ISSN 2616-5767 Vol.7, Issue 5: 1-7, DOI: 10.25236/AJETS.2024.070501

Overview of UAV structure application

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Abstract: *Unmanned Aerial Vehicle (UAV) technology, as an innovative achievement of aviation science and technology in the 21st century, has shown its unique value and wide application potential in military, civil and other fields. The design and structure of unmanned aerial vehicle is the key to its performance and application. Understanding the structure of UAVs is of great significance for in-depth study of UAVs, so that we can use UAVs better. This paper mainly reviews the structure and function of UAV, provides a more comprehensive overview of the structure of UAV, analyzes the main structural characteristics and application scenarios of UAV. The future development trend is also prospected.*

Keywords: *UAV, UAV configuration, structure and application*

1. Introduction

The origins of drones date back to the early 1900s, when they were first used for military reconnaissance and target guidance. With the development of information technology, drones gradually became an indispensable force in military operations in the late 20th century. In the progress of artificial intelligence, big data and other technologies, the intelligent level of UAVs is constantly improving, and its application scenarios are also constantly expanding. In recent years, the rapid development of UAV technology, its outstanding reconnaissance, surveillance, strike and other capabilities and flexibility and concealment characteristics make it change the traditional combat mode and become an important equipment in modern war. Uav is increasingly widely used in civilian fields, such as logistics distribution, high-altitude work, engineering construction, agricultural plant protection, environmental monitoring, disaster relief and so on. Deeply integrated with the industry, it has improved production efficiency and quality of life, and greatly reduced labor costs and safety risks. Nowadays, drones can not only provide new means for social public services, but also it has become a new driving force for national economic development and can provide new space for regional economic development.

On the one hand, the security issue is particularly important. Payload security, software security and communication security are the three core security technologies of UAV. Payload data transmission needs encryption means to prevent data from being intercepted or tampered with, and control constant method and state estimation method are also used to detect sensor spoofing attacks. Through gray box and black box methods for vulnerability mining, such as binary pile, dynamic stain analysis, fuzzy testing, etc., to prevent and control stream hijacking attacks, detect buffer overflow and illegal function execution and virtualization technology to isolate memory space, prevent memory corruption attacks, to jointly maintain software. Relying on symmetric cryptography and asymmetric cryptography, the UAS communication network is encrypted and authenticated, and by optimizing the channel security model, the system's security capacity is enhanced, and the system's ability to defend against interference attacks and eavesdropping attacks is improved to ensure communication security.

On the other hand, the continuous improvement of the technical capability of UAVs is also reflected in the significant progress of communication link, autopilot data link and artificial intelligence, etc. The development of these technologies also improves the design and performance of UAVs, so that it has a stronger ability in executing tasks. In particular, advanced communication technology, no matter the use of radio or satellite communication, can ensure the stable connection between the UAV and the ground control station, but also ensure the long distance and safe and reliable data transmission. As the control center of UAV, the autopilot can accurately process the information obtained by various sensors, so as to ensure the stable flight and accurate navigation of UAV. Taken together, these technologies not only give the UAV more possibilities, but also provide a strong support for its performance improvement.

At the same time, combined with the intelligent characteristics of the UAV data link, the working parameters can be dynamically adjusted according to the electromagnetic environment and communication needs. While enhancing the adaptability and efficiency of the UAV, the application of artificial intelligence technology, such as path planning and target recognition, has greatly improved the autonomous decision-making ability of the UAV. Making it more objective and reliable in the execution of tasks to make decisions and implementation.

It is these technological advances that provide more flexibility and innovation space for the configuration design of UAVs. The drone's own configuration, including the layout and configuration of its key components such as racks, motors and sensors, directly affects its flight performance and mission execution capability. The optimized UAV configuration can not only improve flight efficiency and reduce energy consumption, but also enable it to better cope with various complex flight environments and mission requirements, so as to enhance the reliability and autonomy of the UAV. A clear understanding of the structure of the UAV will help us to carry out more in-depth research in terms of function understanding, optimization design and performance improvement. Therefore, this paper will mainly discuss and draw lessons from the structure of UAV.

2. Construction of the drone

2.1. Unmanned mechanism shape

The flight control system is the "brain" of the UAV, including sensors, flight control algorithms, navigation systems, etc., which together ensure the stable flight and accurate navigation of the UAV. The frame is the "skeleton" of the drone, including the arm, wing, fuselage, etc. It usually uses low-density and low-strength materials to maintain its flexibility and stability. The motor and the electric regulator constitute the "muscle" of the UAV and play a role in providing power during the whole flight process. The electric regulator can not only convert the type of current required by the motor, but also control the rotation speed of the motor. The flight controller communicates the command to speed up or slow down by controlling the electric modulation, and at the same time, the electric modulation prepares the battery for the next movement. The blades are like the "limbs" of the drone. An electric motor drives the blades to rotate, creating the Bernoulli effect, which creates a pressure difference between the upper and lower surfaces, thus achieving lift (See Figure 1). The motor, fuel tank, and generator act as the "heart" of the drone, while the electric plate is similar to the "blood vessel", which is responsible for transferring energy to various parts. As a visual organ, the eyes perceive the outside world. Also for drones, the guiding module allows it to see the world and complete positioning, route planning, navigation and other work. In addition, it can receive satellite signals to determine its own altitude and speed. The "cerebellum" of the inertial navigation mechanism (INS) UAV obtains information such as position, attitude and acceleration of the UAV through inertial measurement components (IMU) such as gyroscopes and inertial sensors. [1] Generally speaking, there is also an "electronic compass" in the navigation module, which judges its operating direction by sensing the earth's magnetic field. Of course, it is necessary to avoid the interference of strong magnetic field as much as possible, so as to ensure the accuracy and safety of flight (See Figure 2).

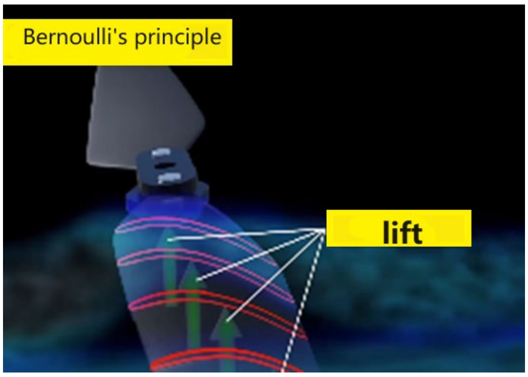

Figure 1: The source of lift

ISSN 2616-5767 Vol.7, Issue 5: 1-7, DOI: 10.25236/AJETS.2024.070501

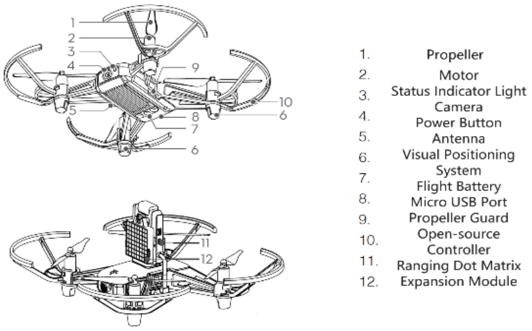

Figure 2: Structure

2.2. Specific wing structure

(1) Fixed wing type

The disadvantage of multi-rotor UAV is short endurance and weak load capacity. At this point, fixed-wing UAV and rotor UAV are obviously superior to multi-rotor UAV, because their power supply is fuel engine, so in the control mode, multi-rotor UAV is the easiest to control, not subject to site restrictions, so it is popular in the civilian field.(Seeing Figure 3)

Figure 3: Fixed wing type UAV

(2) Multi-rotor type

Multi-rotor UAV is a UAV with three or more rotor shafts, which drives the motor to rotate through the rotor rotation on each shaft to produce a certain lift and propulsion force, and there are three common four-axis, six-axis and eight-axis.

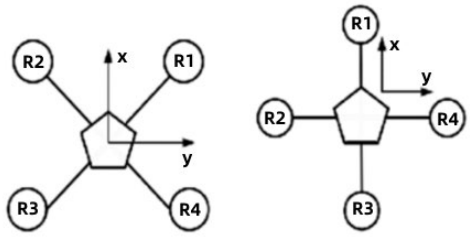

Figure 4: Multi-rotor type UAV

The four-axis multi-rotor layout is roughly divided into two types (Figure 4) (" X "type and" + "type). Structurally, both of them are composed of three parts, including arm, rotor and control system, and both of them have vertical arms in the same side, the center is the control terminal, and the four rotors are separated at the end of the arm. In terms of function, the speed of the four terminal motors is adjusted. This method is to control the flight dynamics with the help of the lift and torque generated by the propeller. In order to maintain balance, we set the rotation mode of the propeller: two diagonal propellers should rotate in the same direction, and their two sides should rotate in the opposite direction (As shown in Figure 5).

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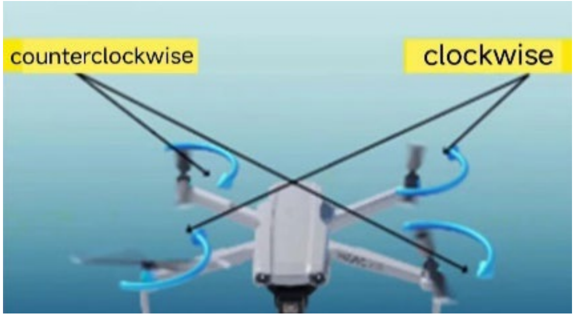

Figure 5: Torque cancellation

In this way, the torque generated during the rotation of the propeller can be eliminated, the position change and posture control of the four-rotor aircraft are completed, and the safety performance and stable operation of the aircraft can be guaranteed (the six-axis and eight-axis are similar) [2]. Although the "X" type control method is easier, because of its unique structural characteristics, it avoids the problem of image limitation, and also has a higher degree of flexibility, which is the reason why the "X" type is more common now. In addition, the current common four-rotor UAV battery energy density per kilogram is about 160~200Wh, generally equipped with a battery capacity between 5000mA~10000mA, which is equivalent to a fully charged case can fly in the air for 20~30 minutes, depending on the flight control system, sensors, UAV weight and other factors. In terms of improvement, the storage technology has not been fundamentally changed, the storage density improvement space is not large, if you want to increase the total amount of storage, you need a heavier battery, which will also lead to an increase in its own weight, resulting in an increase in power consumption, so after reaching a certain peak, it means that reducing the weight of the drone has become the main factor to improve the endurance.

Figure 6: Six-axis multi-rotor UAV

Figure 7: Eight-axis multi-rotor UAV

Figure 8: Coaxial eight-rotor UAV

The six-axis multi-rotor UAV (as shown in Figure 6) has six propellers evenly distributed on the outside of the fuselage. The aircraft adjusts its attitude by coordinating the rotational speed difference of each rotor. It has the advantages of heavy load, vertical takeoff and landing, fixed point hovering and accurate flight data, etc. Accurate flight and fixed point hovering are of great significance for data collection. At present, the six-axis multi-rotor UAV is playing an important role in low-altitude data analysis. [3]

Eight-axis multi-rotor UAV is composed of 8 arms and 8 rotors (See Figure 7), and another kind of coaxial eight-rotor is based on the "x" type four-rotor UAV, the eight propellers are divided into four pairs, and each arm is installed at the end of the opposite spin pair (see Figure 8). They not only enhance the driving ability and carrying capacity of the aircraft, but also improve the reliability of the flight system.

(3) Flapping wing

Flapping wing aircraft can adjust the movement parameters of the wings to achieve suspended flight, which generates lift through the flapping of the wings. (As shown in Figure 9) The flapping wing can use the generated eddy currents to increase the lift during the flapping process. However, due to the complex aerodynamic mechanism of the flapping wing, its model has great uncertainty, and it needs to design a stable and fast controller to realize autonomous flight. [4]

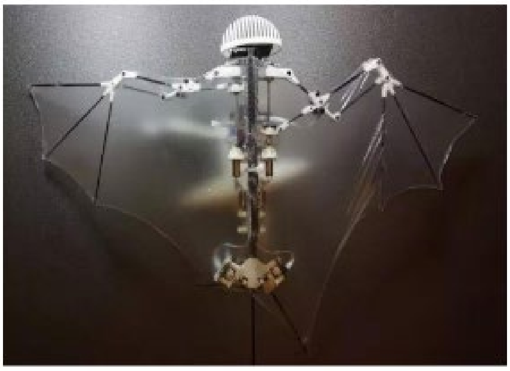

Figure 9: Flapping wing

(4) Hybrid wing

The flight control system of hybrid wing UAV is a highly complex and fine system, which fully combines the advantages of the above three types of UAV in the shape design and power supply mode, so it has higher flexibility and payload capacity. The multi-input, multi-output and strong coupling nonlinear system is the power model of hybrid wing UAV. The flight control system needs to accurately control these different flight modes, and the control system needs to adjust the attitude, speed, height and other parameters of the aircraft in real time to ensure the stability and accuracy of the flight. In addition, the control system needs to deal with the complexity of the transition stage when the hybrid wing UAV changes from the vertical take-off and landing mode to the horizontal flight mode. For example, a quadrotor provides lift during the take-off phase and is converted to a fixed-wing mode after reaching a certain speed. [5] However, this can improve the flight height, speed and endurance of hybrid wing UAVs.

(5) Parachute wing UAV

The parachute wing UAV system consists of four parts: UAV platform subsystem, launching

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subsystem, data link subsystem and mission payload subsystem. According to the platform system, it is mainly divided into non-airdrop launch sub-system and airdrop launch sub-system. Its main working process: first, the parachute wing UAV is fixed on the floor slide rail of the transport aircraft, and then the gravity airdrop method is adopted to leave the aircraft, and after leaving the aircraft, the guiding umbrella is opened, the stabilizing umbrella is opened, and the wing is opened.

The parachute, the parafoil, inflates, fills, and the onboard flight control is powered on and starts working (See Figure 10).

Figure 10: Parachute wing UAV

(6) Unmanned airship

As traditional aircraft, people use air buoyancy to get airborne, usually by filling the inside with helium gas bags. The outer shell is made of synthetic fiber, the middle sash window is used to carry the cargo, and the rudder and elevator at the tail are used to control the direction and height, respectively.

Figure 11: Unmanned airship

Propellers on either side are the source of forward power. Due to the wind resistance brought by its huge size, its normal speed is only about 160 kilometers per hour. In recent years, because the unmanned airship has the ability to provide surveillance communication, remote sensing and other services, people have greatly increased their attention in recent years [6]. At present, it is mainly used in Marine research, meteorological exploration, rescue and disaster relief and other aspects in China (See Figure 11).

(7) Tilting rotor

Tilt-rotor UAVs have both fixed wings and rotors that can switch between horizontal and vertical directions. It can not only complete horizontal lifting, but also improve high-speed endurance. The integration of the two rotors makes it have the advantages of low cost and strong adaptability. But at the same time, there are also downwash weight gain effect when lifting and hovering and complex aerodynamic interference caused by tilting transition stage of the wing. [7] Its excellent aerodynamic layout and flight performance make it have a broad application range and development prospects. For example, China's CH-10 unmanned tilt-rotor aircraft is one of the representatives of this technology. It not only has the vertical lifting and hovering capabilities of helicopters, but also has the advantages of long range and fast speed of fixed-wing UAVs. Its main task is to serve as an unmanned platform

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accompanying large and medium-sized surface ships of the navy or army field forces to carry out information support tasks.

3. Future challenges and opportunities

3.1. Intelligence and autonomy

Future UAVs will be more intelligent and have a stronger ability to make autonomous decisions and perform tasks. Uavs need to accurately perceive and understand their surroundings, including obstacle recognition, terrain mapping and dynamic object tracking, etc. Uavs must be able to autonomously make decisions and plan mission execution paths based on perceived information. In complex or unknown environments, real-time and accurate decision making is being tested by UAVs.

3.2. High Performance Algorithm

Integrating and fusing data from different sensors, such as radar, camera, Lidar and IMU, requires complex data processing and fusing algorithms in order to obtain accurate and reliable environmental information and drone status estimation. Modern high performance computing hardware (Gpus, FPGas, ASics, etc.) allows drones to have enough computing power to implement complex artificial intelligence algorithms, thus improving the autonomy and real-time performance of drone collaboration.

3.3. Human-Computer Interaction

The interactions that UAV intelligent collaboration needs to deal with are still extremely complex, involving a large amount of heterogeneous uncertain information, and the cognitive and behavioral models of UAV are still to be explored. With the innovation of human-computer interaction technology and step by step research, emerging technologies such as virtual reality, augmented reality and brain-computer interface can significantly improve the efficiency and accuracy of UAV collaborative work. The development of UAV technology is promoting the innovation of aviation science and technology and the expansion of application fields, and UAV will play a more important role in the future development of society.

4. Conclusion

This paper summarizes the structure and function of UAV and the characteristics of UAV modeling, involving the core components of flight, key technologies, application fields and development trends. Facing the challenges of intelligence, autonomy and human-computer interaction, UAV technology is developing towards higher environment perception, real-time decision making, diversification of structure and application-oriented. Drones are expected to play a more critical role in the future society, driving the further development of their application fields.

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