ISSN: 2664-9640

Research on base station express delivery system of high density residential buildings based on UAV

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Abstract

At present, the end logistics of the express industry still mainly depends on human delivery, which has high delivery cost and low efficiency. The express tram shuttling through the streets not only causes traffic congestion, but also becomes a potential traffic hazard. Therefore, it is increasingly important to find a more efficient, safe and accurate express delivery method. The space utilization rate based on high-rise buildings is low. In today's relatively mature period of UAV technology, the establishment of UAV three-dimensional delivery and distribution system and taking UAV as express delivery terminal will greatly improve the utilization of high-rise space, reduce labor cost and improve delivery efficiency. Based on the above problems, this paper designs and relies on the four rotor UAV as the express delivery terminal, which can not only reduce the terminal delivery cost and save labor cost, but also make effective use of high-rise space and improve the resource utilization of air space. The equipment mainly relies on the ultrasonic module to detect the distance between the aircraft and the ground; Optical flow sensor for flight fixed point; The gyro sensor and accelerometer adjust the flight attitude, and the modules combine with each other to control the flight attitude of the aircraft to ensure the smooth flight of the aircraft. In addition, openmv camera identifies obstacles to realize the safe operation of express transportation. Through the three-dimensional delivery system of high-density residential area of UAV, UAV is used to replace manual delivery of express, so as to realize the automation, unmanned and informatization of express delivery, improve the delivery efficiency and service quality of express, so as to alleviate the spear between express demand and express service ability, discuss the harmonious development of smart city system in the future, and promote the reform of express industry.

Keywords

Express delivery, UAV, 3D delivery and distribution system, regional density stratified base station.

1. Research background

With the development of e-commerce, express delivery industry has also become an indispensable part of people's life, with broad development prospects.In addition, in recent years, with the promulgation of relevant laws and regulations and development plans of the express industry, it actively guides the industry to gradually move towards standardization, standardization and convenience, which also fully reflects the country attaches great importance to the express industry.

But at present, the end of the express industry logistics still mainly rely on manpower, high cost, low efficiency, but also backward infrastructure, security problems, such as residents' mistakes

ISSN: 2664-9640

also make the later search workload more tedious, so find more efficient, more safe and more accurate express delivery way is more important.

2. Three-dimensional UAV delivery system for high-density residential area

2.1. System Overview

This system will promote distribution to wisdom city, solve the problem of high density residential express delivery, when a large number of express after truck delivery village delivery area, different areas of express concentrated to the roof section layered base station express ark, staff to express express box loading, and distribution by drones.When the user needs to send the express delivery, it can use the windowsill simple express cabinet to send the equipment.

Using APH thinking research method of the UAV high density residential distribution problems involved in an orderly ladder hierarchy, in the feasibility of these problems to design the solution, in the simulation method associated UAV status list and express cabinet status list, through physical simulation and mathematical simulation to create a similar model, and then indirectly through the model to verify the feasibility of the scheme, catch the feasibility strategy optimization on this basis.

The system designs a set of three-dimensional delivery system, and the express delivery is completed through the collaborative work of uav, self-service delivery cabinet and dispatching center.System core module includes: express drones, self-service express cabinet, density section layered base station, flight with "inertia + sensor + GPS + photoelectric navigation" mode obstacle avoidance, automatic landing express fixed-point, in the uplink data chain for remote control, downward data chain, data transmission function to realize the high speed, broadband, confidential effect, and enhance the drone anti-interference ability, ensure the security of the delivery and designated return.To lift the payload.The vortex axis power system with better push-to-weight ratio performance will be studied, combined with new energy electric technology to provide more lasting survival power for the UAV.

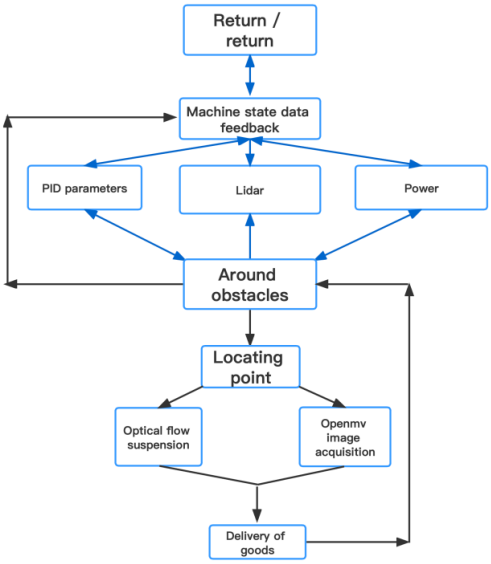

Figure1.System Design and implementation diagram

The implementation of the system can effectively eliminate the danger of express "burst warehouse", improve industry service quality, reduce the express delay rate, complaints, but also can reduce operating costs, warehouse costs, labor costs, etc., enhance industry

ISSN: 2664-9640

competitiveness, make the express delivery more reliable, fast, is also a bright spot of wisdom city construction.

2.2. System Features

2.2.1. Classified base stations in density section based on rational utilization of resources

Autonomous delivery without no control, Therefore, in addition to the signal transmission source of the UAV itself, a certain number of control base stations should be placed in the future delivery area, The stability of the signal transmitting source is guaranteed, Since the drones may cause damage to the buildings in the residential area after entering the residential area, On the other hand, it is also highly likely to cause a certain personal injury situation, Therefore, the control situation of the UAV must be accurately grasped, Therefore, the regional setting of the signal transmission source must ensure that there are no dead corners, Ensure the reliability of the signal source, Greatly to reduce the operation of the drone caused by unclear signal instructions.

1) Optimized architecture of regional density base station placement

(1) Floor 6-10th floor, building spacing of 6-9 meters

For the construction of regional signal base station, extensive resettlement can be carried out, and the signal transmitting base station can be placed in the center area of the house. According to the distribution of the floor:

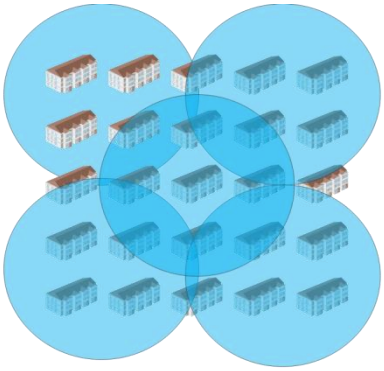

Figure2.Schematic diagram of the signal base station construction

(2) Building 11th floor and above, the building spacing is more than 13 meters

In the high-rise building area, the building height is high and the house spacing is large. In order to ensure the reliability of the signal, the scheme is divided into signal base station construction in the central floor at the back of the roof. The specific base station construction situation is shown in the figure as follows:

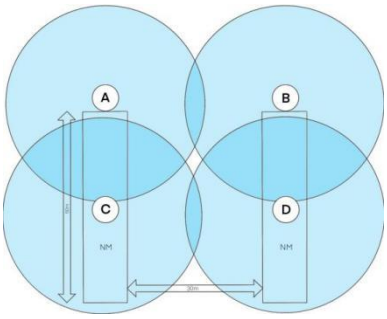

Figure3.Brief diagram of signal base station in vertical area of high-rise area

ISSN: 2664-9640

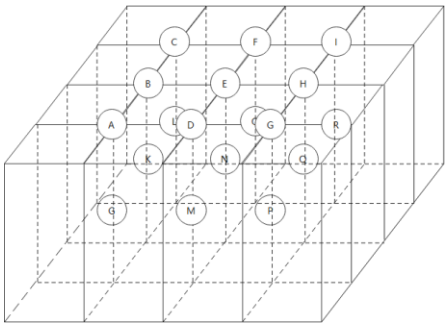

Figure4. 2D stereo image

(Image analysis: In the two-dimensional space, the space square represents the building area, and the circle represents the position of the signal transmitter in the three-dimensional space.)

The UAV transmits data through 4G \ 5G \ wife and radio communication remote sensing technology and dispatch center and self-service express cabinet, sends its own geographic coordinates and status information to the dispatch center in real time, receives instructions from the dispatch center, flies in GPS automatic navigation mode, and sends the landing request, local task report and local operation status report to the destination express cabinet after entering the target area. After receiving the landing request response, the express cabinet guides the UAV to land, load and unload the express at the top of the express cabinet.

2.2.2. Reflection of stratified base station energy saving model

(1) Adopt regional seamless connection base station construction

By measuring the range of signal transmission sources of each base station, a large number of overlap of multidimensional base station can be reduced as far as possible, that is, to avoid the signal interference and unclear signal indication, and also to control the number of base station construction, save resources and improve the utilization efficiency of resources.

(2) Plane and vertical vertical layered construction

In multi-storey and low areas, base stations in low-power plane areas are usually used, which greatly reduces the number of base stations and reduces the energy consumption of high-intensity signals when continuously sending signals. In high-intensity residential areas, it also ensures the seamless connection of signal radiation sources in high-density residential areas.

In high-rise residential area, because the building floor height and building spacing is larger, so using the plane area and three-dimensional area two-way base station construction, ensure the stability of the signal source, at the same time, three-dimensional base station construction, make the signal radiation area more extensive, for a single base station without greater signal power, save energy, ensure the continuity of use.

2.2.3. Smart Window sill express delivery desk

After the drone sends a landing request, mission report and operation status report to the delivery cabinet, The express cabinet inputs the number of the UAV, the mission and the mission priority into the system, The delivery cabinet will send the express list information to the dispatch center in real time, Including basic express information, express priority, express delivery time, Our cabinet express delivery congestion status report, The shutdown platform is allocated by the queuing decision system, After the drone received the order to land in the delivery cabinet, Return the local GPS receiver by receiving the infrared laser positioning signal and the local number to the delivery cabinet, The delivery cabinet will accurately grasp the drone coordinate information, And guide the drone to land accurately.When the UAV queue congestion state occurs, the queue congestion report will be sent to the dispatch center, which will stop sending the loading and unloading instructions of the delivery cabinet to the UAV.

Express cabinet of the user windowsill "send" express delivery desk

ISSN: 2664-9640

Users deliver express delivery through the windowsill express cabinet: when the user presses the delivery button, If the delivery cabinet is not full, an empty delivery door, Users remove a delivery box from the delivery box rack, And put the express delivery into the express box, Then put the delivery box into the delivery box and close the door, The delivery box will check whether the express delivery meets the standard, Including weight, risk degree and other tests, If the test reaches the standard, Users will be prompted for delivery information and delivery levels, After confirming that the destination is reached, Prices will be given based on delivery weight, delivery distance, and delivery priority, Users can pay on the site, It can also be paid online or delivered by the express delivery receiver according to the demand.Finally, the drone will deliver the express to the base station on the roof of the building, divided by the staff, the express cabinet will fully accept the express information to the express box through Bluetooth, the express box will record the express information for the identification of the express.

The user windowsill of the express cabinet "receives" the express delivery desk

After the drone connects with the delivery cabinet, the express box is brought into the express box by the mechanical transmission device. The express cabinet will verify the express according to the information of the drone task report and the memory module of the delivery box, and send a mobile phone message to the user to remind the express has arrived, and give the password and warm prompt.If the user exceeds the time limit for charging the delivery box according to the time limit, which at all time keeps the delivery box in circulation.

(Express box: The delivery box is built-in Bluetooth and memory module, which is mainly used to package express delivery, easy to carry by drones, and the identification of express delivery.When the express box is idle, it is placed on the express box frame of the express cabinet, which can be collected and sent by the users by themselves.

Delivery desk: simple express cabinet, mainly used for users to receive and deliver express delivery. Express items are delivered by drone at the user delivery platform, and the user will take out the express delivery.When the user sends the express, the express is placed in the express box, and the drone will carry it to the express cabinet of the base station on the roof, and then the staff will collect the classification at a unified time.）

3. UAV design

3.1. Product function

The main functions of the four rotor vehicle are as follows:

1) Data filtering and fusion based on ARM microprocessor TM4C123G microchip to achieve real regulation of aircraft in high-density residential areas.

2) The combination of optical flow, gyroscope and PID algorithm to control the stability of the vehicle load operation.

3) Lidar gives altitude control to the uav in the community to ensure the detection and feedback of the placement points during the designated delivery of logistics flight.

4) Use optical current sensor to obtain real-time flight speed for speed loop control.

5) Feedback of obstacles during flight transportation through OpenMV to achieve fixed distance flight to ensure flight safety.

6) OpenMV realizes the function of collecting goods and taking photos, and can be used to store procedures and save photos, so as to facilitate the later logistics and after-sales pickup inquiry.

3.2. Structure Overview

3.2.1. Design and implementation of flow chart

(1)System composition

Figure5.System structure design drawing

3.2.2. Program Design and Implementation

(1) System software design

The software part realizes the functions of aircraft fixed altitude navigation, flying around obstacles, fixed landing and express delivery and other functions.

(2) Flight attitude control

FIR filtering and attitude fusion interpret the flight attitude Angle of the aircraft, and the data is processed by the cascade PID algorithm program, so as to control the speed of the motor, so that the UAV flies smoothly in the load operation.

(3) Flight altitude control

According to the transmission time difference of ultrasonic acquisition, the altitude of the aircraft from the ground is calculated, and the throttle amount is constantly changed through the PID algorithm program, so that the flight altitude is controlled in a reasonable range.

3.2.3. Design and implementation of aircraft attitude solution

(1) Flight attitude control and calculation

The carrier of four rotor UAV rotates around three axes for a short time. The initial coordinate of the aircraft is $P_0 = (X_0, Y_0, Z_0)$and the attitude coordinate after rotation is $P_2 = (X_2, Y_2, Z_2)$; The arbitrary attitude of the aircraft in space can be realized by three-axis rotation: pitch angle Θ, roll angle Φ and yaw angleΦ.

Note C is the aircraft attitude rotation matrix, including $P_2 = (X_2, Y_2, Z_2) = C * P_0$

η_n is the attitude after the nth solution, in a short time, it changes very little, including:Θ Φ φ

$$C=\begin{bmatrix} \cos\theta\cos\phi & \cos\theta\cos\varphi+\sin\theta\sin\varphi & \cos\phi\sin\varphi-\sin\theta\cos\varphi \\ -\sin\phi & \cos\phi\cos\varphi & \cos\phi\sin\varphi \\ \sin\theta\cos\phi & \sin\theta\sin\phi\cos\varphi-\cos\theta\sin\varphi & \sin\theta\sin\phi\cos\varphi+\cos\phi\cos\varphi \end{bmatrix} \tag{1}$$

$$\approx\begin{bmatrix} 1 & \phi & -\theta \\ -\phi & 1 & \varphi \\ \theta & -\varphi & 1 \end{bmatrix} \tag{1}$$

ΔCNote as the aircraft carrier coordinate increment rotation matrix, then there is:

$$\Delta C \approx \begin{bmatrix} 1 & \Delta\phi & -\Delta\theta \\ -\Delta\phi & 1 & \Delta\varphi \\ \Delta\theta & -\Delta\varphi & 1 \end{bmatrix} \tag{2}$$

It can be concluded that the algorithm of attitude solution through the gyroscope is:

$$\eta_{n+1} = \Delta C \cdot \eta_n \approx \begin{bmatrix} 1 & \Delta\phi & -\Delta\theta \\ -\Delta\phi & 1 & \Delta\varphi \\ \Delta\theta & -\Delta\varphi & 1 \end{bmatrix} \cdot \eta_n \tag{3}$$

3.3. Design test

(1) Obstacle avoidance flight function test:

ISSN: 2664-9640

Test method and conditions: obstacles with simulated building construction height of about 2m, bottom width and length of about 0.5m

Table1.obstacle flight function test table

Test times	flight altitude /m	Whether to find an obstacle	Whether the sound and light prompt is correct	Is it normal for obstacle avoidance	flight time /s	Delivery point difference / cm
1	2	deny	yes	deny	160	5
2	1.5	yes	yes	yes	155	3
3	1	yes	yes	yes	142	6
4	0.5	yes	yes	yes	160	2

3.4. System characteristics

3.4.1. Innovation

(1) Innovation of the research perspective

UAV distribution and urban residential distribution are very concerned contents in the current urban distribution market. However, most of the research related to UAV distribution is novel, although the research ideas are similar to the optimization of traditional vehicle ordinary distribution path.This system fully analyzes the customers and UAV systems of uav residential areas, not only considering the needs of instant delivery customers, but also the characteristics of UAV itself, and taking into account the perspective of city managers, and also mentions the constraints of no-fly zone.

Distribution also adopts the establishment of the roof distribution station, change the establishment of the traditional basic ground base station, but the whole distribution into top and bottom, make full use of the roof resources and space resources, make the distribution work more professional, standardized, from the perspective of the whole drone residential instant delivery considering the important aspects.

(2) Innovation of research methods

This system mainly adopts hierarchical, block, comparative study of ARM microprocessor TM4C123G microchip microchip function realization, The proposed distribution function will be simulated and tested, The physical design is compared and improved from the physical layer-> data structure layer-> application layer, To achieve data filtering and fusion in real-world scenarios, Finally, the PID algorithm processing part, the gyroscope implementation part, the camera aerial photography part, the external expansion buzzer part, the power system part, the optical flow control part and the ultrasonic part of the system driving components are embedded and adjusted, Modify the adaptive parameters, Improve the system's stability.

3.4.2. Science and technology

UAV delivery known as "air express", with technology change and innovation service as the core, do not rely on ground traffic and not constrained by terrain congenital advantage, will have the opportunity for high value-added goods, create different, high specification delivery experience, let users feel the logistics service ability unprecedented qualitative leap, is for the technology leap of a real experience.

3.4.3. Development viability

It is a consensus that the use cost of advanced equipment is high. The single transportation cost of drones is only a few cents, and when the distance is far, it is only the same as the human delivery price, so the cost is relatively low.Because the express logistics distribution mode needs labor to complete, the cost of labor and delivery is much higher than the cost of drone delivery.Traditional manual delivery is inefficient.Due to the influence of traffic conditions and

human restrictions, the efficiency of manual delivery is only about 50% of the drone delivery, and the cost of manual delivery is high, and the labor cost will be higher and higher in the future.According to data analysis, drone delivery takes about 30min per 10 kilometers, which only accounts for 30% of the manual delivery cost.

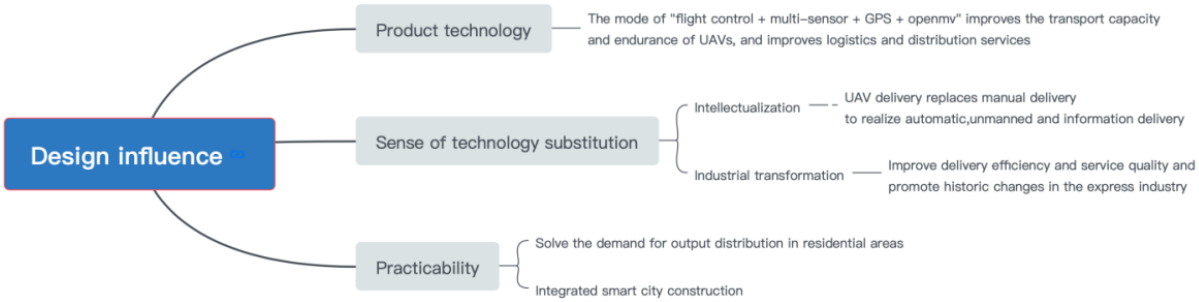

Figure6.Design Influence

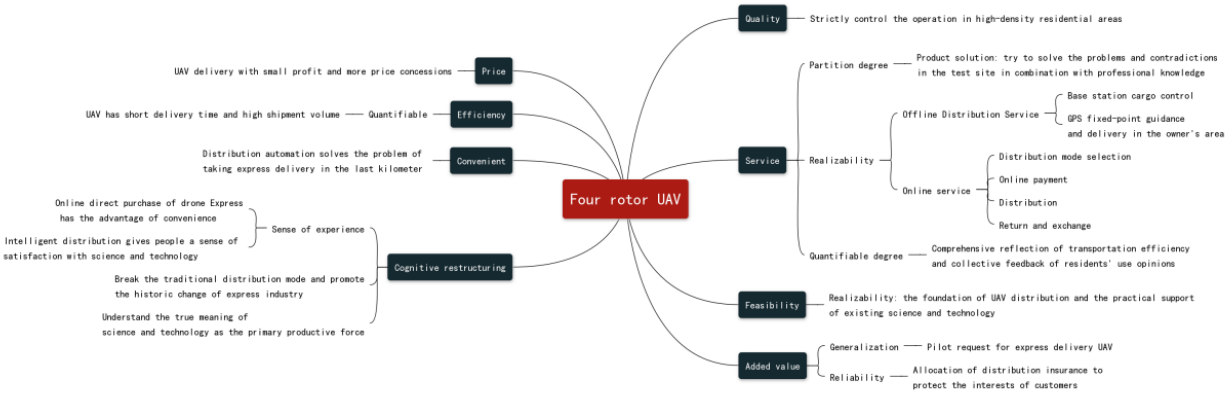

Figure7.Impact effect diagram

Acknowledgments

Funded by the innovation and entrepreneurship training program for college students of Anhui University of Finance and economics, Project No.202110378170. The ownership of the research results of the project belongs to Anhui University of Finance and economics

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