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Construction of an Artificial Intelligence Real-time Logistics Supply and Demand Co-ordination Mechanism Platform Based on a Three-dimensional Matrix Curve Model

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The logistics industry is an important part of industry and commerce; it is slowly developing from automation to intelligence, which has become the new profit point for enterprises. This article builds a simple, shared, and easy-to-use platform for a real-time logistics supply and demand co-ordination mechanism to realize the collection, release, and intelligent matching of cargo transportation resources and transportation vehicle resource information, effectively solving many of the problems in the logistics market, improving the efficiency of logistics management operations, and reducing logistics. A distance matrix solution algorithm based on the road network layered model is proposed to quickly solve the distance matrix under the complex road network model. A comprehensive judgment method based on the membership function was used to quantify the cost of sorting the carriages. At the same time, a compound cost objective function model was established with a mathematical model of the vehicle routing problem with return pickup. The membership function of uncertain vehicle speed is fitted with traffic flow data, and the membership function of shipment weight and volume is fitted with the business data of actual logistics enterprises. Aiming at the logistics scheduling problem, a rule-based genetic algorithm was proposed to achieve the purpose of optimizing the scheduling results and improving the operation efficiency. A method for optimizing cargo location based on an adaptive immune genetic algorithm was proposed, which significantly improved the intelligence of the warehouse and the operational efficiency of the warehouse.

Keywords: intelligent logistics, supply and demand coordination mechanism, genetic algorithm, adaptive immunity

1. INTRODUCTION

With the implementation of Industry 4.0, the concept of intelligent logistics is becoming more and more popular

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[1]. As the most important part of logistics, more attention has been focused on the scheduling problem of intelligent logistics. The supply chain is a core functional network chain structure model that connects suppliers, manufacturers, distributors, and retailers to end users through information flow, logistics, and capital flow [2–4]. It is an organizational model with a wider scope than previous enterprises. It can be said that it breaks through the concept of traditional enterprises. At the same time, the supply chain is also a value-added process, which can bring increased revenue to related companies. With the development of supply chain management thinking, an increasing amount of companies realize that future market competition will be reflected more in the competition between supply chains, and enterprises will improve their market competitiveness by forming supply chain alliances [5, 6]. As the goals of the various companies in the supply chain system are not completely consistent, in order to maximize the overall benefits, each stakeholder must co-operate [7].

Due to the influence of uncertainties in the external and internal environment of the supply chain, there is an imbalance in the logistics supply and demand in all links of the supply chain. As a measure to buffer the mismatch between supply and demand, inventory also reflects the imbalance between supply and demand in logistics [8]. The method of controlling the imbalance of logistics supply and demand in the supply chain is an important aspect of how to adopt a certain inventory strategy to reduce the inventory level while meeting a certain service level. Relevant scholars have studied the balancing methods of process-oriented production logistics, and established an index model of process-oriented production logistics balance [9]. The contract completion rate, production load rate, and production equilibrium rate are used as indicators to measure the degree of process-oriented production logistics balance [10, 11]. By establishing a model of the quantity and time of logistics for process-based production, without considering the influence of uncertain factors, a quantitative analysis of how to adjust the imbalance of process-based production logistics is made [12]. Researchers have studied the logistics balance method on the processing assembly line, and proposed a redistribution of the components on the existing production assembly line while ensuring the improvement of the benefits, and provided a high-efficiency, low-cost logistics balance method for the transformation of the existing processing assembly line [13]. Relevant scholars have proposed a method for defining supply chain inventory management strategies based on the supply chain level inventory concept and fuzzy set theory [14, 15]. The level inventory concept reflects the integrated management of supply chain inventory. The fuzzy set theory is used to describe market demand and inventory cost. The researchers extended the static control strategy of the supply chain to dynamic situations, studied the dynamic inventory balance problem of the supply chain, and adjusted the delivery time of the supply chain retail network based on real-time demand information [16]. They established the supply chain dynamics inventory model, used to decide the retailer's shipping time and inventory level. Relevant scholars have studied the supply chain inventory decision-making in a time-varying demand environment, and discussed the optimization of out-of-stock points in the case of equal-period replenishment and the optimization of out-of-stock points and replenishment-point in the case of non-equal replenishment [17, 18]. In the context of time-varying demand, the overall optimization of non-isochronous replenishment and replenishment has obvious advantages in reducing inventory costs. Researchers have studied the value of supply chain information sharing under random lead times, and established a traditional ordering strategy and cost model for retailers under discrete random lead times [19, 20]. The results show that by sharing lead time information, retailers can reduce reorder points and lower their expected costs.

This article uses the new idea of Internet + to build functions, mainly including function building, database building, UI, platform component building, and involving business logic, low-fidelity prototypes, database models, and component models among others. Its core functions are to implement matching algorithms. There are two aspects of the user's physical examination. We analyze the actual characteristics of the complex road network model in detail, construct a distance matrix solution algorithm based on the road network layered model, and achieve a fast, accurate and efficient solution of the distance matrix. A comprehensive judgment method based on membership function is proposed to accurately quantify the cost of sorting the carriages. In order to improve the operating efficiency and utilization of the shuttle, a rule-based genetic algorithm is proposed, which provides a new idea for solving the problem of the circular track shuttle scheduling. The degree of influence of efficiency, dispersion, and gravity on the optimization of cargo space is converted into weights. Based on this, a cargo space optimization model with the ultimate goal of improving turnover efficiency is established. A cargo space optimization decision based on adaptive immune genetic algorithm is proposed.

The rest of this article is organized as follows: Section 2 builds a public information platform for logistics supply and demand co-ordination mechanisms. Section 3 establishes a mathematical model for the problem of vehicle routing with a return trip, taking into account uncertain factors. Section 4 studies the supply and demand co-ordination scheduling optimization of a real-time logistics system based on artificial intelligence hybrid algorithm. Section 5 provides a summary of the article.

2. CONSTRUCTION OF A PUBLIC INFORMATION PLATFORM FOR A LOGISTICS SUPPLY AND DEMAND CO-ORDINATION MECHANISM

2.1 Platform Function Construction

According to the functional requirements of a business, this paper's logistics information platform will cover websites, shipping centers, fleet centers, search engines, instant messaging and operational back-offices. Business support is provided in order to build a logistics information platform website with distinctive features, excellent experience and a

Figure 1 Overview of Overall System Functions.

leading model. The overall functional view of the logistics information platform is shown in Figure 1.

1) Construction of supply management

When members need to announce their transportation requirements, they can log in to the platform, click the "Release Sources" tab, enter the source release function interface, maintain the source information as required, and click the publish button. After the system automatically determines that the request is qualified, it will approve the release success. If the information does not meet the relevant requirements, it will tell the user of the information that needs to be modified.

The function of this part is to operate the various systems of the source of supply to ensure that the desired system state of the source of supply is consistent with the actual state. The specific functions are shown in Table 1.

2) Construction of vehicle source management

When members need to publish vehicle source information, they can log in to the platform, click the "Publish vehicle source" tab, enter the vehicle source publishing function interface, maintain the vehicle source information as required, and the system automatically judges that it is successful. If the information does not meet the relevant requirements, it will prompt the user for the information that needs to be modified.

The function of this part is to operate various systems of the vehicle source management to ensure that the desired system

Table 1 Function List of Supply Management Module.

Function points	Function description
New	This function allows an individual or an enterprise to announce the source of supply. The information that needs to be entered mainly includes the item name, quality, volume, number, person in charge, mobile phone, estimated freight, origin, and destination.
Source maintenance	When members need to modify the maintained content, they can choose their functions and use the functions of "Maintenance" and "Close" respectively, according to their needs.
Turn off	When the owner of the goods and the vehicle owner reach an agreement, a shipping order is generated, and the system can automatically turn off the source of supply.
Source search	Members can find conditions on the platform to find sources of supply; if the content cannot be queried according to the corresponding conditions, a system message "No such source!" is displayed.
Re-launch source	In special circumstances, the source of the goods needs to be announced again. The owner of the goods can use the resend function according to the actual situation to resend the source after adjustment.
Quotation maintenance	Every time changes are made to the source of supply, the quotation method must also be changed. Different quotation methods will enter the corresponding operation page to make the changes.
Edit source	When the owner needs to edit the goods, this function can be used. After editing, the announcement can be submitted again.

Table 2 Function List of Vehicle Source Management Module.

Function points	Function description
New	This function allows an individual or an enterprise to which the vehicle source belongs to announce the vehicle source. The information that needs to be entered mainly includes the item name, quality, volume, number, person in charge, mobile phone, estimated freight, origin, and destination.
Vehicle source maintenance	When members need to modify the content that has been entered, they can choose their functions and use the functions such as "Maintenance" and "Close" to perform the respective operations, according to their needs.
Re-launch source	In special circumstances, the vehicle source needs to be announced again. The owner can use the retransmission function according to the actual situation to retransmit the vehicle source after adjustment.
Edit car source	When the owner needs to edit the car source, this function can be used. After editing, it can be submitted for publication again.
Car source search	Members can search for the source of the vehicle through the conditions on the platform; if the content cannot be queried according to the corresponding conditions, the message "No such vehicle source!" is displayed.
Turn off	When the owner of the goods and the car owner reach an agreement, a shipping bill is generated, and the system can automatically turn off the car source; alternatively if the car source is not released for the time being, it can also be turned off.

state of the vehicle source management is consistent with the actual state. The specific functions are shown in Table 2:

3) Construction of waybill management

For a single source of supply, the owner of the car and the owner of the shipper negotiate the waybill quotation. After reaching an agreement, they maintain the price and generate the waybill. The main function of the waybill management function is to determine the freight rate, the transportation agreement, and generate the waybill. The specific functions are shown in Table 3.

2.2 Platform Component Construction

1) Functional component construction

The related functions and services involved in each logical layer are constructed in accordance with business categories, functional categories, and associations. The specific component construction is shown in Figure 2.

2) Public component construction

The public component list of the logistics public information platform is shown in Table 4.

Table 3 List of Functions of the Waybill Management Module.

Function point name	Function point content description
Information search	The owner of the vehicle searches the platform for a list of sources that meets his own transportation capacity.
Modify interface	Members can perform "Quote", "Rush order", "Negotiate" and other operations from this interface.
Grab orders	Members can perform "Grab order" operations from this interface.
Fill in the rush order information	In the "Rush order" interface, the information of the rush order, including the company name, the person in charge and the mobile phone is entered, and then the "Rush order" is performed.
Surrounding supply	The owner can use the surrounding source function to search the source list near the owner's search location.
Bargain	The owner can use this function to implement the "Negotiation" operation on the waybill.
Search comparison	The owner of the goods can view and compare prices from the quotation information in the source at any time.
Fill in the quote information	After entering the quotation function, the corresponding quotation content is filled in and then a quotation is made.
Choose a quote	In the list of quotations, the owner selects the best quotation for them and clicks "Confirm". The status of the quotation information will change to "Quotation confirmation", and other quotations will be excluded.
Source selection	The owner can use this function to select a source list that meets the requirements according to the corresponding conditions.
Waybill generation	The cargo owner completes the maintenance of the transportation order information according to the quotation information of the vehicle owner and generates a waybill.

Table 4 List of Common Components.

Common component name	Responsibilities	System logic layering
Tool components	Provide tools commonly used in development	Technical service layer
Distributed cache component	Provide distributed session sharing	Technical service layer
Unified authorization component	Provide business structure such as organization structure, permission model, menu, etc.	Technical service layer
Page label component	Provide form, list and other page elements	Interface control layer
Report display components	Provide various graphical representations of data	Interface control layer
Single sign-on (SSO) component	Provide seamless single sign-on between applications	Technical service layer

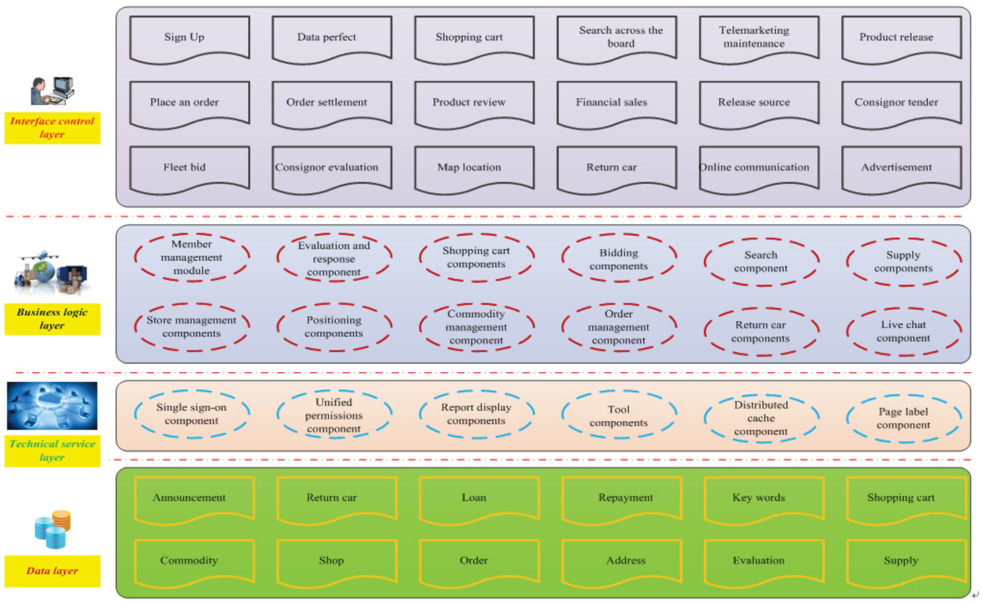

Figure 2 Logical Layering Diagram.

3. MATHEMATICAL MODEL OF VEHICLE ROUTING PROBLEM WITH BACKHAUL TAKING INTO ACCOUNT UNCERTAIN FACTORS

3.1 Scheduling Process Analysis

The first step of the entire scheduling process for vehicles with backhaul pickup is the customer's information and vehicle information. The method to be used to formulate the least-cost scheduling scheme and complete the tasks of distribution and pickup is a problem to be solved in the pre-scheduling process of vehicles with return pickup.

Taking customer information Z, vehicle information S, and navigation map information $G(V, A)$ as inputs, the distribution and pickup pre-scheduling is performed to obtain the scheduling solution with the lowest transportation cost, as shown in Figure 3.

The pre-scheduling scheme for vehicles with return pick-up in Figure 3 mainly includes the stowage relationship between transport vehicles and goods (customers), customer service orders, and vehicle routing.

Based on the pre-scheduling optimized solution x, the transportation vehicle loads the goods of the customer to be delivered, drives out of the central yard, and in turn goes to the customer to be served.

Generally, when we formulate a specific dispatching plan, we must consider the load limit, volume limit and size limit of each transport vehicle, and the service time limit of the customer. At the same time, in order to ensure the customer service level, we require that the customer's receiving and delivery services must be completed at the same time; in addition, to ensure the effectiveness and single serviceability, we also require that the same customer's goods must be loaded on the same vehicle. In addition, the pre-scheduling of vehicles with return pick-up only considers the case of a non-full load.

3.2 Compound Cost Objective Function

By analyzing the cost structure in the actual distribution and pickup process, the composite cost objective function of the mathematical model of the vehicle routing problem with return pickup is determined by the fuel consumption cost, driver cost, vehicle depreciation cost, and car cost.

We define the scheduling scheme X as follows:

$$X = \{x_k | k = 1, 2, \ldots, K\} \tag{1}$$

Where the variable K represents the number of vehicles actually used in the scheduling scheme, and also the number of lines in the scheduling scheme; the variable x_k represents the k-th route, which is defined as follows:

$$x_k = (e_k, Y_k) \tag{2}$$

Where the variable e_k represents the real number of the transportation vehicle corresponding to the k-th line in the scheduling scheme; the variable Y_k represents the set of the real numbers of all customers on the k-th line in the scheduling scheme, which is called the customer grouping set.

The customer grouping set Y_k is defined as follows:

$$Y_k = \{y_{kf} | f = 0, 1, 2, \ldots, N_{k-1}, N_k\} \tag{3}$$

Where the variable N_k represents the total number of all "child-level routes" on the k-th driving route in the scheduling scheme (the child-level route refers to a section between every two customers on the vehicle driving route). The number of customers on the k-th line can be expressed as (N_{k-1}); the variable y_{kf} is the real number of the f-th customer on the k-th driving line:

$$f = 0, N_k \quad y_{kf} = 0 \tag{4}$$

The above formula indicates that the starting point and ending point of the k-th route are the central freight yard.

3.3 Distance Matrix Solution Algorithm Based on Hierarchical Road Network

After obtaining the hierarchical road network model, by extending the above-mentioned shortest path calculation method based on the hierarchical road network and repeatedly applying the Dijkstra algorithm, a fast calculation of the shortest distance matrix D between multiple source points can be realized.

In the backbone network model GE, the Dijkstra algorithm is repeatedly applied to calculate the distance matrix between each node in the set of target nodes P. The Dijkstra algorithm is used to solve the distance matrix based on the hierarchical road network. The time complexity is as follows:

$$C_h = n(n_s C_s + C_F) \tag{5}$$

$$C_F = O(n|V_F|^2) \tag{6}$$

$$C_s = O(|V_s|^2 n_s) \tag{7}$$

Where C_F is the calculation complexity of the shortest distance solution in the backbone network model, n is the number of target nodes, $|V_F|$ is the number of nodes in the backbone network model, and C_S is the calculation complexity of the shortest distance solution in the local network model. $|VS|$ is the number of nodes in the local branch network model, and n_S is the number of local branch network models divided in the hierarchical network model. By substituting each parameter in a layered road network instance into the above three calculation formulas, it can be obtained that the complexity of the shortest path calculation method based on the layered road network is only 1% of the traditional accurate method.

Using the above approximation method to calculate the shortest distance between nodes, some errors will inevitably occur. This kind of error can usually be ignored, however when the distance between two nodes is relatively small, or when the two nodes belong to the same local road network, the error is large. At this time, it cannot be ignored, and it needs to be corrected by supplementary precise path finding.

For each pair of nodes (P_i, P_j) in the target node set P, if either of the following two conditions is met, an accurate algorithm needs to be used to recalculate the shortest distance:

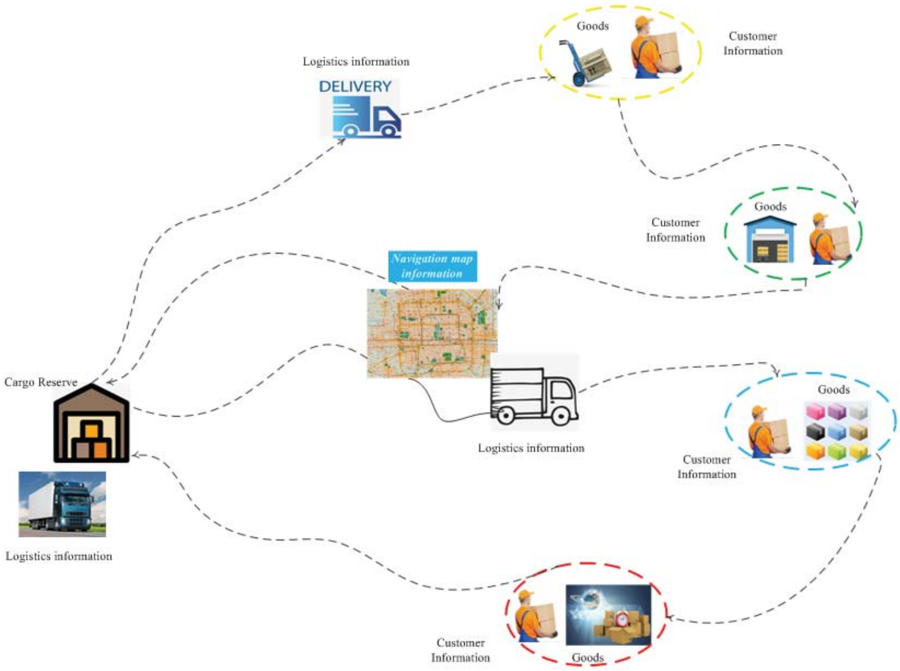

Figure 3 Pre-Scheduling Diagram of Vehicles With Return Pickup.

1) Two nodes belong to the same local branch network model;
2) The Euclidean distance between two nodes is less than the threshold $D_{\min}$;

The parameter $D_{\min}$ represents the shortest distance threshold between the nodes that need to be modified, and a certain and small value should be selected according to the actual road network structure at the beginning of the calculation.

The implementation of the above algorithm needs to repeatedly use the precise algorithm to calculate the shortest distance, but the value of $D_{\min}$ is usually small, so that the accurate algorithm can be completed quickly within a small search range, and the amount of calculation is relatively small. In addition, the number of nodes in the above two conditions is also very small. Therefore, compared with the shortest distance matrix solution algorithm in the complete road network model, the shortest distance matrix solution algorithm based on the layered road network still has a relatively low computational complexity and time.

3.4 Uncertain Characteristics of Shipment Weight and Volume

In the process of actual logistics operations, the shipping customer does not usually have the precise measurement conditions and tools. As a result, when the shipping orders are created, the customer cannot give the exact weight and volume of the goods to be sent. However, efficient and accurate logistics scheduling calculations must be based on accurate, unambiguous business data. The above description obviously does not meet the needs of scheduling calculations, so it is necessary to quantify the uncertain characteristics of the weight and volume of the goods described by the shipping customer description.

By fitting the basic business data of a large logistics company, we can establish the membership function curve of the weight and volume of the shipping customer's goods, as shown in Figure 4.

4. RESEARCH ON SUPPLY AND DEMAND COORDINATION AND SCHEDULING OPTIMIZATION OF A REAL-TIME LOGISTICS SYSTEM BASED ON AN ARTIFICIAL INTELLIGENCE HYBRID ALGORITHM

4.1 Rule Scheduling and Hybrid Genetic Algorithm Based on Rule-Based Hybrid Genetic Algorithm

Rule scheduling is widely used in existing scheduling systems as it is an instant scheduling strategy. Its biggest advantage is that the algorithm complexity is low, and it can therefore be applied to dynamic real-time scheduling and complex large-scale scheduling problems. When the system and the task issuing system are integrated into one, other systems can trigger rule scheduling when a new task is issued or the state of a vehicle changes; when the system is running independently, data exchange with other systems can be completed through the database, and timed operation is adopted.

The starting crossing is the same, and different tasks at the crossing are terminated, and the tasks whose ending is far from the starting crossing are given priority.

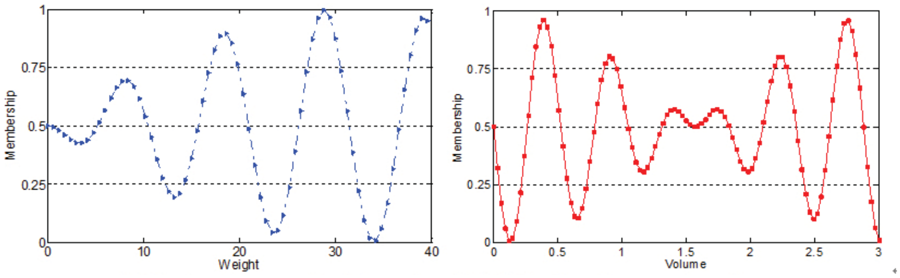

Figure 4 Membership Curve of Shipment Weight and Volume.

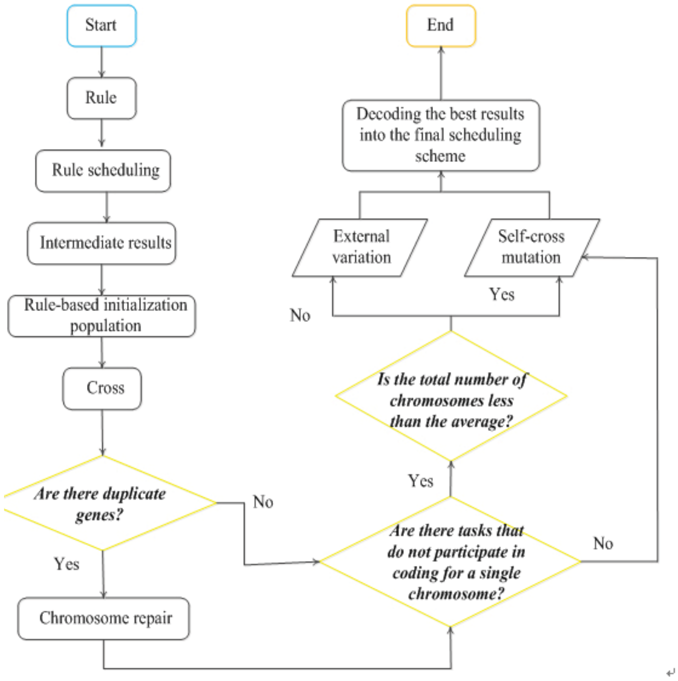

Figure 5 Algorithm Flow.

Aiming at the intermittent issue of task instructions in practical engineering applications and the requirement of time-effective scheduling calculations, this paper combines a rule scheduling algorithm with an intelligent algorithm to propose a rule-based hybrid algorithm. In order to ensure the quality of the initial population and optimize the initial population coding, the rules proposed in this article are as follows:

In the chromosome, in adjacent tasks assigned to the same vehicle, the starting crossing of the next task is as close as possible to the ending crossing of the previous task without exceeding the starting crossing of the previous task. The algorithm flow is shown in Figure 5.

The main steps of the algorithm are as follows:

Step 1: The algorithm performs scheduling according to the scheduling rules and obtains intermediate results;

Step 2: The algorithm obtains half of the individuals in the initial population based on the intermediate results combined with the genetic algorithm coding method and Rule 3, and the remaining half of the individuals are obtained based on Rule 3.

Step 3: GA algorithm performs the optimization operation to obtain the final result, and the decoding scheme is obtained through decoding.

4.2 Experimental Analysis

1) Model experiment of rule-based hybrid genetic algorithm

Figure 6 shows the comparison of the optimization effect between a rule-based hybrid genetic algorithm and rule scheduling. Figure 7 is a comparison of the convergence algebra of a rule-based hybrid genetic algorithm and a traditional genetic algorithm.

It can be seen from Figure 6 that the rule-based hybrid genetic algorithm has a better optimization effect than rule scheduling under different task numbers, and this difference becomes more apparent as the number of tasks increases. It can be seen from Figure 7 that the rule-based genetic algorithm can obtain the optimal solution after a small number of iterations.

The rule scheduling algorithm has the characteristics of low complexity, and the scheduling solution can be obtained in a short time. However, due to the limitations of its scheduling rules, the solution finally obtained by the scheduling algorithm decreases with the increase of the storage scale.

Compared with the traditional genetic algorithm, the rule-based adaptive genetic algorithm uses the adaptive probability calculation formula adopted by the cross mutation operator to make it more difficult for the algorithm to fall into the

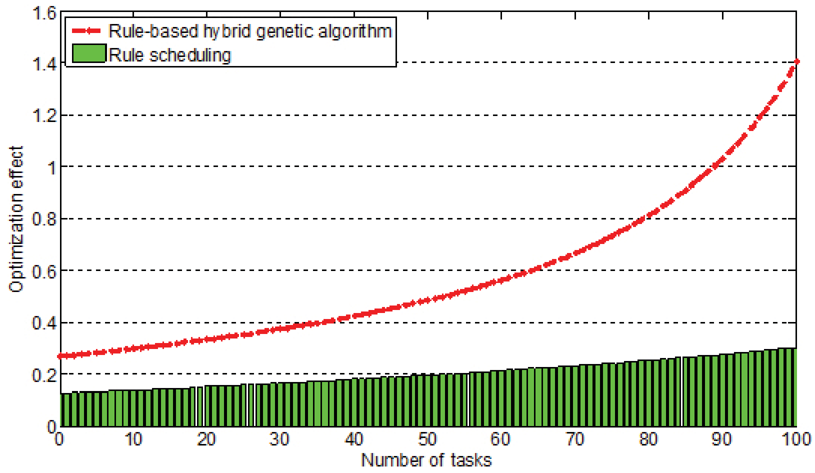

Figure 6 Comparison of Algorithm Optimization Effects.

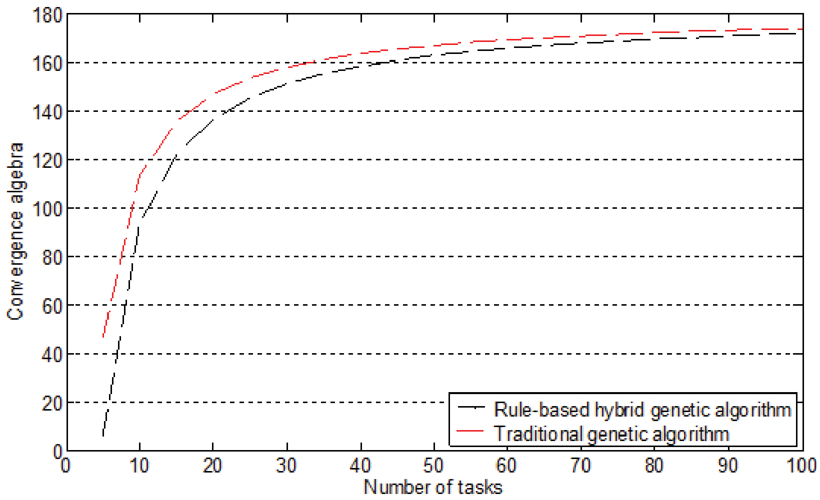

Figure 7 Convergence Algebra Comparison of the Algorithm.

local optimal solution. Moreover, due to the limitations of the genetic algorithm itself, the convergence algebra of the algorithm is greatly affected by the mass of the initial population, and it is not easy to converge to the global optimal solution. The rule-based hybrid genetic algorithm combines rule scheduling and GA algorithm. By optimizing the quality of the initial population, the algorithm promotes the algorithm to converge to a better calculation result as soon as possible, and it can obtain better results in fewer iterations. Therefore the rule-based adaptive genetic algorithm proposed in this paper can solve the problem of scheduling of circular rail shuttles better.

2) Inventory optimization model experiment based on adaptive immune genetic algorithm

The specific operation of the allocation method used in this article is sequential allocation. That is, from Shelf 1 to Shelf 20, each row of shelves is allocated one by one from the first to the last one. In this paper, the objective function value calculated by sequential allocation is more than the objective function value obtained by the adaptive immune genetic algorithm to compare the advantages and disadvantages of the two schemes. Because the optimization goals are the minimum values, the larger the objective function value, the worse the optimization effect. On the contrary, the smaller the objective function value, the better the optimization effect.

In this paper, every 10 groups of tasks were taken as a sampling point, and the sequential allocation and adaptive immune genetic algorithm were assigned to the value of the objective function, and the comparison value was calculated.

Figure 8 is a comparison curve of sequential allocation and adaptive immune genetic algorithm allocation on the optimization effect of storage efficiency in the storage process. Figure 9 is a comparison curve of sequential optimization and adaptive immune genetic algorithm allocation on the optimization effect of dispersion in the storage process. Figure 10 is a comparison curve of sequential allocation and adaptive immune genetic algorithm allocation on the optimization effect of the principle of gravity during storage.

It can be seen from Figure 8, Figure 9, and Figure 10 that in the early stage of cargo storage, because the number of cargoes is small, the result of the objective function obtained by the adaptive immune genetic algorithm is not much different from the result obtained by sequential allocation. Even at the beginning, for the two objective functions of dispersion and gravity optimization, the result obtained by sequential allocation is smaller, that is, the optimization effect

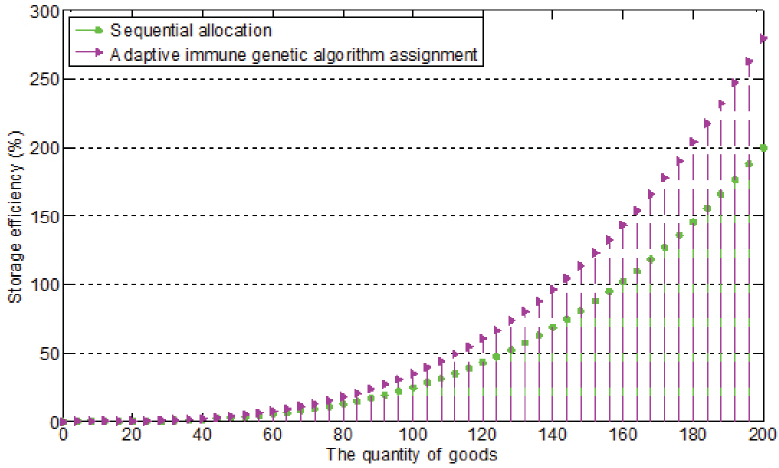

Figure 8 Optimization Comparison of Storage Efficiency.

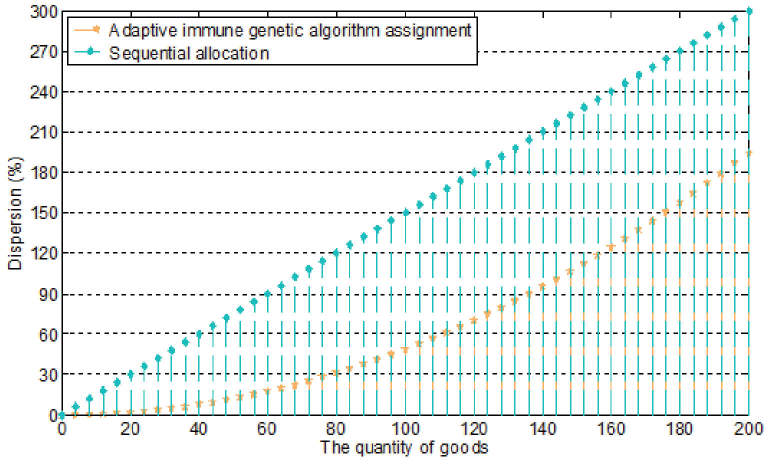

Figure 9 Comparison of Dispersion Optimization.

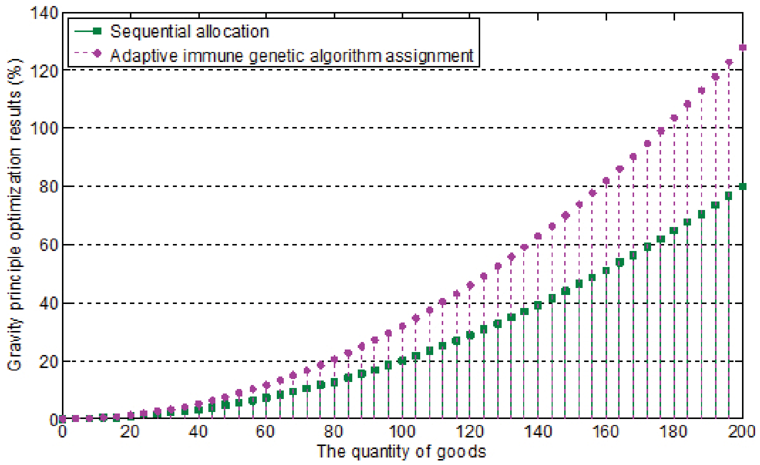

Figure 10 Comparison of Optimization of Gravity Principles.

is better. However, with the increase of stored goods, the objective function result obtained by sequential allocation is much larger than the objective function result obtained by adaptive immune genetic algorithm, and the situation becomes increasingly obvious.

In this article, the smaller the objective function of the optimal allocation of cargo space, the better the optimization effect. It can be concluded that the optimization effect is not much different from that of an adaptive immune genetic algorithm when allocating small batches of cargo storage based on sequential allocation of cargo locations. However, with the increase of stored goods, the optimization effect based on adaptive immune genetic algorithm is getting better and better than sequential allocation.

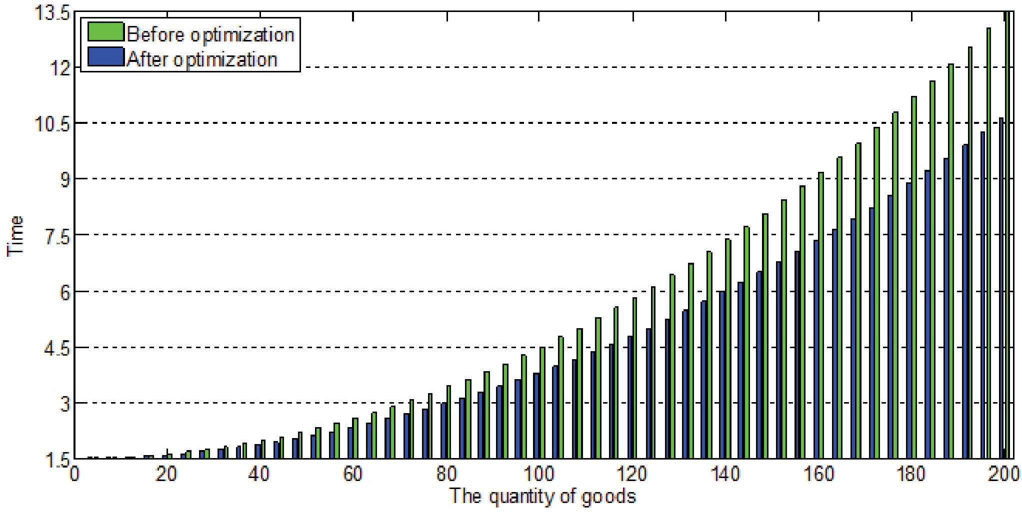

Figure 11 Comparison of Time Taken for Cargo Storage Optimization.

It can be seen that the storage location optimization solution based on the adaptive immune genetic algorithm proposed in this paper can better meet the optimization goal of the storage location when dealing with the storage problem of the three-dimensional warehouse with a large amount of storage, thereby achieving the optimization efficiency. It can be seen from Figure 11 that the same task takes significantly less time after optimization than the time before optimization.

5. CONCLUSION

Based on the accumulated experience and practical conclusions of vehicle and cargo matching, this article innovatively presents an algorithm for matching vehicle and cargo data, and modularizes the matching algorithm in the logistics information platform. A user-friendly system style with good interaction is constructed. Aiming at the problem of vehicle routing with backhaul taking into account uncertain factors, the artificial intelligence algorithm is used as the theoretical basis to focus on the vehicle pre-scheduling optimization problems encountered in the actual logistics distribution and pickup integration process. The distance matrix calculation method based on the road network layered model is very suitable for solving the shortest distance between multiple customers in an actual complex road network model. It can not only achieve high calculation accuracy, but also greatly reduces the calculation intensity and calculating time. The comprehensive judgment method based on the membership function can effectively solve the extra loading and unloading costs due to the finishing of the car. Based on this, a composite cost objective function that comprehensively considers the fuel consumption cost, vehicle depreciation cost, driver cost and finishing car cost can be effectively evaluated. A hybrid genetic algorithm based on rules is proposed, which has a slower convergence speed than traditional genetic algorithms. At the same time, the scheduling results are more reasonable than regular scheduling. It can effectively implement intelligent decision-making for storage-type tracks and improve the efficiency of intelligent storage operations. An adaptive immune genetic algorithm for cargo warehousing location optimization model was proposed to realize the intelligent decision of cargo location allocation in the warehousing system, which effectively solved the problem of cargo warehousing and storage warehousing location selection, and reached the goal of improving storage operation efficiency.

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