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A drone with a combination of dual rotors and fixed wings

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Abstract: *The idea of tiltrotor has been proposed and pushed forward since people's first work in the direction originated in 1902. Successful works such as Bell Boeing V-22 Osprey are still on active military duty in the US and showing its remarkable efficiency in transportation and cargo handling, which is also served as one of the reference prototypes in this drone project. Tiltrotor aircraft shares desirable merits from fix wing and rotor aircraft, enabling it to take off and land vertically, hover at low speed in the air, while achieving a faster cruise speed than a rotor one. To be specific, the technique of vertical launching and landing allows a low request to the size of landing place, which is helpful when the design is utilized in extreme conditions (lack of landing space); The technique of tilted propeller provides extra propulsion to the aircraft, enabling it to keep a relatively high cruise speed. The capacities of hovering and other functions shared by rotor aircraft are also useful depending on purpose. This project aims to design a tiltrotor drone which shares all the merits of tiltrotor aircraft above and keeps the advantage of drones such as remote control, small size, and flexibility. The design achieves those merits by adding 2 remotely controlled rotating propellers. In other words, when the launch altitude meets the expectation, rotors, or the propellers are controlled to rotate 90 degrees reaching horizontal to provide forward propulsion. When used in application, this design is capable of handling similar tasks that can be done by normal rotor drone with a higher efficiency because of its high cruising speed. For example, when using it in aerial photography, people will spend less time waiting for drone traveling to the desired viewpoint.*

Keywords: *Drone, drone traveling, dual rotors*

1. Introduction

Unmanned aerial vehicle (UAV) has been developed after the First World War, well known for remote-controlled aircraft that do not require a pilot to board the aircraft. In modern days, they are developed on the basis of electrical controls for the purposes of logistics transportation, agriculture, security aid, geographical mapping, etc. Most types of UAV share merits of little size (increasing portability), flexibility (enabling them to grab or hoist cargos), and low request of launching space (ignoring the terrain or size of launching space). The technology of regular mode of drone is progress with a high-level application. Successful works such as quadcopter UAV produced by Apple Company give users extraordinary experiences in aerial photography. However, the design of UAV is still staying in the mode of standard rotor aircraft model or fix wing model. On behalf of contributing to the development of UAV, this project is seeking methods to apply the tiltrotor related principles which gained success in the field of airplane designing on drone design. The completion of this project would make progress in the application of tiltrotor model on drone and hence provide a selection of one type of more efficient UAV.

This project aims to design a tiltrotor drone with 2 distantly controlled tilted propellers. Tiltrotor design ever gained successes in projects such as Bell Boeing V-22 Osprey, aircrafts which are still on active military duty in the US and showing its remarkable efficiency in transportation and cargo handling. As mentioned, the key component enabling the tiltrotor drone to share the merits of rotor and fix wing aircraft is those propelling plants: the propulsion unit is a cylindrical device on which is connected with a rotor. The designed tiltrotor drone possesses two identical units on both sides of fix wings connected with the body. Two units are designed to be concentric so that they are controlled to lift or fall at the same time. In general, there are two modes depending on the angle of tilt rotor: in launching and landing mode,

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the propulsion unit provides force pointing upward, cancelling the gravity and gaining upward acceleration. In this model, the drone is capable of completing vertical take-off, landing and hover. The other mode is the cruise mode, in which the propellers are set to horizon to provide horizontal force accelerating the drone to travel between points. Except for two standard modes mentioned above, in different flying tasks, the tiltrotor drone also needs adjustment in the rotation angle of propulsion unit. For example, to raise the altitude of drone in the air, propellers need to tilt up to a certain angle (less than 90 degrees) to gain extra upward force. Other parts of the drone also play vital roles: the fix wings provide necessary upward force to cancel the gravity of the drone, preventing the trajectory from gradually dropping down. Therefore, the propulsion units are designed to be freely controlled by users remotely. An embedded system is designed to calculate and control the tilted angle in order to complete certain tasks from users. [3]

2. Manuscript Preparation

WIn addition to the fuselage structure, the 3D model we made contains additional structures such as rotor propellers, rotor sleeves, solar panels, and cameras. They are mostly connected to the fuselage by weeks, and the solar panels are fixed by welding. The rotor structure can change its orientation during take-off, flight, and landing to meet different needs and achieve all goals with the lowest energy consumption and the smallest environmental requirements. Solar panels strengthen the endurance of drones and solve the problem that traditional drones generally have weak endurance and cannot fly with rotors for a long time. The fixed-wing wing enables the UAV to have long-distance flight capability, and uses the pressure difference between the upper and lower wings to maintain balance during the flight. The camera is to increase the operation function of the drone, so that it has its own vision.

In solidworks modeling, we draw the fuselage, rotor, rotor sleeve, rotor sleeve fixed axis, solar panel, camera, camera mount, and camera rotation axis separately. And then cooperated with each other to produce the UAV assembly drawing with variable rotor direction and fixed other parts. The total length of the UAV's wings is about 1.4 meters, and the size is moderate, suitable for daily air travel. The solar panel is located on the top of the aircraft, which is more conducive to direct light and improves the utilization rate of solar energy. The camera is located at the bottom of the aircraft and is used to observe the front and bottom of the drone. The isometric drawing of the drone is shown below.

After completing the modeling, perform simulation in vrep. The simulation is mainly divided into take-off and flight, both of which can be implemented smoothly. In the takeoff simulation process, set the total mass of the aircraft to 3kg, and adjust the rotor to face upward so that it can rotate to generate upward power. Using joints, adding a motor to the propeller, the control speed limit is 2500 °/s, and the speed acceleration is 2500 °/s2. In addition, the vertical guidance force is added to balance the weight, so that the aircraft stays in the air stably, achieving the effect of stable takeoff. The final renderings are as Fig.1.

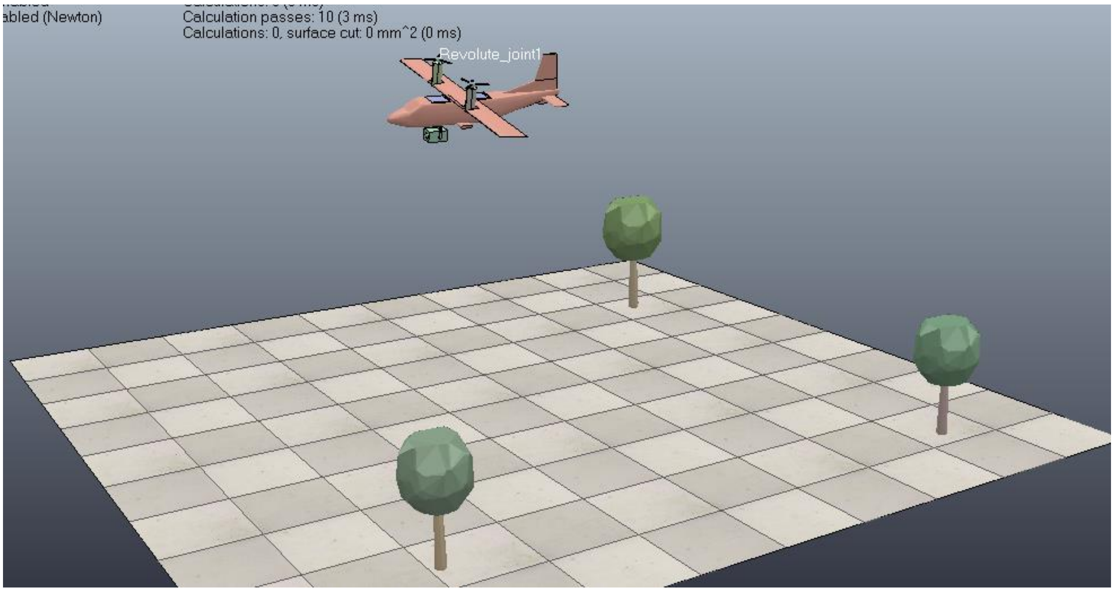

Figure 1: Is the simulation of stable take-off and air stay of the aircraft in v-rep.

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In the process of forward simulation, the total mass of the aircraft is also set to 3kg, and the rotor is adjusted forward so that it can rotate to generate forward power. Using joints, adding a motor to the propeller, the control speed limit is 2500 °/s, and the speed acceleration is 2500 °/s2. Then add the guiding force in the forward direction to balance the air resistance to make the aircraft fly forward and achieve the effect of stable forward flight. The final renderings are as Fig.2.

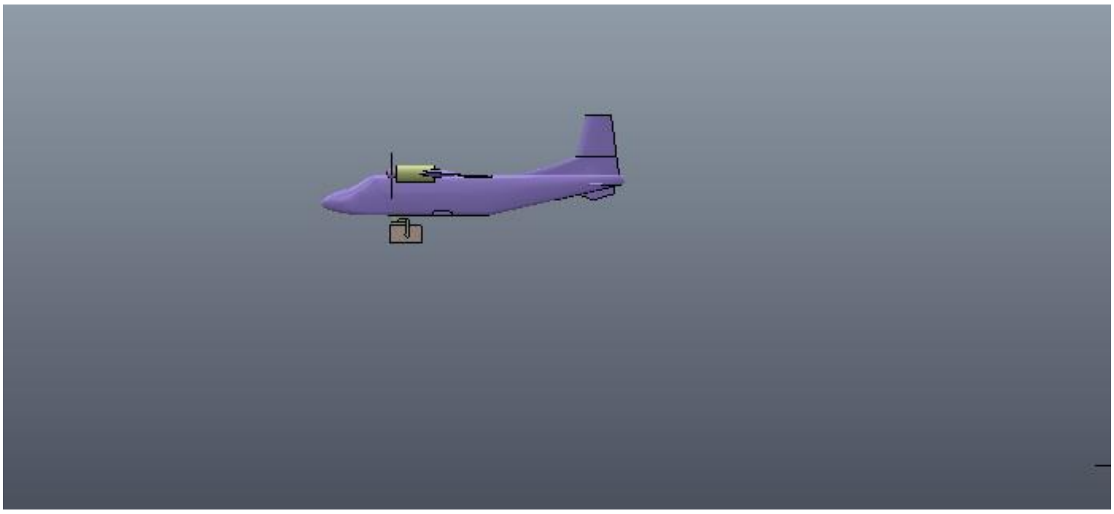

Figure 2: Is is the simulation of the aircraft flying forward in v-rep.

After the realization of modeling and simulation, the stability and innovation of the model have been verified, and it can meet the two main goals of vertical take-off and long-distance smooth forwarding. The follow-up function is mainly realized through the information transmission and interaction of the camera, which can probably be applied to many fields of traffic and police.

3. Conclusions

The success of model simulation in Vrep indicates that tiltrotor design can be applied to small mass drones to implement some basic movements such as launching and cruise: in launching simulation, the test done model showed the capability of overcoming the gravity using propelling force provided by rotor in vertical position to maintain a constant climbing speed, which meets the expectation that drone should launch vertically with equilibrium in horizontal force component; in cruise simulation, the test drone model showed the capability of moving forward with equilibrium of vertical force component when propellers are in horizontal position, which meets the expectation that the lift force provided by buoyancy of fixed wings should be able to cancel gravity to achieve equilibrium when the drone driven by propellers in enough high speed; in inter-process simulation, it is expected that the test drone should drop down initially before it achieves high enough speed (since the launching process does not provide any forward force), and the acceleration can be controlled after this process to adjust height. [4]

Grantly, there are many improvements that can be made to further understand the tiltrotor model. For example, the inter-process changing the direction of rotor is important to be further studied: the trajectory and force system can be modelled in math to predict the specific magnitude of initial velocity possibly gained in this process. To be specific, in the tilting process, the rotor rotates 90 degrees causing the continuous reduction of lifting force and increasing of forward force while increasing horizontal component of force provides extra lifting force due to buoyancy. In general, the trajectory is predicted as the following figure.

As mentioned, the tiltrotor design combines the merits of fixed wings and rotor aircraft, so applying it to UAV, or drones, will produce significant application values. The model design in this paper can be used for aerial photo shooting or life detection. It possesses the natural advantage of higher cruise speed, lower launching space requirement, higher flexibility, and longer cruise duration (achieved by small solar panels assembled on the body) compared with other types of UVAs, in turn, improving user experience. In the future, the tiltrotor drones might be further studied to increase the accuracy of movements so that they would be capable of launching and cruising in more severe environments and doing more precise jobs.

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