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APPLICATION OF IMPROVED GENETIC ALGORITHM AND DEEP LEARNING IN COLD CHAIN LOGISTICS DISTRIBUTION DEMAND PREDICTION

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Abstract. In order to solve the problem of inaccurate prediction results caused by the excessive impact of downstream on upstream suppliers in the process of cold chain logistics transportation demand prediction, the author proposes a demand prediction system Multi agent based on improved genetic algorithm and deep learning. The system will improve genetic algorithm, combine deep learning with practical problems in cold chain logistics supply chain, and evaluate the improved model through instance simulation. The results are as follows: After optimization, the order quantity of each stratum reduces the influence of retailers on upstream suppliers by more than 70%; As for the overall transportation cost, it shows a continuous upward trend within 20 cycles, while the total cost of each cycle fluctuates in a lower range after optimization, reducing the overall total cost by about 50%. It shows the reliability of the improved demand forecasting system in this study to greatly reduce storage and transportation costs.

Key words: Cold chain logistics, Demand forecasting, Deep Learning, Improved genetic algorithm

1. Introduction. As a complex service industry, the logistics industry integrates transportation, storage, freight forwarding, information and other industries, and is also a basic and strategic industry supporting the development of the national economy, the state attaches great importance to its development, thus issuing a series of policies to support and guide the development of high-quality green logistics and achieve cost reduction and efficiency increase in the logistics industry. For example, the "green logistics index composition and accounting method" released in 2018 is used to solve the problems of resource waste, high energy consumption, high emission and so on in the development of logistics in China, in order to promote the sustainable development of modern logistics; In 2019, the National Development and Reform Commission issued the Opinions on Promoting High-quality Development of Logistics and Forming a Strong Domestic Market, in order to promote high-quality development of logistics and solve the problems of high cost and low efficiency of logistics in some fields. In 2020, the Implementation Opinions on Further Reducing Logistics Costs issued by the National Development and Reform Commission and the Ministry of Transport proposed to actively accelerate the development of smart logistics, actively promote logistics to reduce costs and increase efficiency to adapt to the construction of a modern economic system [1].

Nowadays, logistics has been integrated into every link of economic production and has played a great role in fighting against the COVID-19 epidemic [2]. As an important part of the logistics industry, cold chain logistics plays an important role in ensuring food safety of urban and rural residents, improving the quality of life of urban and rural residents, promoting rural revitalization and high-quality development of agriculture, and meeting diversified consumer demands in the market.

The core purpose of cold chain logistics is to ensure the safety of food and drugs in the cold chain process, reduce the cost of the cold chain, and improve the added value of the cold chain, which is the basic link in the production and circulation of fresh agricultural, food and medicine, biological products and other enterprises [3].

At present, there are many problems in cold chain transportation, such as high transportation cost and poor professionalism, large market gap, strong demand for cold chain transportation, unbalanced supply chain, disorderly competition and internal friction. In the 2019 logistics industry report, it was shown that the annual transportation cost accounted for 51.91% of the total social logistics cost in 2018, accounting for the largest proportion, the specific data is shown in Figure 1.1.

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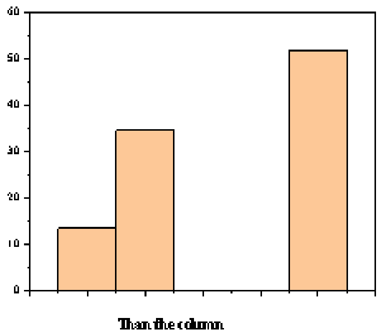

Fig. 1.1: Proportion of logistics expenses in 2018

In short, with the promotion of fresh e-commerce, the cold chain logistics in the logistics industry has risen sharply from its affiliated status to the focus and hot spot of all walks of life, and moved to the front of the logistics industry. And the cold chain logistics industry also needs to accelerate the transformation and upgrading, the first is to improve the efficiency and benefit of cold chain distribution and distribution center.

2. Literature Review. The particularity of cold chain logistics makes it a complex system engineering: It covers a cross-field integrated system of modern technologies such as food and pharmaceutical engineering, biopharmaceutical engineering, packaging, storage and transportation technology, preservation and refrigeration technology, circulation and processing technology, and refrigeration technology [4]. At the micro level, the quality of cold chain logistics is related to the food safety of every household. From a macro perspective, the development of cold chain logistics industry has become increasingly important in the development of national economy and society.

Therefore, it is urgent to improve the efficiency and benefit of cold chain logistics. Although the cold chain logistics started late in China, the degree of organization, specialization, marketization and information of the industry is low, however, from 2014 to 2015, domestic e-commerce involved in fresh agricultural products and food, so cold chain logistics was pushed to the forefront of the market, and became a touchstone of fresh e-commerce, the cold chain industry thus set off a wave of investment, cold chain IT (information technology), cold chain real estate, cold chain equipment, cold chain exhibition, cold chain agent, cold chain express transport, cold chain information, cold chain finance and other sectors. Due to the continuous innovation of fresh e-commerce B2B, B2C, C2B, 020 and other marketing and cold chain modes, the field of cold chain logistics has undoubtedly accelerated into an unprecedented period of rapid development. Accompanied by it is the urgent need for the continuous improvement of the efficiency of cold chain logistics distribution and the efficiency of distribution center, which is also the key to the better and faster development of fresh agricultural products market and cold chain logistics industry.

However, when the well-known domestic e-commerce companies like tea land investment and operation of fresh agricultural products online sales and offline cold chain logistics and distribution, industry analysis results are that more than 95% of fresh e-commerce operations serious losses, goods wear or decay rate is high. The reasons are as follows: First, cold chain logistics itself is a field with high technology and information content, and the ability of domestic cold chain logistics to effectively integrate social resources is very low; Secondly, there is a shortage of professionals in cold chain logistics of fresh products, resulting in the interruption of operation from time to time; Finally, the lack of standardization system of cold chain logistics is serious, and the benefits and efficiency of cold chain logistics are not satisfactory.

The distribution of cold chain logistics covers fresh agricultural products or other goods that need the cold chain, the whole process from the cold chain logistics distribution center to the production place (supplier) and the sales place (demand supplier) should be properly arranged in the process, so that when the distribution cold chain vehicles pass through these distribution nodes in a planned way, it can also meet certain constraints (including vehicle mileage limit, delivery time, distribution vehicle capacity limit, cargo demand requirements, etc.), so as to optimize the whole cold chain logistics distribution system (such as shortest distribution time, shortest distance, lowest cost, least number of vehicles, etc.).

Regarding demand forecasting, He, B. points out that demand forecasting is the basis of all management decisions in logistics and supply chain management. Demand forecasting is the starting point of all planning activities and execution processes, whether the supply chain system is push or pull. Considering the push process executed in anticipation of customer demand, procurement, production, transportation, operational activities and actions all require demand prediction as data input, and the same is true for the push process [5].

For research on demand forecasting, Xing and X. H. combined artificial neural networks and simple statistical methods to establish a hybrid modeling method to predict one-hour urban traffic flow [6]. Xu, X. used the neural network model to predict the oil demand of automobile and industrial lubricating oil manufacturing companies, and the prediction results were in good agreement with the actual demand [7]. Li, B. Using grey model and parameter optimization through Fourier series and Markov chain, a prediction system for end-of-life vehicles is developed to predict the number of end-of-life vehicles that will be generated in the future. However, compared to existing products, it is challenging to predict the demand for new products, because historical sales data cannot be used as indicators of future sales, and few scholars have studied quantitative methods for new product prediction in existing studies, especially the quantification of demand uncertainty [8]. Yu, N., proposed a new demand forecasting method, which combined K-means, random forest and quantile regression forest [9].

About the forecast of logistics demand, many scholars use different methods to forecast. Wang, H. established the autoregressive integral moving average model (ARIMA) for the short-term prediction of postal logistics in B city [10]. Chai, X. applied the combined prediction model of GM(1, 1) and BP neural network to predict the cold chain logistics demand of aquatic products in Dalian [11]. Zhang, Y. Applied fuzzy cognitive map to comprehensively consider the influence of various economic factors on social logistics demand, and determined the influence weight for prediction [12]. Wei, C. Based on the gravity model, forecast regional logistics demand by combining relevant economic theories, mathematical modeling methods, samples, attributes and existing specific problems of regional economic development [13].

In conclusion, the green development of cold chain logistics to achieve cost reduction and efficiency improvement is the driving force and direction of its long-term development, in order to further improve transportation efficiency and reduce costs, distribution links need to be strictly controlled, reasonable planning of distribution vehicle transportation path. Optimization of vehicle transportation routes can not only reduce product loss but also reduce costs, this study is based on artificial neural network to study the demand prediction of cold chain logistics.

3. Research methods.

3.1. Logistics demand forecast. Logistics demand refers to the demands of various enterprises, institutions and consumers in the process of social and economic activities, accompanied by logistics activities such as transportation, storage, loading, unloading, handling and distribution. The complete forecasting process should firstly clarify the requirements of the prediction object, the time limit of the prediction and the accuracy of the prediction results [14]. Secondly, relevant data are collected and processed, and then appropriate prediction methods are selected according to the characteristics of the predicted objects [15]. Finally, the accuracy and reliability of the prediction results are analyzed and evaluated. Therefore, logistics demand forecasting uses historical data and market information to scientifically analyze, assess and infer the future status of logistics demand. The general steps are shown in Figure 3.1.

3.2. Multi agent model. It is assumed that there is only one enterprise at each level of the supply chain, and each enterprise is willing to communicate and share demand information, and each enterprise's manager is willing to share real information. The supply chain model is shown in Figure 3.2.

In this study, Multi-Agent intelligent system is used to control the demand of each level in the supply chain, reduce the total cost of the entire supply chain, the structural model of the system is shown in Figure 3.3.

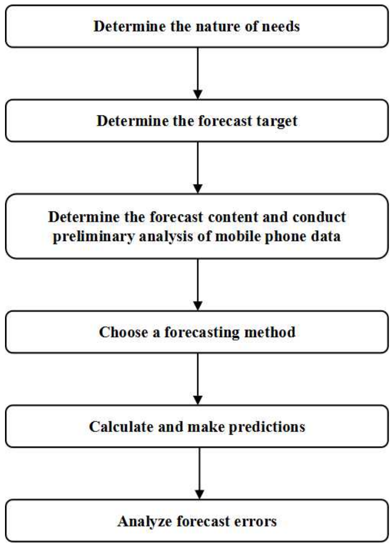

Fig. 3.1: Logistics demand forecasting process

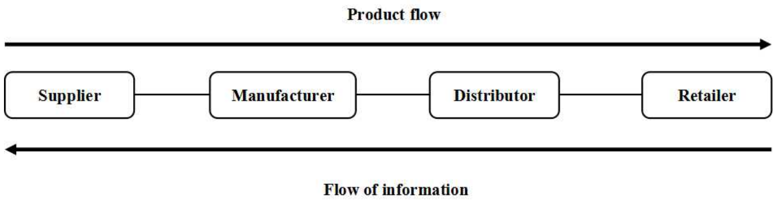

Fig. 3.2: assumes a supply chain model

The system can be divided into two parts: Hierarchical Agent and demand forecasting Agent, the information exchange between them is timely and sufficient, and they can respond quickly to the information of various changes of supply chain enterprises [16].

3.3. Artificial neural network design. Genetic algorithm (GA) is a kind of adaptive global optimization probabilistic search algorithm which simulates the biological evolution process in natural environment. This algorithm is simple, practical, robust and suitable for parallel processing. The calculation steps of genetic algorithm: First, the computer randomly determines an initial population, and then selects individuals in the population according to the fitness value or some competition rules, the next generation population is generated by various genetic operators, until the termination condition is met to stop the operation, otherwise it will continue to evolve in this way. The specific optimization steps are as follows:

1.The encoding: When genetic algorithms are used to solve optimization problems, the solution data of the understanding space are not directly processed, but are represented as the genotype string structure data of the genetic space by coding. Choosing different encoding schemes will have a great impact on the optimization performance (quality and efficiency) of the algorithm[17].

2.Initialize: According to the given system parameters, the computer randomly generates a certain size of initial population.

3.Calculate fitness: The objective function is taken as the overall operation cost of the supply chain, in order to minimize it, the inverse of the objective function is taken as the fitness function of each individual.

4.Selection operator: In order to ensure that the genetic algorithm converges to the global optimum, the selection operator adopts the optimal preservation strategy, so that the optimal individual directly enters

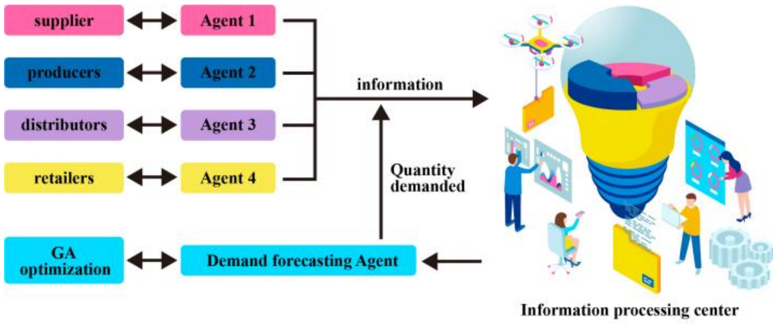

Fig. 3.3: Model of Multi agent system

the next generation, and other individuals select and copy according to the size of their fitness by using the roulette method.

5.Crossover operator: In order to ensure the diversity of individuals, the overall crossover strategy is adopted here. As shown in Equations 3.1 and 3.2:

$$x_{oi} = \alpha_i + (1 - \alpha) y_i \tag{3.1}$$

$$y_{oi} = \alpha y_i + (1 - \alpha) x_i \tag{3.2}$$

where, x_{oi} and y_{oi} are offspring individuals, x_i and y_i are previous generation individuals, α is a randomnumber in [0,1].

6.Mutation operator: The inversion mutation operator is adopted, and the operation method is as follows: Let x_i be the parent individual executing mutation, where component gray mutates and $x_k \epsilon [a_k, b_k]$, then the offspring individual y_k generated by inversion mutation is

$$y_k = \frac{(x_k - a_k)a_k + (b_k - x_k)b_k}{b_k - a_k} \tag{3.3}$$

7.Stop criterion inheritance: After the algorithm runs to the maximum number of evolutionary generations, it stops and outputs the best individual in the current generation as the optimal solution. Otherwise, go to Step 3.

4. Result Analysis.

4.1. Case Analysis. Taking the process of a certain fruit from harvesting to storage, midway cold chain transportation, and finally sold to consumers as an example, according to the established model, the computer was used to simulate the optimization before and after the optimization, and the results were analyzed.

In the optimization system design, the population number of genetic algorithm is set as 60, the maximum evolutionary algebra is 80 generations, the crossover probability is 0.9 and the variation probability is 0.01, the daily scale function is taken as the minimum sum of total costs, and the design variable is taken as the order quantity of suppliers, manufacturers, distributors and retailers in the first week[18].

In the supply chain model, the mixed ordering strategy is adopted, and the manufacturer is set to adopt the continuous inventory checking strategy, suppliers and distributors adopt a periodic inventory check strategy, while retailers adopt a discretionary strategy.

Assume that the unit costs at each level of the supply chain are shown in Table 4.1.

Customer demand is randomly generated by the computer in the range of [5,15].

20 ordering cycles were randomly generated to simulate, and the results before and after optimization with the artificial neural network were shown in Figure 4.1, 4.2 and 4.3.

Table 4.1: Unit cost of each member in the supply chain

	Unit inventory cost	Cost per order	Single transport cost	Single backorder cost
supplier	4	2	2	6
producers	4	2	3	5
distributors	3	3	3	6
retailers	2	2	2	4

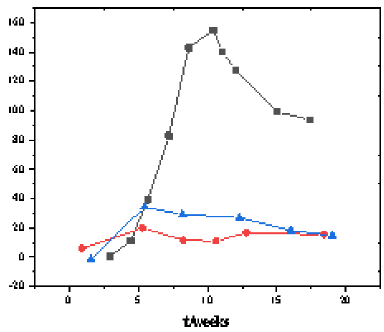

Fig. 4.1: Change of order quantity before optimization

As can be seen from the above Figure, when the retailer's order quantity changes slightly, the order quantity of its upstream strata changes significantly, especially the most upstream supplier, whose order quantity changes by more than 5 times in some periods. This change will also cause a significant increase in the overall cost of the supply chain.

After the artificial neural network is used to predict the demand, the order quantity changes of each member are shown in Figure 4.2.

As can be seen from Figure 4.2, after optimization, the order quantity of each stratum is relatively close to the customer demand, and the curve is relatively stable, this method effectively reduces the influence of retailers on upstream suppliers by more than 70%[19,20].

The operation cost of supply chain cycle before and after optimization is calculated and compared, and the result is shown in Figure 4.3.

As can be seen from Figure 4.3, when customer demand changes before optimization, the total cost of each cycle increases rapidly to a higher level, after optimization, the total cost of each cycle fluctuates within a low range, and the overall total cost is reduced by about 50%, this indicates that the optimization of the artificial neural network can effectively reduce the total cost of the supply chain.

5. Conclusion. In order to reduce the overall operation cost of supply chain, a reasonable demand prediction model is formulated, based on the integration of computer information, a Multagent model of multi-level supply chain is constructed, the artificial neural network is integrated into it, and the optimization model of multilevel supply chain demand forecasting based on genetic algorithm is put forward, and the example is analyzed by computer simulation.

The conclusions are as follows:

1. After optimization, the order quantity of each stratum is close to the customer demand, which reduces the influence of retailers on upstream suppliers by more than 70%, indicating that the optimized model can effectively reduce the disturbance of the market.
2. The cycle total cost of the example increases rapidly to a higher level and shows a continuous upward

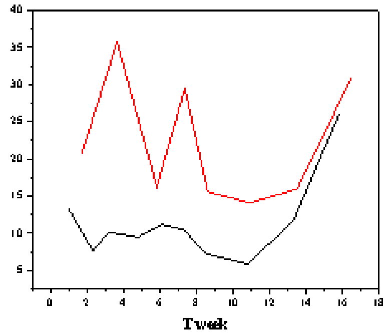

Fig. 4.2: Change of order quantity after optimization

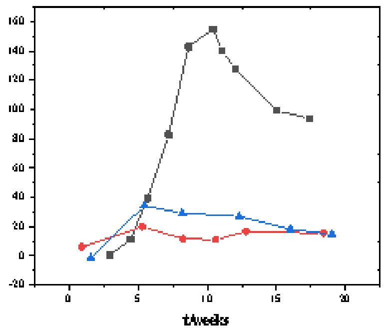

Fig. 4.3: Comparison of overall cycle cost before and after optimization

trend within 20 cycles, after optimization, the total cost of each cycle fluctuates within a lower range, and the overall total cost is reduced by about 50%.

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