A Method for Planning the Transportation Route of Fresh Agricultural Products Based on Ant Colony Algorithm

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Abstract: The current fresh agricultural product transportation route planning matrix is generally set in a single form, resulting in low path planning efficiency and increased path transportation time. Therefore, the design and analysis of a fresh agricultural product transportation route planning method based on the ant colony algorithm is proposed in this paper. The optimal path problem and planning nodes are described based on actual planning needs and standards. A multi-objective form is adopted to improve path planning efficiency, and a multi-objective optimal planning matrix and ant colony calculation line planning model are designed. Based on this, path planning processing is implemented using time and space route correction. The test results show that compared to the traditional CiteSpace fresh agricultural product transportation route planning test group and the traditional improved genetic algorithm fresh agricultural product transportation route planning test group, a better control of the path transportation time within 150 minutes is achieved by the ant colony algorithm fresh agricultural product transportation route planning test group designed this time. This indicates that the designed transportation route is considered the optimal route. Furthermore, after research, it was found that the arrival times of the six selected delivery points were all before the expected earliest arrival time, suggesting that this planning method has greater effectiveness and practical application value.

Keywords: Ant Colony Fresh Agricultural Products; Transportation of Fresh Agricultural Products; Transportation Routes; Planning Methods; Transportation Control

Introduction

At this stage, in order to improve the real-time circulation efficiency and speed of fresh agricultural products in the market, the method of segmental transportation for fresh agricultural products will be adopted by most cities. The so-called combined transportation mainly refers to a composite product transportation method that is connected and transferred by two or more means of transportation, and then the current transportation goal is finally achieved. The efficiency of transportation is generally high, so it is often used in the transportation of fresh agricultural products. However, certain problems and deficiencies exist in the practical application process, the most serious of which is the optimal planning of transportation routes. The traditional form of transportation route planning for fresh agricultural products is mostly single objective. The traditional CiteSpace transportation route planning method and the traditional improved genetic algorithm transportation route planning method have been addressed in references [1] and [2]. Although these methods can achieve the expected route planning and calculation, they lack specificity and stability. Additionally, they are influenced by external environmental factors and specific factors, resulting in difficulties in achieving the optimal standard for the final route planning results [3].Therefore, the proposal is made for the design and verification analysis of the fresh agricultural product transportation route planning method based on the ant colony algorithm. The ant colony algorithm is actually a probabilistic algorithm used for finding the optimal path, possessing characteristics such as distribution calculation, data integration, and information feedback. The fresh agricultural product transportation route planning is linked with the ant colony algorithm. To a certain extent, it can further expand the scope of actual route planning, gradually construct a more flexible and adaptable transportation route planning structure, and strengthen the error control of overall route planning [4]. Furthermore, with the assistance and support of the ant colony algorithm, the calculation of the optimal and shortest route can be accomplished within the shortest possible time, reducing the constraints of transportation mileage, and providing references for the future development of the fresh agricultural product distribution industry and route planning technology [5].

1. Ant colony calculation and planning method for constructing transportation routes of fresh agricultural products

1.1 Description of the optimal transportation path problem and setting of planning nodes

Planning the transportation path of fresh agricultural goods is a highly challenging task. Not only must the path crossing attribute be taken into consideration, but also the impact of external factors such as urban traffic control and other specific factors need to be identified [6]. Firstly, the determination of the orientation weight of the transport route for fresh agricultural products is required. With the assistance of the ant colony algorithm, a particle matrix is constructed, planning nodes are set within the specified range, and each particle corresponds to the associated point of a line. The calculation of the orientation weight is carried out as shown in the following formula 1:

$$M = \lambda - \sum_{k=1} \mu k + \rho \lambda^2 \quad (1)$$

In formula 1, M represents the directional weight value, λ represents the coverage range of adjacent nodes, μ represents the distance between nodes, k represents the number of nodes, and ρ represents the conversion difference. The paths are sorted based on the size of the weights to form a specific set. The optimal path planning problem, which assumes that the transport path includes the start node A and the end node B, is described as a weighted directed graph to acquire essential values and information. The setting of planning nodes must correspond to the associated points in order to establish an independent path planning space for subsequent utilization [7].

1.2 Design multi-objective optimal planning matrix and ant colony calculation route planning model

The dataset mentioned above is imported into the current path planning matrix, and the planning problem to be solved is also imported, thereby establishing an ant colony foraging space. Each single transport truck is considered equivalent to an ant, and the foraging trajectory represents the optimal path for transportation. The current transportation route of fresh agricultural products is planned using the ant colony algorithm, which involves the transmission of information between ant colonies [8]. The transportation starting point A is designated as the ant nest, and the transportation endpoint B is marked as the food location. The calculation of the path for the ants to search for food in the matrix is conducted, as shown in formula 2.

$$H(t) = \sum_{n=1} S_n S_p \, ()2$$

In Formula 2, $H(t)$ represents the path for ants to find food (optimal transportation planning path), S represents the actual number of ants, n represents the node deviation, and p represents the end point deviation. On this basis, constraints were set to build the ant colony calculation route planning model, as shown in Figure 1 below:

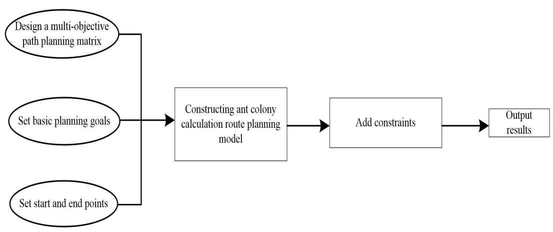

Figure 1 Structure diagram of ant colony calculation route planning model

Based on Figure 1, the structure of the ant colony calculation route planning model is designed. The deployed nodes are utilized to monitor, identify, and calibrate each route. The established transportation path planning constraints are imported into the model to create the upper and lower limit standards for ant foraging time. These standards represent the maximum and minimum time limits for path planning. The design and extension of the model are completed to further enhance the effectiveness of path planning.

1.3 Time+Space route correction for path planning processing

The time+space route correction, so-called, refers to when an unexpected event occurs during transportation and renders the original path unusable. In conjunction with the current situation, corrections are made to time+space in order to establish the optimal transportation path. This correction aims to reduce transportation costs, shorten transportation time, and ensure the smooth arrival of the transported product at the designated location.

Through the ant colony algorithm, the calculation of the reference value for time + space line correction is carried out respectively. These values are utilized as standards for correction and comparison during transportation to ensure the safety and stability of the corrected path. Additionally, with the support and assistance of the ant colony algorithm, the planning and positioning of the secondary path will be more precise and dependable. Once the basic correction is completed, model comparison is employed to verify the feasibility of the planned path, thus enabling the execution of the transportation task.

2. Method testing

The main objective of this study is to analyze and validate the practical application effectiveness of the fresh agricultural product transportation route planning method based on the ant colony algorithm. To ensure the authenticity and reliability of the final test results, a comparative analysis approach is employed. The reference includes the traditional CiteSpace agricultural product transportation route planning testing group, the traditional improved genetic algorithm agricultural product transportation route planning testing group, and the ant colony algorithm agricultural product transportation route planning testing group designed in this study. The final test results are compared and studied based on actual measurement requirements and standards. Subsequently, the initial testing environment is established by incorporating the ant colony algorithm.

2.1 Test preparation

The test method environment of the fresh agricultural product transportation route planning method is overlapped by incorporating the ant colony algorithm. G city is selected as the primary focus for logistics distribution and route planning of fresh agricultural products. Due to a large number of traffic lines and significant daily operational pressure in G city, the transportation process of agricultural products often experiences time extensions, rot, deterioration, and other issues, resulting in uncontrollable economic losses. The current logistics transport routes of the city are displayed in Figure 2 below:

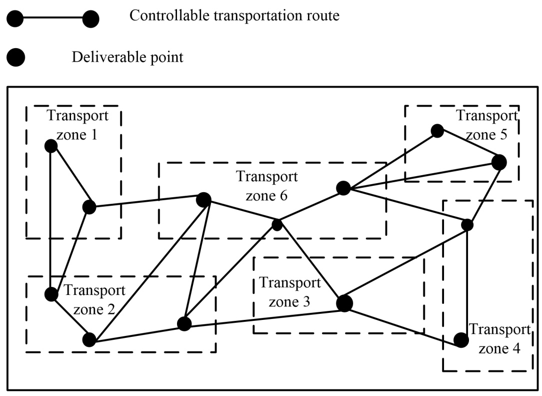

Figure 2 Graphical representation of transportation routes and transfer points for agricultural products in G city

With the synthesis of Figure 2, the completion of the setting and analysis of transportation routes and transit points for agricultural products in G city is achieved. The transportation transit points within the designated area are connected to establish a complete transportation path for fresh agricultural products. Within this range, 6 distribution points, randomly selected as key distribution stations for agricultural products, are chosen, with blueberries selected as the specific product. In accordance with customer requirements, a certain quantity of blueberries will be delivered to these 6 delivery points, and refrigeration will be employed during transportation for preservation purposes. The final transportation is accomplished by utilizing a transportation structure that involves the selection of refrigerated container trucks and urban cold chain distribution trucks. Based on the current path planning requirements and standards, the initial testing indicators and parameters are established, as depicted in Table 1.

Table 1 Initial test indicators and parameter settings table

Initial testing Indicator Name	Initialization Standard value	Measured parameters Standard value
Number of delivery points/piece	12	18
Number of times the path can be planned/time	3	3
Composite transportation limit difference	0.35	0.17
Transportation time/h	12	10
Line travel speed/km/h	25	30
Loss limit ratio	3.15	4.22

Based on the initial test indicators and parameters defined in Table 1, the calculation of the expected ratio of fresh agricultural product path planning is carried out by combining the ant colony algorithm with the data and information obtained. This calculation is represented by the following formula 3:

$$\eta = \sum_{i=1} \alpha i + (m-n)\varepsilon - \alpha^2 \quad (3)$$

In formula 3, η represents the expected ratio of transportation path planning, α represents the distribution demand, i represents the distribution intermodal road section, m represents the total coverage, n represents the stacking range, and n represents the deviation value of unit path planning.Using the obtained expected ratio of agricultural product route planning, the basic path planning restrictions and constraints are incorporated into the model to establish the fundamental test environment. Subsequently, the test method for the agricultural product transport route planning method in G city is meticulously tested and analyzed by incorporating the ant colony algorithm.

2.2 Testing process and result analysis

In the testing environment that has been constructed above, specific testing and validation analysis are conducted by integrating the ant colony algorithm. The customer time and demand information for the testing is provided in Table 2 as follows:

Table 2 Basic information on customer time and delivery demand

Delivery point	Blueberry demand/kg	Expected earliest arrival time	Expected latest arrival time
Delivery point 1	3500	12:00	13:30
Delivery point 2	4000	12:40	13:50
Delivery point 3	3250	13:00	14:20
Delivery point 4	3450	12:30	14:00
Delivery point 5	3750	13:10	14:30
Delivery point 6	4200	13:20	14:50

Based on the analysis and understanding of the basic information of customer time and distribution demand in Table 2, the basic information is being analyzed and understood for mastering. Near the lower line within the controllable transportation path planning scope, a certain number of monitoring nodes are set, and these nodes are associated with each other and overlapping to cover the integrated transportation area. The preparation of 6 vehicles for separate transportation is also being done.Before transportation, the route planning of the overall control identification platform is optimized using the ant colony algorithm. It should be noted that if a transportation vehicle encounters an emergency on the road, the optimal path can be replanned using the platform. By employing the ant colony algorithm, the construction of the optimal driving route is initiated to form independent unit planning particles, with subsequent calculation of the optimal objective function as shown in formula 4.

$$U(t) = r(t) - \left| \frac{2\theta d}{m} \right| \quad (4)$$

In Formula 4, $U(t)$ represents the optimal objective function, $r(t)$ represents the path distance, m represents the conversion ratio, θ represents the transportation time, and d represents the controllable transportation distance.Based on the current measurement requirements, the calculation of the optimal objective function is performed, and it is integrated into the model. The data and information during transportation are recorded and integrated, while the ant colony algorithm is incorporated to plan and measure the ant colony particles. The total path time is then calculated, as depicted in formula 5.

$$L = (1+\varphi)^2 - \xi\Re \times \tau \quad (5)$$

In Formula 5, L represents the total time of the path, φ represents the total distance of transportation, ξ represents the time of connecting transportation, $\Re$ represents the number of connecting times, and τ represents the controllable deviation. Combined with the above measurement, the calculation of the total time spent on the path is completed, and the analysis is made in combination with the actual measurement requirements, as shown in Figure 3 below:

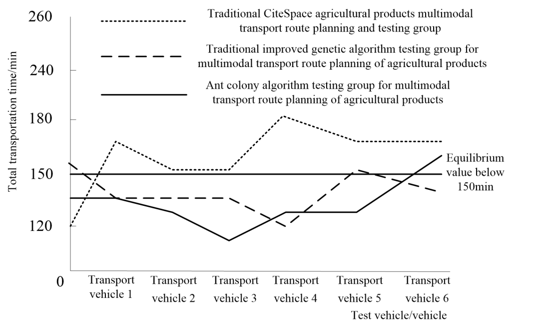

Figure 3 Comparison and analysis of test results

Based on Figure 3, the analysis of test results is completed: The final route transportation time obtained by this design is observed to be better controlled within 150 minutes when compared with the traditional CiteSpace transportation route planning test group and the traditional improved genetic algorithm transportation route planning test group. This indicates that the optimal route of the designed transportation route has been achieved. After conducting the investigation, it is discovered that the arrival time of the selected 6 distribution points is earlier than the earliest expected arrival time. This finding indicates that this planning method demonstrates a better effect and holds practical application value.

3. Conclusion

In summary, the design and practical application of a fresh agricultural product transportation route planning method based on the ant colony algorithm is presented. Compared to the initial route planning form, the transportation route planning structure designed using this comprehensive ant colony algorithm offers greater flexibility and diversity, as well as enhanced stability and reliability. Furthermore, in complex background environments, it can accurately design and formulate the optimal transportation route for fresh agricultural products.Moreover, with the aid and support of the ant colony algorithm, the route planning process can also integrate measurement and calculation to design the optimal route. This, to a certain extent, further reduces distribution costs and simplifies various aspects of logistics transportation, thereby better addressing the transportation needs of fresh agricultural products.

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