more, more attractive. The formation mechanism of positive feedback, to achieve a harmonious high organization state of the act of collective self catalytic current research for large-scale conscription, and it is namely only chemical tracing draft.

Individual ants in real life and intelligence is very simple, but they can coordinate with each other, division of labor, cooperation to complete the nesting, foraging, migration, such as cleaning the nest complex behavior, especially the ants have the ability to find the shortest path from the nest to a food source in the absence of any visible cue conditions, and with the environment changes to search the new path, new choice [1]. This is because ants secrete a pheromone in its path; other ants can sense the presence of this material and the strength, and to guide their direction of motion, which tend toward the pheromone strength to move in the direction of. Ant colony algorithm is from group behavior in real nature ant foraging was inspired by. In the ant colony algorithm, in order to realize the real ant abstraction, put forward the concept of artificial ants.

Optimization is an important research topic in the field of scientific research, engineering technology and economic management. Particle swarm optimization algorithm of (PSO) through the observation of the birds, fish and human social behavior by Kennedy and Eberhart, a novel evolutionary algorithm proposed in 1995. Although the PSO algorithm is developed rapidly and has made achievements, but its theoretical basis is still relatively weak, especially the parameter setting and optimization problems in the basic model algorithm are not mature in theory and research. In view of the development history of PSO is short, it is based on the theory and application has some defects, which need to be solved [2]. Through the analysis, and it is characteristics of the inductive step of the PSO algorithm.

Bionic optimization algorithm is an important branch in the field of artificial intelligence, genetic algorithm

simulation, including simulation of natural selection in biology and genetic mechanism of ant colony algorithm the foraging behavior of ants group and simulated birds flocking particle swarm algorithm.

PSO unlike other evolutionary algorithms that cross, mutation, selection and other evolutionary operators to the individual, but the group (swarm) of the individual as search particles have no mass and volume of space in the D dimension (particle), each particle to a certain speed in the solution space to move, and gather to the best position the history of pbest and local historical best position, the candidate solution of evolution. PSO algorithm has good bio social background [3] and easy to understand, less parameters and is easy to realize, the nonlinear, multi peak has strong global search ability, has been widespread concern in the scientific research and engineering practice. The paper present novel model of Particle swarm optimization for data mining based on improved ant colony algorithm.

2. Research on improved ant colony algorithm

The experts found that a single ant has some capacity simple. But the ant can complete a series of complex task. This phenomenon is the high coordination is completed by 1991. M.Dorigo was the first to propose a new bionic algorithm ACA. Study on the behavior of ants. The basic principle and mathematical model are applied to seek the traveling salesman problem (TSP) solution.

Artificial ants and ants, is a group of mutual cooperation of individuals, each ant can establish a solution, the ant colony cooperation to find globally optimal solution. Artificial ants and real ants have common tasks, to find the optimal path. Artificial ants and real ants are through the use of pheromones for indirect communication.

Ant colony system (Ant Colony System), this algorithm is present in heuristic algorithm research focus and front subject, has been successfully used in solving the traveling salesman problem, ant colony algorithm has much more superiority and broad prospect in solving the complex optimization problem [4]. However, according to observation and experiment, multiple ant in the colony movement is random, the diffusion range is very large, in a relatively short period of time it is difficult to find a better path, is easy to appear in the process of algorithm implementation stagnation and slow convergence phenomena. In the defects of this condition, scholars have proposed an adaptive ant colony algorithm, by adaptively adjusting the volatilization factor during operation to change the path of the pheromone concentration, so as to effectively overcome the local optimum easily into the traditional ant colony algorithm solution and slow convergence phenomena.

When a node s receives a node,. Information, if there are nodes, node s will compare it to adjacent nodes of the ID. If not, the node,. Information added to the adjacent node in the linked list; if there is the updated node,. Energy value, and compared with the minimum energy level set beforehand, if less than the minimum energy level of the nodes is defined as death nodes, delete from the adjacent node in the linked list, as is shown by equation(1).

$$\tau_{ij}(t+n) = (1-\rho) * \tau_{ij}(t) + \Delta\tau_{ij} \tag{1}$$

To find an effective solution to the problem has important practical significance. Ant colony algorithm is put forward by DorigoM, the algorithm uses a distributed parallel computer system, easy to combine with other methods, and has strong robustness, and is an ideal method for solving TSP problem. The main idea of the algorithm is: the simulation of ant foraging behavior.

Ant colony optimization algorithm is a heuristic algorithm of ant foraging behavior heuristics proposed [5]. In the foraging path selection, at first because each ant only know the local information, unable to find the shortest path from the nest to a food source, but the ant foraging path through pheromone release, indirectly complete path information and the other ants exchange, and eventually the whole ant obtained the global optimal path (global optimization results).

In the biological community system of nature, was surprised to find that the social insects and social vertebrates can find new sources of food, the division of labor in group, building complex nests, spanning thousands of kilometers to migrate to the designated area and scheduling and coordination in a narrow space. This social animal self-organizing behavior aroused widespread concern, many scholars of the behavior of mathematical modeling and computer simulation of swarm intelligence that has the following characteristics and advantages, as is shown by equation(2).

$$\psi(t) = \sqrt{2}\sum_{i} g(k)\phi(2t-i) \tag{2}$$

Ant K they completed a tour, the path traversed by the ant K is a feasible solution of the TSP problem. (1) Type of η ij is a heuristic factor, known as the visibility factor. In the AS algorithm, η ij usually take between the city I and city J distance. Alpha and beta are reflected in the relative importance of movement in the process of ants have accumulated information and heuristic information. When all the ants to complete a tour, pheromone updating according to equation.

It can not be adjusted by formula of pheromone concentration alleviate this phenomenon. Will fall into the local convergence can not find the global optimal solution: transfer probability is too large, although the convergence rate is faster, but will lead to premature convergence [6]. So the principle of positive feedback caused by self catalysis is intended to strengthen the good performance of the solution, but prone to stagnation. The author presents a survey to ACA on some of the ideas, and the application and development prospect is presented.

Using ant colony algorithm to solve the TSP problem is a recursive process, when, the ants on the city, set the initial amount of information on each path, each ant according to the formula of probability 3 decision from city to city. Said to have how many ants after path; that near the city have a greater likelihood of being selected. Used to control both the ants choose influence degree. Through a cycle, according to the formula 1; 2; the calculation and update information of each path, the energy consumed for Formula 3 [7].

$$\Delta \tau_{i,j} = \sum_{k=1}^{m} \Delta \tau_{i,j}^{k} \tag{3}$$

It selects the next adjacent vertex, the probability of VJ pij: ij e (I η said, J) heuristic on the predict value. VI local heuristic values can be any type of cost, such as distance, cost etc.. The use of information concentration Uij and heuristic in the vertex Vi ant value η E let Uij denote the edge e (I, J) on the pheromone concentration, ∈ V; E (I, J) ∈ (V, E) be a connected undirected graph, V is a collection of vertices in graph G, E is the set of edges. VI, VJ basic is ant colony optimization algorithm.

Selection of ant algorithm is the direction of the wireless sensor network monitoring area is divided into eight different quadrants, slope and keep the direction of not more than 1. And different on the eight quadrant identified ID, ant can be obtained by using the linear algorithm (soon we linear equation y = + 6 common cylinder to the implicit function F (x, y) = y - H - 6 = O, every time when the displacement in the direction of X axis on the step, the Y axis whether the slope displacement K decided to realize path) and the improved algorithm is based on the nodes are connected to the ant table accessed, in the ant path, the path length will change according to the need, in order to improve the efficiency of ants select the path.

The P (0 < p <1) represents the path pheromone evaporation coefficient, 1- ρ indicates the persistence coefficient of pheromone; delta tau ij incremental ij pheromone in the iterative edge. Delta tau and Kij represents a K ant in this iteration edge ij amount of pheromone. If the ant K without side ij, and it is delta tau Kij value is zero [8]. Delta tau Kij expressed as.

The AS algorithm is actually a kind of positive feedback principle and algorithm are heuristic algorithm combination. In the choice of the path, not only makes use of the ant pheromone on a path, and use the city as the distance between the reciprocal of heuristic factor. The experimental results show that, the performance of ant cycle system model is better than the ant quantity system and ant density system model has better. This is because the ant cycle system using global information updating pheromone quantity, and ant quantity system and ant density system model using local information. The time complexity of AS (NC*n2*m) algorithm for space, the space complexity is S (n) =O (N2) +O (n*m), where NC denotes the number of iterations, n city, M is the number of ants:

$$\omega_t = \omega_{\max} - \frac{\omega_{\max} - \omega_{\min}}{t_{\max}} \times t \tag{4}$$

In the leading position in the world of swarm intelligence ACO and swarm robots these two aspects, to study specific meta heuristic focusing on ACO, the main research is to develop a reasonable experimental methods on, using a set of experiential learning and meta heuristic construction development tools, especially the research is to design and improve the method stochastic local search algorithm and heuristic algorithm theory.

Proof of the convergence of a special subset of ACO algorithm is a good entry method. The stochastic optimization

algorithm, strength ratio convergence solution converges strongly, but usually only need to prove that the algorithm can find the optimal solution, so the real need is the study of the convergence problem [9]. The theoretical results, a special subset algorithm is extended to the general ACO algorithm is feasible.

The main non intelligence through cooperation showed the characteristics of intelligent behavior is a kind of computing technology of biological groups based on behavior rule. It is influenced by social insects, such as ants, bees and social vertebrates, such as birds, fish and inspired by the herd, solve distributed problem. In the premise of no centralized control and does not provide a global model, provides a new idea for finding solutions for the complex distributed problems.

$$SSD = \sum_{X \in \Omega_i} [I_k(W(X, P) - I_{k-1}(X))]^2 \tag{5}$$

(1) Robust: modification of the ant colony algorithm model slightly, it can be applied to other problems.

(2) Distributed computing: the ant colony algorithm is a novel evolutionary algorithm based on population, has a parallel nature, easy to implement.

(3) Easy to combine with other methods: ant colony algorithm is easily combined with other heuristic algorithms, to improve the performance of the algorithm.

ACA, illustrated from its basic principle, model, pseudo code flow, the Oliver30 TSP problem analysis, but not on the parameters of the basic model for a detailed theoretical description, and the stop condition definition is vague, mutation mechanism mainly rely on the experience of decision subsequently introduced to accelerate the convergence rate, to obtain a better solution. Cycle is shortened, and its validity is demonstrated by the computer simulation level.

Due to residual information on the path of the dominant role of positive feedback, information is relatively weak, random search, so that the convergence speed of ant colony algorithm is very slow; and in the 1 choice, because the information is feedback effect dominates, the randomness weakened search, although the algorithm has faster convergence speed, but is easy to fall into local optimal state. Therefore, the ant colony algorithm pheromone volatility 1 must be integrated into global search ability and convergence speed of the two performance indicators, and the actual requirements of application conditions for specific problems, the global search ability and convergence speed of two aspects to make reasonable or compromise choice.

ACO through the many simple ants use pheromones to communicate with each other, data processing to make the groups can be distributed. In this paper, using ACO in the routing search is easy to realize, parallel processing, as well as the characteristics of fast convergence, the wireless sensor network routing protocol (ACL), the design of the data packet and packet transmission rules of ACRP, and gives an overview of ACRP and its related algorithm implementation process and detail, analysis of ACI impact of convergence and time complexity.

3. Data mining of particle swarm optimization

The PSO algorithm is simulated social model too simple, the parameter to form groups to search, said a solution by optimization problems with each particle, through the interaction between particles, so that the individual in the group moved to the target area, so as to find optimal regions of complex search spaces. It is not based on genetic algorithm crossover and mutation operators, each particle to search according to their position and velocity, the search and update process is to follow the current optimal solution of it [10]. Therefore, PSO algorithm can find the optimal solution faster.

Birds foraging in the migration process have the characteristics of both decentralized and centralized. There is always a bird to smell food is better, which has good insight to the general direction of the food source, so the bird will have better food source of information. Due to find food on the way, and they always mutual transmission of information and it is especially the good news. So, under the guidance of the good news, eventually led to the birds "like a swarm of bees" to the food source, reached in a cluster of food source. The PSO algorithm from the population behavior be inspired and used for solving optimization problems. The biggest characteristic of the particle swarm algorithm is simple, easy to understand, and has a few parameters, easy to implement, thus the short term obtained the very big development.

In the above simulation using only three simple rules, you can simulate very close to the phenomenon of the flight of

birds and the bird model, it differs in: birds are attracted to fly into the habitat. In the simulation, the beginning each bird no specific target, just use simple rules to determine their direction of flight and flight speed (each bird tries to and stay birds do not collide with each other), and when a bird flew into the habitat, it around the bird will follow fly to the habitat, in this way, the whole flock will fall in habitat.

Social neighborhood usually by particle storage array index number division, which is a division of means, most are: ring topology (ring or circle topology), wheel topology (wheel topology) or star topology (star topology), tower topology (pyramid topology), von Neumann topology [11]. For different optimization problems, the topology performance vary; but in general, the random topological tend to most of the problems can exhibit better performance, followed by von Neumann topology. The random topology is analyzed, and the random topology in the version of the standard PSO.

The basic concept of particle swarm optimization algorithm in the predatory behavior of birds: a flock of birds in the space of random search for food, assumption in this region of space is only a piece of food, all the birds do not know where the food is, but they know the current location away from the food and how far, then find what is optimal strategy for food? The most simple and effective method is to search for the nearest to the food of birds. Particle swarm optimization algorithm is derived from such models and the enlightenment, and it is used to solve the optimization problem. Particle swarm optimization algorithm, the optimization problem of each potential solution is to search a bird in space, called the "particle", as is shown by figure1.

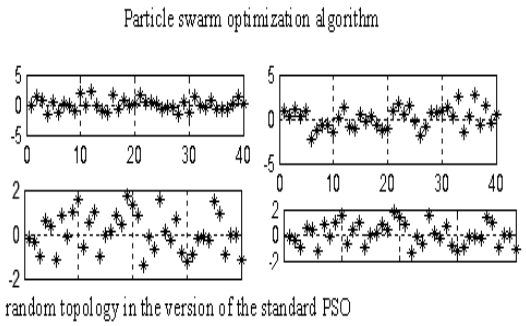

Figure1. Random topology in the version of the standard PSO

A PSO algorithm and ant colony algorithm was similar, but the basic idea is to simulate the biology group behavior to construct stochastic optimization algorithm [12]. The same point particle swarm algorithm and ant colony algorithm is a global optimization algorithm, which is the probability of uncertainty,, between each agent through mutual cooperation to better adapt to the environment, demonstrated the ability to interact with the environment, and has parallel nature. All individuals are stored knowledge of optimal solution. Uncertainty in the complex environment, can improve the algorithm of individual adaptability constantly learning through.

In D dimension target in the search space of N particles, a particle swarm optimization, where each particle is a vector of D dimension, space where it is expressed as Xi = (Xi1, xi2,... , xiD), i=1, 2,... N. The space location of particle is a solution to the problem of multi-objective optimization, put it into the fitness function can be used to calculate the fitness value, according to the fitness value of the measured particle size or it.

The dynamic hierarchical tree as the neighborhood structure, the best location history better particles in the upper, the velocity of each particle by its own historical best position and grade tree in the last node of the particle particle historical best position. The master servant model (Master - slaver model), which contains a main groups, a plurality of servants group, and group of independent search, the best position of main populations in the servants groups on the search. The niche (niche) technology into the PSO and it is the PSO (Niching Particle Swarm niche Optimizer). For search using multiple groups, each interval algebra is the whole group randomly divided again, proposed a dynamic multi group PSOS.

All particles are an adaptation is determined by the value of the function to be optimized (fitness value), each particle has a speed determines the direction and the distance they fly. Then the particle will follow the optimal particle current search in the solution space, as is shown by equation (6).

$$\Omega_{ij} = \{(i-1)l+1 \leqslant x < il,\ (j-1)l+1 \leqslant y < jl\} \quad (6)$$

The ant colony algorithm using the positive feedback mechanism, each individual intelligent perception of local information and the global information can't directly use, so need long search time, and prone to stagnation. Particle swarm algorithm uses one-way information sharing mechanism, the optimal values of the current search to the global sharing; principle is relatively simple, required less code and parameters.

The first part speed of particles previously; the second part is the "cognitive" part, thinking of the particles themselves; the third part is the "social" part, said particles between social information sharing. At present, although the relative importance of social and cognitive part of the model has not yet been given from the theoretical conclusion, but some studies have shown that for some problems, the social part of the model is more important for the cognitive part, as is shown by equation(7).

$$x_{ij}^{t+1} = x_{ij}^{t} + v_{ij}^{t+1} \times T_0 \times (1 - \frac{k_0 t}{I_{\max}}) \tag{7}$$

Crossover operation is performed on the particle position and velocity, the Gauss mutation into PSO; here the use of mutation, selection and breeding a variety of operations at the same time adaptively determine the velocity updating formula neighborhood in the best position and inertia weight and acceleration constant; using the differential evolution (DE) operation choice best particle velocity updating formula; and use DE to optimize the PSO inertia weight and acceleration constant. In addition, some other search techniques combined with the PSO algorithm to improve the local search ability, also a hybrid method is proposed based on PSO and Levenberg-Marquardt.

Using PSO algorithm to train the BP network, the position vector defined particle swarm element is BP network connection weights and threshold value of individual. The initialization vector, and then search for the optimal location with the PSO algorithm, the following are the force error index (fitness) minimum.

The previous velocity of particles from the sociological angle to look, called the memory, is in the role of inertia to continue in the original direction of movement; "cognitive (Cognition)", said particles own experience, in their own experience traction optimal position for "social movement; (Social)" part, said particles information sharing and cooperation, which guide the particle to particle swarm optimal position in it.

The biological immune system is a highly nonlinear system robust, distributed, and adaptive and has the ability of learning and memory ability, strong recognition. The literature the immune information processing mechanism of immune system (antibody diversity, immune memory, immune self adjustment etc.) into PSO, which presents vaccination immune PSO based on immune memory immune PSO. Quantum behaved particle swarm optimization, the quantum individual discrete PSO, here he is mainly based on quantum behaved particle position update.

4. Novel model of Particle swarm optimization for data mining based on improved ant colony algorithm

The state transition rules for a new path to explore a better and more reasonable provides a method and a priori knowledge. In basic ant colony algorithm, ant completely depends on the probability of path selection, using a random proportional rule, ant colony system using different decision rules, called the pseudo random proportional rule. The decision rules with dual power. Decision rules can be based on the a priori knowledge of the problem can also have a tendency to search.

The particle number, the more time spent, iterative algebraic corresponding may reduce. If the number is too small, it is easy to fall into local extremum, iteration times more can not jump; if too many particle number, every generation of evolutionary effect is limited, but the calculation has spent a lot of time, to achieve the same effect in the optimal solution of the case need to wait for a long time, is not worthwhile. Normally 20-50. But for the difficult issues or specific category of problem, the particle number advisable to 100 or 200. The maximum velocity, particle: moving distance decided the maximum particle in a loop, the value set by the users themselves. Maximum speed is a very important parameter.

On the influence of information in ant colony algorithm Q on the performance of the algorithm and its selection in real application, also can be analyzed by computer simulation experiment and determine. Above the columns of the TSP problem as the research object, 1, 0.3 expected heuristic factor, information factor = inspired ρ 0.6, pheromone residues algorithm parameters constant = taken as: ant colony number m, the stop condition of the operation is adjacent to two cycles in different search optimal solution is less than 0.001, the ant cycle total amount of information released a week were Q = { 1, 12, 120}.

Artificial ants according to formula (8) for a next hop node. Rule 4 when the artificial ants to reach none sink nodes

and unable to move according to the rules, the artificial ants back to the first node re search. The node number rule 5 will have been put into the K ant tabu list. Rule 6 if the artificial ants within 1 hop will find the sink node, and it is the artificial ants search not to participate in the future. Rule 7 artificial ants' nodes at each generation search stopping criteria for search is the sink node. The total path stops for the neighboring iterations 3 search of the same.

$$S_x(\omega) = \frac{1}{2\pi} \sum_{k=-\infty}^{\infty} R(k) e^{-j\omega k} \tag{8}$$

The particle population size N: smaller clusters can fully explore the solution space, avoiding the evaluation and calculation of fitness value too much time. General [20 -40], for most of the problems, the 10 particles have been sufficient to achieve good results, for the difficult problems or specific category of problem; the particle number can reach 100200. Particle length (dimension): This is determined by the optimization problem, is the problem of length of solution. The particle coordinate range: determined by the optimization problem, every one can set different range. Moving distance determines the maximum particle in a loop, usually set as particles range width. Learning factor: and usually equal to 2, but the literature also has other values, in general, and in the range between 0 and 4.

Ant colony algorithm will search behavior of ants to can improve the quality of solution and convergence speed near the optimal solution, thus improving algorithm performance. But this way of searching will make the premature convergence behavior are more likely to happen. Max min ant system can effectively avoid the premature convergence. The difference between MMAS and AS lies in the following three aspects: at the end of each cycle, only an ant to update the pheromone, the ant is the global optimum or iteration best ant.

There are two important steps of particle swarm optimization algorithm to solve the optimization problem in the process of the problem: the coding and fitness function. Particle swarm algorithm is not as general genetic algorithm using binary code, but with real number coding. For the current problems, the particle can be directly coding, fitness function is equation (9).

$$x = \frac{2}{2 - \varphi - \sqrt{\varphi^2 - 4\varphi}} \tag{9}$$

Best worst ant system. In view of the AS search efficiency and poor quality of the disadvantages, best worst ant system to enhance the guiding the search process, the ant search more focused on to the current best path to find the location of the circulation field, both to avoid the premature convergence, and shorten the search time.

The simulation conditions specific to: randomly scattered 200 nodes in a square area 150m x 189m; 1 data source node located at (66,454); 1 (560*860); the destination node in the communication distance of nodes is 330m. Transmission energy 660MW hypothesis node, receiving 395mw of energy consumption; the initial energy of all nodes are the same, for the 10.1 node energy reduces 5J, start a residual energy notification mechanism. = ρ 0.1, network of pheromone evaporation per second at a time, = μ 000 (J is the unit of energy), as shown below figure2.

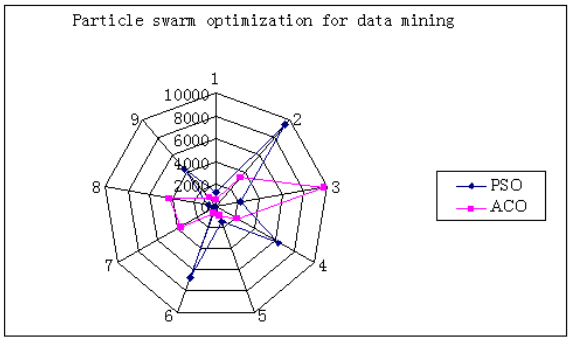

Figure2. Particle swarm optimization for data mining based on improved ant colony algorithm with PSO

Quality of ant colony algorithm in iterative times and have certain advantages, but for the actual situation of computer network at present, still need longer search time. The paper present novel model of Particle swarm optimization for data mining based on improved ant colony algorithm. Although the parallelism can alleviate this problem to some extent, improve the speed of the computer and ant colony algorithm, but for large complex

computer network, this is a big obstacle. The basic ant colony algorithm in solving some small scale is TSP problem when the performance is satisfactory. But as the problem size increases, the ant system is difficult to find in the number of cycles within acceptable optimal solution.

CONCLUSION

Dynamic ant colony algorithm compared with the traditional ant colony algorithm and the max min ant colony algorithm, lies in the improvement of the main; the former in the iterative process, in the choice of target city standards, without the use of a fixed standard, so as to reduce the evolutionary stagnation phenomenon of the latter two based on pheromone and heuristic function to choose the target city, how to based on these two factors on the performance of algorithm selection city is ant colony algorithm is crucial to the pheromone strength does not limit, so easy to fall into local optimal solution, MMAS the pheromone strength given certain range limits, and greatly improve the performance of the algorithm.

The basic particle swarm algorithm stability is mainly due to the algorithm is simple in concept, fewer parameters, randomness, strongly depending on solution initialization and function characteristics. Different solution initialization may lead to different optimal solutions, a simple function is easier to obtain the optimal solution, and function more complex it is easy to fall into local extremum, which leads to the stability of the algorithm is poor.

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