Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 14, No. 1, 2025

Research on Optimization Design of Intelligent Aircraft

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Abstract: Demand analysis and concept research of intelligent deform-able aircraft, overall and subsystem design technology of intelligent deform-able aircraft. From the perspective of basic scientific problems and bottleneck technologies, the main problems lie in two aspects, namely: aerodynamics, flight mechanics and flight control of deform-able aircraft, deform-able structure, drive and deformation control. The connotation of intelligent deform-able aircraft, deform-able technical indicators, deform-able materials and structures, and cost-effectiveness analysis. Technical difficulties for each performance indicator mentioned above, some novel technologies and methods are used to improve the performance of cross-medium aircraft, which are mainly divided into variable wing technology, variable blade technology, variable density technology and structural buffer technology.

Keywords: Intelligent systems, aircraft, material design, aerodynamics.

1. Introduction

With the development of artificial intelligence and aircraft-related technologies and industries, more and more aircraft systems and products are deeply integrated into various application fields, which also puts higher requirements on traditional aircraft technology, especially in how to better interact and collaborate with people.[1] This type of aircraft system that needs to interact and collaborate with humans is called a human-machine intelligent system. It combines the respective advantages of humans and aircraft to better complete complex human-machine collaborative tasks. Its ultimate goal is to achieve the natural integration of humans and aircraft in application scenarios. Human-machine intelligence technology is the theoretical and technical support for human-machine intelligence systems to achieve their goals.[2] It mainly combines traditional aircraft technology and artificial intelligence technology to improve the naturalness, safety and robustness of aircraft-human interaction and collaboration in terms of system modeling, perception and interaction, collaborative control and human-in-the-loop optimization.[3]

The technology of intelligent aircraft is very advanced. It can achieve autonomous flight through advanced sensors, processors and communication technologies. Generally, intelligent aircraft are mainly composed of four parts, including sensors, processors, communicators and energy devices. Among them, sensors play the role of sensing environmental information; processors are the brains of intelligent aircraft, controlling the movement of the entire aircraft and executing tasks. The communicator is responsible for transmitting signals that can receive and send data, and the energy device provides the energy required by the aircraft.[4]

The various application fields of intelligent aircraft are very wide. In the field of aviation, intelligent aircraft can fly unmanned aircraft, realize autonomous control, and perform various tasks in a safe, convenient and efficient manner. In the military, intelligent aircraft can search for targets, detect, monitor and attack enemies without human intervention. In the field of logistics, intelligent aircraft can realize automatic distribution of goods, improve transportation efficiency, and reduce the waste of human and material resources. In the fields of photography and architecture, intelligent aircraft can perform more sophisticated photography and architectural measurement tasks and reduce labor intensity.[5]

Although intelligent aircraft have advanced technology and a wide range of applications, they also have some potential risks and problems. First, the data security of intelligent aircraft cannot be ignored, because the data involved in the aircraft may cause leakage of national security or other confidential information. Secondly, since intelligent aircraft can achieve autonomous flight, safety issues also need to be given enough attention. For example, if an aircraft fails, it may cause casualties or other adverse consequences. In addition, in the absence of perfect regulations and systems, the flight of intelligent aircraft may also collide with other aircraft or flying objects, causing accidents and other problems.[6]

2. Intelligent Aircraft Technology Problems

Intelligent aircraft is used for military purposes to conduct reconnaissance and destruction of the enemy. Its current prototype is a bit like a drone, but it is more advanced and intelligent. Its main function is to conduct military reconnaissance and destruction of the enemy, but this destruction must be fatal. Its shape can be strange and can be deformed at any time to hide itself. The most important thing is that it must be small and exquisite, as small as a bird, a fish, or even an earthworm, or even a group of flies, mosquitoes, fleas, and huge monsters, which are easy to be discovered. Traditional intelligent aircraft generally have greater resistance during flight, and cannot use wings to quickly help the aircraft adjust its flight attitude, which affects the smoothness of the aircraft's flight and reduces the safety of the aircraft when adjusting its attitude.[7]

Traditional intelligent aircraft cannot effectively reduce the resistance of the aircraft during flight, reduce the smoothness of the aircraft during flight, reduce the overall stability of the aircraft, and cannot make good use of the movable wings to adjust the flight attitude of the aircraft. It cannot guarantee the safety of the aircraft when switching attitudes, which easily causes instability when the aircraft switches attitudes. It is not safe and reliable, so that the device does not have good resistance reduction and attitude switching functions. It cannot complete takeoff under various conditions under the action of multiple jets, which reduces the adaptability of the aircraft and reduces the endurance of the aircraft.[8]

(I) Technical problems solved

In view of the shortcomings of existing technologies, this study provides an intelligent aircraft, which solves the problems that the intelligent aircraft does not have good resistance reduction and attitude switching functions and cannot take off under various conditions under the action of multiple jets.

(II) Technical Solution

To achieve the above objectives, this study is implemented through the following technical solution: an intelligent aircraft, including a frame, one side of the frame is fixedly connected to a head, and both sides of the top and bottom of the frame are fixedly connected to ejectors. The bottom of the inner cavity of the frame is fixedly connected to a support plate, and the top of the support plate is fixedly connected to a steering gear.The output shaft of the steering gear is fixedly connected with a swing arm, and movable shafts are fixedly connected to both sides of the swing arm surface. The surfaces of the two movable shafts are respectively movably connected with a first movable wing and a second movable wing, and the interior of the first movable wing and the interior of the second movable wing are both provided with a first opening. The end of the movable shaft away from the swing arm passes through the first opening and extends to one side of the first opening, and the surface of the movable shaft extending to one side of the first opening is fixedly connected with a locking sleeve. One side of the first movable wing and one side of the second movable wing both pass through the frame and extend to the outside of the frame.

(1) An intelligent aircraft, wherein a first movable wing and a second movable wing are movably connected to each other through surfaces of two movable shafts, and a first opening is provided inside the first movable wing and inside the second movable wing. One end of the movable shaft away from the swing arm passes through the first opening and extends to one side of the first opening, and a locking sleeve is fixedly connected to the surface of the movable shaft extending to one side of the first opening. One side of the first movable wing and one side of the second movable wing both pass through the frame and extend to the outside of the frame, and one end of the fixed shaft passes through the second opening and extends to one side of the second opening. The fixed axis surface has fixedly connected to both sides thereof limit blocks used in conjunction with the first movable wing and the second movable wing, which can effectively reduce the resistance of the aircraft during flight and increase the smoothness of the aircraft during flight. It improves the overall stability of the aircraft, and can make good use of the movable wings to adjust the flight attitude of the aircraft, ensuring the safety of the aircraft when switching attitudes, avoiding instability when the aircraft switches attitudes, and being safe and reliable. It enables the device to have good resistance reduction and attitude switching functions.

(2) An intelligent aircraft, wherein a head is fixedly connected to one side of a frame, and ejectors are fixedly connected to both sides of the top and bottom of the frame. A support plate is fixedly connected to the bottom of the inner cavity of the frame, and a steering gear is fixedly connected to the top of the support plate. The output shaft of the steering gear is fixedly connected to a swing arm, and movable shafts are fixedly connected to both sides of the surface of the swing arm. The surfaces of the two movable shafts are respectively movable connected with a first movable wing and a second movable wing, which can complete takeoff under various conditions under the action of multiple jets, thereby improving the adaptability of the aircraft and increasing the endurance of the aircraft.

3. Aerodynamic Simulation

The atmosphere within 20km from the ground is the territory of various aircraft. At an altitude of 20km~100km, hypersonic aircraft show their prowess. In outer space with an altitude of more than 300km, aircraft can fly in orbit around the earth's satellite. However, at an altitude of 100km~300km, the residual air makes it impossible for aircraft to fly for a long time, so this part of the airspace has not been used.

The atmospheric density in this airspace is extremely low. According to traditional aerodynamic theory, it is not enough to generate lift to maintain its flight in this airspace, and there is considerable resistance. The aerodynamics of the upper atmosphere develops slowly and cannot meet the development needs of aircraft in this airspace.

Under the atmospheric environment conditions of low/ultra-low Earth orbits of 100km~200km, the drag coefficient and atmospheric density are the biggest factors affecting the unpredictable aerodynamic force of aircraft. Ultra-low drag aerodynamic configuration is a prerequisite for aircraft to achieve long-term residence and operation in this airspace. These unpredictable factors make it impossible to design a low drag aerodynamic shape.

According to the existing aerodynamic theory, the lift-to-drag ratio of aircraft in the rarefied flow region is very low, and frictional resistance accounts for a high proportion of the total resistance, which does not meet the needs of low-drag aircraft development. We need to study new theories of upper atmospheric aerodynamics, reveal its interaction mechanism with aircraft, and find the aerodynamic layout of aircraft that can stay in this airspace for a long time based on the nature of the collision between molecules and molecules, and molecules and surfaces

The key difficulties and challenges in the study of upper atmosphere aerodynamics are reflected in its multi-scale characteristics and multi-field coupling, which are also the main aspects that distinguish it from traditional aerodynamics. For example, the interaction between gas molecules and solid surfaces. The new gas-surface interaction model is mainly constructed using molecular dynamics simulation. It is currently in the exploratory stage and faces the problem of being limited by the limitations of time and space scales, and has not yet been verified for correctness.

4. Lattice Boltzmann Method for Base and LES Clear Flow Model

We can integrate powerful volume meshing, fast design changes, GPU graphics acceleration to support transient analysis. Solutions found for external aerodynamics.

We use ultraFluidX, which allows us to perform high-fidelity transient aerodynamic simulations on a single server.

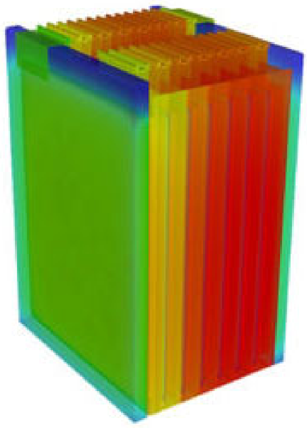

Figure 1. Aerodynamic simulation

In the Altair Virtual Wind Tunnel embedded in the Altair Simulation platform, it is very convenient to set up an external flow field aerodynamic simulation. The corresponding templates can be quickly established for different vehicle models, and the process is clear and error-prone.

The “drag and drop” nature of the Lattice Boltzmann method, the solver’s low mesh quality requirements, the ability to allow for interference and penetration between parts, and fully automatic mesh generation all make it easier to replace parts than in a real wind tunnel, and it becomes feasible to evaluate hundreds of design solutions to meet regulations.

The Lattice Boltzmann method is amenable to massively parallel computing architectures such as GPUs, which provides the stage for unprecedented turnaround times. Our state-of-the-art GPU-optimized algorithms make it possible to run overnight on a single server, while providing highly accurate transient LES aerodynamic simulation results.

Compared to the GPU-based ultraFluidX, traditional simulation methods require thousands of CPU cores to achieve the same level of turnaround time. The GPU-based solution improves computing performance while reducing hardware and electricity costs.Bluff body aerodynamics, especially smart aerodynamics, are highly unsteady physical phenomena in nature. We use ultraFluidX to achieve high-resolution transient LES simulations in a reasonable time, eliminating the need to choose steady-state analysis at the expense of capturing transient physics.

5. Conclusion

In the future, the development of intelligent aircraft will present a broader space. With the continuous innovation and progress of science and technology, intelligent aircraft will become more intelligent and multifunctional. First, the perception ability of intelligent aircraft will be further improved, equipped with more types of sensors, and able to perceive a wider range of environmental information. Secondly, the decision-making ability of intelligent aircraft will be more accurate and faster, and it will be able to make more intelligent decisions in complex environments. Finally, the execution ability of intelligent aircraft will be more efficient and the movements will be more precise, enabling it to complete more complex tasks.

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