

Cold Chain Logistics UAV Path Optimization Enlightenment

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Abstract: As the market size of cold chain logistics in China grows year by year, consumers have significantly improved their requirements for the quality of cold chain items. Meanwhile, national laws and policies supporting the development of cold chain logistics have been introduced successively, which makes the field related to cold chain logistics develop rapidly. However, there are some problems in the development of the cold chains, such as waste of logistics data supervision and high cost of logistics distribution. Especially in the critical situation of the epidemic, the "last mile" delivery without contact is advocated, and the transportation time of cold-chain vehicles is long and the cost is high, which causes great resistance to solving the "last mile". This paper puts forward the corresponding enlightenment according to the relevant literature.

Keywords: Cold chain logistics, Target-task priority, Unbalanced data, UAV.

1. Introduction

Recently, the "14th Five-year Plan" development Plan, the first plan in the field of cold chain logistics in China, has been released, establishing four systems of cold chain logistics operation system, service system, supervision system and support system. Focus on "the first kilometer" and "the last kilometer" to complement the shortcomings of cold chain logistics facilities at both ends. With the occurrence of various uncertainties such as the epidemic, there are more stringent requirements for the "last mile". How to use the data collected in the operation system of cold chain logistics to schedule resources in priority, so that scientific planning path becomes the focus in the field of logistics.

With the rapid development of economy and the continuous improvement of people's living standards, the demand of urban and rural residents for cold chain items keeps rising. Demand doubled 1.5 times between 2015 and 2020; The market size of cold chain logistics has also gradually expanded, increasing by nearly 1.13 times. The number of refrigerated vehicles increased rapidly, from 93,400 in 2015 to 286,700 in 2020, with an increase rate of 206.1%. The capacity of cold storage has more than doubled from 37.4 million tons to 70.8 million tons. The rapid expansion of these scales has put forward higher requirements for the technological innovation and development of the cold chain logistics industry, and it has become more difficult to accurately mine the data of the cold chain logistics.

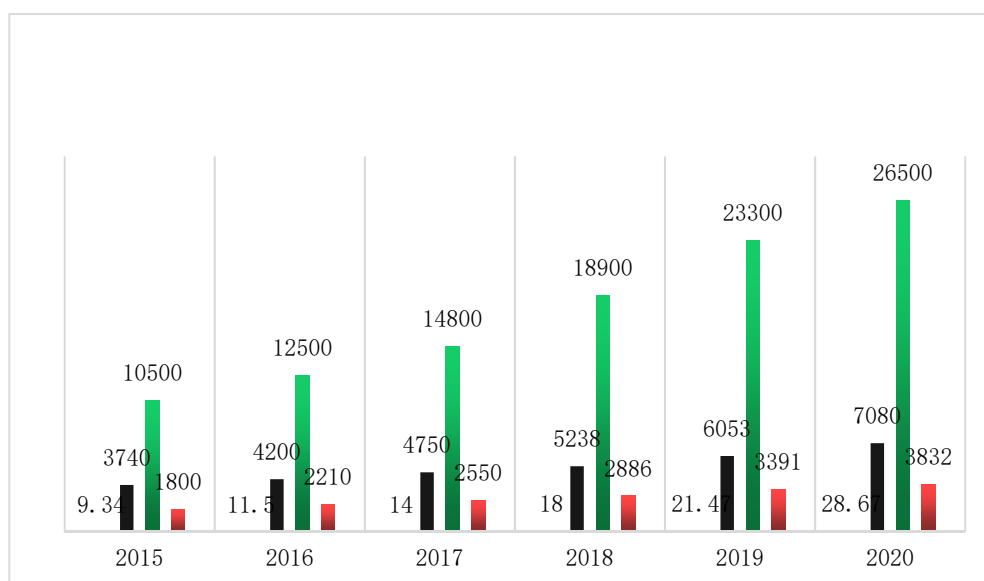


Figure 1. Changes in cold chain logistics 2015-2020

At present, China's cold chain logistics has problems of imperfect infrastructure, non-standard logistics and transportation links and unreasonable transportation allocation. Especially, it is urgent to solve the end distribution of cold-chain medical drugs after the outbreak of the epidemic.

Scientific prioritization of cold-chain medical drugs for each target task point can greatly improve the rescue efficiency. At the same time this kind of transportation has the characteristics of small batch, batches, the task of emergency, emergency medicine for cold chain distribution using

unmanned aerial vehicle (uav) instead of point target task distribution, cold chain vehicle for human is a great save, "contactless" distribution also reduced the risk of infection, but need to consider the operation of the unmanned aerial vehicle (uav) distance, load, and so on and so forth. Cold chain vehicle transportation for UAV transportation is not limited by distance and load, but it has the characteristics of long running time and great influence by road conditions. Longer transport times mean lower carriage temperatures and greater potential for cold chain items to deteriorate.

2. Literature Review

2.1. Information Decision Support Based on Cold Chain Logistics Data

In recent years, with the rapid development of cold chain logistics transportation in China, the cold chain logistics industry has produced inestimable data information. Substantial losses result from multiple risk effects along the cold chain such as lack of traceability, transport delays and failures, temperature abuse, and cross-contamination in transport and storage. In addition, according to data, about 30% of perishable products are wasted in some link of the supply chain [1]. Therefore, in order to ensure the food safety and quality of the cold chain, improve the performance of the cold chain transportation, and the understanding and accessibility of the product environment, it is necessary to emphasize the data of all stages of the cold chain [2]. People begin to analyze and apply data in large quantities, which indicates the arrival of new productivity growth and consumption surplus wave [3]. Cold chain logistics information decision support based on cold chain logistics data is reflected in all links of the logistics industry, such as the distribution system of cold chain logistics transportation, which needs to consider the specific requirements of each distribution point: distribution location, delivery time and different temperature requirements of cold chain goods. Machine learning is needed to mine these data in all aspects of cold chain logistics, so as to establish better distribution methods. The application of this kind of data analysis is receiving more and more attention in cold chain logistics because of its potential to improve flexibility, effectively manage demand fluctuations and deal with cost fluctuations, thus enabling enterprise organizations to do better [4]. At present, more scholars begin to study the support of cold chain data for decision making. For example, temperature monitoring meat supply chain [5], temperature alarm cod supply chain [6], supply chain design for fresh fruit quality maintenance at minimum cost [7] and data-driven decision [8] for frozen fruit distribution [9]. As we all know, temperature is a key indicator in cold chain logistics, visibility and traceability are extremely important. In order to ensure the freshness of food, prolong the shelf life and improve the safety of cold chain items, a cold chain management method was established. Cold chain monitoring and control is an essential part of cold chain management system. Information technologies such as Time Temperature Indicators (TTI) and Wireless Sensor Network (WSN) are the most studied cold chain monitoring methods at present. TTI offers the possibility to continuously monitor and record time-temperature history throughout the supply chain in a simple and economical manner. In view of users' demand for WSN based integrated cold chain shelf-life decision support system,

this system has high cost effectiveness and can be quickly applied to different kinds of perishable food such as aquatic products, vegetables, fruits and meat [10]. Some scholars also studied the model optimization and management decisions of the cold chain from a technical perspective, and made relevant analysis and prediction by using mathematical statistics and BP artificial neural network technology [11]. In the design for cold chain logistics management, the development of "intelligent container" also has a lot of research results. The grid topology of WSN is used to realize the multi-hop intelligent container. The routing protocol of the mesh topology belongs to the plane protocol, and in the plane protocol network, all nodes should be equal in function [12]. The intelligent container has the advantages of good connectivity and stability. In another study on fruit cold chain logistics, Sun and Liu [12] analyzed the current situation of fruit cold chain logistics in China and established a BP neural network model for fruit logistics security early warning.

2.2. Cold Chain Logistics UAV Path Optimization

Single cold chain vehicle or uav path optimization research can not meet the complex and changeable requirements in real life. During the epidemic period, logistics companies such as SF Express and JD achieved great success in terminal logistics distribution by using DRONES, which to some extent indicates that the era of intelligent unmanned vehicles is coming. Considering the advantages and development prospects of UAV, a large number of experts and scholars at home and abroad have put forward many methods and strategies on uav distribution. He has made many contributions to algorithm design, objective function model and strategy solution. Since the duration of a drone's flight is limited by its endurance, it needs to visit one or more charging stations during delivery and finally reach a demand point. Considering that Euclidean distance paths between nodes and facilities are most commonly used in shortest path calculation, a large number of scholars have proposed heuristic algorithms as solving methods [13]. Approximate algorithm and genetic algorithm in solving the questions of group of the route planning of uavs, has certain advantages in the use of approximate algorithm and genetic algorithm of unmanned aerial vehicle (uav) distribution and path optimization problem, and through the experimental results prove that the approximate algorithm and genetic algorithm to solve the problem of multiple unmanned aerial vehicle (uav) route path optimization can get good results (14, 15). Recently, technology roadmap has become more and more popular, and uav technology roadmap has been used in Amazon's latest service Amazon Prime Air [16]. Transportation price and delivery time become several big commercial giants competition comparison index. Amazon has come up with the concept of drone delivery. The cost and time of delivery drove Amazon to opt for drones to achieve faster delivery, lower costs, lower emissions and customer satisfaction. There are also many studies by experts and scholars in the field of path optimization of cold-chain vehicles. Due to the limitations of UAVs, it has certain advantages to use both cold-chain vehicles and UAVs to build cold-chain vehicle-UAV distribution system [17]. According to the data of an American transportation company, the cost of replacing cold-chain vehicles with DRONES in the "last mile" delivery can be reduced by usd 50 million per year [18].

Due to the dispersion of target and task points in cities, cold chain goods have the characteristics of small distribution volume, high requirements for timeliness of goods and high requirements for cold chain logistics transportation. Especially in the case of the epidemic, if cold chain medical supplies are delivered through "no contact", the flight delivery of drones is limited due to the short flight distance and small load. When there are many target task points to be transported, the location close to each target task point is selected by the refrigerated cold chain vehicle as a temporary docking station, and the UAV can be delivered to each target task point from the temporary docking station, which can be delivered quickly and timely. At present, according to statistics, the size of the domestic medical market in 2018 has exceeded 2 trillion yuan. For the delivery of cold-chain medical items by UAV, many companies in the field of UAV logistics have seen this demand and are trying to use UAV for delivery. In 2019, Direct Relief announced the use of drones by MSD, AT&T, Softbox, and Direct Relief to deliver cryogenic medicines and vaccines to remote areas, an event that successfully proved the concept of delivering cold-chain medicines by drone. Volans-i has developed a purely electric drone that can control cold chain transport technology at -70°C , opening up a new approach to distribution for storage and transport that requires a low-temperature environment. AT&T's cloud-based technology is also a breakthrough, allowing researchers to continuously check the temperature of samples and capture and analyze drone flight data in real time. UPS, Matternet and WakeMed are developing unmanned aerial systems to deliver blood samples to hospitals. Although China's UAV technology and systems are popular at home and abroad, and DJI and other UAV technologies are in a leading position in the world, the development and application of medical cold-chain UAV is still in its infancy, and the development of uav technology put into commercial operation is not perfect. Therefore, the development of cold chain UAV distribution system has important research value and application prospect.

2.3. Unbalanced Data Priority Classification of Sample Categories

2.3.1. Data Balance Processing

Equilibration data processing is data sampling, this method need pretreatment on the training set, mainly by reducing the degree of unbalanced data sets to improve the classification performance of less data, the key is how to can not only eliminate a lot of irrelevant information, significantly reduce the degree of unbalanced data at the same time guarantee the least useful information loss, In this way, unbalanced data can be balanced on the data level.

Sampling methods include over-sampling and under-sampling. Less sampling by increasing the samples of a class to improve the classification performance of less data, the most simple sampling method is random replicate less samples, random sampling didn't add any new information, to less class data can make the smaller classifier decision domain, which can lead to a fitting phenomenon, at the same time due to the increase of the sample will be to extend the time of the training of the classifier. For the above problems, SMOTE method [19] is the most sampling method used. This algorithm is a commonly used oversampling algorithm, which improves the classification performance of SMOTE by manually generating sample points of few classes. Because the original non-existent samples were artificially added, the

over-fitting phenomenon was effectively alleviated. At the same time, someone put forward a prediction model based on K-means [20], which mainly uses K-means algorithm to change the data distribution, then calculates the importance of data characteristics by using random forest, and finally puts it into the initial weight of BP neural network for prediction. This model effectively solves the imbalance of sample data. Sun [21] et al creatively designed a new sample weighting mechanism based on SMOTE and time-weighted support vector machine integration algorithm (ADaboost-SVM-TW), embedding SMOTE into the iteration of ADASVM-TW. Raghuvanshi and Shukia et al. [44] proposed a SMOTE CSELM based on SMOTE algorithm, using the advantages of few sampling and class-specific regularization, increase the importance of few samples and determine the decision region of the classifier. The effectiveness of the proposed method is verified by a large number of experiments. Traditional undersampling methods include random undersampling and neighbor cleaning. Random undersampling uses random criteria to eliminate some data of multiple types of samples. The main problem of this method will cause a large amount of useful information missing, thus reducing the classification accuracy. Literature [23, 23] improves the problem of random undersampling. These methods by some algorithms and rules, and find out the boundary of classification for predicting does little data and have a choice to remove of the data, the overlap boundary or cause data from the sort of many kind of data, and out of class data and leaving only safety data and less data as training set of classifiers. Experiments show that [24-26] the classification effect obtained by the improved under-sampling method is more ideal than that obtained by random under-sampling, but the effect is not obvious in some high-dimensional data [27,28]. In this paper, the improved SMOTE oversampling and undersampling method of combining the data sampling, coupled with Super Learner machine learning under the framework of cross validation data sorting, can eliminate noise information, reduce the degree of unbalanced data at the same time ensure minimum information loss, keep most useful sample data for classification prediction.

2.3.2. Prioritize

Priority determination is widely applicable to multi-standard decision-making processes [29]. Priority refers to two or more tasks that need to be done. Priorities are determined according to their priorities. It mainly includes Analytic Hierarchy Process (AHP) [29], Entropy Method (EM) [30], Principal Component Analysis (PCA), PCA [31], Factor Analysis (FA) [32]. Schreiber et al. [32] used analytic hierarchy process to apply consistent fuzzy preference relation to decision matrix and symmetric decision matrix method. Wang and Lu et al. [33] introduced variable weight factor into the analytic hierarchy process, so that the weight of sustainable development indicators assigned by experts could change at any time or in space, and proposed a new and improved weight distribution method called variable weight analytic hierarchy Process, which could better reflect the real state of indicators. Entropy method is a commonly used weighted method to measure value dispersion in decision making. The greater the dispersion, the greater the differentiation, the more information can be derived. At the same time, the index should be given a higher weight, and vice versa. Zhu and Tian [34] et al believed that the entropy method only considered the numerical distinction of indicators and ignored the distinction of grades, thus

indicating that the entropy method could not correctly reflect the importance of the weight of indicators, which would lead to the distortion of decision-making results. Principal component analysis is usually used to analyze data in diverse fields, which is conducive to dimensionality reduction of data in high-dimensional data [35], but is not applicable to daily prioritization of small data. Factor analysis is used to extract fewer factors from a large number of related variables, making it a more manageable data. Through factor analysis, irrelevant questions can be eliminated from the final options. Noora Shrestha [36] proposed a factor analysis method, which used Kaiser-Meyer-Olkin sampling adequacy measure and Bartlett's test to evaluate the decomposability of data. Calculate determinant scores to test multicollinearity between variables. To determine the number of factors to be extracted, Kaiser criteria and Scree tests need to be checked, providing very valuable inputs for decision makers to focus on a few important factors rather than a large number of parameters. The principle of factor analysis is the same as that of principal component analysis.

3. Conclusion

Due to the particularity of the cold chain, in order to improve the quality of cold chain products in each link of the supply chain, it is necessary to monitor and analyze the unbalanced data generated in the logistics link, mine the specific information behind the data, and adjust and optimize the task priorities of the whole cold chain, such as picking, circulation processing, transportation and distribution. So as to achieve a more efficient and convenient cold chain logistics intelligent decision support system. Supply chain link needs special attention of producers, transporters and other variables, and then optimize the uav according to the target task point priority distribution to the hands of customers. Acknowledgment.

In the information society, without high-quality data analysis and application, it is impossible to find the real needs hidden in big data, and it is impossible to increase source and reduce expenditure scientifically. In traditional cold chain logistics, the real role of data is not understood, which leads to cost increase and low efficiency. In today's epidemic situation, it is very important to find out key indicators in a large amount of data in a short period of time, and evaluate the priority of key indicators. Secondly, it is also of great significance to use UAV delivery to optimize the route and reduce costs when priority is considered.

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