

Ocean Fishing Fleet Scheduling Path Optimization Model Research Based On Improved Ant Colony Algorithm

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Abstract : Ocean fishing fleet scheduling is a new problem. It produces with the development of pelagic fishery and fleet size enlargement in recent years. At present, ocean fishing fleet scheduling is relying on operator's experience for artificial scheduling. Just rely on the operator's experience scheduling fishing boats not only low efficiency but also lack of scientific nature. On the basis of the analysis of the characteristics of the problem, a routing model of ocean going vessels fleet scheduling is established and using the randomness and certainty transfer strategy and combining the 2-opt optimization method of ACA to analyze and solve the model. The simulation experimental results show that on ocean fishing fleet scheduling path problem, improved ant colony algorithm can make the algorithm fast convergence and path shorter scheduling scheme can be obtained quickly. It can effectively solve the problem of ocean fishing fleet scheduling path.

Introduction

To build large-scale ocean fishing fleet, will greatly enhance the international competitiveness of China's ocean fishing, and at present our country has many coastal cities have large ocean fishing fleet, but the fleet scheduling optimization research remains to be progress.

At present, there are not many researches on the scheduling of the ocean fishing fleet scheduling at home and abroad. Mainly include the research on the optimization of the ship scheduling optimization and the scheduling optimization of the logistics vehicles. According to the research status, knowledge of ACA is very suitable for fleet scheduling optimization problem. The traditional ACA is slow in convergence, easily trapped in local optimum. So the research focus is improving the ant colony algorithm, and uses it to the fishing boat scheduling optimization problem. This paper mainly analyzes problem how to dispatch the fishing vessel, set up ocean fishing fleet scheduling optimization mathematical model, and using ACA to solve.

Mathematical modeling

Problem description

The scheduling problem of the ocean going vessels can be described as : Have a central port (Numbers for 1), Have R the same type of fishing boat to fishing the same species fish, To N fishing spot for fishing, Based on previous data analysis on fishing point i can get fish content for g_i

($i=1,2,3,\dots,N$), fishing task of fishing boat is K_r , and a fishing spot only send a fishing boat, the problem is under the condition of meeting the task of fishing vessel, to determine a set of scheduling path scheme from the central port to the fishing ground of each point, get the shortest path fleet operations.

Model hypothesis

- 1) Fishing vessels are the same type; all ships are catch squid or tuna.
- 2) According to the information and previous data in fish, determine the fishing point of a fish farm.
- 3) Measurement speed is the average speed of fishing boats.
- 4) There is only one central port, the beginning and ending of each line are in this center of the port.
- 5) Each route is in the ideal situation; do not consider the special circumstances of the weather, wind and waves, etc.

Variable and parameter symbols

Before the establishment of the model, the definition and description of the variables and parameters used in the model are needed.

M: The number of fishing grounds;

N: All fishing points contained in fishing grounds;

i: Single fishing point, $i=(1,2,\dots,N)$, $i=1$ stands for the central port;

r: The serial number of fishing boats, $r=(1,2,\dots,R)$;

R: Number of fishing vessels;

d_{ij} : The distance from i to j;

g_i : The amount of fish caught in the point of i;

T_i : Working hours at the point of i;

K_r : Fishing mission index of fishing boat r;

Mathematical model

Through the above analysis, shortest path as the objective function, the mathematical model of the fleet dispatching of the ocean going vessels is established.

Decision variable:

$$x_{ijr} = \begin{cases} 1, & \text{When the fishing boat } r \text{ from the fishing point } i \text{ to } j \text{ (} i \neq j \text{)} \\ 0, & \text{Other} \end{cases} \quad (1)$$

Objective function:

$$\min Z(i, j, r) = \sum_{i \in N} \sum_{j \in N} \sum_{r \in R} x_{ijr} d_{ij} \quad (2)$$

Constraint condition:

s.t.

$$\sum_{j=2}^N x_{ijr} = \sum_{j=2}^N x_{jir} \leq 1, \quad i=1, r \in \{1, 2, \dots, R\} \quad (3)$$

$$\sum_{j=1}^N \sum_{r=1}^R x_{ijr} \leq R \quad (4)$$

$$\sum_{j=1}^N \sum_{r=1}^R x_{ijr} = 1, \quad i \in \{2, 3, \dots, N\} \quad (5)$$

$$\sum_{i=1}^N \sum_{r=1}^R x_{ijr} = 1, j \in \{2, 3, \dots, N\} \quad (6)$$

$$\sum_{i=1}^N \sum_{j=1}^N g_i x_{ijr} \geq K_r, r \in \{1, 2, \dots, R\} \quad (7)$$

(Eq.3) equation expression every fishing boat from the central port of departure and return to the center of the port;(Eq.4) inequality expression the number of fishing vessels is not more than the total number of R;(Eq.5)(Eq.6) equation expression each fishing spot is caught by a fishing boat. (Eq.7) inequality expression fishing boats from the start to return to the center of the port to reach their own mission indicators.

ACA analyses

Construction heuristic function

Definition $h_i = g_i - K_r$, when $h_i < 0$, expression the i of the fishing point is less than the expected amount of fishing; when $h_i > 0$, expression the i of the fishing point is more than the expected amount of fishing, showed that the fishing boat had no need to be sent to other fishing grounds.

On the premise that the distance of the fishing boat is reasonable, in the first phase, as far as possible to the $h_i > 0$ of the catch point; in the second phase, priority to the fishing point $h_i < 0$.

Thus, A dynamic adjustment method is designed to conversion two selection stage heuristic function $u(i, j)$. As shown below,

$$u(i, j) = \begin{cases} 1/(Z_{ij} + h_i) & , Z_{ij} \geq l K_r \\ 1/(Z_{ij} + h_i) & , Z_{ij} \leq l K_r \end{cases} \quad (8)$$

$l \in (0, 1)$ is an adjustable parameter.

Transfer strategy of ACA

Transfer strategy of ACA used the combination of random and deterministic, Formula of transfer strategy is:

$$j = \begin{cases} \max_{k \in N_i} ([t(i, k)]^a \times [h(i, k)]^b \times [u(i, k)]^g), & q \leq q_0; \\ p, & q > q_0. \end{cases} \quad (9)$$

q_0 is a constant, N_i expression a collection of optional next nodes for the capture point i ; When $q \leq q_0$, using deterministic search, according to the existing information, The node is chosen as the next node which path of $\text{total_info}(i, j)$ is large; When $q > q_0$, using random search, according to the $P(i, j)$ select the next node, probability formula $P(i, j)$ as shown below,

$$P(i, j) = \begin{cases} \frac{[t(i, j)]^a \times [h(i, j)]^b \times [u(i, j)]^g}{\sum_{i \in N_i} [t(i, k)]^a \times [h(i, k)]^b \times [u(i, k)]^g}, & j \in N_i; \\ 0, & \text{others.} \end{cases} \quad (10)$$

Move to the next node in accordance with the above transfer strategy, and then the constraint conditions are judged. If the conditions are met, the transfer is carried out, and renewed local pheromone.

2-opt method is used to optimize the solution

2-opt method is applied to the concept of local search. Through swapping edges, the initial solution is adjusted in the neighborhood of the initial feasible solution. The feasible solution is improved by each adjustment, until the solution can not be improved in the neighborhood.

Exchange method: Using (i,j)、(i+1,j+1) instead of (i,i+1)、(j,j+1), The path (i+1,...,j) in the post-switched line is reversed, can make the feasible solution is improved. Exchange conditions as shown in Fig.1.

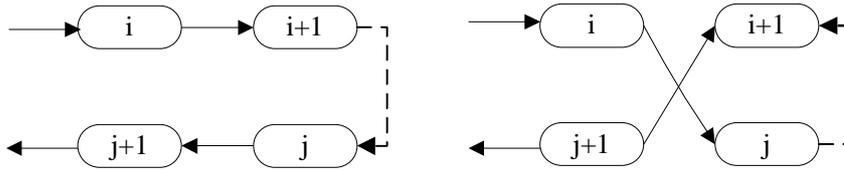


Fig.1: 2-opt sketch map

Each ant builds a solution at the end of each cycle, Take their own solution as the starting point and the local optimal solution is obtained by using 2-opt, At last, according to the local optimal solution to updated information on the edge, and speed up the convergence.

Update pheromone

In order to avoid the residual information covering heuristic information because of too much residual information, after each step of the ant or the completion of all the fishing points of the traversal, need to update the residual information processing. This update strategy mimics the characteristics of human brain memory, at the same time as new information is stored in the brain, storage in the brain of the old information with time gradually fade away. Thus, amount of information in (t+n) moment can be adjusted according to the following rules on (i, j).

$$t(t+n) = (1-r)g_{ij}(t) + \Delta t_{ij}(t) \quad (11)$$

$$\Delta t_{ij}(t) = \sum_{r=1}^R \Delta t_{ij}^r(t) \quad (12)$$

$$\Delta t_{ij}^r(t) = \begin{cases} \frac{Q}{L_r}, & \text{If ant } r \text{ pass through } (i, j) \text{ in this cycle} \\ 0, & \text{else} \end{cases} \quad (13)$$

Simulation analyses

An ocean fishery Company has a number of tuna fishing boat, According to the information and data analysis to fish in previous years, there are 30 tuna fishing point. Analysis on how to dispatch the fishing boat to the fishing spots, determine the scheduling scheme.

In this paper, process of ant colony algorithm is programmed using MATLAB language. Initial parameters of operation: $m=60$, $N_{\max}=100$, $\alpha=1$, $\beta=1$, $\gamma=2$, $\rho=0.15$, $Q=50$

Analysis of the convergence of the algorithm

The convergence curve of the algorithm can be got by many times,

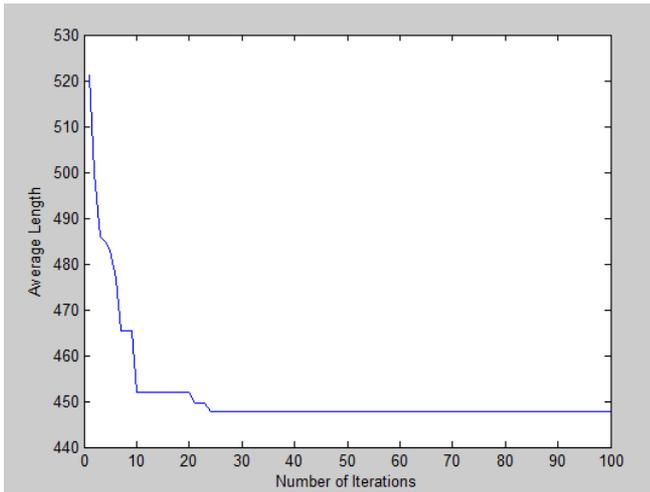


Fig.2: Ant colony algorithm convergence curve

From the curves we can see that the average path length fluctuation tends to be stable at 20-30 times of iteration. It shows that the algorithm can quickly converge.

Analysis of the experimental results

The ACA of the program running 10 times, the results obtained are as follows:

Table 1: Solutions for multiple runs

Run number	Shortest path(results)
1	351.5269
2	355.3702
3	351.0890
4	352.5155
5	353.9448
6	351.7084
7	345.9385
8	352.3715
9	354.6006
10	355.9527

Take one of the smallest solution $Z=345.9385$. At this time, the fishing boat running track line as shown in Fig 3,

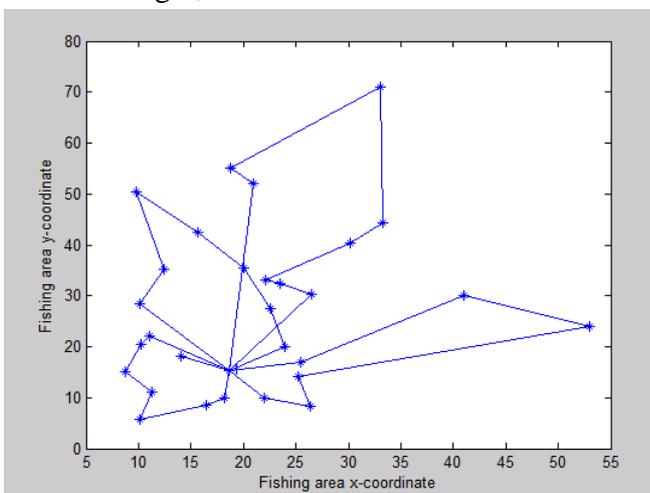


Fig.3: Fishing boat running track

Details of the program runs:

Best_route = 1 28 2 16 15 8 18 25 1 11 20 3 19 23 26 24 27 1 6 4 5 29 30 7 1 14 13 21 22 9 12 17 1
10 1

Best_length=345.9385

According to the results of the program can be a fishing fleet scheduling scheme. Fishing boat 1 navigation path: 1→28→2→16→15→8→18→25→1; Fishing boat 2 navigation path: 1→11→20→3→19→23→26→24→27→1; Fishing boat 3 navigation path: 1→6→4→5→29→30→7→1; Fishing boat 4 navigation path: 1→14→13→21→22→9→12→17→1; Fishing boat 5 navigation path: 1→10→1. Through the model can get the shortest path of the scheduling scheme, can be used as a reference for the fleet of ocean fishery enterprises.

Conclusions

This paper analyzes and discusses the problem of the route of the ocean going vessel fleet scheduling, setting up a mathematical model ,using transfer strategy based on the combination of random and deterministic and 2-opt optimization method of ant colony algorithm to analyze and solve the model. The simulation experimental results show that on ocean fishing fleet scheduling path problem, improved ant colony algorithm can make the algorithm fast convergence and path shorter scheduling scheme can be obtained quickly. It shows that the model is reasonable and the algorithm is effective.

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