Study of Intelligent Unmanned Aerial Vehicle Delivery System

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Abstract. In view of the terminal distribution link that has several shortcomings in the whole logistics chain such as the highest cost, the lowest efficiency and the most serious pollution, a kind of intelligent machine nest hub in this thesis, which carries out the analysis on the working principle of the machine nest hub system. In the meantime, the structure composition and control system of the machine nest hub is also designed. Based on the system designed in this thesis, it can enlighten the uninterrupted unmanned and automatic operation of the package delivery assembly end of UAV, and is able to handle the huge growth of orders in an effective way, so as to make the express delivery of UAV become more efficient and convenient.

Keywords: UAV distribution, intelligence, machine nest hub, terminal distribution.

1. Introduction
With the rapid development of the logistics industry, intelligent distribution has important practical significance. However, due to the limitations of artificial intelligence applications and technology promotion, there are still few reports on product materials related to UAV distribution and real-time information processing at home and abroad. Therefore, research on UAV-based intelligent distribution systems is particularly urgent.

Currently, mechanization, automation and intelligent technologies have been integrated into and spread in the logistics industry, which is an irreversible trend. The use of UAV to deliver packages has become the next thought-provoking topic in smart logistics. Parcel delivery by means of UAV is conducive to the development of "the specialty of 'highway in the sky'" and the establishment of the efficient three-dimensional logistics system of "heaven and earth fusion". At present, main processes of using UAV to deliver packages are as follows: Loading, taking off, cruising, landing, unloading, distributing, and returning. Loading was mainly by manual works. The package assembly process requires a lot of manual works. However, the demographic dividend will keep receding. The traditional manual work would result in a bottleneck of the development of UAV in the logistics industry, which cannot meet the needs of logistics enterprises to reduce costs and increase efficiency. Also, package by manual works has some disadvantages, such as low intelligence, long time of single ground service, low efficiency operation and difficult to realize scale. To this end, the need for a deeper level of automated end logistics operation is obvious. Thus, it is of paramount research value to realize the efficient and intelligent preparation of express parcels to UAVs for express delivery. In this paper, an intelligent nest center system based on UAV is designed and developed, which contributes to
dealing with the problem that traditional manual assembly mode restricts the large-scale and efficient application of UAV delivery effectively, saving UAV delivery costs and improving delivery efficiency, thus providing a new solution for the large-scale use of UAVs for parcel delivery in the industry in the future.

2. The Structure and Working Principle of the System

The three-dimensional structure design is adopted by the machine nest center system whose core modules mainly include: package distribution and load module, correcting device of top position, quick replacement of battery module and UAV parking module (including AGV). The system is connected with the intelligent distribution center existing and being widely used in express transportation industry. The packages shall be distributed in the distribution center, and then transported to the machine nest hub by an external conveyor belt. After that, the packages shall be loaded in multi-cabin logistics UAV carriers through a mechanical structure by a load device in the nest center. Upon the completion of the loading process, the UAV will launch to the destination for package delivery. The UAV can not only be consigned by AGV to the UAV parking module for temporary storage in the nest, but also can be moved out of UAV parking module for delivery. More importantly, the design of the quick replacement of battery module can make the UAV replace the battery while loading goods to realize the fast supplement of electric energy.

2.1 System Working Principle

AGV car will transport the logistics UAV that is parked in the nest under the status of non-task after the receipt of the task instruction, which then is based on the docking device of UAV parking module to reach the lifting platform. The height of the UAV will be reduced to the first layer from the second layer after it stops steadily on the loading platform of the lifting platform. For this height, it is set up to correspond to the position where the package can be assembled, so as to be convenient for the express package to be assembled. At the time of goods assembly, the power of UAV can be rapidly supplemented through the way of replacing batteries, so that the flow efficiency of the single machine of UAV can be improved. The lift platform will carry the UAV from the height of the first layer to the third layer (the outer space of the machine nest) after the package assembly is completed by UAV, which enables the UAV to take off to the destination for package delivery at this time.

The lifting platform will rise from the first the height of the first layer to the top opening of the height of the third layer after the logistics UAV completes the external delivery task and returns to the machine nest hub to get ready to perform a new delivery task, which makes the upper surface of the loading platform able to be parallel to the top surface. Through the application of RTK positioning and guidance technology to park UAV on the top of the nest, certain parking position error can be overcome by the correction device installed on the top, so as to accurately park UAV on the loading platform of the lifting platform.

After completing the accurate positioning of the UAV on the loading platform, the lifting platform will carry the UAV to reduce to the height of the first layer from the height of the third layer. The bottom plate of the cargo hold is opened downward after the UAV completes the external delivery task and returns. As a result, the operation of the bottom plate of the cargo hold will be completed by UAV through the assistance of push rod device at the bottom of the feeder belt at the time that the UAV reaches the height of the first layer. The loading can be carried out again after UAV closes all the bottom plates of the cargo hold.

2.2 System Workflow

The emergence of drone technology has greatly improved the efficiency of production operations, avoided the impact of operating conditions and subjective judgments on the accuracy of the work results, and achieved better and more accurate remote delivery and faster identification of package information. Its essence is to use the convenient functions of the UAV to collect, process, calculate, and finally perform actual detection, control, and application of images from specific objects. Since
the use of manual delivery methods has long been unable to meet the needs of production and modern logistics, and the use of drones has overcome this well, the wide application of drone distribution systems will surely promote the development of intelligent and automated logistics.

The machine nest hub is a system which is automatic and intelligent and can realize automatic sorting and loading of logistics UAV packages, parking and deployment of logistics UAV, receiving and releasing of logistics UAV and fast supplement of electric energy of logistics UAV. The system integrates various functions as a whole, which can achieve actual realization for the effect of 7×24 hours uninterrupted automatic operation of UAV package assembly terminal (delivery end). Its working process is shown in Fig.1.

![Figure 1. Operation Flow Chart of Machine Nest Hub](image)

3. The Design of Core Module

3.1 The Main Problem to be Solved

At present, the demand for intelligent distribution is on the rise. With the development of industrialization, especially the development of drones, the application of drones' special transportation processing technology in high-end industries will continue to expand. The superiority embodied by the drone distribution system Will be unmatched by manual delivery.

The first is data collection. For data from the network, including the Internet of Things and equipment information systems, most of the data without failure characteristics, time-domain analysis methods must be adopted to eliminate the false and preserve the truth, collect heterogeneous or even heterogeneous data as much as possible, and then compare with historical data to verify the data from multiple angles. Comprehensiveness and credibility.

The second is data storage. In order to achieve the goals of low cost, low energy consumption, and high reliability, redundant configuration, distribution and cloud computing technologies must be adopted to classify and store data.

The third is data processing. It is still a technical difficulty to use the semantics of the data to construct the information association set and to clarify the corresponding relationship between the state evaluation and the characteristic parameters.

The fourth is visual presentation. At present, the application of no-failure industrial big data is not about deep data mining. Existing data mining algorithms are difficult to apply in the industry or in intelligent manufacturing.
3.2 The Design of Parcel Shunt and Assembly Module

The package assembly module is centered on the lifting platform with four groups of feeder transmission belts setting around and each group of feeder transmission belts is composed of upstream feeder transmission belts and downward feeder transmission belts, so there are altogether eight feeder transmission belts in the whole module, which is matched with the eight cabins of the multi-cabin logistics UAV. What connects the feeder transmission belt is the main transmission belt, it is distributed around the periphery of the feeder transmission belt in square shape. The location of the feeder transmission belt and the main transmission belt forms the shape of matts.

Package inlet and package outlet are set for the main transmission belt, they can join up the transmission belt of the logistics distribution center. An RFID identifier is set up at the entrance to read the package information and assign the corresponding drone cargo bay. After passing through the package entrance the package on the transmission belt in the logistics distribution center can enter the UAV assembly link, or pass through this module and exit from the package exit to the destination. The connection between the main transmission belt, the connection between the main transmission belt and the branch transmission belt, make the transmission path got connected by the way of dislocation, or realize the transformation of the direction of parcel transportation by using the high-speed balance sorting machine.

When the lifting platform vertically conveys the UAV to the first floor, the automatic assembly of goods can be realized, and the UAV can quickly replace the modular battery when it carries out assembly of goods. Specific process: After the UAV is parked stably on the first floor, the battery replacement racks on both sides will move to one end close to the lifting platform from one end far away from the lifting platform due to the movement of respective screw sliding table module group. The form of its receiving and releasing port complements the shape of the battery compartment housing of the UAV. When the battery replacement racks on both sides get close at the same time, the structure will firmly fix the battery compartment housing of the UAV. In addition, the push plate at the tail end of push rod is a rectangular electromagnet which can be electrified to produce magnetism and used to pull out the original battery out of power on the UAV. The well-charged nodular battery is chosen by the rotatable modular battery storage bin to reach the receiving and releasing port by rotation, and then the push rod motor drives the push rod to push out the modular battery from the battery charging bin to be installed into UAV battery compartment. As for the detail about the battery quick replacement module.

3.3 The Design of UAV Parking Module

When the UAV is lifted by the lifting platform to the second floor, it can be connected with the docking assembly of the UAV parking module, and then will be transported by the AGV to be parked in an empty parking lot. In the process of UAV reaching to the UAV parking module from the rotating table, the transfer of docking assembly is needed. The specific process is as follows: After the AGV goes onto the docking assembly, the docking assembly will move to one end close to the lifting platform under the action of 4 groups of screw sliding tables from one end close to the gate position, and then the conveyer belt on the rotating table will start to move to make the UAV transfer to the rotating table of docking assembly from the rotating table. The lifting platform can return to the first floor after the transfer, and the docking assembly will carry the AGV and the UAV to one end close to the UAV parking area. The AGV push rod will rise after the transfer and the UAV will be lifted up from the ground by the push plate, and then the AGV will leave the docking assembly and go onto the mainline rail to reach the empty parking lot for parking. After the AGV holding the UAV reaches to the target gate position, the push rod of AGV will return to the home position, and the UAV will be stably parked on the gate position. After the placement, the AGV can return to the permanent position for charging and waiting for next scheduling task. The process of the UAV moving to the lifting platform from the gate position to execute the delivery task is subject to the inverse step compared to the above one as shown in the Fig.2.
4. Conclusions
A This paper has carried a focused research on an important part of intelligent distribution of the UAV express package, namely, a machine nest hub. It will be coordinated with the connecting cabinet to form a closed loop of whole automatic operation of UAV package delivery. The system is expected to achieve the effect of 7×24 hours uninterrupted unmanned and automatic operation of UAV package assembly terminal (delivery end), which can effectively solve the huge growth of order volume, eliminate the risk of "insufficient capacity" of express, improve the service quality of express industry, reduce the delay rate, damage rate, loss rate and complaint rate of express. Simultaneously, it can reduce the operation cost, warehouse cost, labor cost, etc., so as to improve the industrial competitiveness, make the delivery safer, more reliable and faster, and provide a new solution for large-scale of future logistics and efficient use of UAV for package terminal delivery, which will provide certain referential significance and guiding value for related industries.

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