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RESEARCH ON UAV IN LOGISTICS DISTRIBUTION

Introduction

1. As we all know, in 2020, the COVID-19 that swept the world disrupted the world, many industries had to shut down, and some enterprises' original work plans and development strategies were suspended, causing serious economic losses. During the epidemic prevention and control period, facing the pressure of medical supplies in hospitals and communities during isolation and people's demand for daily necessities during self-isolation at home, the unmanned delivery system has highlighted its important role in the "last mile" terminal delivery service chain because of its "high efficiency" and "zero infection". Going out less, not focusing, a large number of shopping from offline to online, and contactless delivery are important drivers for the growth of e-commerce and unmanned delivery mode express delivery against the trend.

2. The difficulty of "last mile" distribution is still severe. In large and medium-sized cities in China and Ukraine, with the popularization of "Cai niao Post Station" and "Feng chao Express Cabinet" and Ukraine's "Нова пошта", the distribution efficiency has been greatly improved. However, problems such as high end-of-logistics distribution costs, high workload of express employees, substandard means of transportation, and lack of safety guarantees have made it difficult for the entire express industry to recruit and retain workers, and the cost has soared. For fresh goods and other urgent items in urban distribution, it is also difficult to guarantee the time. After the express mail enters areas such as community buildings, it is relatively inconvenient to navigate and find the route, resulting in a decrease in delivery efficiency. At the same time, high-frequency delivery and all-weather delivery are also severe challenges to the rider's energy and time.

3. UAV terminal distribution is a key measure to solve the shortage of logistics labor force. In Ukraine, according to national population forecasts, by 2030, the proportion of Ukraine's population over the age of 60 will exceed 26 %, and the proportion of the population over 65 will account for 20 %. According to the forecast previously released by the United Nations Population Department, by 2050, Ukraine’s population over the age of 60 will account for 37% of the total population, and the gradual aging of the population has become one of the most pressing social and demographic issues in modern Ukraine. In China, as of the end of 2021, the population aged 60 and over will reach 267 million, accounting for 18.9 % of the total population, and it is continuing to grow at the fastest rate in the world. "China Development Report 2020: Development Trends and Policies of China's Population Aging" predicts that the period of the "14th Five-Year Plan" is a critical period for China to build a socialist modern power.

The express delivery industry has always been a labor-intensive industry. With the disappearance of the demographic dividend, the logistics development model relying on human resources will be unsustainable, and it will not be able to meet the needs of the increasingly rapid development of the logistics industry. The use of artificial intelligence technology to carry out drone distribution at the end of logistics is an effective measure to deal with the aging population and solve the labor shortage.

4. The maturity of artificial intelligence technology has become the engine of drone delivery. With the explosion of mobile Internet technology and cloud computing technology, a historically unimaginable amount of data has been accumulated, which provides sufficient material and motivation for the subsequent development of artificial intelligence. The rapid development of artificial intelligence technology represented by deep neural network has greatly crossed the "technical gap" between science and application, ushering in a new climax of explosive growth. As the core force of a new round of technological revolution and industrial transformation, artificial intelligence is promoting the upgrading of traditional industries. Intelligent

computing can reconstruct the operation process of cargo transportation. With the development of artificial intelligence, the cargo transportation process may be decomposed into several parallel processes. In addition to the interconnection of equipment, artificial intelligence may also be applied to vehicles and equipment. Vehicles can automatically arrange loading and unloading time with the distribution center, and automatically arrange repair time with the maintenance center. Within the scope of the cargo transportation system, using artificial intelligence technology, many activities such as automatic decision-making, automatic detection, and automatic repair can be automatically sorted according to the process. These activities can also not enter the cloud computing center platform, greatly improving the system computing efficiency and responsiveness.

Determine the scope of UAV logistics distribution

1. Determination of drone delivery weight. The damage caused by manual delivery has always been a major problem for logistics companies. Statistics show that the damage rate is related to the weight of the express. Most of the damage occurs within the range of 1.5–10 kg, especially the largest number of damages occurs in the range of 3–10 kg, accounting for more than 50 %. The safety of express mail is greatly improved by drone delivery, so the most damaged express mail in the range of 3~10 kg is selected as the main delivery target.

2. Determination of drone delivery distance. The delivery range of ordinary express delivery is small, and it is customary to call the delivery at the end of the "last mile" delivery. The delivery range in the city is about 1 km, and the range in rural areas is much larger. One courier can cover several administrative villages. At present, the range of drones with relatively mature technology can reach about 20 km, and the single range can reach 10km, which can expand the range of terminal delivery from 1km to 10 km. The expansion of the distribution area can greatly reduce the number of sorting centers, which is conducive to the centralized development of manpower and material resources and the configuration of intelligent facilities and equipment, adapting to the intelligent transformation of the logistics industry.

3. Determination of drone delivery objects. With the improvement of people's living standards, everyone's requirements for quality of life are getting higher and higher. Online shopping for green and pollution-free fresh products has become the norm, but fresh food distribution has always had problems of poor timeliness, low efficiency, and high cost. UAV delivery has the characteristics of convenience, speed, high safety, and long delivery distance. Therefore, starting with fresh goods that have high time requirements, customers can complete the order from online to delivery to the door within 30 minutes, ensuring the freshness and timeliness of the goods; secondly, consider the delivery of urgent and valuable items.

4. Positioning of drone delivery areas. UAVs have the characteristics of fast speed and wide delivery area. Firstly, they deliver valuable, urgent and fresh items to rural areas, and secondly, they deliver urgent heavy items and fresh items in bustling and congested cities.

According to different needs, the load capacity and battery life of domestic and foreign mainstream logistics drones are shown in Table 1.

Table 1

Load capacity and battery life of domestic and foreign mainstream logistics drones

Model	Load capacity/kg	Voyage/km
DHL((third generation Parcelcopter)	2.2	8.3
Amazon (2nd generation Prime Air)	2.2	24
China Post (Jieyan TR5)	5	20
SF Express (XAIRWAY)	10	20
Jingdong (Y–3)	10	20

UAV distribution process and related technical equipment

1. UAV delivery process (Fig. 1)

2. UAV information technology. Background information system: receive and process order information and confirm order delivery status, control UAV order scheduling queue according to order processing results and feed back the goods information of the order, control UAV delivery order scheduling queuing, and plan the optimized path of UAV from distribution center to target delivery location.

Cloud database: communicate with the background information system to realize data storage and call. The cloud database includes a 3D geographic information database and an order information database. The 3D geographic information database stores the location information model (3D) of each target delivery location, drone route, and flight area.

UAV flight control center: The coordinate position and flight parameters of each UAV can be clearly seen through the large screen of the dispatch center. The operation dispatching center can comprehensively manage and monitor the flight routes, the performance and status of delivery drones, and order data. With the scheduling based on the flight control center, it will realize the automatic loading, take-off, cruise, landing, unloading, distribution, and return flight of drones covering the entire process of logistics distribution, which can ensure flight safety and convenient and accurate delivery.

Face recognition system: The face recognition system takes face recognition technology as the core, uses computer image processing technology to extract portrait feature points from video, and uses the principle of biostatistics to analyze and establish a mathematical model. It is used to identify customers with drones, so as to prevent the goods from being taken away by criminals and cause problems with the safety of goods.

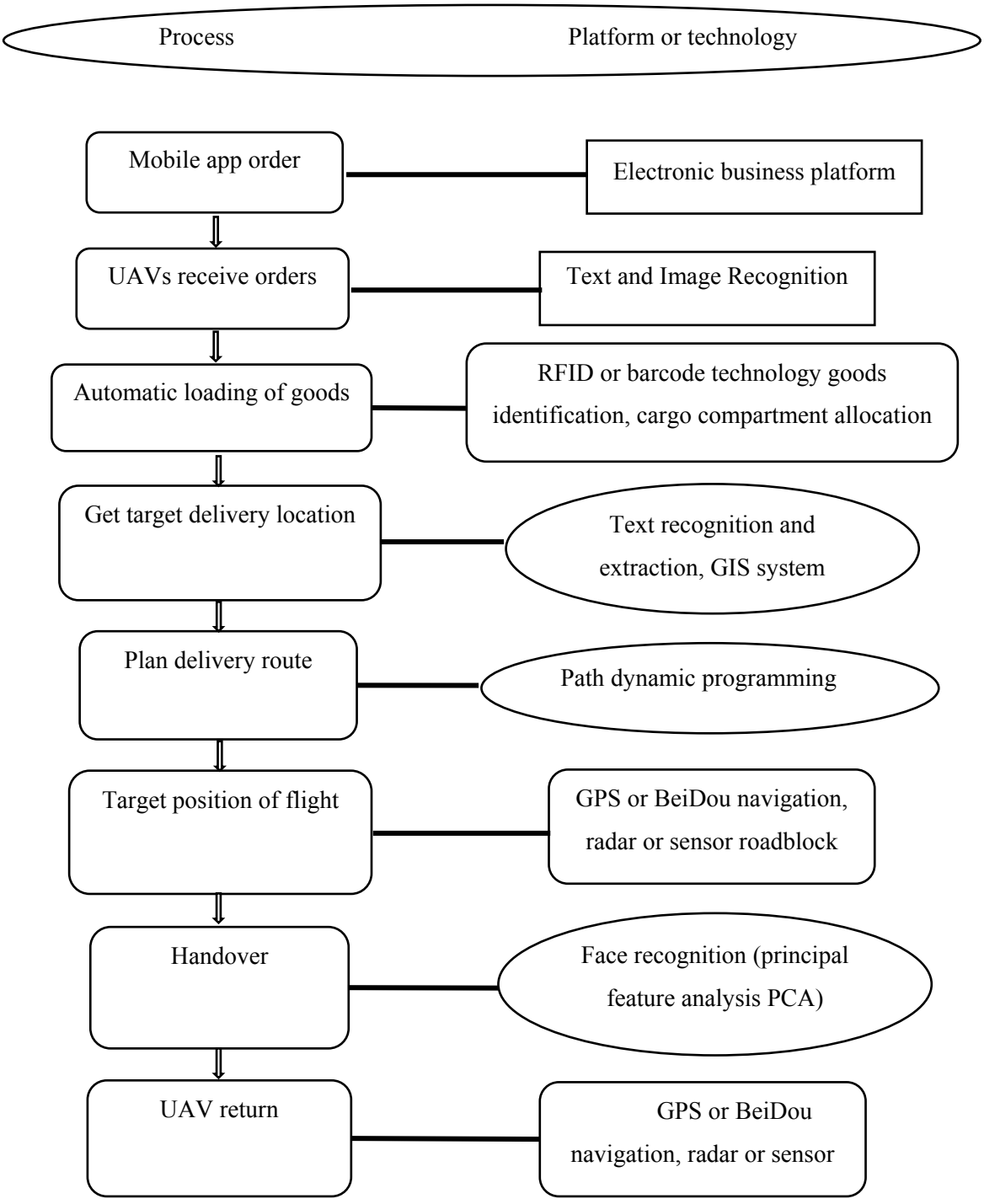

Fig. 1. UAV delivery process and technology matching diagram

UAV obstacle avoidance system: used to successfully detect and avoid static and dynamic obstacles in the flight path to avoid collision accidents.

User Terminal App: Place orders for drone delivery and confirm delivery information.

3. UAV-related devices. UAV receiving device: used for UAV to identify the target delivery location, receive the target goods delivered by the UAV at the target delivery location, and feed back the receiving status of the goods to the background information system.

UAV: Obtain the target delivery location and delivery time, automatically load the target goods and start the delivery flight of the drone at the delivery time, deliver the target goods to the target delivery location according to the track path, and deliver the target goods to the outdoor home improvement receiving device, and then return; or start the delivery flight of the drone at the delivery time, fly to the target delivery location according to the track path, load the target goods and return; the battery of the drone is the bottleneck of battery life.

Problems and Countermeasures in the Development of UAV Distribution

Despite the rapid development of UAV technology, it has not been widely used in UAV distribution. There are mainly the following problems, such as poor endurance, airspace restrictions and distribution safety issues.

1. The problem of poor endurance of drones. At present, the lithium batteries used in drone batteries in the world have the characteristics of poor battery life and unstable power supply. The battery life is mostly 30 to 60 minutes, which cannot meet the requirements of drones for long-distance delivery of goods, and has become a key issue in the logistics and distribution of drones. In view of the theoretical bottleneck that lithium batteries are limited by their energy power density and cannot achieve higher multiples, it is imminent to change the power system of drones. Recently developed fuel cells using hydrogen as energy have the advantages of low noise, low pollution, high energy efficiency, and long life. However, hydrogen fuel cells also have certain shortcomings. The discharge power is low, and the high energy required for aircraft take-off is not easy to meet. This shortcoming can be met by lithium batteries. In this way, the high energy density of the fuel cell can be utilized. It is used for long-term discharge during the flight. With the help of the high power density of the lithium battery, the high-power discharge during the take-off stage enables the drone to take off smoothly. With complementary advantages, lithium batteries and fuel cells can be combined to form a hybrid system to achieve the effect of not only improving the instantaneous power of the drone, but also prolonging the battery life.

2. Airspace restrictions for UAV delivery. In recent years, with the maturity of artificial intelligence technology, the application scope and development momentum of drones are rapid, and the application in the field of logistics distribution is also becoming more and more extensive. As a new type of distribution tool, it can greatly improve the distribution efficiency, but there are still hidden dangers in its operation. In view of civil aviation security, national military secrets, and information security of sensitive government departments, the flying airspace of civilian drones is restricted. In order to effectively promote the development of UAV logistics and distribution, it is recommended to further expand the pilot reform of low-altitude airspace management, and promote the establishment of mechanisms such as the classification of low-altitude airspace, the construction of low-altitude air route networks, and the guarantee of cross-city general aviation flight services. Select areas with a good general aviation industry foundation and great development potential to set up inter-provincial low-altitude flight routes to realize short-distance transportation, cross-regional delivery of general aviation aircraft, and regular flights in transition. Simplify the flight approval process, optimize the approval process, and shorten the approval time limit.

3. Drone delivery safety issues. Safety issues Here we mainly discuss the safety of the drone itself, the safety of the express delivery, and the safety of the public's personal and property safety.

- The safety of the drone itself. When drones are used for logistics and distribution, they are remotely controlled. It is impossible for the operator to fully grasp all the situations. The drones may be attacked intentionally or unintentionally, such as birds, slingshots, etc., or even intercepted by criminals. During the flight, encountering strong winds, heavy rains and other weather will also threaten the safety of drones. For the situation where UAVs are attacked, external attacks can be reduced or avoided by designing hostile control and attack avoidance devices for UAVs. For the safety of drones caused by weather, it can be improved from the selection of drone materials and streamlined design to meet the needs of normal logistics and distribution in windy and heavy rainy weather.
- Express shipment security. The light-duty UAV can deliver one courier at a time by grabbing, which can avoid manual assistance in placing the goods. After reaching the destination, the UAV can also directly place the courier at the designated location, with a high degree of automation, which can effectively improve

the delivery efficiency. However, the disadvantage of this method is that there is a risk of the goods falling during the operation of the drone, the goods will be damaged, and it will cause hidden dangers to public safety. At present, in order to prevent the express delivery from falling, most logistics drones use express boxes to carry the express delivery, so as to prevent the express delivery from falling during the flight of the drone, the items are broken, and it also prevents harm to people and objects on the ground.

- Public personal and property safety. In terms of public safety, due to the fact that logistics drones may deviate from the route and fly randomly during the delivery process, it will affect the aviation flight; during the flight, there will be mechanical failure, insufficient battery power, encountering obstacles and other accidents, which will cause serious impact on the ground personnel, buildings and objects, and affect the safety of the public's personal and property safety. In order to prevent the occurrence of public safety of drones, geo-restriction is first carried out. For no-fly zones such as airports, military bases, and government departments, the flight area of drones is restricted and cannot be entered. If the UAV encounters an important mechanical failure, or the remote control fails, the UAV is equipped with an emergency landing device to ensure that it can land safely. When the battery power is low and the drone completely loses power, the drone should be equipped with a parachute to reduce the impact on the ground and ensure the safety of the drone, cargo, and people and objects on the ground. In addition, it is necessary to equip the UAV with a device that can still be found by positioning in a powerless state.

Conclusions

With the further maturity of artificial intelligence technology and the further increase of labor costs, the development of smart logistics is imperative. Unmanned logistics is an effective means to solve the "last mile" terminal distribution. Unmanned aerial vehicle is an effective measure to deal with the low delivery efficiency of urban congestion, and it is also an effective way to solve the high cost of delivery in remote areas. In the near future, the poor battery life of drones, airspace restrictions and delivery safety issues will be resolved, which will be the beginning of widespread application of drone delivery.

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Лі Хаоян

ДОСЛІДЖЕННЯ БПЛА В ЛОГІСТИЧНОМУ РОЗПОДІЛІ

Ця стаття бере за відправну точку епідемію COVID-19 і аналізує труднощі доставки дронів в «останню милю» в контексті різкого старіння населення. Доставка «останньої милі» означає, що після того, як клієнти зроблять покупки через електронну комерцію, придбані товари доставляються до пункту розповсюдження, а потім товари доставляються клієнту з сортувального центру за допомогою певного транспортного засобу для забезпечення обслуговування «від дверей до дверей». «Остання миля» розподілу не є справжньою милею, а означає відстань від логістичного сортувального центру до клієнта та процес доставки товару до клієнта за допомогою засобів транспортування. Через те, що це невелика відстань, це, як кажуть, називається кілометровою доставкою. Ця дистрибуція на короткі відстані є останньою ланкою всієї ланки логістики та єдиною ланкою, яка безпосередньо контактує з клієнтами віч-на-віч, що має велике значення. Зі зрілістю технології штучного інтелекту з'явилася розповсюдження БПЛА. У цьому документі викладено масштаби

розповсюдження, процес розповсюдження та технічне обладнання поточного розвитку розповсюдження БПЛА, аналізуються проблеми витривалості БПЛА, обмеження повітряного простору та безпеки розповсюдження, а також пропонуються відповідні контрзаходи. Інтелектуальні обчислення можуть реконструювати процес логістики.З розвитком штучного інтелекту логістичний процес може бути розкладений на кілька паралельних процесів. У межах логістичної системи за допомогою технології штучного інтелекту багато дій, таких як автоматичне прийняття рішень, автоматичне виявлення та автоматичний ремонт, можуть бути автоматично сортовані відповідно до процесу. Ці дії також не можуть входити в платформу центру хмарних обчислень, що значно покращує ефективність обчислень системи та швидкість реагування. Завдяки легкій вазі та високій швидкості БПЛА можуть уникати міських заторів і перетинати спеціальні місцевості, такі як гори та озера. Використання БПЛА може скоротити час доставки та зменшити витрати на логістику, таким чином роблячи його логістичний розподіл все більш і більш широко використовуваним. В останні роки через сильну заразність епідемії нової корони безконтактна доставка привернула широку увагу, що сприяло просуванню та застосуванню зовнішніх логістичних засобів доставки, таких як дрони, дрони та роботи-доставники.

Ключові слова: БПЛА; Термінальна доставка; остання миля; оптимізація шляху

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This article takes the COVID-19 epidemic as the starting point, and analyzes the difficulty of delivering drones in the "last mile" in the context of a severely aging population. The last mile delivery means that after customers shop through e-commerce, the purchased items are delivered to the distribution point, and then the goods are delivered to the customer from a sorting center through a certain means of transportation to achieve door-to-door service. The "last mile" of distribution is not a real mile, but refers to the distance from the logistics sorting center to the customer, and the process of delivering the goods to the customer through the means of transportation. Because it is a short distance, it is called one-kilometer delivery as the saying goes. This short-distance distribution is the last link of the entire logistics link and the only link that directly contacts customers face-to-face, which is of great significance. With the maturity of artificial intelligence technology, UAV distribution has emerged. This paper expounds the distribution scope, distribution process and technical equipment of the current development of UAV distribution, analyzes the problems of UAV endurance, airspace restrictions, and distribution safety, and puts forward corresponding countermeasures. Intelligent computing can reconstruct the logistics operation process. With the development of artificial intelligence, the logistics process may be decomposed into several parallel processes. Within the scope of the logistics system, using artificial intelligence technology, many activities such as automatic decision-making, automatic detection, and automatic repair can be automatically sorted according to the process. These activities can also not enter the cloud computing center platform, greatly improving the system computing efficiency and responsiveness. Because of its light weight and fast speed, UAVs can avoid urban traffic congestion and can cross special terrains such as mountains and lakes. The use of UAVs can shorten logistics delivery time and reduce logistics costs, so that its application scope of logistics distribution is getting wider and wider. In recent years, due to the strong contagiousness of the new crown epidemic, contactless distribution has attracted widespread attention, which has promoted the promotion and application of cutting-edge logistics distribution tools such as drones, drone vehicles and delivery robots.

Keywords: UAV; terminal delivery; last mile; path optimization.

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