Problem Research on the Optimal Way of UAV on Account of Ant Colony Algorithm

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Abstract: The sealing and control combat planning of the port is to protect our maritime transport line and lifeline. By increasing the possibility of discovering hostile ships, it can reduce the threat of hostile forces to our interests. It is of great significance to the security and stability of the port, and even related to the important security of the port in the state of battle. This paper studies and discusses the function of UAV target recognition, and proposes the optimal path problem of using the positive feedback and robustness.

1 INTRODUCTION

The identification of the merchant ships coming to the port is an important part of the port containment operations. At present, for the optimal path problem of UAV (Li Yongxia, 2016), we can use the model of ant colony algorithm, so as to build the path planning model built on ant colony algorithm. Specifically, it takes advantage of the good parallelism and simple structure. By comparing the solution obtained by iteration, the more effective solution is chosen. After repeated iterations, the optimal solution can be obtained.

2 INTRODUCTION OF THE ANT COLONY ALGORITHM

Ant colony algorithm (Deng Zijie, 2022) was founded in 1991 by Italian scholar Dorigo etc. It is another emerging heuristic search algorithm after neural network, genetic algorithm and immune algorithm. In the process of studying ant foraging, they found that the behavior of individual ants was relatively simple, but the ant colony as a whole could reflect some intelligent behavior. For example, ant colonies can care for the shortest path to the food source in different surroundings. This is because the ants in the colony can transmit information through some information mechanism. After further research found that the ants will release in the path of a can be called "pheromone" material, ants in the colony of "pheromone" perception, they will walk along the "pheromone" concentration higher path, and each passing ants will leave "pheromone", this forms a similar positive feedback mechanism, so after a period of time, the colony will along the shortest path to the food source, as shown in figure 1.

Ants with shorter paths release more pheromones. With the advancement of time, the accumulated concentration of pheromones on shorter paths gradually increases, and the number of ants choosing this path is also increasing (GUO Yanyong, 2016). Eventually, the whole ant will focus on the best path under the action of positive feedback, which corresponds to the problem to be optimized.

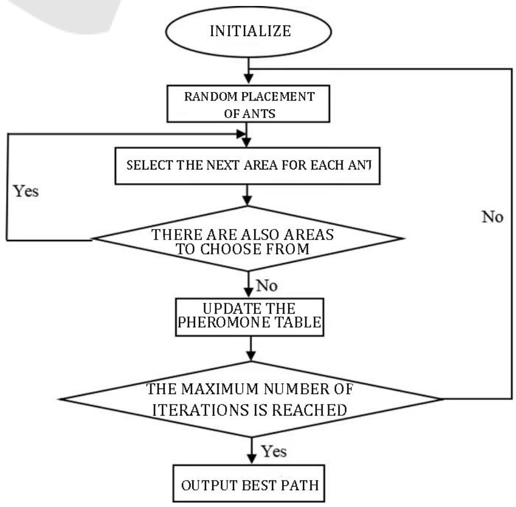

Figure 1: Block diagram of the ant colony algorithm program.

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3 ESTABLISHMENT OF THE ANT COLONY ALGORITHM

Through the ant colony algorithm, a new simulation evolution algorithm based on the positive feedback principle, we build the ant colony optimization algorithm model for the optimization path problem of UAV reconnaissance route and the target planning problem of interception scheme (Suwartof Basuki, 2016). As a biomimetic algorithm and universal stochastic optimization method, it was gradually applied to the problem of drone target interception, after the success of the famous "Travel quotient problem" (TSP) was achieved.

In order to solve the UAV reconnaissance route for the classified results in the model, the shortest path can be solved for the UAV starting from the fixed point. The shortest flight distance of UAV is the optimized target, and the expression is as follows

$$\min L = d_{s0,c(1)st} + \sum_{i=2}^{n-1} A_{c(1)st,c(84)st} + d_{c(84)st,s(0)}$$

Specifically L the distance from the starting point; $s0$ to the starting point from the starting point; $d_{s0,c(1)st}$ from the starting point of the first merchant ship; A_{ij} the first starting point from the starting point; $\sum_{i=2}^{n-1} A_{c(1)st,c(84)st}$ the distance matrix of the distance from the first merchant ship point to the 84th merchant ship point; $d_{c(84)st,s(0)}$ d the distance from the starting point from the 84th merchant ship point.

To simulate the whole process of interception, we need to add the following constraints

$$\begin{cases} D_{c(1)st} > 0 \\ \sum_{i=1}^{j} D_{c(i)st} \le c, i \in \{1,2,\cdots,n\} \\ \sum_{i=1}^{j} c(i)st = 0, \mathrm{i} \in \{1,2,\cdots,n\} \\ \sum_{i=1}^{j} D_i = 0 \end{cases}$$

In the following, we use the classical TSP [JUY SUN G Y, 2019] model to elaborate how to solve practical problems based on the ant colony algorithm. For the TSP model, in order to lose generality, let the number of ants in the whole ant group be, the distance between the merchant ship, and the pheromone dimension in the connection path between the merchant ship and the merchant ship. $\tau_{ij}(0) = \tau(0)$ At the time of beginning, the ant is placed in diverse merchant ships, and the pheromone concentration in the connecting way among the merchant ships is the identical, and then the ant will choose the route with a certain probability, or the probability of the time ant moving from the merchant ship to the merchant ship. Because the "ant TSP" strategy is defined by two aspects, first the expectation of access to an area and the concentration of pheromone released by other ants

$$P_{ij}^{k}(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^{\alpha} \cdot [\eta_{ij}(t)]^{\beta}}{[\tau_{is}(t)]^{\alpha} \cdot [\eta_{is}(t)]^{\beta}}, & j \in allow_k \\ 0, & j \notin allow_k \end{cases}.$$

It is the enlightening function which α is the expected degree of the ant moving from the merchant ship to the merchant ship; β at the beginning of the element.

In the process of ant traversal of various merchant ships, similar to the actual situation, while the ant releases the pheromones, the strength of the pheromones in the connecting path between each merchant ship also gradually disappears through volatilization. To $\rho(0 < \rho < 1)$ describe this feature, indicate the degree of pheromones. So, when all the ants have through all the merchant ships, the concentration of information on the connecting paths between individual merchant ships is

$$\begin{cases} \tau_{ij}(t+1) = (1-\rho) \cdot \tau_{ij}(t) + \Delta\tau_{ij} \\ \Delta\tau_{ij} = \sum_{k=1}^{m} \Delta\tau_{ij}{}^{k} \end{cases}, 0 < \rho < 1 .$$

Where $\Delta\tau_{ij}$ the pheromone concentration increased for the release of the pheromone on the connecting route to the i and j merchant ship and the pheromone concentration increased for the k ants. $\Delta\tau_{ij}{}^{k}$ are the general values can be calculated by the ant week system model as Q. Where the pheromone constant indicates the total amount of pheromone released by the ant during a cycle; L_k it is the k overall length of the ant's way.

For the process of solving the TSP problem algorithm of the ant colony algorithm, the specific meaning of each step is:

Step 1: initialization analysis of related parameters, including the size of the colony, pheromone factor, inspired function factor, pheromone will send salary, pheromone in constant maximum iteration, data into the program, the most basic data processing, here we can generate the distance matrix between merchant and merchant ships.

Step 2: randomly place the drone M above the merchant ship A, and calculate its next arrival area for each ant, until all the ants reach all areas.

Step 3: Calculate the path length of each ant is L_w, record the optimal solution in the number of iterations at that time, and update the pheromone concentration on the link path of each region.

The algorithm design processes of the algorithm are as follows:

Table 1: 84 Merchant ship coordinates for the UAV to pass through.

Ship serial number	Initial coordinate x (in km)	Initial coordinate y (in km)
1	221.9130377	318.7406891
2	354.8172353	233.5129434
3	278.0278095	243.2512393
4	227.5655101	319.8244224
5	255.9664355	310.4559588
6	265.0472664	321.1379047
…	…	…
82	254.9713644	578.7172865
83	413.2561561	470.8937358
84	237.0798546	340.9776534

(1) Data Preparation
Clearing environment variables first is to prevent existing variables from interfering at the same time the merchant ship position coordinates are read from the data file.

(2) Calculate the Merchant Ship Distance Matrix
According to the distance formula of two points in the plane geometry, the distance between two merchant ships is easily calculated from the merchant coordinate matrix. However, it should be noted that the element on the diagonal of the calculated matrix is 0, but to ensure that the denominator of the enlightening function is not zero, the elements on the diagonal need to be fixed to a sufficiently small positive number. Judging from the order of magnitude of the data, it is enough to correct it to the following 10^{-3}.

(3) Initialization Parameters
Before the calculation, we initialized the parameters, and so as to speed up the execution of this program, some processes variables involved in the program need to be pre-allocated.

(4) Find to the Best Path Iteratively
This step is the core of the entire algorithm. Build, first of all, according to the transfer probability of the ant solution space, namely each ant each merchant access, until all the merchant ship, and then calculate the length of the ants through the path, and update the merchant link after each iteration pheromone update pheromone consensus path pheromone concentration, after cycle iteration, record the optimal path and length.

4 MODEL SOLUTION AND ANALYSIS

To facilitate the analysis and research, on the one hand, we show the calculation results digital or graphically; on the other hand, we display the data that can display the optimization process of the program to directly present the optimization track of the program. Through the use of Matlab's program, the shortest path can find the shortest distance in the process of program optimization, and the results of its operation are as follows.

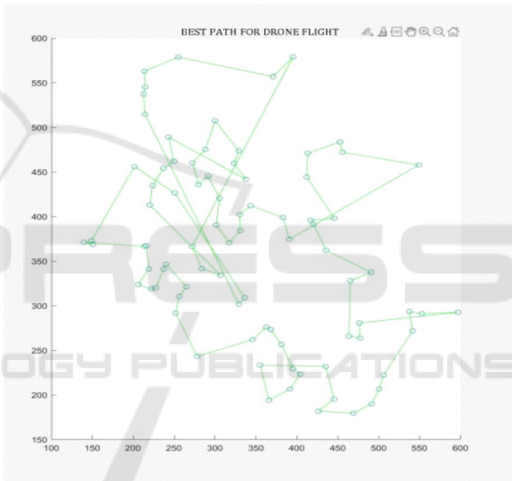

Figure 2: The best driving route of the drone.

Figure 2 shows the best route for the UAV to experience all merchant ships. According to the route, the UAV can take the shortest time and experience the shortest path.

As shown in Figure 3, the UAV should start from the 56th merchant ship position, and according to the optimum solution of the ant colony algorithm, then pass through 50,53... to 28, which can make the UAV travel time and the shortest path.

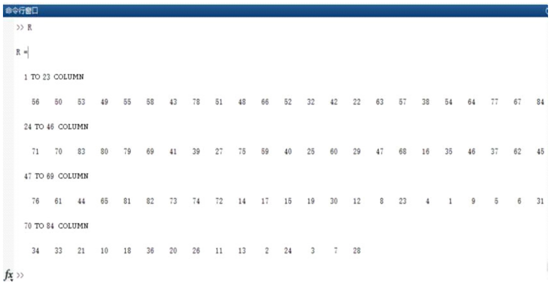

Figure 3: Driving path of the drone.

As shown in Figure 4, the red line shows the shortest distance that can be reached by the ant colony algorithm after 200 iterations, around 3300km.

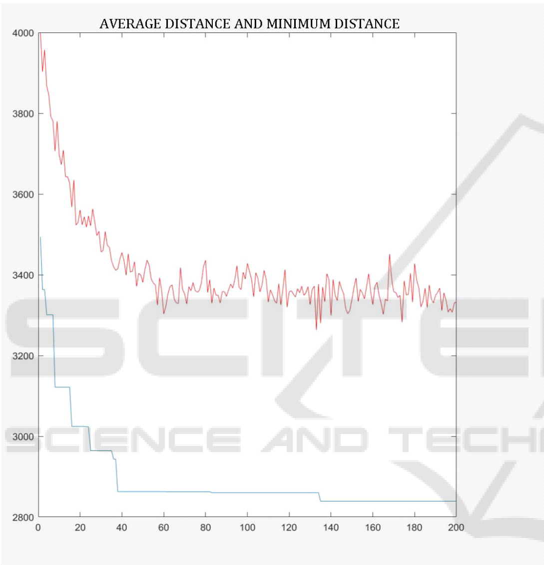

Figure 4: Ant colony algorithm results on the mean distance and the shortest distance.

Through the above research and demonstration, we first use the KNN algorithm to classify the three types of merchant ships, and obtain the location of the center point. After the classification training, its accuracy is relatively high. Secondly, in order to solve the UAV reconnaissance route after the classified results in the model, we use the ant colony algorithm to solve the best driving route from the fixed point. From the comparison of algorithm performance, compared with the genetic algorithm, when the number of merchant ships is small and the distance is close, both the ant colony algorithm and the genetic algorithm can find the optimal solution, and the convergence rate of the ant colony algorithm is fast. When the quantity of merchant ships is large and the distance is far, the ant colony algorithm can still find the optimal solution, while the genetic algorithm has no optimal solution, the ant colony algorithm often takes the global optimal comparing with other heuristic algorithms as the goal to solve the problem, with good robustness, many improvement directions, and is suitable for the solution of various problems.

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