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Research on the Development of Intelligent Logistics Technology--Taking Community End-of-Life Delivery as an Example

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Abstract: The development of the Internet has brought new opportunities for the development of the logistics industry, allowing China's logistics enterprises to grow rapidly. With the establishment of more logistics companies, the domestic logistics industry has formed a huge logistics network that leads the world. Affected by the epidemic, contact-free intelligent distribution has become a new direction for the development of community distribution. With the rapid development and growth of the e-commerce field, the demand for logistics and distribution has increased dramatically, and shortening the distribution time of each transportation link and reducing labor costs have become the focus of the logistics field. This paper focuses on intelligent express cabinets, unmanned delivery vehicles, and drone distribution. It analyzes the development history and current state of these technologies. The paper highlights how intelligent technology improves supply chain efficiency. It also identifies the existing shortcomings and risks in the application of intelligent technology in logistics and distribution. Finally, it offers optimization suggestions.

Keywords: Intelligent express cabinets, unmanned delivery vehicles, drone distribution.

1. Introduction

The development of the Internet has brought new opportunities for the development of the logistics industry, allowing China's logistics enterprises to grow rapidly. With the establishment of more logistics companies, the domestic logistics industry has formed a huge logistics network that leads the world. Affected by the epidemic, contact-free intelligent distribution has become a new direction for the development of community distribution. With the rapid development and growth of the e-commerce sector, people's online shopping demand has increased dramatically, and the demand for logistics and distribution has increased dramatically. The cost of end-to-end logistics and distribution has become higher and higher, and shortening the distribution time of the end transportation link and lowering the labor cost have become the focus of the logistics field. The traditional way of home delivery service is no longer fully in line with the current demand, in this case, the emergence of intelligent express cabinets, unmanned vehicles, drones and other intelligent end logistics facilities for this series of problems provides an effective solution strategy.

This paper delves into the current situation and customer needs in logistics and distribution. It focuses on emerging intelligent terminal distribution tools such as intelligent express cabinets,

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unmanned delivery vehicles, and drones. The paper provides a detailed examination of how these technologies are actually used in the development process.

Through an in-depth analysis of the advantages and shortcomings of these intelligent terminal distribution methods shown in actual operation, this paper reveals its possible defects and potential risks. On this basis, this paper further proposes targeted optimization measures and improvement suggestions, aiming to promote the healthy and sustainable development of the logistics and distribution industry, enhance the efficiency and service quality of terminal distribution, and optimize the customer experience.

2. Overview of Intelligent Logistics Technology

The rapid development of Internet technology has injected a powerful impetus into the overall progress of the logistics industry, bringing unprecedented development opportunities for China's logistics enterprises, and enabling them to rise rapidly in a short period of time. As an increasing number of logistics companies have been established and put into operation, China has gradually built up a huge domestic logistics network with wide coverage, advanced technology and efficient services, which has a leading position in the global arena. However, the sudden epidemic has brought a huge impact on the global economy and has also given rise to new changes in the logistics and distribution model. In this context, contact-free intelligent distribution has become the new trend and development direction of community distribution to reduce direct contact between people and ensure public health safety.

Along with the rapid expansion of the field of e-commerce and growing, people's online shopping needs surge, which leads to a significant rise in logistics and distribution needs. This change causes the cost of end-to-end logistics and distribution to keep increasing. Ensuring service quality while shortening delivery times at the end of the transportation link is crucial. Reducing labor costs has become a key issue that the logistics industry needs to resolve.

In such a market environment, the traditional way of home delivery service has gradually revealed its limitations and is no longer fully adapted to the needs of modern logistics. Stage pick-up delivery obviously requires relatively high labor costs, and can not well meet customer demand. In the face of this challenge, intelligent express cabinets, unmanned delivery vehicles, drones and other intelligent terminal logistics facilities came into being, their emergence to solve the high cost of terminal distribution, low efficiency and other issues to provide a practical and effective solution. These intelligent logistics facilities not only improve distribution efficiency but also reduce operating costs through technological innovation, opening up a new path for the sustainable development of the logistics industry.

Intelligent courier cabinet is a newborn logistics equipment in recent years with the continuous development of the courier industry, is an all-weather 24-hour work of intelligent courier cabinet for courier delivery and sending self-service equipment, mainly installed in residential neighborhoods, colleges and universities and other places with high flow of people, is one of the important ways of modern logistics end distribution [1]. With the research and development of unmanned technology, unmanned delivery vehicles have also become a new way of logistics end distribution. Compared with high-speed unmanned vehicles and passenger-carrying unmanned vehicles, the safety design requirements of low-speed cargo-carrying unmanned vehicles are relatively low, so their design difficulty and manufacturing cost are significantly reduced. In the field of postal express terminal distribution, the application scenarios of small low-speed unmanned cargo vehicles are extremely matched with the characteristics of fixed scenarios, single tasks, and high demand, which makes it an ideal platform for many businesses to compete and show their strength[2]. There is a big difference in the maturity of the use of drones in various segments, compared with the application in aerial photography, agriculture, plant protection, disaster relief, surveying and mapping, the combination of

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drones and the logistics industry is not so mature, and it is in a high-speed growth period. China's Shunfeng put forward the idea of drone logistics as early as 2012 and carried out cargo test flights in 2013. Under the incentive of government support and broad market, SF, Meituan, Jingdong, and other express delivery and e-commerce platforms have tested the water and layout of drone logistics, relying on the patented drone technology of DJI and other technology companies, China's drone logistics is developing rapidly[3].

3. Application of Intelligent Technology in the Field of Logistics and Distribution

3.1. Intelligent Express Cabinet

The initial use of smart courier lockers originated in Germany, where logistics industry leader DHL played a central role and was responsible for the majority of smart locker deployments. In the United States, property and real estate developers buy smart express cabinets. They are funded by e-commerce and logistics companies. In Japan, nearly every building has intelligent express cabinets. These are either government-funded or built by property management firms themselves[1].

Since 2010, when China Post installed the first intelligent parcel delivery terminal, the smart courier cabinet industry has been developing rapidly in China, and the boom was ushered in between 2012 and 2015 due to capital pursuit, forming a market pattern in which courier companies, e-commerce platforms and independent third-party enterprises compete together. China Postal Express Yi, Feng Chao express lockers and other aimed at strengthening the control of terminal distribution, Jingdong, Suning and other e-commerce platforms focus on improving customer experience, third-party enterprises strive for market share. National policies are continually promoting industry development. The number of intelligent express cabinets has significantly increased. The rate of express parcels being placed into cabinets has also risen. In 2019, the number of intelligent express cabinets reached 406,000. The rate of express into the cabinet grew from 1% in 2014 to 10.5% in 2019. The epidemic has further promoted market development.

Compared with traditional distribution methods, intelligent express cabinet distribution has a variety of significant advantages. First of all, the intelligent express cabinet provides flexible scheduling. It is able to realize all-weather 24-hour uninterrupted service, allowing customers to self-service in any free time to send or pick up the courier. In addition, the location of the intelligent express locker is fixed, avoiding the problem of inaccessibility of couriers in certain residential areas, companies or schools. Secondly, the intelligent express cabinet improves the security of the delivery. Each express is stored in an independent cabinet compartment, effectively protecting the customer's express and personal privacy security. Customers through the pickup verification code or face recognition technology to receive the courier, effectively preventing others from accidentally taking or stealing the courier. Finally, the intelligent express cabinet high degree of intelligence, easy to operate. Customers do not need to have direct contact with the courier to self-service pickup, which is particularly important during the epidemic, helping to protect the personal health and safety of customers[2].

Intelligent express cabinet as a new type of logistics and distribution solutions, has been rapidly popularized in many cities in China. At present, intelligent express cabinets are mainly distributed in first-tier and new first-tier cities, especially in densely populated and economically developed areas, such as Beijing, Shanghai, Guangzhou, Shenzhen, etc., the coverage rate of intelligent express cabinets is relatively high. These express cabinets are usually set up in residential neighborhoods, office buildings, commercial centers, subway stations and other convenient locations, so as to facilitate users to send and receive express delivery at any time.

With the continuous maturity of the technology and the gradual development of user habits, the number and types of intelligent express cabinets are also increasing. Some well-known courier

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cabinet brands, such as Feng Nest, Courier Easy, Nest, etc., has laid a large number of courier cabinets across the country, forming a more complete courier cabinet network. The popularization of intelligent express cabinets not only improves the efficiency of express delivery, but also provides consumers with a more convenient and safe express service experience.

3.2. Unmanned Delivery Vehicle

In the field of postal express terminal distribution, the application scenario of small low-speed unmanned delivery vehicles matches very well, characterized by a fixed environment, specialized tasks, and high demand, which makes them an important platform for competition among various businesses. As an industry pioneer of low-speed unmanned vehicles, Cainiao Network focuses on promoting its unmanned delivery service in university campuses with relatively closed environments, concentrated business and high acceptance of new things. Cainiao Stage has been operating in these campuses for quite a long time, and its “Little Donkey” unmanned vehicle has gradually taken over the delivery tasks in the campuses, which has been widely recognized by the students. During the Tmall “Double 11” shopping festival in 2022, the number of unmanned vehicles in more than 400 colleges and universities increased to more than 700, twice as many as the previous year, and the delivery volume exceeded 4 million pieces. Jingdong Logistics, on the other hand, plans to continue to develop and put into use thousands of intelligent express vehicles in the next two to three years to expand the coverage of unmanned delivery services. China Post, on the other hand, has partnered with Baidu Apollo Intelligent Technology to develop unmanned delivery vehicles suitable for delivery within neighborhoods, aiming to make them a new force in neighborhood logistics and distribution[3]. By the end of 2021, the volume of express delivery business in China had reached 108.3 billion pieces, while the size of the unmanned delivery market exceeded RMB 300 billion. Unmanned distribution shows significant value in ensuring smooth supply, providing contact-free services, and building new and beautiful digital service scenarios, and it will undoubtedly become an emerging hot area for epidemic prevention and control and promoting production[4].

Unmanned delivery vehicles can work 24 hours a day, are not limited by working hours, and can operate under different weather and terrain conditions, such as rain, snow, or nighttime, which can significantly improve delivery efficiency. In the long run, unmanned delivery vehicles can reduce the reliance on human delivery personnel, thereby reducing labor costs. Unmanned delivery vehicles enable contact-free delivery. This reduces the risk of virus transmission. They offer flexible delivery services to meet customer needs. Customers can book delivery times. This protects the safety of consumers and delivery personnel. It also improves customer satisfaction significantly. Unmanned delivery vehicles can collect a large amount of distribution data in real time, and by networking and analyzing this data, companies can optimize distribution routes and logistics management.

3.3. Drone Delivery

Amazon.com pioneered the concept of drone delivery and announced its plans for a drone delivery service in 2013. It then actually demonstrated the first delivery of a drone for express delivery in October 2016, with the entire process from order to package delivery taking just 13 minutes. [5] Its from receiving Google, UPS and other companies that have also launched their own drone logistics programs. Under the support and guidance of policies, these enterprises have developed rapidly and maintained a leading position in the global arena. At the same time, European countries are also actively promoting the application of drones in the field of logistics, and the global drone logistics industry is growing rapidly as a result[6].

In China, Shunfeng began to conceptualize drone logistics as early as 2012 and carried out cargo-carrying test flights in 2013. Thanks to the government's supportive policies and the promotion of a

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broad market, express delivery and e-commerce platforms such as SF, Meituan, and Jingdong have begun to explore and layout drone logistics. Relying on the patented drone technology provided by DJI and other technology companies, China's drone logistics industry is making rapid progress. Domestic drone logistics and distribution is currently in the development and growth stage, and has entered the trial operation mode. Therefore, domestic research on drone logistics and distribution is still mainly based on drone technology and logistics industry. Yang Xiaojie and Zheng Wei analyzed the operation mechanism of quadcopter UAVs from the motion principle of UAVs and constructed a set of urban logistics simulation system. Through the experiments of drone logistics and distribution, they found that drone distribution shows better distribution results compared with traditional distribution methods[7].

Drone distribution has obvious advantages in improving efficiency, reducing costs, and enhancing safety. In urban environments, drones can quickly traverse congested ground traffic and can significantly reduce delivery time. It also helps to reduce the pressure of ground traffic and reduce traffic congestion caused by delivery vehicles. In hard-to-reach areas such as mountains and waters, drones are compact and able to enter narrow spaces, making them suitable for a wide range of complex environments.

In a blue paper released in 2018, Morgan Stanley predicted that the market size of the global urban air transportation industry will reach $1.5 trillion by 2040, with half of the market share going to the aerial automated delivery sector. According to the Shenzhen UAV Industry Association, the size of the domestic UAV market will increase to RMB 160 billion by 2024, of which the market size of UAVs for express logistics will be about RMB 30 billion[6]. Drone delivery can significantly improve the efficiency of logistics and achieve fast and accurate delivery of goods, especially in areas with inconvenient transportation or complex geographic environments. With the continuous progress of technology, the cost of drone delivery is gradually decreasing, making large-scale commercial operation possible. Finally, the gradual improvement of drone regulations globally has provided a guarantee for the legalization and standardization of drone delivery. As a result, the drone delivery market is expected to witness rapid growth and become an important force in the future logistics and distribution sector.

4. Shortcomings and Pitfalls

Although the popularization of intelligent express lockers has achieved remarkable results, the coverage rate of intelligent express lockers still needs to be improved in some second-tier and following cities and rural areas. The popularization of these areas faces many challenges, such as investment costs, operation and maintenance, and user acceptance.

Unmanned delivery vehicles and drone delivery are not widely used yet. Drone delivery has great potential, but it faces several challenges. The technology is not fully mature, which limits drone performance and reliability. Strict regulations restrict where and how drones can operate. High costs mean that drone delivery's economic benefits are not yet optimized. In addition, inadequate infrastructure has hindered the establishment of drone delivery networks, and a lack of professional operators has constrained the expansion of drone delivery services. Safety concerns are a major focus for the public and regulators. Limited public acceptance is hindering the spread of drone delivery. The absence of uniform technical standards is causing market confusion. Unclear business models mean that the commercial viability of drone delivery remains unexplored.

These challenges need to be addressed together through technological innovation, regulatory updates, infrastructure development and market education.

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5. Optimization Recommendations

5.1. Increase Investment in Scientific Research and Promote Technological Optimization and Innovation

In order to improve the performance and user experience of the intelligent express locker, the R&D team should be committed to its continuous upgrading and improvement. This includes solving technical problems that occur in the pickup process and strengthening after-sales service to ensure that problems encountered by users in the process of use can be solved in a timely and effective manner. In addition, the team is also gradually optimizing the form factor of the smart express cabinets. By adjusting the size of the compartments and increasing the storage weight, the application efficiency of the smart express cabinets has been significantly improved to better meet the needs of different users and different types of express delivery. At the same time, the development and promotion of frozen and refrigerated intelligent express cabinets can be developed to meet the market for fresh, frozen food and other special goods distribution needs. Such innovation will further broaden the application scenarios of intelligent express cabinets, providing users with more comprehensive and personalized services.

For unmanned delivery vehicles, more advanced sensors are used to improve the vehicle's ability to perceive the surrounding environment. Decision-making algorithms are developed and optimized, and efficient communication protocols and network architectures applicable to unmanned delivery vehicles are researched and developed to improve the vehicles' ability to cope with complex traffic conditions.

Currently, the full-load endurance of drones is about 45 minutes, and sometimes even more than 1 hour, which is sufficient to cope with most short-distance and small-volume distribution tasks, but there are limitations for the transportation of goods with large weights or quantity, and also insufficient to meet the demand for high-frequency and small-volume end-of-line distribution. [8] Technicians need to improve the load capacity of drones while designing stronger and lighter fuselage structures to balance load and flight performance to meet the distribution needs of different types of goods.

5.2. Improve the Regulatory System

In the current field of campus express delivery, both express delivery companies and e-commerce platforms, have not yet developed a unified industry standard to guide the use and management of intelligent express cabinets. In order to realize the full popularity of intelligent express lockers, the development of clear standards is particularly important. The development and implementation of these standards, it can ensure the rational use of intelligent express lockers, improve the service quality of campus express delivery, and also provide norms and guidance for the development of the industry.

In order to promote the development of the unmanned delivery vehicle industry, a comprehensive system of standards should be established, including vehicle specifications, performance standards and safety norms. This involves several specific aspects. First, it includes establishing a standard system for unmanned delivery vehicles. Second, it entails setting vehicle indicators, which include the size, speed, power, and load of these vehicles. Finally, it involves formulating standards for road testing and product safety of unmanned delivery vehicles.

At the same time, clarify the main body responsible for unmanned delivery vehicles, study the type and amount of insurance for unmanned delivery vehicles, and explore the safety regulation model applicable to unmanned delivery vehicles. Through these measures, the safety and compliance

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of unmanned delivery vehicles during operation can be ensured, providing a solid legal and institutional foundation for the development of the unmanned delivery vehicle industry.

6. Conclusion

Through the research of intelligent express cabinets, unmanned vehicles and drones, this paper summarizes and analyzes the development history and status quo of the three technologies. It is found that the application of intelligent technology has improved the efficiency of the supply chain. At the same time, it also found the shortcomings and hidden dangers of these technologies. This study provides suggestions for intelligent logistics optimization in order to promote the healthy and sustainable development of this field.

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