Optimization of land transportation path for navel orange transportation by OQ Airlines

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Abstract

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The most important advantage of air transportation is that it requires less time for cargo transportation. However, the time consumption of land freight may lead to an overall increase in transportation time. This article takes the navel orange transportation of OQ Airlines as an example to analyze its land transportation routes and solve the problem of navel orange land transportation. Due to the fact that most navel oranges are located in rugged mountainous areas, the transportation route for picking navel oranges is too long, and goods cannot be transported centrally in the mountainous areas, which affects the efficiency of transporting navel oranges to the airport. This article uses K-means clustering algorithm and genetic algorithm to analyze the origin of goods and generate freight hubs. By establishing a simple TSP model to calculate the optimal land transportation route for the generated freight hub, and then comparing it with the original land transportation distance, to verify whether establishing an originating hub can shorten the land transportation distance of goods.

Key words
cargo transportation； Cargo distribution point； K-means clustering algorithm； genetic algorithm

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1 Introduction

1.1 Research Background and Significance

Cargo transportation is a crucial component of modern aviation logistics and air freight services. Since entering the 21st century, China's air cargo transportation has entered a period of rapid development and has continuously expanded its domestic and international cargo transportation business. However, some problems are inevitable during cargo transportation, such as how to ensure that goods arrive on time and how to deliver goods within their shelf life to customers. These are issues that need to be addressed during the cargo transportation process and are also the problems discussed in this paper. For OQ Airlines, although there is an air transportation route for navel oranges, research is still needed on how to improve the transportation efficiency of navel oranges and ensure the yield rate of the finished product. The purpose of this topic is to analyze the current situation of OQ Airlines' navel orange land logistics and to use the K-means clustering algorithm and genetic algorithm to analyze the starting points of cargo transportation, thereby obtaining an efficient land cargo transportation route.

1.2 Theoretical framework

Within the theoretical framework of transportation and logistics management, the roles and advantages of air and land transportation in cargo shipment, as well as methods for enhancing transportation efficiency through optimizing land routes, are encompassed. This framework delves into various strategies, algorithms, and technologies applied in addressing land transportation issues, particularly focusing on the comparison and selection of transportation modes, supply chain management, logistics network design and optimization, inventory management, transportation cost analysis and control, application of information technology, and risk management. These topics encompass analyzing the characteristics and applicability of different transportation modes, optimizing logistics and information flows within the supply chain, designing logistics networks to reduce costs and improve service levels, balancing costs and service levels through appropriate inventory strategies, analyzing and reducing transportation costs through route optimization, leveraging information technology to enhance logistics efficiency and visibility, and addressing various risks encountered in logistics transportation. Within this thesis, emphasis is placed on transportation cost analysis and control, supply chain management, and logistics network design and optimization.

1.3 **Research Objectives and Content**

After years of development, aviation logistics has become an important driving force for global economic development and has advantages unmatched by other logistics methods, such as speed and high transportation efficiency. Therefore, it is necessary for airlines to improve the efficiency of cargo transportation. The use of the K-means clustering algorithm and genetic algorithm has been validated in practice and is a feasible method. The efficiency of air freight is important for airlines, affecting the service quality, customer satisfaction, and market competitiveness of the airline. This paper can help OQ Airlines establish a prototype of a land cargo transportation network, thereby improving the efficiency of cargo transportation and meeting various customer requirements.

1.4 Research Methods and Approaches

First, Information on navel orange planting areas needs to be obtained through practical research methods.. Then, the K-means clustering algorithm and genetic algorithm are used to analyze the distribution locations of navel oranges to identify potential transportation hub locations. Finally, these are compared with actual transportation routes to determine if transportation distances have been reduced.

In this paper, the data to be handled exhibit characteristics of relatively large quantity and wide range, thus requiring the adoption of appropriate algorithms for analysis and the prevention of obtaining results that are locally optimal.

By consulting relevant literature, it was found that the K-means clustering algorithm has significant advantages in solving problems such as small computational dimensions and numerical values. (Xu Jiajun & Wang Fanjing, 2023; Wang Qiuping, 2023; Meng & Liu, 2007)

K-means is a simple and effective clustering algorithm that iteratively assigns data points to K clusters and updates the center point of each cluster to the average of all data points in that cluster until convergence occurs. It usually has a fast execution speed, especially for large-scale datasets, making it an ideal choice for processing large amounts of cargo data. In addition, it is suitable for various data types and fields, and has shown good applicability in dealing with the problem of cargo distribution points. By adjusting the number of clusters (K value), the accuracy and quality of clustering results can be adjusted, providing flexibility to meet the needs of different situations. Moreover, the clustering results generated by K-means are relatively easy to interpret, and the center point of each cluster can intuitively represent the characteristics of that cluster, which is helpful for subsequent analysis and decision-making. When dealing with multiple individuals in a population, genetic algorithms can reduce the likelihood of getting stuck in local optima.

Genetic algorithms have a wide range of search capabilities, simulating natural selection and genetic mechanisms to conduct extensive searches in the solution space, avoiding getting stuck in local optima, and thus possessing high global optimization capabilities. Secondly, genetic algorithms have strong parallelism and can handle multiple individuals simultaneously, accelerating the search process, making them particularly suitable for solving complex optimization problems. In addition, genetic algorithms have strong adaptability and can adaptively adjust according to the nature and requirements of the problem, continuously improve individual fitness through operations such as crossover and mutation, and gradually optimize the solution. For multimodal problems, genetic algorithms can simultaneously maintain and discover populations of multiple solutions, thus possessing good processing capabilities. In addition, genetic algorithms flexibly handle the constraints of problems and are easy to combine with them. Through the design of adaptive functions and operators, they effectively handle optimization problems with constraints. Finally, the basic principle of genetic algorithm is relatively simple, easy to implement, and the selection of parameters and operators has a certain degree of flexibility, which can be adjusted and optimized according to specific problems.

Additionally, genetic algorithms can reduce the occurrence of falling into locally optimal solutions when dealing with multiple individuals in a population.

Therefore, this paper addresses the problem of goods distribution point locations using both the K-means clustering algorithm and genetic algorithms, followed by optimization of transportation routes through the establishment of mathematical models.

Main research question: How to reduce the time it takes for navel oranges to be transported to the airport and how to ensure their freshness				
	Sub problem	Theoretical foundation	Research methods	result
1	How to shorten the land transportation time required for navel oranges to be transported to the airport	6	A study was conducted on how to shorten the transportation distance required for navel oranges to the airport through algorithm analysis and data	Through algorithmic analysis of the collected data, the transportation distance of navel oranges to the airport was successfully

			collection.	reduced, thus solving the problems of long transportation time and freshness of navel oranges to the airport
2	How to maintain the freshness of navel oranges during transportation	8	Research on how navel oranges maintain freshness during transportation through the proposed research approach.	By proposing transportation plans in both physical and biochemical aspects, the freshness issues that navel oranges are prone to during transportation due to collision, compression, temperature, and gas are further solved.
Final conclusion: The land transportation route of navel oranges can be optimized using k-means clustering algorithm, genetic algorithm, and establishing a simple tsp model to reduce the transportation time on the road and ensure the freshness of navel oranges when transported to the airport. The proposed method further solves the freshness problem of navel oranges during transportation.				

2 Literature Review

2.1 Overview of Research on Transportation Route Planning Aided by K-means Clustering Algorithm and Genetic Algorithm

K-means Clustering Algorithm

There is research proposed that the k-means clustering method could be used to analyze existing transportation hubs, thereby obtaining a relatively reasonable and effective location for transportation hubs. Therefore, the k-means clustering method can also be used to analyze the origin of navel oranges to determine corresponding cargo distribution points.(Meng&Liu 2007)

Scholars mentioned in their research that the k-means clustering algorithm could be used to reasonably infer the location of logistics distribution centers, and that the k-means clustering algorithm could be applied to the location of multi-level logistics distribution networks, with certain practical application value. Hence, the k-means clustering algorithm can be used to analyze the data information of the origin of navel oranges to perfect the location of the navel orange distribution centers.(Wang,Chen& Zhang 2022)

Moreover,Scholar mentioned that the k-means clustering algorithm could be used in constrained cargo transportation problems to provide suggestions for cargo transportation. Therefore, the k-means clustering algorithm can make a more reasonable plan for the constrained transportation of navel oranges. In summary, the k-means clustering algorithm has been sufficiently practiced internationally for the site selection of goods, and thus can be used to analyze the site selection for goods. (Nguyen 2022)

Domestically,Scholars proposed that the k-means clustering algorithm could be used to provide suggestions for the location of transportation hubs, and optimized the k-means clustering algorithm by changing some parameters, making it more efficient. (Lu Linglan & Qin Jiangtao 2019)

Scholars proposed that the k-means clustering algorithm could be used in more urgent situations to plan emergency logistics facilities based on the number of buildings and the population of residents in urban communities. Since navel oranges mostly grow in mountainous areas, the k-means clustering algorithm can be used to analyze the cargo distribution points for navel oranges.(Chen Ming 2023)

Genetic Algorithm

Internationally, Scholars proposed that genetic algorithms could be used to optimize the transportation routes of garbage trucks, so after obtaining the cargo distribution points of navel oranges through the K-means clustering algorithm, they can be analyzed to obtain reasonable transportation routes. (Zhang 2022)

Scholars suggested that due to the limited transportation routes and vehicles in the West Bandung area, genetic algorithms could be used to solve the transportation plans of three different vehicles on three different routes in the West Bandung area. From this research, we can conclude that genetic algorithms can be used to analyze Fengjie navel oranges when vehicles and roads are limited.(Yogaswara& Saputra 2019)

Scholars solved actual transportation and logistics problems by applying genetic algorithms to the data provided by transportation or logistics companies. In summary, genetic algorithms have been sufficiently practiced internationally for transportation route planning, and thus can be used to plan transportation routes for goods. (Arkhipov 2020)

Domestically, Scholars proposed in his research that the logistics industry plays a crucial role in the continuous development of the national economy. With the proposal of high-quality development, the need to reduce the total cost of social logistics is becoming more urgent. The vehicle routing problem, as a key research topic in the logistics industry, has become a hot issue today. He took the vehicle routing problem as the research object and explored vehicle routes through genetic algorithms, proposing better transportation routes. Therefore, there are corresponding experts in China who have analyzed related fields.(Qiu Longlong 2023)

Similarly,Scholars proposed that genetic algorithms could be used to optimize delivery routes in emergencies, ensuring that anti-epidemic materials could reach the people in the epidemic area within the specified time during the epidemic, ensuring their daily life. Therefore, when customers have requirements for the transportation time of navel oranges and the shelf life of navel oranges, genetic algorithms can be used to plan the land transportation routes of navel oranges to reduce the land transportation time of navel oranges, thereby meeting customer needs. (Tao Jiantong 2023)

Scholars,solved problems by combining genetic algorithms with the actual situation of logistics company distribution, improving the original point-to-point delivery method, and ultimately obtaining an optimized delivery plan that meets all transportation requirements and has the lowest transportation cost. In summary, genetic algorithms have been sufficiently practiced domestically for transportation route planning, and thus can be used to plan transportation routes for goods.(Fang Junhao & Li Junling ,2022)(Gai Shan 2007)

Current Research Status at Home and Abroad

A review of the relevant literature shows that international research mainly involves complex supply chains and logistics networks, with researchers focusing on how to optimize the transportation, storage, and distribution of fruits to reduce losses, improve the quality of goods, and extend the shelf life of goods. With the increase in China's fruit export volume, domestic research is dedicated to improving the supply chain and cold chain logistics of Chinese fruits to enhance the quality of fruits and reduce transportation losses. Therefore, this paper can draw on relevant literature from home and abroad for thesis writing.

3 OQ Airlines

Some information related to OQ Airlines was obtained by reading thesis research.(Wang Cheng's 2014)

3.1 Market Position

OQ Airlines enjoys a significant advantage in terms of geographical location. Headquartered in Chongqing, a city in the southwestern region of China, OQ Airlines has a strategic position in connecting the southwestern region with other areas. The southwestern region is one of the densely populated and rapidly developing areas in China, allowing OQ Airlines to capture a considerable market share in this region. OQ Airlines has a relative advantage in route networks, with a focus primarily on domestic routes in China, especially those connecting Chongqing and its surrounding areas. Although its route network may be relatively limited, it can still maintain a certain market share within its service area. In the Chinese aviation market, OQ Airlines faces competition from other major airlines and low-cost carriers. For instance, large airlines like China Southern Airlines and China Eastern Airlines have strong competitiveness on domestic routes, while some low-cost carriers attract passengers through their pricing strategies. OQ Airlines maintains a strong brand image and service quality, which significantly influences its market position. A positive brand image and high-quality service can attract more passengers, thereby increasing market share. Conversely, poor service quality or safety records may negatively impact market reputation and reduce market position. The policy environment in Chongqing is relatively favorable, and government policies also influence the market position of airlines. Government support policies, regulatory measures, and the extent of openness in international routes all affect the development and competitive position of airlines. Overall, OQ Airlines holds a relatively stable market position in the Chinese aviation market but faces challenges from competitors, service quality, policy environment, and other aspects. To enhance its market position, OQ Airlines needs to continuously improve its service quality, optimize its route network, and adapt flexibly to changes in the market and policy environment.

3.2 Route Network

The route network of OQ Airlines is a crucial component of its operations, significantly impacting the company's market position and profitability. Domestically, OQ Airlines' routes cover major cities and tourist destinations in China, including Beijing, Shanghai, Guangzhou, Shenzhen, Chengdu, and Chongqing. Additionally, it may operate routes connecting primary and secondary cities to meet passenger demand between different urban areas. In the southwestern region of China, where Chongqing is located, OQ Airlines enjoys a strategic advantage and likely operates

numerous routes connecting provinces and cities in the southwest, such as Guizhou, Yunnan, Sichuan, and Tibet. Internationally, OQ Airlines may also operate routes connecting China with major cities in Southeast Asia and the Asia-Pacific region, such as Bangkok, Singapore, Seoul, and Tokyo, offering outbound travel and business travel options for passengers. OQ Airlines engages in codeshare agreements and alliance partnerships with other airlines, expanding its route network and providing passengers with more route options and connecting services. Seasonal routes are also part of its operations, adjusting routes according to seasonal demands to meet the needs of peak tourism seasons, such as winter skiing or summer beach vacations. The design of the route network is closely related to aircraft types and flight frequencies. OQ Airlines selects appropriate aircraft types and schedules reasonable flight frequencies based on route demands and market strategies to meet passenger travel needs. Overall, OQ Airlines' route network is relatively comprehensive, covering major domestic cities and the southwestern region of China, as well as operating some international routes, providing passengers with a wide range of route choices. Continuous optimization and expansion of the route network can help OQ Airlines enhance its market position, increase revenue sources, and improve profitability.

3.3 Fleet Size

The fleet size of OQ Airlines significantly impacts its operational capabilities and market competitiveness. OQ Airlines' fleet size may be relatively small, typically consisting of narrow-body and a few wide-body aircraft. The size of the fleet directly affects the airline's capacity and service coverage. The aircraft fleet of OQ Airlines primarily comprises aircraft from mainstream manufacturers such as Boeing and Airbus, including models like the Boeing 737 and Airbus A320. Different aircraft types have varying operational capabilities and applicability, and the airline may select different aircraft types based on route demands and market strategies to compose its fleet. OQ Airlines maintains relatively strict requirements for aircraft age and technical standards to ensure safe and reliable operations. Additionally, it gradually updates older aircraft, introducing newer models to enhance aviation service levels and passenger experiences. OQ Airlines also has detailed expansion plans, which may include fleet expansion initiatives based on aviation market demands and company development strategies. This might involve purchasing new aircraft, expanding the existing fleet, or engaging in leasing or purchasing second-hand aircraft to increase fleet size, meeting market demands, and enhancing market competitiveness. OQ Airlines also demonstrates relatively efficient operational efficiency, with fleet size directly related to the airline's operational efficiency. A moderately sized fleet allows for better management and maintenance, reducing operating costs, increasing aircraft utilization rates, and strengthening the company's profitability. OQ Airlines has a clear market positioning, and its relatively small fleet size may indicate a focus on specific regions or route markets rather than comprehensive coverage of

multiple market sectors. In conclusion, the fleet size of OQ Airlines is an important component of its operational strategy and market competitiveness. Through proper fleet planning and management, OQ Airlines can improve operational efficiency, meet market demands, enhance competitiveness, and achieve sustained and healthy development.

3.4 Cargo Services

OQ Airlines possesses distinctive characteristics and advantages in cargo services. Firstly, within its route network, OQ Airlines offers a range of cargo services covering major domestic cities and some international destinations. This provides convenient options for transporting goods, supporting commercial and logistics activities. In response to market demand, OQ Airlines provides regular cargo flights to meet customers' needs for fast and reliable cargo transportation. Increasing flight frequencies enhances the flexibility and efficiency of cargo transportation. OQ Airlines operates dedicated cargo aircraft, such as the Boeing 747 freighter or the Airbus A330 freighter, with large cargo hold capacities and adaptability to transport various types of goods. The airline collaborates with logistics companies or freight forwarders to offer door-to-door cargo services. Through close cooperation with logistics partners, it provides integrated cargo solutions to meet diverse customer needs. OQ Airlines enhances the operational efficiency and service levels of its cargo business through optimized cargo flight schedules, strengthened cargo handling operations, and providing traceable cargo services. Additionally, OQ Airlines provides international cargo services, including cross-border freight and cargo services on international routes, connecting China with other countries and regions, supporting international trade and logistics needs. In summary, OQ Airlines may have a competitive edge in cargo services by offering diversified cargo products and services, meeting various customer needs, providing efficient and reliable cargo transportation solutions, and supporting customers' business activities and global trade.

4 Issues in Navel Orange Transportation

4.1 Current Status of Fruit Transportation

Transporting fruits to international and domestic destinations is an essential service for airlines. However, challenges may arise in the transportation of fruits like navel oranges, including:

1. Preservation Requirements: Fruits like navel oranges require specific preservation conditions, such as suitable temperatures and humidity levels during transportation, to ensure freshness and quality. Airlines need to ensure that the temperature and humidity control systems in cargo holds meet these preservation requirements.

2. Transit Time: Fruits have a relatively short shelf life and need to be transported to their destination promptly to avoid spoilage and quality deterioration. Airlines must provide fast transportation services to minimize transit time and maintain fruit freshness as much as possible.

3. Packaging and Handling: Proper packaging and handling are essential for fruits during transportation to prevent crushing, collisions, and damage. Airlines need to ensure that the packaging meets transportation requirements and handle fruits with care during loading and unloading to prevent damage.

4. Cargo Tracking: Due to the high preservation requirements of fruits, customers may need real-time information on the transportation status and arrival time of their cargo. Airlines need to provide cargo tracking services to ensure that customers can monitor the location and condition of their cargo at all times.

5. Transportation Costs: Due to the preservation requirements and short transit times of fruits, air transportation typically incurs higher costs compared to sea or land transportation. Airlines need to balance transportation costs with customer demands and provide reasonable prices and services.

6. Legal Regulations: International transportation of fruits may involve various international trade regulations and quarantine requirements. Airlines need to comply with relevant laws and regulations to ensure the legality and safety of cargo.

In summary, airlines face a series of challenges in transporting navel oranges and other fruits, including preservation requirements, transit time, packaging handling, cargo tracking, transportation costs, and legal regulations, to ensure the safe, timely delivery of cargo while maintaining high quality.

4.2 Issues with Navel Oranges and Simple Solutions

Research by Scholar indicates that logistics issues significantly increase the import and export costs of blueberries in the United States. (He Ben 2022)

Scholar study mentions delays in logistics, where 4,000 containers of Chilean cherries failed to enter the Chinese market on time, severely impacting cherry exports. Additionally, approximately 30% of the cherries experienced problems due to prolonged storage, leading to a significant drop in prices. Due to delays in customs clearance, most cherries missed their optimal selling period, resulting in substantial price reductions, with some prices dropping to one-third of their original value.(Zhou Zhou's 2022)

Similar problems are found not only in Chilean cherries and American blueberries but also in Chinese navel oranges.Scholar research suggests that poor transportation conditions at certain navel orange export locations significantly affect export prices and overseas demand.(Zou Xiaoli's 2022)

Scholars mention that with the rapid development of the Chinese economy, the export volume of Chinese fruits, including navel oranges, has increased significantly. (Li Zhizhen & Wang Qiuping 2023)

Furthermore,Scholars analyze the transportation methods applicable to navel oranges, suggesting that modern transportation methods can improve transportation efficiency for navel oranges. Establishing suitable cargo consolidation points can also enhance transportation efficiency and reduce the rate of damaged fruits. (Xu Jiajun & Wang Fanjing 2023)

Therefore, analyzing existing navel orange production points using appropriate research methods can determine corresponding cargo consolidation points. Subsequently, analyzing these cargo consolidation points using research methods can establish reasonable transportation routes.

5 Navel Orange Production Area

Fengjie County, under the jurisdiction of Chongqing Municipality, is located in the Three Gorges Reservoir Area of the Yangtze River. It serves as the eastern gateway to Chongqing, bordered by Wushan County to the east, Yunyang County to the west, Enshi City of Hubei Province to the south, and Wuxi County to the north. The entire area covers 4,098 square kilometers.

Fengjie County is characterized by mountainous terrain, mainly part of the Three Gorges of the Yangtze River, with complex and varied topography. Surrounded by undulating mountain ranges and hills, the land features high and low elevations, towering peaks, and deep valleys. This mountainous terrain contributes to Fengjie's unique natural landscapes and climatic characteristics.

Additionally, Fengjie is situated in the core area of the Three Gorges of the Yangtze River, the longest river in China and the third longest in the world. Within Fengjie's borders, the Yangtze River converges with its tributaries such as the Wu Gorge, forming spectacular river landscapes. These rivers play a significant role in the local ecological environment and economic development.

Apart from the gorge landscapes of the Three Gorges of the Yangtze River, Fengjie also encompasses some high plateau and hilly areas. These areas feature relatively gentle terrain, fertile soil, and are suitable for agricultural production and human habitation. In these regions, people cultivate rice, fruit trees, and other crops, contributing to the development of the agricultural economy.

The mountainous area in Fengjie County accounts for 88.3% of the total area, with middle mountains (elevation above 1000 meters) covering 80.01% of the total area. The overall terrain and landform characteristics are higher in the southeast and northeast, with the central part slightly flatter to the west. The farther away from the Yangtze River, the higher the elevation, with only a small amount of flat river valleys.

In April 2020, Fengjie County was selected as one of the second batch of national rural collective property rights system reform pilot units. In 2020, the gross domestic product (GDP) of Fengjie County reached 32.314 billion yuan, an increase of 2.5% year-on-year. In 2021, the annual GDP reached 37.254 billion yuan, an increase of 8.4% year-on-year (8.3% for the whole city), with an average annual growth rate of 5.1% over the two years (6.1% for the whole city).

Anping Town, subordinate to Fengjie County in Chongqing Municipality, is situated in the central-western part of Fengjie County, with a total area of 144.69 square kilometers. Anping Town got its

name because boatmen, in order to ensure safety, named the place where they lived at night "Anping Chang," thus giving rise to the name "Anping." During the late Ming and early Qing dynasties, the Anping Town area belonged to the southern bank. In June 2010, Anping Township was changed to Anping Town.

Anping Town is located in the eastern segment of the Qiyao Mountains, with the terrain generally sloping higher in the south and lower in the north, higher in the west and lower in the east. The landform is mostly mountainous, with elevations ranging from 146 to 1557 meters, exhibiting a typical three-dimensional climate. It can be broadly categorized into three types: the first type is the low mountain area along the river, which is the main navel orange production area; the second type is the middle mountain terrace area, with over 2000 acres of arable land, serving as an important rice-growing area and suitable for the development of large-leaf vegetables and late-maturing navel oranges; the third type is the high mountain area, suitable for the cultivation of fruit trees, medicinal herbs, and tobacco.

In 2011, the total fiscal revenue of Anping Town was 21.04 million yuan, an increase of 15.4% over 2010. In 2018, Anping Town had seven industrial enterprises and four comprehensive shops or supermarkets with a business area exceeding 50 square meters.

"Fengjie Navel Orange" as a characteristic fruit of Chongqing, has moderately thick peel, is crisp and easy to peel, has tender and pulpy flesh with few seeds, is juicy and refreshing, with a clean and fragrant aftertaste, and has a moderate sweet and sour taste. Its base was established in 1979 when the Ministry of Commerce approved the establishment of a 20,000-mu export navel orange base. It has undergone three development stages from 1985 to 1990, 1991 to 1996, and 1997 to 2002. With the implementation of a series of strategies and policies to assist agriculture, such as the national "Rural Revitalization Strategy" more and more farmers have chosen to plant navel oranges. After gaining fame across China and even worldwide, the demand for Fengjie navel oranges has continued to rise.

By 2005, Fengjie County had planted over 8.5 million navel orange trees in areas below 600 meters above sea level on both sides of the Yangtze River Basin, establishing 150,000 acres of orchards with a yield of 124,000 tons and a output value of 250 million yuan, accounting for 20% of the county's agricultural output value, becoming the leading industry of the whole county. In 2009, the former General Administration of Quality Supervision, Inspection and Quarantine approved the implementation of geographical indication protection for "Fengjie Navel Orange" In 2020, Fengjie Navel Orange was selected for protection in the second batch of Central European geographical

indication lists. By 2021, Fengjie Navel Orange was selected as one of the "Top 100 Favorite Chinese Brands by Consumers," becoming the only fruit selected in the ranking throughout China.

In recent years, the government has continuously invested in helping farmers pull electric wires, repair roads, build cold storage, and organize orchard land, resulting in improved infrastructure and promoting the development of Fengjie navel oranges. However, due to Chongqing's special geographical factors, with a large area of mountainous terrain and rugged rural roads, it is not conducive to the transportation of agricultural products. As Fengjie navel oranges develop and grow step by step, new problems continue to emerge, resulting in severe transportation obstacles for Fengjie navel oranges, seriously affecting farmers' economic income, and hindering rural development. For example, in Santuo Village, Anping Town, Fengjie County, where the majority of villagers rely on planting navel oranges for a living, a few years ago, due to blocked traffic and difficult mountain roads, during the winter, no one in the entire Anping Town would buy oranges. "At that time, after the oranges were ripe, they were all harvested at once, piled up at home, covered with plastic sheets, and farmers could only wait for merchants to come and buy them cheaply. First, they would transport their oranges by truck to the Yangtze River wharf, and then hire boats to transport them to Wanzhou, Chongqing, and other places. The transportation cost alone accounted for half of the selling price. After a trip, they could only earn a meager income, and sometimes even suffer losses." recalled Orange farmer .(Cao 2021)

Figure1.Backward transportation equipment in Fengjie County

Improving basic hardware facilities can be relatively easy in a short period of time. For example, Fengjie County has improved the infrastructure of the 100,000 mu high-quality navel orange planting base in the main production areas, including the construction of facilities such as water conservancy, roads, and pipelines. However, compared to this, Chongqing's complex mountainous terrain, soil improvement, advanced irrigation, fertilization, and green production technologies, as well as farmers' management and sales models, always hinder the development of Fengjie navel oranges. For example, the entire Fengjie County has not yet built a professional wholesale and retail market for navel oranges. Customers from other places and overseas can only market their

products in local markets, which can easily lead to information asymmetry between production and sales, thereby hindering the sale of Fengjie navel oranges in the world.

There are several reasons why the Fengjie area of Chongqing can become one of the main planting areas for Chinese navel oranges:

1. Suitable climatic conditions: Fengjie has a mild and humid climate with distinct seasons, abundant sunshine, and rainfall, making it very suitable for the growth of navel oranges. The hot and humid summers are conducive to the growth and ripening of fruits, while the sunny winters help increase the sweetness and quality of the fruits.

2. Rich soil resources: The soil in Fengjie is fertile, deep, and rich in organic matter and minerals, providing excellent nutritional conditions for the growth of navel oranges. Good soil drainage is conducive to root development and water absorption.

3. Large planting areas: Fengjie has vast planting bases, with navel oranges grown in mountainous and hilly areas as well as plains. The large area of planting bases, expanding planting scale year by year, has formed a certain industrial agglomeration effect.

4. Scientific planting management: Farmers in Fengjie have accumulated rich experience in navel orange cultivation, emphasizing scientific planting management, including proper fertilization, timely irrigation, and prevention and control of diseases and pests. The use of advanced planting techniques and management methods has increased the yield and quality of navel oranges.

5. Selection of high-quality varieties: The navel oranges planted in Fengjie mainly include sweet oranges, mandarins, and grapefruits, which have good taste, smooth skin, and juicy fruits, and are welcomed by the market and consumers.

Despite the high quality of the produced navel oranges, facing backward transportation and closed information channels, Fengjie navel oranges cannot achieve high returns. Additionally, prolonged delays in transportation to airports can significantly increase the rate of damaged fruits, affecting the export volume of navel oranges. Therefore, this thesis proposes to analyze existing navel orange production areas using the k-means clustering algorithm and genetic algorithm to establish collection points for navel oranges, which will then be collected by purchasers and transported to OQ Airlines, thereby reducing the transportation time from navel orange production areas to OQ Airlines and increasing the freshness of navel oranges.

6 Research methods

In this paper, it is necessary to analyze the origin of collected goods to determine distribution points, thus requiring the selection of suitable algorithms to assist in this process implementation. Additionally, after obtaining specific distribution points of goods, it is necessary to plan transportation routes on land through establishing mathematical models to obtain optimized transportation routes.

6.1 Establishment of the Algorithm Mode

Description of the Problem

After computing the locations of goods distribution points through a two-stage algorithm, it is necessary to plan the collection routes for the goods. Due to a lack of in-depth and specific study in this field at the undergraduate level, only a simple TSP (Traveling Salesman Problem) model can be established to plan the transportation routes.

Based on the existing problems and related research in this paper (Xu Jiajun & Wang Fanjing, 2023; Meng & Liu, 2007), the TSP problem is described as follows: There are k-1 cargo distribution points and one purchaser (1-2-…-k) - all goods need to be transported to the purchaser. The purchaser dispatches vehicles for carriage. - The objective is to find the shortest itinerary that meets the freight demand.

The set of vertices is $V = \{1, 2, \ldots, n\}$, and the distance from point i to point j is $i,j \in v$.

The mathematical model is as follows:

$$\text{Min } z = \sum_{i=1}^{n} \sum_{j=1}^{n} C_{ij} X_{ij} \quad (1)$$

$$\sum_{j=1}^{n} X_{ij} = 1, i \in v \quad (2)$$

$$\sum_{i=1}^{n} X_{ij} = 1, j \in v \quad (3)$$

$$\sum_{j=1}^{n} X_{j} = 1, i \in v \quad (4)$$

$$\sum_{i=1}^{n} X_{i} = 1, j \in v \quad (5)$$

$$\sum_{i,j \in S} X_{ij} \leq |S| - 1, \forall S \subseteq v, 1 < |S| < n \quad (6)$$

$$X_{ij} \in \{0,1\}, i \in v, j \in v \qquad (7)$$

$$y_{ik} \leq Y, \exists\, i \in v, k \in v \qquad (8)$$

In the above model: Equations (2) and (3) ensure that each vertex is passed only once, and Equation (6) constrains the model to avoid the generation of sub-tours. Since the location of each cargo distribution point in this paper is uncertain, a specific algorithm is required to determine the location of each cargo distribution point.

6.2 Two-Stage Algorithm Combining Clustering and Genetic Approaches

Algorithm Concept and Design

Based on the literature reviewed (Xu Jiajun & Wang Fanjing, 2023; Li Qing & Wei Guangcun, 2020; Meng & Liu, 2007), it is known that the K-means clustering algorithm is particularly effective for problems with smaller dimensions and numerical values. At the same time, genetic algorithms, when dealing with multiple individuals in a population, can reduce the chances of falling into local optima. Therefore, this paper employs the K-means clustering algorithm to address the issue of cargo consolidation point locations and uses genetic algorithms to calculate the optimal route.

Table1.Clustering and Genetic Flowchart

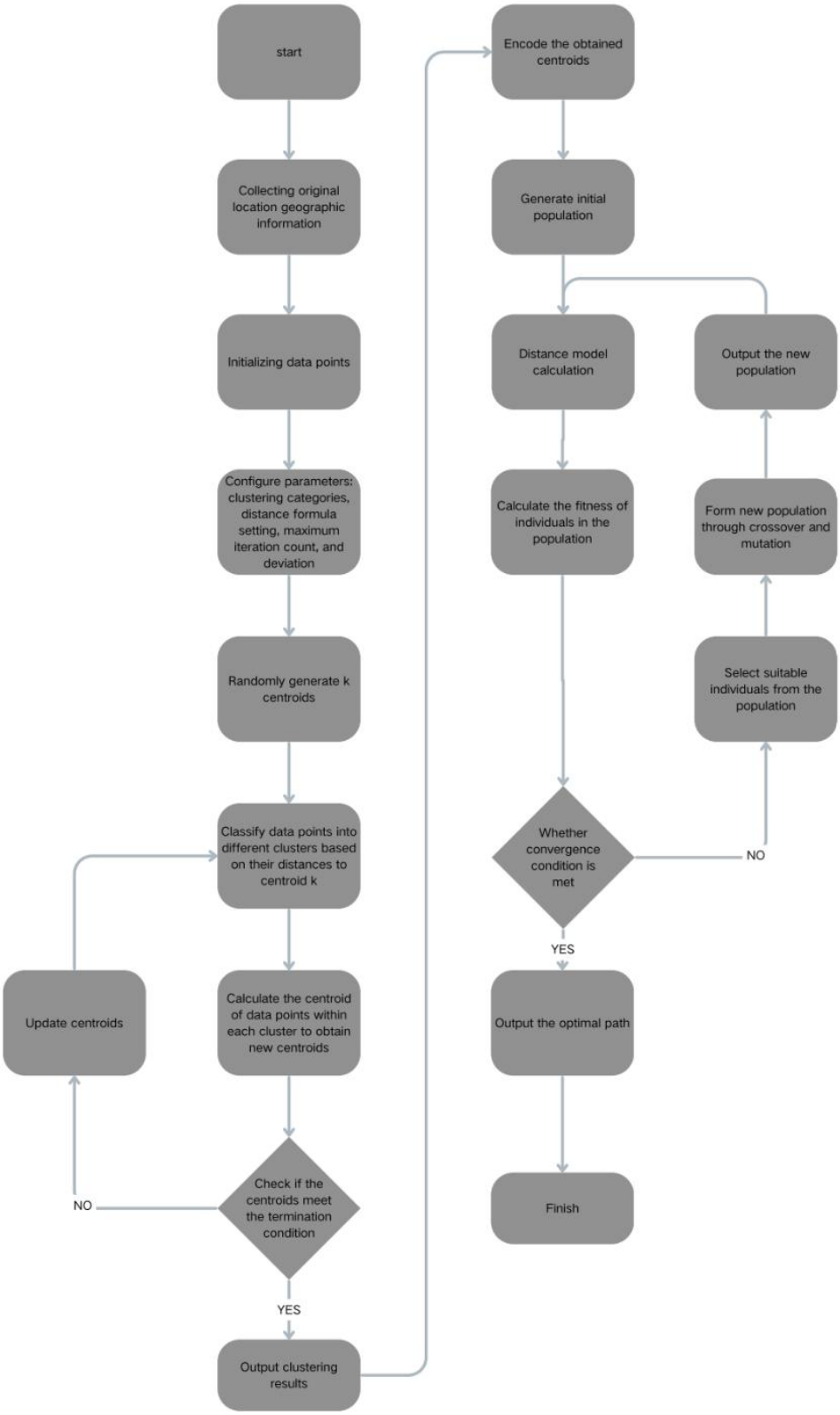


Figure 2.Clustering and Genetic Flowchart

Introduction to Clustering and Genetic Algorithms

The K-means algorithm is a classic clustering algorithm based on data classification and can be widely applied in n-dimensional data spaces. It iteratively divides a given set of sample data into different clusters, ensuring that the data within each cluster are as similar as possible and as different as possible from data in other clusters. The basic idea of the

K-means algorithm is to first divide the entire dataset into k clusters (depending on the initial data points' concentration), and randomly select k sample data points from the dataset as the initial cluster centers. Once the initial cluster centers are determined, the distances from the remaining data points to each cluster center are calculated using the surface distance formula. These distances serve as criteria for classifying the data points into clusters, resulting in an initial cluster distribution. After obtaining the initial cluster distribution, the center point of each cluster is recalculated, and if it differs from the previous center point, a new iteration adjustment is made until the clustering converges to the required level for the research, at which point the iteration stops, and the algorithm ends.

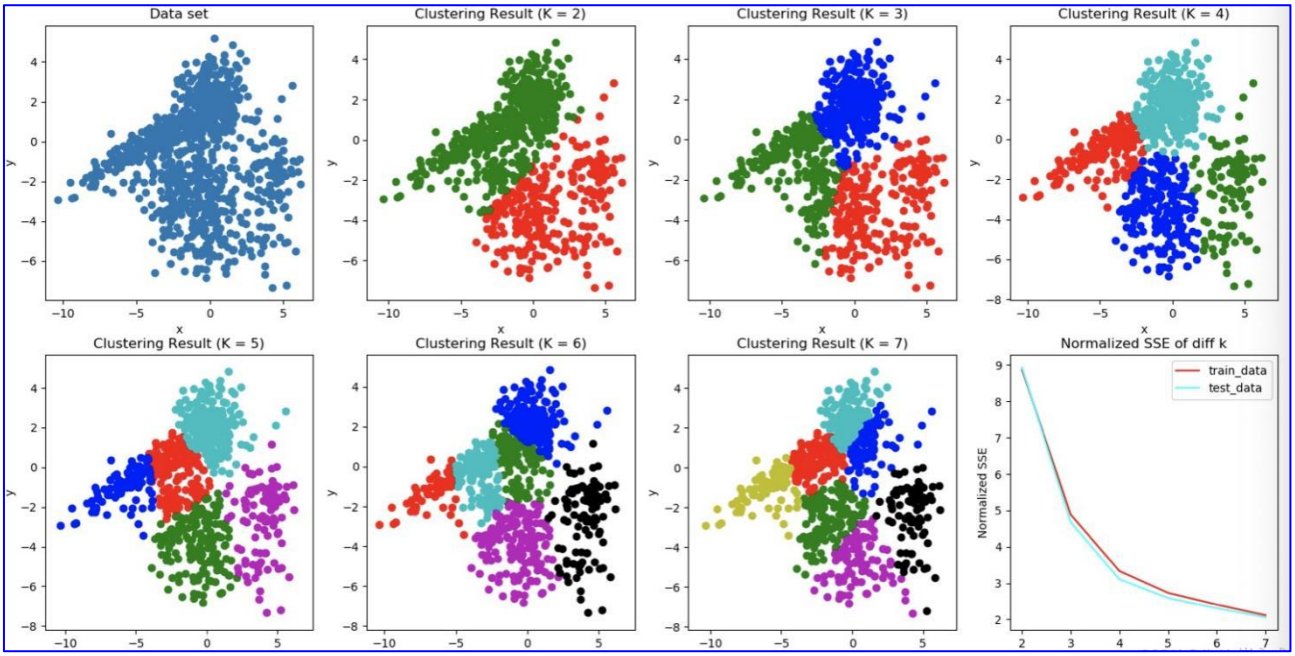


Figure 3.Running process of k-means clustering algorithm

Genetic algorithms are random global search and optimization methods developed by mimicking the evolutionary mechanisms of biological organisms in nature, drawing inspiration from Darwin's theory of evolution and Mendel's genetics. Essentially, it is an efficient, parallel, and global search method that automatically acquires and accumulates knowledge about the search space during the search process and adaptively controls the search process to obtain the best solution.

Genetic algorithms use population search techniques, representing a group of problem solutions with a population. A new generation of populations is produced by applying a series of genetic operations such as selection, crossover, and mutation to the current population, gradually evolving the population to a state containing approximate optimal solutions.

Implementation Steps:

1. Identify the original data and locate the corresponding farmers on the map, considering them as initial data points.
2. Set K centroids for the data points (determined by the clustering situation of the initial data points).
3. Perform cluster analysis on the data points. Classify the data points based on their distances to the centroids, using spherical distance to calculate the distances between data points and centroids, and assign data points to the nearest centroid.
4. Calculate new centroids. After classifying all data, resulting in K collections, determine new centroids by calculating the central positions of data points within different categories.
5. Determine the optimal centroids. When the new centroids become stable and convergent compared to subsequent centroids, it can be assumed that the clustering has achieved the desired result, and the algorithm terminates, producing the optimal centroids. These optimal centroids represent the locations for goods distribution centers.
6. Encode the data points. Number the locations of the goods distribution centers and the supply and marketing cooperatives, sequentially arrange the points passed, and form a genome using the sequence of numbers passed.
7. Generate populations and individuals. Encode the paths passing through all data points to form the initial population, considering one path as an individual.
8. Establish and calculate the fitness function. Calculate the fitness of each individual in the population. Since the goal of this model is the shortest route among all paths, the objective function needs to be transformed into a maximum and non-negative fitness function, expressed as Fitness=1-（Z-min Z/max Z-min Z）.
9. Perform crossover and mutation. Due to the large number of populations involved in this paper, individuals are selected for crossover and mutation using random convenience sampling. Let n point be the number of individuals to be selected, with equidistant selection of individuals, and the distance of the selection pointer is$0.8*1/\mathrm{n\ point}$, with the position of the first pointer determined by a uniform random number from$0.8*1/\mathrm{n\ point}$. Literature

(0.8*1/ n point) suggests that a crossover rate between 0.6 and 0.8 yields better evolutionary effects. In the experiments of this paper, the crossover rate is set between 0.5 and 0.9, with a default rate of 0.6.

10. Determine the termination condition, insert the new individuals into the population for iterative computation, record the optimal solutions from multiple iterations, and determine the optimal individual by comparing its stability.
11. Output the optimal path.

Spherical Distance:

$$S = R\arccos[\cos\beta_1 \cos\beta_2 2\cos(\alpha_1 - \alpha_2) + \sin\beta_1 \sin\beta_2] \quad (2\text{-}3\text{-}1)$$

In the above formula: (R) is the radius of the sphere, which in this case is the Earth's radius taken as 6371km. (α_1, β_1) Latitude and longitude angles of point A}), (α_2, β_2) Latitude and longitude angles of point B.

Euclidean Distance:

$$L=\sqrt{(a_2 - a_1)^2 + (b_2 - b_1)^2} \quad (2\text{-}3\text{-}2)$$

In the above formula: (L) is the distance between two points, (a_1, b_1) Coordinates of mass point 1, (a_2, b_2) Coordinates of mass point 2.

7 Example Analysis

7.1 Analysis of Target Area and Points

Anping Town is situated in the eastern segment of the residual range of Qiyao Mountain. The terrain slopes from south to north, with higher elevation in the west and lower elevation in the east. The area is characterized by mountainous terrain, with prominent peaks such as Tianyunguan, Yinjiabao, and Dabao. The highest point within the area is Yinjiabao, located in Group 3 of Xiaozhi Village, with an elevation of 1487 meters, while the lowest point is in Santuo Village, at an elevation of 135 meters. According to the survey, there are approximately 150 households engaged in the cultivation of navel oranges. The positions of data points were recorded, and analysis using Tencent's visualization map yielded an image

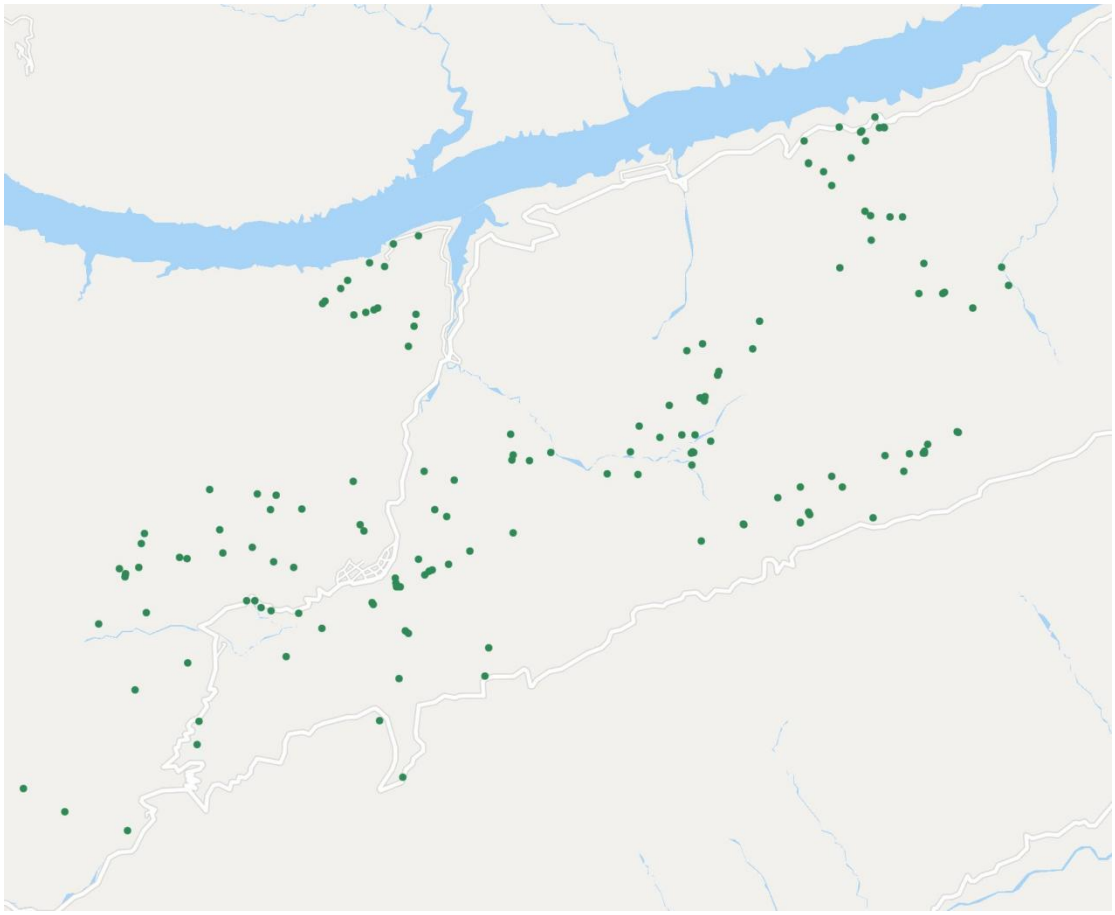


Figure 4.The location of farmers

7.2 Algorithm Procedure

Cluster Analysis

K-means clustering analysis was conducted on the households, resulting in different clusters and the locations of fields and embankments. The positions of the embankments were recorded through multiple iterations, and by comparison, stable results regarding the positions of embankments were obtained (Table 3). The horizontal axis represents the number of iterations, while the vertical axis represents the sum of latitude and longitude during multiple iterations. The vertical axis values fluctuate significantly between 1 to 9 iterations, but stabilize after the 9th iteration. Visual analysis through imaging (Figure 3) illustrates the distribution of clusters and embankments. Different colors represent different clusters, with red dots indicating the centroids of corresponding clusters and the positions of embankments.

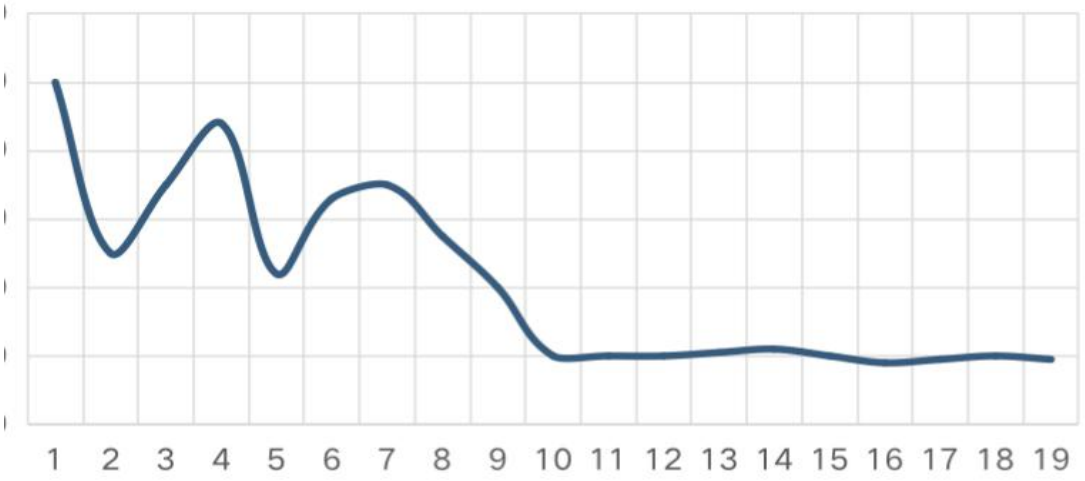


Figure 5.The approaching situation of particle position

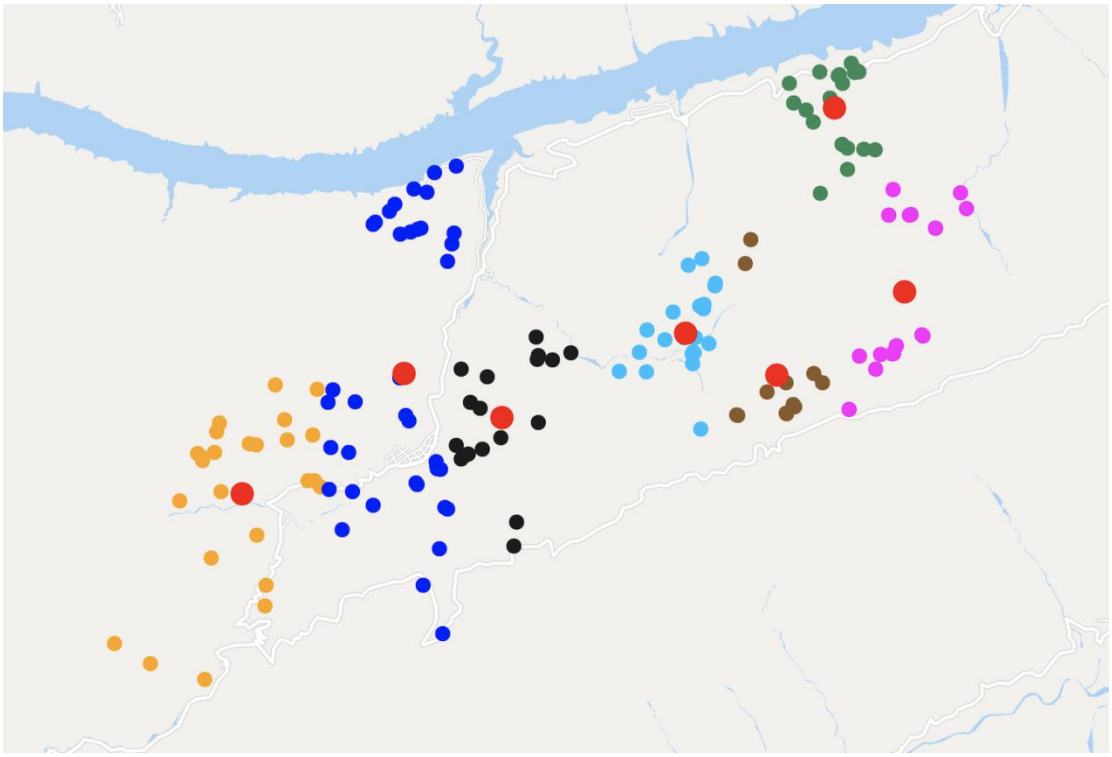
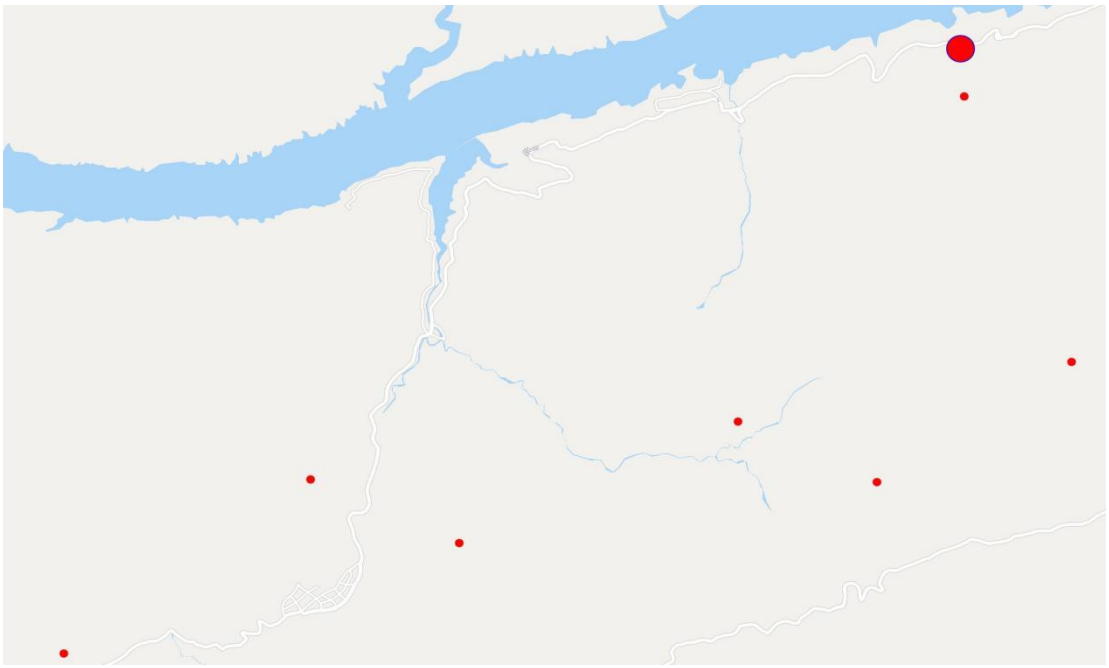


Figure 6.A clustering situation in multiple clusters

Genetic Analysis

Using the location data of embankments obtained from Table 3 and known positions of supply and marketing cooperatives as data points, a schematic diagram (Table 4) of the positions of goods concentration points and purchasers' locations was generated using Tencent visualization maps. The slightly smaller red dots represent the positions of goods concentration points, while the slightly larger red dots represent the positions of purchasers.Figure 3.A clustering situation in multiple clusters



By establishing the TSP model in this project, the optimal routes for the positions of purchasers and goods concentration points can be calculated.（Figure4）

Figure 7.road map

Record the number of centroids selected, the length of the optimal route, and the maximum distance between the origin of goods and the goods concentration point (Table 4), facilitating comparative analysis.

Table 1.The relationship between the number of particles, field dams, and paths

Unit: km

K	2	3	4	5	6	7	8	9	10	11
$Max\ y_{ij}$	5.58	3.51	3.21	3.27	2.37	2.79	2.28	2.28	1.82	2.18
Min Z	66.89	71.52	88.75	74.64	99.01	75.77	79.70	112.78	97.37	101.87

Through surveys of farmers in Anping Town, Fengjie County, it was found that the majority are willing to accept goods concentration points located approximately 3 kilometers away from the origin of goods. Therefore, in order to minimize the distance traveled by purchasers while ensuring the shortest route for goods collection, this case selected 7 centroids to establish embankments, thereby reducing costs.

Through inquiries with orange purchasers, it was determined that the transportation of oranges to the airport requires approximately 324 kilometers of travel distance using a one-to-one collection method. Additionally, each farmer needs to process their oranges before they can be transported to the airport, significantly reducing the efficiency of orange transportation.

By inputting the established goods concentration points, purchaser, and airport locations into mapping software, the current transportation distance was estimated to be approximately 246 kilometers. Compared to the actual transportation distance, there is indeed a reduction in transportation distance, indicating the feasibility of this optimization solution.

8 Measures to Protect Fruits in Other Aspects

After transportation, various quality parameters of fruits undergo changes. Determining whether these changes are due to damage or natural aging of the fruits requires corresponding damage evaluation, which also provides theoretical basis for assessing the effectiveness of cushioning packaging and identifying areas for improvement. Damage evaluation mainly involves physical and biochemical aspects.

8.1 Physical Aspect

Physical measurements mainly include: damage area or volume, hardness, and viscoelasticity. Measuring damage area and volume is a commonly used and important method, which can directly compare the size of damage and the effectiveness of packaging cushioning. After damage, most fruit varieties exhibit browning of the damaged area due to oxidation, which differs significantly in color from undamaged areas and is easily detectable. By measuring and calculating the damage rate of area and volume, the extent of damage can be quantified. Hardness is an important indicator of fruit ripeness. The hardness of fruit is mainly influenced by substances such as pectin and cellulose within the cells. When original pectin degrades into soluble pectin and cellulose is degraded by cellulase, the support force of the cell wall decreases, leading to a decrease in fruit hardness. Measuring the change in fruit hardness before and after transportation can provide a basis for assessing the degree of damage. When measuring hardness, the puncture depth of the fruit should be determined according to the actual size of the fruit, often taking half of the difference between the longitudinal and transverse diameters of the fruit, while avoiding contact with the core. In addition, changes in the structure and substances of the damaged parts of fruits can also be detected using physical methods such as ultrasound, X-rays, energy absorption, relative conductivity, weight loss rate, and color. Overall damage relationships can also be detected. For example, after vibrating stacked apples, a spatial distribution map of fruit damage can be drawn based on the damage condition of each fruit, revealing the damage chain of fruits.

8.2 Biochemical Aspect

Biochemical measurements mainly include: malondialdehyde (MDA) content, soluble solids content, and ethylene release. When fruits are damaged, the membrane lipids of internal cells will undergo peroxidation and decomposition to produce malondialdehyde, especially in aging and damaged fruits. Therefore, the level of malondialdehyde directly reflects the degree of fruit damage. Soluble solids refer to all soluble compounds in liquid or fluid food, including sugars, acids, vitamins, and minerals, which are commonly used technical parameters in the food industry. In fruit

evaluation, soluble solids can be directly used to reflect the sugar content in fruits and judge fruit ripeness. When determining, fruit juice is squeezed, and the refractive index of the juice is measured using an Abbe refractometer. The maturity and quality of fruits are evaluated based on the soluble solids content. For example, mechanical damage can decrease the soluble solids content in Fuji apples. Ethylene is a plant growth regulator and an important substance required for fruit ripening after harvest. During fruit ripening, ethylene production is high, and when fruits are mechanically damaged, ethylene production within the fruit can increase several times, known as stress ethylene or adversity ethylene. Ethylene also has a self-promoting effect, meaning its accumulation can stimulate fruits to produce more ethylene. Studies have shown that with increasing damage severity, the ethylene release of fruits such as Fuji apples increases. In addition, indicators such as respiration rate, VC content, and the activity of corresponding enzymes can be used to evaluate the extent of fruit damage.

Therefore, by improving the physical and biochemical aspects during the transportation of navel oranges, the rate of defective oranges can be reduced.

8.3 Specific Improvement Methods

Appropriate Packaging

Mesh bags or net bags: This packaging method allows air circulation while preventing oranges from colliding and squeezing. Transparent net bags can be chosen so that consumers can see the quality of the oranges.

Foam mesh sleeves: Foam mesh sleeves provide more protection, preventing oranges from impact and compression during transportation. This packaging method also ensures air circulation.

Cartons: Some navel oranges may be packed in cartons, which are suitable for large-scale transportation. Fillers such as wood shavings or foam particles can be placed inside the cartons to reduce the movement of oranges during transportation.

Individual packaging: If necessary, each navel orange can be individually packaged, usually using transparent plastic film or bags. This packaging method keeps oranges clean and prevents contamination from other items during transportation and storage.

Adding protective pads: Adding some soft pads or fillers, such as foam pads or soft paper pads, to the packaging can reduce the vibration and compression of oranges during transportation.

Partitioning and Isolation of Navel Oranges during Transportation can ensure that oranges of different qualities and varieties do not affect each other and can more effectively manage inventory. Here are some common methods:

Partitioning by quality: Divide navel oranges into different batches or areas according to their ripeness and quality. This ensures that high-quality oranges are not affected by low-quality oranges, and it is easier to identify and handle products of different qualities.

Partitioning by variety: If there are different varieties of navel oranges, such as different varieties or sizes, they can be divided into different areas. This ensures that different types of oranges are not mixed together, facilitating management and distribution.

Partitioning by destination or customer: If navel oranges will be shipped to different destinations or different customers, they can be partitioned according to destination or customer. This ensures that each customer or destination receives the products they need, while also helping to manage orders and inventory.

Setting partitions or isolation areas: Set partitions or isolation areas in transport vehicles or storage facilities to separate oranges of different batches or varieties. This ensures that oranges do not mix with each other and makes it easier to manage and inspect inventory.

Labeling and recording: Label and record each partition, including information such as quality, variety, and destination. This ensures that each partition can be correctly identified and managed, reducing confusion and errors.

Moreover, controlling the temperature and humidity of navel oranges during transportation is crucial to ensuring their freshness and quality. Here are some methods to control the temperature and humidity of navel oranges:

Choose appropriate transportation tools: Select transportation tools with temperature and humidity control functions, such as refrigerated trucks or containers. These equipment can maintain stable temperature and humidity during transportation, preventing navel oranges from being affected by overheating or overcooling.

Use fresh-keeping packaging: Package navel oranges in packaging materials with fresh-keeping functions, such as breathable plastic bags or cling film. These packaging materials can help prevent moisture loss, maintain the humidity of navel oranges, and reduce the risk of rot.

Monitor temperature and humidity: Regularly monitor the temperature and humidity inside transportation vehicles during transportation. Temperature and humidity sensors or monitoring

devices can be used for real-time monitoring, and temperature and humidity settings of transportation vehicles can be adjusted promptly.

Control ventilation: Properly control ventilation during transportation to ensure air circulation and prevent navel oranges from overheating or becoming too moist. Adjust the size and position of ventilation openings according to the actual situation.

Avoid temperature shocks: Try to avoid drastic temperature changes during transportation, which may cause navel oranges to freeze or discolor. Pay attention to avoiding temperature shocks during loading and unloading.

Biochemical Aspect

Prevent pests and diseases: Before harvesting and packaging navel oranges,

ensure that they come from healthy orchards and take appropriate measures to prevent the occurrence of pests and diseases. This includes regular inspection of orchards and spraying of insecticides and fungicides.

Inspection and screening: During packaging, carefully inspect and screen navel oranges, removing those that are damaged or already infected to prevent the spread of pathogens or pests.

Temperature control: Maintaining appropriate temperature is crucial to preventing navel oranges from rotting and inhibiting the growth of bacteria. Use refrigeration equipment or refrigerated vehicles to control the temperature of navel oranges and ensure that they remain within the appropriate temperature range throughout transportation.

Humidity control: Moderate humidity helps slow down the rotting of navel oranges. During transportation, use breathable packaging materials or humidifiers to maintain the proper humidity level.

Handling damaged fruits: For navel oranges damaged during transportation, promptly handle them, removing the damaged parts to prevent the spread of rot to other oranges.

Fast transportation: Try to shorten the time from harvesting to transportation of navel oranges, avoiding long-term storage and delays, to reduce the chance of navel oranges being affected by external environmental factors.

Regular inspection: Regularly inspect the condition of navel oranges during transportation, and promptly handle any abnormal situations to prevent further deterioration of the problem.

Therefore, during the transportation of goods, the above processing methods can be used to package navel oranges to ensure their freshness. Ensure that the navel orange is fresh when it reaches the customer's hands.

9 Outlook and Conclusion

The study discovered that due to the long transportation distance of navel oranges, significant time is consumed, leading to a considerable impact on their freshness upon arrival at the airport. Hence, shortening the transportation distance of navel oranges became the primary research focus. Subsequently, through an analysis of dispersed navel orange planting locations, this study successfully utilized a combination of K-means clustering algorithm and genetic algorithm to determine suitable distribution points for goods. The STP model was then employed to analyze these distribution points and optimize the transportation routes for navel oranges. In this process, the following conclusions were drawn:

Firstly, the combination of K-means clustering algorithm and genetic algorithm effectively handled data from dispersed navel orange planting locations, accurately determining the location of distribution points, thereby providing a solid foundation for shortening the transportation distance of navel oranges.

Secondly, by utilizing a simple STP model to analyze distribution points, we could better understand the relationships between various distribution points, optimize navel orange transportation routes, and reduce transportation costs and time.

Additionally, several preservation methods helpful in maintaining the freshness of navel oranges during transportation were proposed, such as thermal insulation containers, dedicated transport vehicles, and appropriate packaging. These measures can effectively prolong the shelf life of navel oranges, maintain their freshness and quality, and enhance the value of goods during transportation.

In conclusion, this research made significant progress in analyzing the distance to airports for navel orange transportation, analyzing planting locations, and determining distribution points. It provides effective optimization solutions and preservation measures for navel orange transportation, which are of great significance for enhancing the development of the navel orange industry.

10 Shortcomings and Future Research Prospects:

10.1 Shortcomings:

Firstly, the algorithm models used in this paper require a large amount of data to ensure the accuracy of the results, making it difficult to apply them in areas with limited data.

Secondly, the STP model used in this paper is relatively simple and cannot handle relatively complex transportation route planning problems, such as those involving multiple vehicles with time window constraints, which still requires more time to learn and address.

10.2 Future Research Prospects:

Although this paper has made significant progress in areas such as the distance navel oranges are transported to airports, analysis of navel orange planting sites, and determination of distribution points, there are still some aspects that need further research and improvement to further enhance the efficiency and quality of navel orange transportation.

Firstly, future research can further optimize the method of determining distribution points by considering more factors such as traffic congestion, weather conditions, etc., to improve the accuracy and adaptability of route planning.

Secondly, to address the issue of long transportation time for navel oranges on land, exploring faster and more efficient transportation methods, such as improving transportation tools and optimizing logistics organization, to shorten transportation time and enhance the freshness of navel oranges.

Furthermore, future research can delve into preservation technologies for navel oranges during transportation, developing more advanced preservation equipment and methods to further extend the shelf life of navel oranges and ensure their quality is effectively maintained during transportation.

Moreover, considering the importance of environmental protection and sustainable development, future research can explore environmental issues in navel orange transportation, such as reducing energy consumption during transportation and lowering carbon emissions, to promote the sustainable development of the navel orange industry.

In conclusion, future research can further deepen our understanding and optimization of the navel orange transportation process to enhance the competitiveness and sustainable development capabilities of the navel orange industry.

Sources

Arkhipov, D. I., Wu, D., Wu, T., & Regan, A. C. (2020). A Parallel Genetic Algorithm Framework for Transportation Planning and Logistics Management. IEEE access, 8, 106506-106515. URL：https://doi.org/10.1109/ACCESS.2020.2997812

cao, yu s.a. 走进乡村看小康|阡陌纵横奔小康 乡村振兴在"路"上. URL：https://m.gmw.cn/baijia/2021-09/23/35185419.html.

chen, ming s.a. 基于 K-means 聚类算法的城市应急物流设施规划——以长春市某阶段蔬菜投放数据为例 - 百度文库. URL: https://wenku.baidu.com/view/8ca2d7bbbe64783e0912a21614791711cc7979c2.html?_wkts_=1714714008830&bdQuery=.

Le, T. D. C., Nguyen, D. D., Oláh, J., & Pakurár, M. (2022). CLUSTERING ALGORITHM FOR A VEHICLE ROUTING PROBLEM WITH TIME WINDOWS. Transport (Vilnius, Lithuania), 37(1), 17-27.URL： https://doi.org/10.3846/transport.2022.16850

li, qing s.a. 万方数据知识服务平台. URL: https://d.wanfangdata.com.cn/periodical/xjsfdxxb202101001.

李 & 何 2020. 改进遗传算法在容量约束车辆路径问题中的应用研究. 供应链管理, 1, 3, pp. 10. URL: https://xueshu.baidu.com/usercenter/paper/show?paperid=1k7n0mh0fb3g0vx0sm480rx0x8135322.

lu, linden 2019. URL: http://www.c-s-a.org.cn/csaen/ch/reader/view_abstract.aspx?file_no=7029.

Meng, Y., & Liu, X. (2007). Application of K-means Algorithm Based on Ant Clustering Algorithm in Macroscopic Planning of Highway Transportation Hub. URL：https://doi.org/10.1109/ISITAE.2007.4409331

宋 2019. 遗传聚类算法的改进及其在基因表达数据分析中的应用. URL: https://xueshu.baidu.com/usercenter/paper/show?paperid=1d4t0ge0nu140am0h10g0cj0ne496763&site=xueshu_se.

Yogaswara, Y., & Saputra, L. S. M. D. (2019). Genetic Algorithm for Waste Transportation Route in Eastern Bandung (Case Study: PD. Kebersihan Kota Bandung). IOP conference series. Materials Science and Engineering, 528(1), 12041.URL： https://doi.org/10.1088/1757-899X/528/1/012041

姜, 杨, 杜 & 周 1999. 车辆路径问题的遗传算法研究. 系统工程理论与实践, 19, 6, pp. 40–45. URL: https://doi.org/10.3321/j.issn:1000-6788.1999.06.007.

Zhang, Y., Luo, X., Han, X., Lu, Y., Wei, J., & Yu, C. (2022). Optimization of Urban Waste Transportation Route Based on Genetic Algorithm. Security and communication networks, 2022, 1-10. URL：https://doi.org/10.1155/2022/8337653

Appendices

Appendix 1. Record of conversation with navel orange purchaser

脐橙采购商座谈：探讨收购和运输路程

主持人：感谢各位脐橙采购商的光临。今天我们聚在一起的目的是探讨一下关于脐橙的收购和运输情况。首先，我想问一下，您们每年从供应商那里收购的脐橙量大概是多少？

采购商 1：我们每年从果农那里收购大约几百吨的脐橙，主要运输至机场用于出口或者运输至其他区域。

采购商 2：我们公司的脐橙采购量大约是上千吨左右，主要供应到各大连锁超市和餐饮企业。

主持人：听起来都是大批量的采购，那么在收购之后，您们是如何运输这些脐橙的呢？

采购商 3：我们一般会使用冷藏车辆来运输脐橙，以保持其新鲜度，同时会在冷藏车中灌输惰性气体以保证水果的新鲜程度。

采购商 1：是的，我们也是采用同样的方式，确保脐橙在运输过程中保持最佳的品质。

主持人：了解，那么在运输的过程中，您们通常会选择怎样的路线？

采购商 2：我们会选择最短的路线，以减少运输时间和成本。

采购商 3：同时，我们也会考虑到路况和交通情况，选择最安全、最畅通的路线。

主持人：那么，您们运输脐橙至机场的路程大概有多远呢？

采购商 1：我们公司一般会选择距离较近的机场，大约有 324 公里左右的距离。

采购商 2：我们公司的机场距离稍远一些，大约有 336 公里左右的距离。

主持人：谢谢各位的分享，通过这次座谈，我们对脐橙的采购和运输情况有了更深入的了解。

Appendix 2.Survey questionnaire for fruit farmers

脐橙种植情况

添加问卷说明

*1.您种植脐橙的年限

- 1–3年
- 3–5年
- 5年以上

*2.您脐橙种植的规模

- 1–5亩
- 5–10亩
- 10亩以上

*3.您成熟的脐橙是如何进行运输的呢?

- 个人运输
- 交由承包商运输
- 由采购商收购

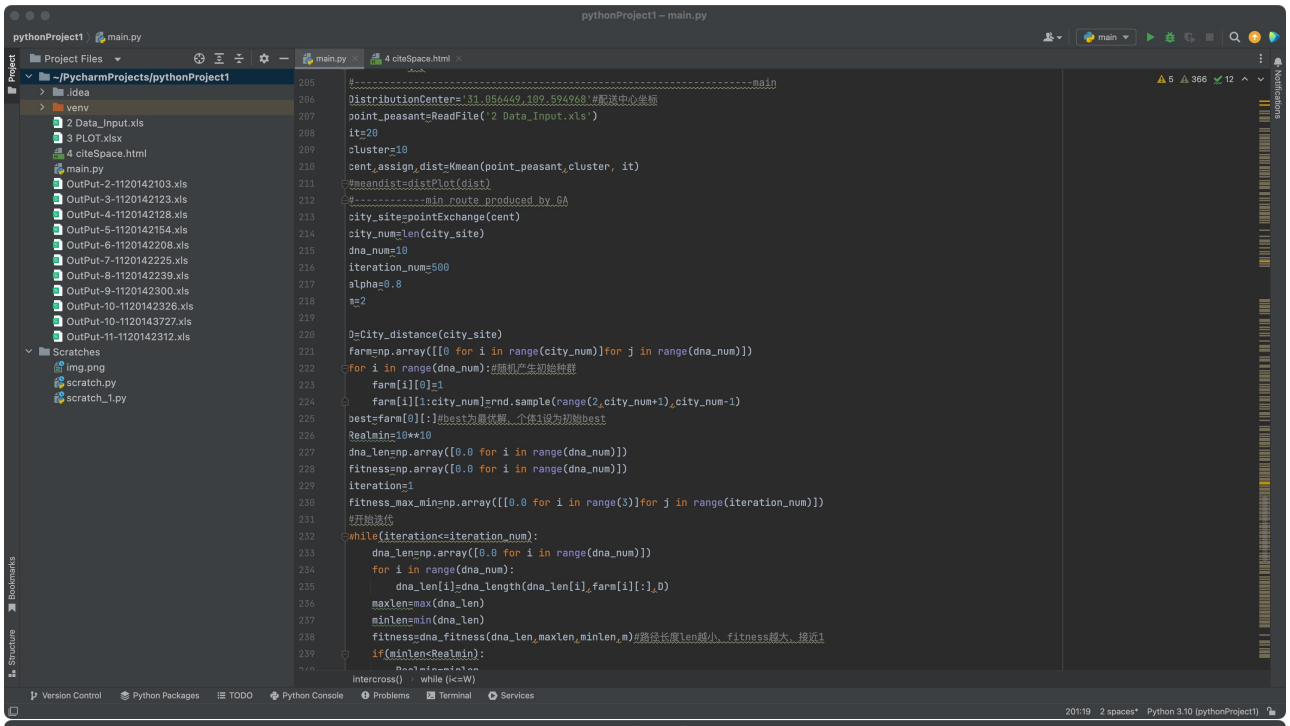
* 4.您可以接受脐橙运送到指定的脐橙聚集点然后由采购商统一收购吗?

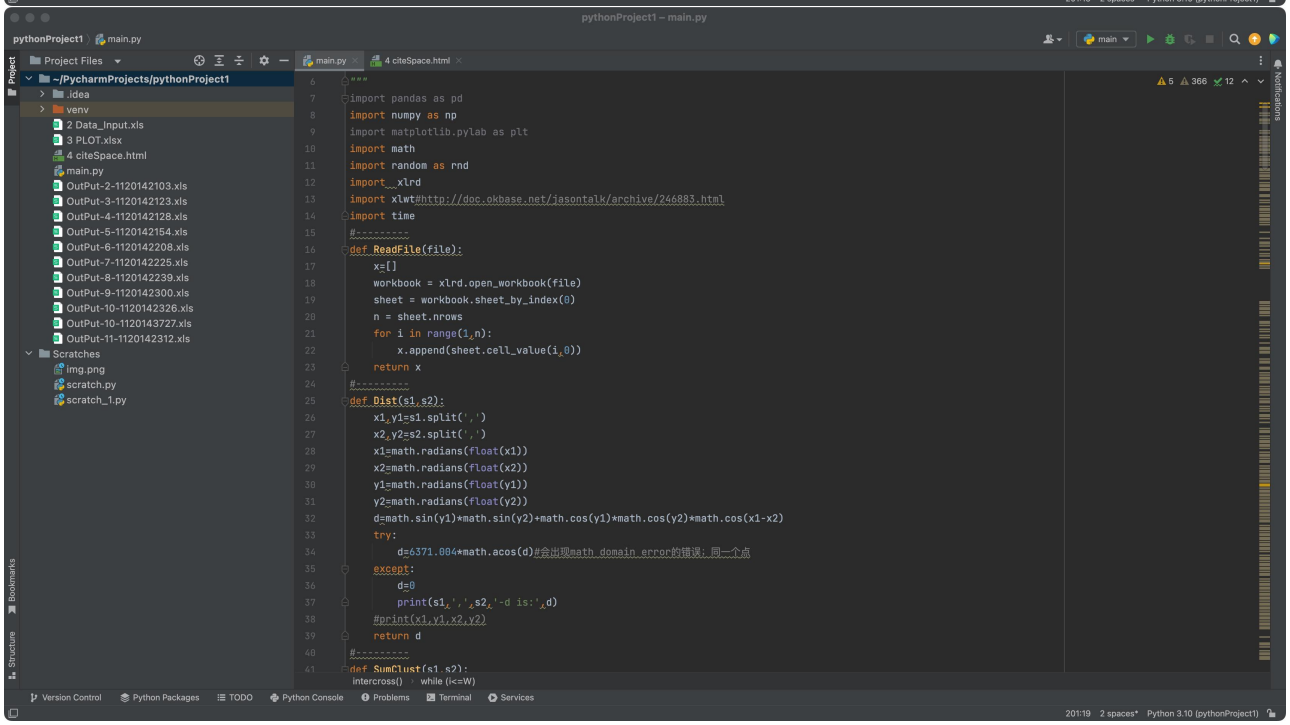
- ○ 是
- ○ 否

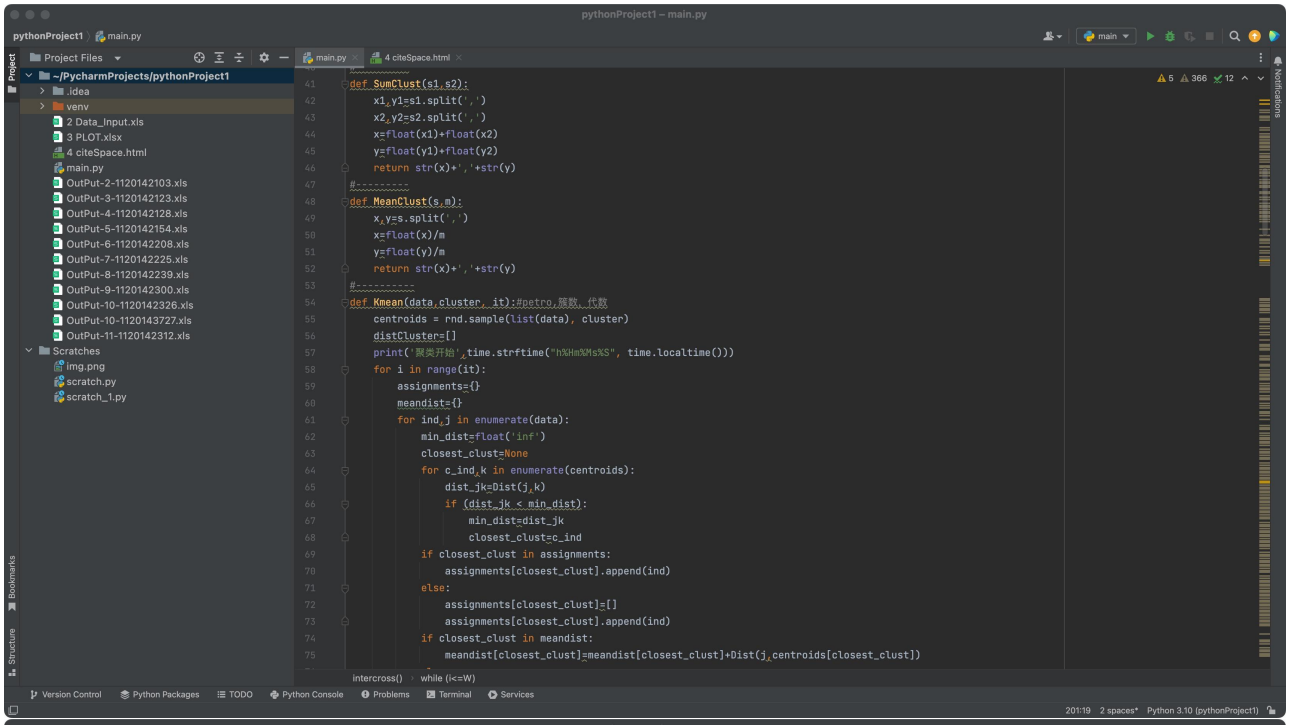
* 5.您可以接受脐橙聚集点距离您的果园的距离是多少?

- ○ 1km以内
- ○ 2–3km
- ○ 3km以上

Appendix 3. Partial software data






pythonProject1 – main.py
pythonProject1 › main.py
Project Files
~/PycharmProjects/pythonProject1
.idea
venv
2 Data_Input.xls
3 PLOT.xlsx
4 citeSpace.html
main.py
OutPut-2-1120142103.xls
OutPut-3-1120142123.xls
OutPut-4-1120142128.xls
OutPut-5-1120142154.xls
OutPut-6-1120142208.xls
OutPut-7-1120142225.xls
OutPut-8-1120142239.xls
OutPut-9-1120142300.xls
OutPut-10-1120142326.xls
OutPut-10-1120143727.xls
OutPut-11-1120142312.xls
Scratches
img.png
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scratch_1.py
main.py
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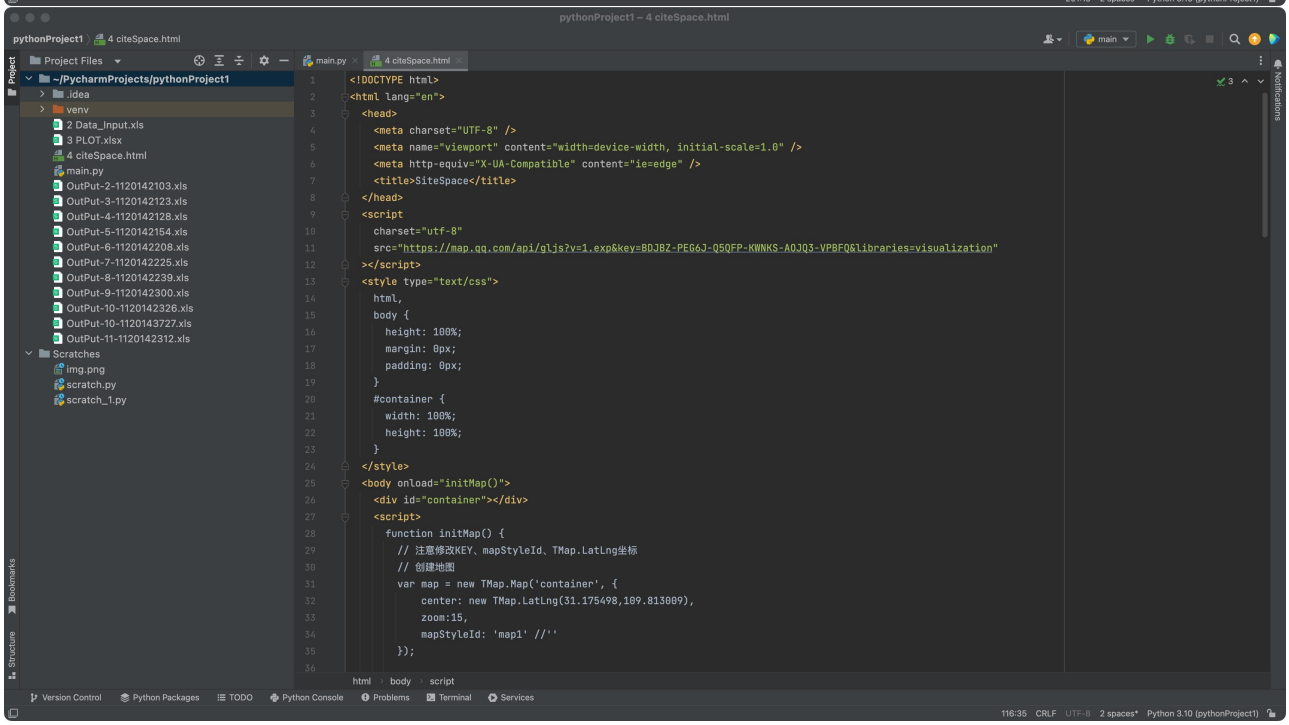
def SumClust(s1,s2):
x1,y1=s1.split(',')
x2,y2=s2.split(',')
x=float(x1)+float(x2)
y=float(y1)+float(y2)
return str(x)+','+str(y)
def MeanClust(s,m):
x,y=s.split(',')
x=float(x)/m
y=float(y)/m
return str(x)+','+str(y)
def Kmean(data,cluster, it):#petro,簇数, 代数
centroids = rnd.sample(list(data), cluster)
distCluster=[]
print('聚类开始',time.strftime("h%Hm%Ms%S", time.localtime()))
for i in range(it):
assignments={}
meandist={}
for ind,j in enumerate(data):
min_dist=float('inf')
closest_clust=None
for c_ind,k in enumerate(centroids):
dist_jk=Dist(j,k)
if (dist_jk < min_dist):
min_dist=dist_jk
closest_clust=c_ind
if closest_clust in assignments:
assignments[closest_clust].append(ind)
else:
assignments[closest_clust]=[]
assignments[closest_clust].append(ind)
if closest_clust in meandist:
meandist[closest_clust]=meandist[closest_clust]+Dist(j,centroids[closest_clust])
intercross() › while (i<=W)
Version Control
Python Packages
TODO
Python Console
Problems
Terminal
Services
201:19
2 spaces*
Python 3.10 (pythonProject1)


pythonProject1 – 4 citeSpace.html
pythonProject1 › 4 citeSpace.html
Project Files
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OutPut-10-1120142326.xls
OutPut-10-1120143727.xls
OutPut-11-1120142312.xls
Scratches
img.png
scratch.py
scratch_1.py
main.py
4 citeSpace.html
<!DOCTYPE html>
<html lang="en">
<head>
<meta charset="UTF-8" />
<meta name="viewport" content="width=device-width, initial-scale=1.0" />
<meta http-equiv="X-UA-Compatible" content="ie=edge" />
<title>SiteSpace</title>
</head>
<script
charset="utf-8"
src="https://map.qq.com/api/gljs?v=1.exp&key=BDJBZ-PEG6J-Q5QFP-KWNKS-AOJQ3-VPBFQ&libraries=visualization"
></script>
<style type="text/css">
html,
body {
height: 100%;
margin: 0px;
padding: 0px;
}
#container {
width: 100%;
height: 100%;
}
</style>
<body onload="initMap()">

<script>
function initMap() {
// 注意修改KEY、mapStyleId、TMap.LatLng坐标
// 创建地图
var map = new TMap.Map('container', {
center: new TMap.LatLng(31.175498,109.813009),
zoom:15,
mapStyleId: 'map1' //''
});
html › body › script
Version Control
Python Packages
TODO
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CRLF
UTF-8
2 spaces*
Python 3.10 (pythonProject1)