Visualization of Forward Flapping Flight

EE 368/CS 232 – Project Proposal

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Motivation

In bird flight research, it is important to quantitatively and accurately estimate the flapping flight kinematics of the bird. For instance, for studying the vortex wake aerodynamics of a bird using Particle Image Velocimetry techniques, an accurate representation of the wingbeat kinematics of the bird is important for accurately estimating the flight forces. The different flight kinematics might include the wingbeat frequency, wingbeat amplitude, wing phase, mean forward flight velocity, and wing velocity [1]. Knowing if the bird is accelerating, decelerating, climbing, or descending during the measurements, or data acquisition, is also important.

It is common for researchers to paint markers on the wing and body of the birds for obtaining flight kinematics [2, 3]. This project deals with obtaining flight kinematics without using markers.

Goals

In my research, I am currently using Stereo Particle Image Velocimetry to study the wake aerodynamics of forward flapping flight of a bird. In addition to using four high-speed cameras (Phantom Miro M310) recording at 1,000 Hz to study the motion of the air particles left behind the bird, I am using a fifth high-speed camera (Phantom Miro LC310) to study the motion of the bird while in flight. My plan is to use image processing techniques to study the kinematics of the bird while in flight. I will position the high-speed camera such that the bird is flying concentric to the camera lens center.

Techniques that I will use are the following: I will preprocess the videos to take care of the effects of uneven background lighting. I will remove the background from each frame to only focus on the bird. I will threshold and binarize the images to find the flapping frequency and wing amplitude as a function of time of each flight.

I will calculate the forward velocity of the bird as a function of time. I will do this by using image correlation to match the phase of one frame of each wing beat to the same phase of each subsequent wingbeat. Since the size of the bird will be changing, I will scale each frame by an appropriate number. I will gather each matched frame from the start of the flight to the end of the flight and relate the time it takes for the wing phase to repeat to the size of the bird. I will use these parameters to get an average velocity for each wingbeat.

Figure 1. Three frames from a video taken from the high-speed camera at 1000 Hz. The Parrotlet is flying away from the camera.

References

[1] Henningsson, P., Spedding, G. R. & Hedenstrom, A. 2008. Vortex wake and flight kinematics of a swift in cruising flight in a wind tunnel. J. Exp. Biol. 211, 717 – 730. (doi:10.1242/jeb.012146)

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[3] Berg, A.M. Biewener A. A. 2010. Wing and body kinematics of takoff and landing flight in the pigeon (Columba livia). J. Exp. Biol. 213, 1651-1658.