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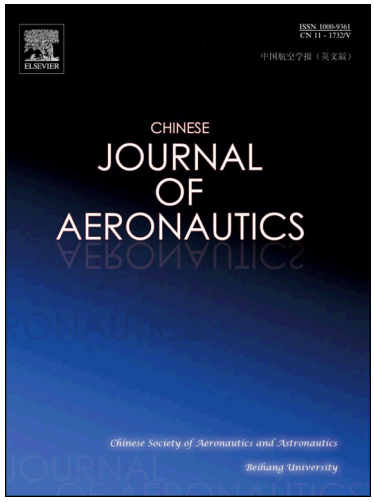

Review Article

Control techniques of tilt rotor unmanned aerial vehicle systems: A review

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Control techniques of tilt rotor unmanned aerial vehicle systems: A review

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Abstract

The tilt rotor unmanned aerial vehicle (TRUAV) exhibits special application value due to its unique rotor structure. However, varying dynamics and aerodynamic interference caused by tiltable rotors are great technical challenges and key issues for TRUAV's high-powered flight controls, which have attracted the attention of many researchers. This paper outlines the concept of TRUAV and some typical TRUAV platforms while focusing on control techniques. TRUAV structural features, dynamics modeling, and flight control methods are discussed, and major challenges and corresponding developmental tendencies associated with TRUAV flight control are summarized.

Keywords: Tilt rotors; Unmanned aerial vehicle (UAV); Flight control; Dynamics modeling; Aircraft structures; Review

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1. Introduction

Aircraft technology has developed for more than a century since the Wright brothers completed their first flight experiments of planes with motors in 1903.[1] Many aircraft with both conventional and novel structures have been developed to meet various tasking requirements. Fixed-wing and rotorcraft aerial vehicles, as representations of aircraft with conventional structures, have played irreplaceable roles in aviation development for a long time. Fixed-wing aerial vehicles are equipped with wings and driven forward by propellers or turbine jet engines. Therefore, they have greater flight mileage, less noise, and higher cruise speed than other aircraft, and have been widely used for commercial and military purposes. However, takeoff environment affects normal flight and they cannot hover at a fixed position. Rotorcraft aerial vehicles, such as helicopters, which are driven by propellers with a swashplate in the vertical direction, can hover in one spot, but cruise speed and flight endurance are low. To combine the advantages of both vehicles, researchers worldwide have focused on aircraft with both high-speed cruise and vertical takeoff and landing (VTOL) ability.[2] This led to the concept of tilt rotor aerial vehicles. A great deal of attention has been drawn to it because this type of aerial vehicle meets commercial demands[3] along with its new technical characteristics.[4]

Tilt rotor aerial vehicles are aircraft that rely on wings and rotors for generating lift.[5] They have three flight modes: helicopter, transition, and airplane modes, as shown in Fig. 1. Because of the variable rotor tilt angle, the most attractive characteristic of tilt rotor aerial vehicles is that they possess the capability to hover in place, as helicopters, while achieving much higher cruise speeds than conventional rotorcraft in airplane mode. Since this concept was proposed, many tilt rotor aircraft have been developed,[5] including the XV-15 and V-22 "Osprey" (see Fig. 2(a)) researched and developed by Bell and Boeing; the V-22 has since become the most valuable tilt rotor aircraft in the world. As control techniques,