Abstract

Making an Unmanned Aerial Vehicle (UAV) land in a style similar to a bird has many benefits. For example, electric powered UAVs could land on power lines to recharge their batteries, on branches for stealthy surveillance, or on the sides of buildings to perch in an urban setting. The main problem with landing an UAV at a high angle of attack, similar to a bird, is controlling the aircraft while in a stall, since the wings don’t produce enough lift to be effective at adjusting the orientation of the aircraft. Birds have a perfect process to land while in a stall 100% of the time, which is why it is so important to understand this and translate it to an UAV. By tracking different parts of a bird using multiple cameras at different angles (photogrammetry), information will be gathered to observe how a bird controls itself during its landing maneuver, which will help us understand all of the mechanics necessary to be translated to an UAV.

Introduction

Compared to how a standard aircraft flies, a bird is very complicated. For a UAV, the center of mass is in front of the wing. The wings provide lift, while the tail provides a down force to keep the UAV stabilized (Figure 1). For a bird, the wings and the tail both provide lift because the center of gravity is located towards the back side of the wings where the chest muscles are located. This causes problems when translating a bird’s landing sequence to that of an UAV. In order for a standard UAV to land like a bird, it would have to go into a high angle of attack, which means an increase to the elevators on the tail would cause the UAV to rotate until it is almost vertical and then would stall. For a bird to begin the landing sequence (Figure 2), it launches their feet forward which causes a rotational force that rotates the bird into its high angle of attack. After that, the wings and tail slow down the bird until it lands. The bird is then able to control itself during a stall. Future expected results from more advanced photogrammetry should reveal what methods the bird uses to control itself during a stall.

Methods

To analyze how birds maintain control during a stall, we needed to track exactly what parts of the birds move and how these parts move. For the first round of data (Figure 3), a program called Tracker was used to track the beaks, tails, and wingtips. The problem with Tracker is that all data comes from user input which could lead to a lot of small errors. To fix this problem, the next step is to film birds using a method called photogrammetry, which films the birds from different angles and uses triangulation to track multiple points of the birds almost perfectly. Once the more precise data is collected, we will analyze what the birds are doing to keep control during a stall and find the best method to utilize this on an UAV. Then a mathematical model of the UAV will be made on MATLAB to further improve the design. Lastly, a UAV model will be made and tested to see how effective it is at perching.

Expected Results

At this point, the expected results of how a bird controls its landing are for the legs to start the initial rotation upon landing by creating a moment. Then a combination of wing morphing and tail movement will increase the drag dramatically slowing the bird and eventually causing a stall; whereas, the rotation of the body of the bird could possibly keep it from losing control during a stall. A possible way to implement this on a UAV is by shifting the center of mass backwards on the UAV and making the tail create lift. If the UAV could be stabilized during normal flight with both the wings and the tail creating lift, then it is possible that the UAV could maintain control during higher angles of attack. Another possible way to control the UAV during a stall would be wing morphing so that the surface area of the wing changes. There are many other possible solutions for making an UAV perch like a bird, but until the data is collected we cannot speculate the most effective way to translate a bird perching to an UAV landing.

References


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