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Design of Take-off and Landing Platform System for Quadrotor UAV

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Abstract

In recent years, quadrotor UAVs have been widely used in the fields of surveying and mapping, line inspection, photography and military, and its related industries have also developed rapidly. However, due to the weak endurance and small cruising radius of the existing UAVs, they have not rapidly developed into the military field and large-scale civilian use. Battery capacity, or the use of lightweight materials to make the aircraft body to reduce the load, or improve battery efficiency, etc., but still cannot solve the problem that battery charging takes a lot of time. According to the above phenomenon and the current development status and market size of quadrotor UAV, this paper designs a quadrotor UAV take-off and landing platform system for the situation that the battery charging of quadrotor UAV is a waste of time. The short-term battery replacement and reserve battery charging of the quadrotor UAV are carried out, and the main structure and functional structure of the system are designed.

Keywords

Quadrotor UAV; Take-off and Landing Platform; Mechanical Structure.

1. Introduction

The quadrotor UAV industry is an emerging high-tech industry, which involves many fields from research and development, manufacturing, to use, management and service [1,2]. The upstream of its industrial chain is mainly new materials, electronic components, software design, etc., while in the downstream of its industrial chain, in addition to the military as the main user, it also involves scientific research, agriculture, electricity, transportation, meteorology and many other industries. In recent years, the application direction of drones has been expanding, involving police, energy, land resources, commerce, agriculture, disaster relief and other fields. In the aspect of carrier-based UAV, foreign scholars have a lot of research results. Carrier-based UAVs have become an important part of the U.S. Navy's equipment, and the Fire Scout under development represents one of the development directions of carrier-based UAVs.

The UCARS UAV automatic recovery system, the VISUAL approach and landing virtual imaging system, and the JPALS joint precision approach and landing system developed by radar, photoelectric, satellite and other technical means have promoted the development of UAV automatic landing guidance technology in the United States [3]. The potential of quadrotor UAVs in replacing manpower in high-risk operations, as well as the advantages of low cost, easy manipulation, and high efficiency compared with manned aircraft, make its application fields continue to expand and expand, and the industrial chain. The downstream user base will continue to expand. With the continuous expansion of the quad-rotor UAV market, the short cruising range of quad-rotor UAVs will urgently require corresponding measures, but most of the currently proposed solutions are to increase the

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battery capacity, or use lightweight materials to make the aircraft fuselage In order to reduce the load or improve the battery efficiency, these solutions can only weaken the short cruising range of the quadrotor UAV to a certain extent. To solve this problem, the solution of short-term battery self-replacement and reserve battery charging for quadrotor UAV is designed. To achieve the high endurance work of the quadrotor UAV, a mobile platform is also designed to ensure the coherence and smoothness of the take-off and landing process of the quadrotor UAV, and an omnidirectional wheel train is designed to ensure the rapid movement of the mobile platform. The human-machine take-off and landing platform is supplemented with innovative design, and finally commercialized to solve the current problems.

2. Overall Design

2.1 Technical Parameter

When designing the corresponding structure, first, it is necessary to reasonably arrange the various mechanisms of the quadrotor UAV take-off and landing platform system and the technical parameters of each structural design. Only in this way can we provide a strong basis for the next related function design, more accurately grasp the whole process of the design, and finally realize the expected functions. Table 1 shows the length, width, height and corresponding parameters of the quadrotor UAV take-off and landing platform system.

Table 1. Technical parameters for the design of quadrotor UAV landing platform systems

number	System metrics	technical parameter
1	Use environment	Complex terrain such as land
2	Geometric dimensions (mm)	953×701×617
3	user target audience	quadcopter drone
4	Driving speed (km/h)	15-30
5	Feeding mechanism moving distance (mm)	325
6	Movement distance of rotary clamping mechanism (mm)	90
7	Rotation angle of rotating mechanism	360
8	Rotation speed of rotating mechanism (r/min)	40

It can be seen from the above chart that the designed quadrotor UAV take-off and landing platform system can be used in flat terrain and rugged places. In different use environments, if you want to realize the free movement of the quadrotor UAV take-off and landing platform system, you must It is necessary to reasonably arrange the mechanism size of the quadrotor UAV take-off and landing platform system. According to the average size of the UAV on the market, it is determined that the overall width of the quad-rotor UAV take-off and landing platform system is 750 mm, and its length can be designed as 1000 mm. However, with the continuous expansion of the current drone market in China, the types of drones in the Chinese drone market will increase by 2022. Therefore, in the design process, to be suitable for different types and sizes of drones, So I designed a small quadrotor drone by myself.

According to the types of UAVs related to the Chinese UAV market and the size and weight of UAVs, and considering the functions to be realized, the length of the quadrotor UAV take-off and landing platform system is finally determined to be 953 mm, so the overall the length, width and height are set at 953 × 701 × 617 mm.

Preliminary design the functions of this product are divided into mobile chassis, rotating mechanism, feeding mechanism and so on. Different mechanisms correspond to the realization of different

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functions. In this process, the focus is on the clamping mechanism in the rotating mechanism of the quadrotor UAV take-off and landing platform system. This mechanism directly determines whether the quad-rotor UAV can be centered on the platform, thus ensuring the stability of the battery replacement process of the quad-rotor UAV. Human-machine landing accuracy requirements, within the allowable range, can assist the quadrotor UAV to complete the battery replacement, as shown in Figure. 1.

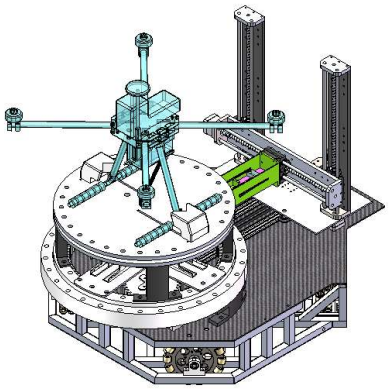

Figure 1. General diagram of the system design of the quadrotor UAV take-off and landing platform system

It can be seen from the above chart that the designed quadrotor UAV take-off and landing platform system can be used in flat terrain and rugged places. Considering the size of man and machine, the size of each mechanism should be reasonably arranged to prevent many problems caused by size problems. After comprehensively considering the functional structure requirements of this design and referring to national standards, the design scope of each functional size is determined as follows: Because the overall system of battery replacement for the take-off and landing platform of the quadrotor UAV is to be realized, it is stipulated that 953×701× 160 mm is the overall size of the chassis mechanism. Because the landing angle of the quadrotor UAV is difficult to guarantee, it is stipulated that 360° is the transformation angle of the rotating mechanism, and the linear clamping change distance is 90 mm. The battery compartment is always guaranteed to be in the same position, so the left and right moving distance of the feeding mechanism ranges from 0 to 325 mm, and the up and down moving distance ranges from 70 to 325 mm.

2.2 Design Requirements.

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The design of the quad-rotor UAV take-off and landing platform system designed and studied in this design is to meet the basic functional requirements of the quad-rotor UAV for battery replacement, and to maximize the convenience of the quad-rotor UAV take-off and landing platform. Free movement, so the basic requirements are as follows:

(1) The safety requirements of the quadrotor UAV take-off and landing platform system

The four-rotor UAV take-off and landing platform system is used in four-rotor UAVs. Compared with other land machinery products, the flight trajectory of the UAV is more difficult to precisely

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control, and the quad-rotor UAV take-off and landing platform the system is more concerned with the ability to autonomously replace the quadrotor UAV battery and reduce the probability of operator errors. Therefore, this design is comprehensively considered from multiple aspects. First, the requirements of each function should be realized, and then safety should be placed in the most important consideration to prevent the quadrotor UAV and the operator from receiving unnecessary design. harm.

(2) Functional requirements of the quadrotor UAV take-off and landing platform system

In addition to the functions of the general UAV take-off and landing platform system, the quad-rotor UAV take-off and landing platform system should also have the function of automatic battery replacement and the function of storing multiple battery compartments, which can maximize the improvement of the quad-rotor UAV. Replacing the battery efficiency, thereby avoiding excessive occupation of human resources, thereby improving the work efficiency of the entire society.

(3) Requirements for the use of terrain of the quadrotor UAV take-off and landing platform system

The use environment of this design is mostly flat terrain such as squares and roads and various slightly uneven terrains, so ensuring the landing position of the drone should be a major consideration, that is, the design has no quadrotor in the use environment. The man-machine take-off and landing platform should ensure that it fits the drone base as completely as possible, but the premise is that it must meet the requirements of each function, and then reasonably arrange the structural space of the four-rotor drone landing platform to prevent the use of space. A series of unnecessary troubles caused by the problem.

3. Scheme Design

3.1 Material Selection

After reading many documents and consulting relevant company website information, it was decided to adopt the traditional method of welding for the processing and manufacturing process of the quadrotor UAV take-off and landing platform system. The material of the chassis mechanism of the four-rotor UAV take-off and landing platform system, after investigation, the material is a square non-solid relatively lightweight aluminum material, which is widely used in automobiles, ships, aerospace, aviation, electrical appliances, agriculture, electromechanical, household and other industries. The aluminum tube is a kind of high-strength duralumin, which can be strengthened by heat treatment. It has moderate plasticity under annealing, just quenching and hot state. It has two advantages. Copper-aluminum tube welding technology, the second is the advantage of service life: from the perspective of the inner wall of the aluminum tube, since the refrigerant does not contain moisture, the spot welding is good, and the material is shown in Figure. 2.

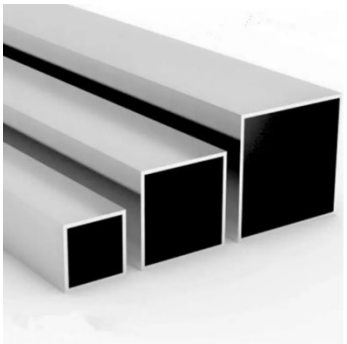

Figure 2. Square aluminums tubes

3.2 Design of Each Functional Mechanism

In view of the movement to be realized by the quadrotor UAV take-off and landing platform system, the modular thinking is used to regard each mechanism as an independent module, and various

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schemes for completing each function are given with reference to each other, and the appropriate one is selected and determined. Institutional configuration. Since there is more than one movement to be completed in this design, the selection of the mechanism should be considered in many ways to prevent unnecessary errors, and not only must complete the basic movement requirements but also meet other conditions, such as economic and stable conditions.

3.3 Comparison and Selection of Chassis Mechanism Gear Train

As shown in Figure. 3, the mechanism is a traditional vehicle wheel train. The mechanism only needs one motor, so that it has a definite movement. The driving method is obvious, that is, a motor is used to directly drive the rotating shaft to make the wheels move. The shaft rotates in the drive to push the wheel, making it complete a full rotation around the shaft to achieve the desired action. The characteristics of this mechanism are that it has a relatively mature mechanism, low driving resistance, high driving device efficiency, fast speed, and good maneuverability.

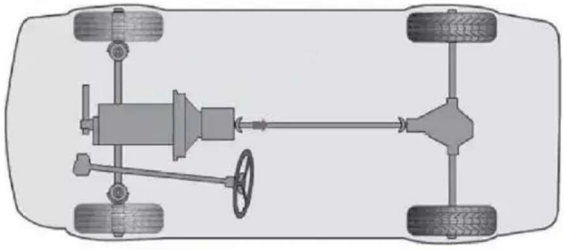

Figure 3. Traditional vehicle wheel systems

As shown in Figure. 4, this mechanism is selected after the initial mechanism has defects. This mechanism can be considered as an omnidirectional wheel train mechanism with four prime movers and fixed motion. Its driving method is obviously that the omnidirectional wheel receives the motion and power from the motor through the shaft and bearing. Compared with the traditional vehicle wheel train, the modified omnidirectional wheel train has no turning radius and can move instantaneously, which improves the quadrotor. The convenience and accuracy of the UAV take-off and landing platform system movement, the position of the four omnidirectional wheels is arranged in a square, which can rely on the structure to offset the same external force, although a certain speed is lost, but considering that the quadrotor is unmanned The initially proposed speed and motor power of the aircraft take-off and landing platform system, this structure can completely negate the part of the speed to cancel each other, so the final choice is the chassis mechanism gear train of the four-rotor UAV take-off and landing platform system.

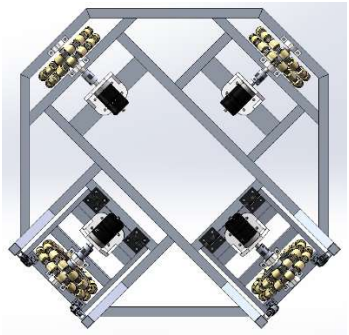

Figure 4. Omni-wheel chassis wheel system

3.4 Selection of Rotary Mechanism

As shown in Figure. 5, the mechanism is a rotating mechanism of a four-rotor UAV take-off and landing platform system. The stepper motor (driving device) 1 is connected to the reduction box to

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control the rotation of the pinion 2, so that the inner meshing with the pinion 2 is made. The meshing gear bearing 8 rotates, and then the inner meshing gear bearing 8 is connected to the lower platform of the drone of the quadrotor drone take-off and landing platform system through the bearing support 3, and the lower platform is connected to the drone take-off and landing platform through the hexagonal copper column, There is a rack and pinion structure between the lower platform and the upper platform, and is connected with the gear through the motor 7, so as to drive the movement of the rack connected with the centering piece 6, and then complete the centering and clamping of the quadrotor UAV, so that the In this way, the replacement of the quadrotor UAV motor is completed. The rotating mechanism contains a battery compartment 5. The battery compartment 5 is connected to the connecting plate 4. The movement of the connecting plate 4 is driven by the internal gear bearing, so that the rotating mechanism is It satisfies the functions of taking off and landing and storing backup batteries of the quadrotor UAV. The above characteristics are obvious. First, the structure is relatively simple, and then the processing is simple, the purchase is convenient, the space requirements are not high when the corresponding actions are completed, and it is easy to replace and repair after damage. Compared with the advantages of this mechanism, its shortcomings are also obvious, that is, the sealing problem of gears, but this problem can be alleviated in the case of semi-sealing, and finally this mechanism is selected as the rotating mechanism of the quadrotor UAV take-off and landing platform system.

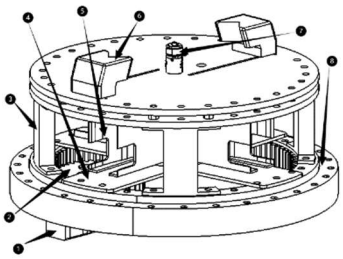

Figure 5. Omni-wheel chassis wheel system

4. Conclusion

First, the overall structure design of the quadrotor UAV take-off and landing platform system was completed, and then the mechanism design analysis and structural design of the chassis mechanism, rotating mechanism and feeding mechanism were carried out respectively, and then the types of motors were selected. The dimensions of key components were drawn up, and the possibility of quadrotor UAV battery replacement by the quadrotor UAV take-off and landing platform system was demonstrated. After the above analysis, the structural foundation was further laid for the next mechanical analysis.

Acknowledgments

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References

[1] Floreano D, Wood R J. Science technology and the future of small autonomous drones[J]. Nature, 2015, 521(7553): 460-466.

[2] Kakaletsis E, Symeonidis C, Tzelepi M, et al. Computer Vision for Autonomous UAV Flight Safety: An Overview and a Vision-based Safe Landing Pipeline Example[J]. Acm Computing Surveys, 2022, 54(9): 1-3.

[3] Tomic T, Schmid K, Lutz P, et al. Toward a Fully Autonomous UAV Research Platform for Indoor and Outdoor Urban Search and Rescue[J]. Ieee Robotics & Automation Magazine, 2012, 19(3): 46-56.