



# Automated aerodynamic performance estimates for flapping flight



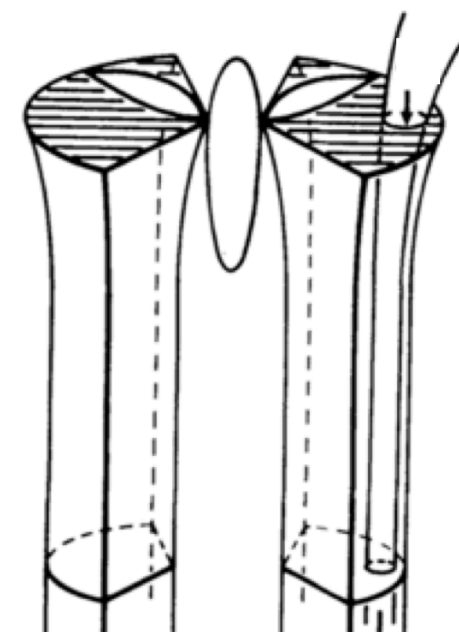
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## Motivation

Quantifying aerodynamic performance for freely flying birds is inherently difficult to do without interfering with their natural flight. Many current methods thus combine kinematic parameters derived from high-speed video with theoretical force and power models. However, these methods often require manual tracking of points in each frame of a video to obtain kinematic data [1, 2].

This project utilizes image processing techniques to automatically extract kinematic data (stroke angle and wingbeat timing) from high speed videos of Pacific parrotlets flying from perch to perch. To analyze aerodynamic performance, this data is then used to estimate power requirements based on actuator disc theory [3, 4].



The idealized wake for a flapping-wing animal. Induced power can be estimated from the change in momentum through the shaded area, i.e. the "actuator disc" [3].

## Future Work

- Reduce the number of parameters needed for robust processing of different flight videos
- Automatically identify optimal region for analysis in new videos
- Track beak to adjust for changes in body orientation during flight

## Related Work and References

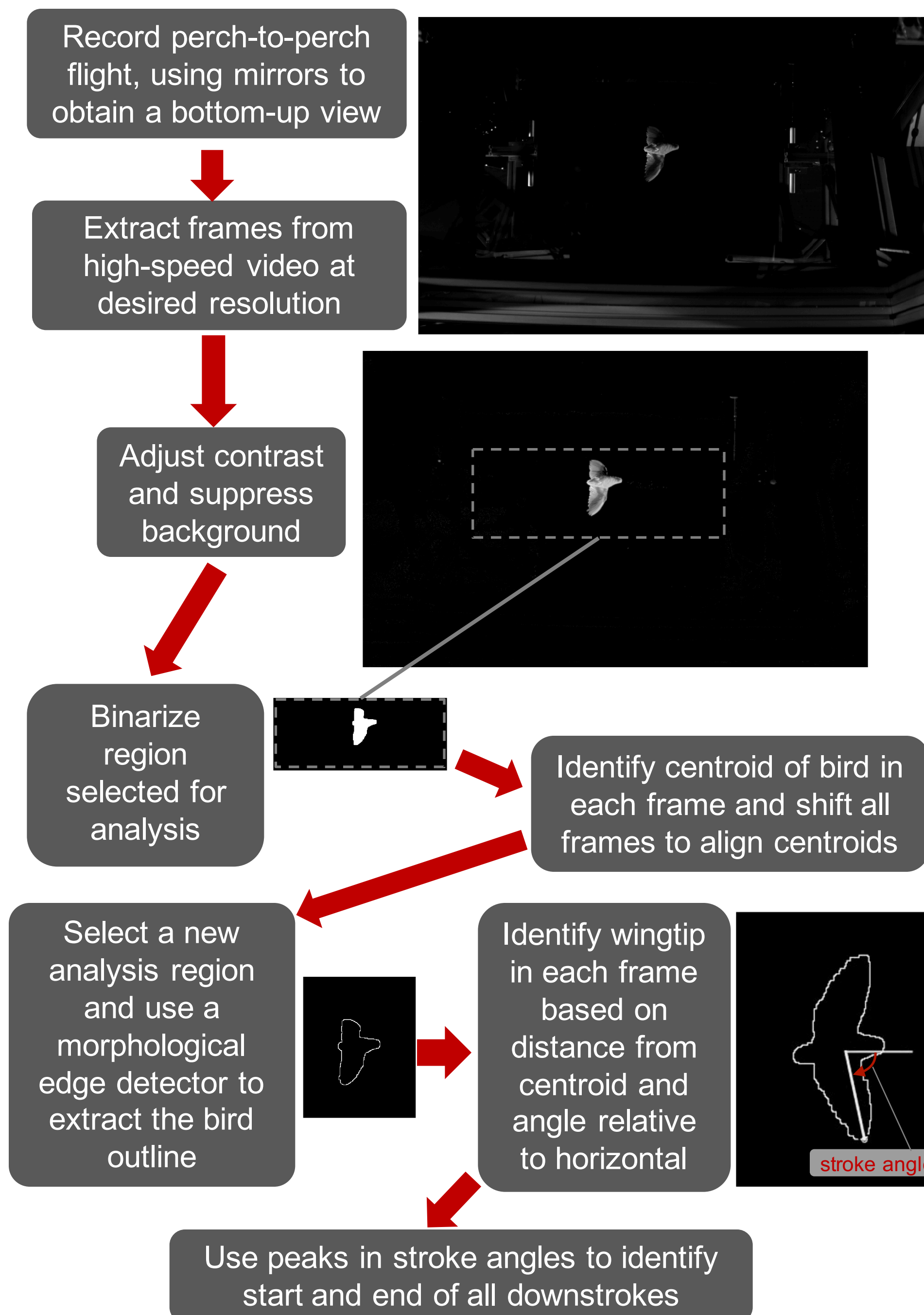
EE 368 projects from past years related to flapping flight:

- Deetjen, Marc. Hovering hummingbird automated segmentation. Spr 2014-15.
- Gutierrez, Eric. Quantitative measurements of forward flapping flight using image processing. Spr 2014-15.
- Ravnan, Eirik. Automatic phase detection of a bird wing in flight using stereo cameras. Aut 2013-14 .

References:

- [1] Berg, A. M. and Biewener, A. A. (2010). Wing and body kinematics of takeoff and landing flight in the pigeon (*Columba livia*). *J. Exp. Biol.* 213, 1651-1658.
- [2] Hedrick, T. L. (2008). Software techniques for two- and three-dimensional kinematic measurements of biological and biomimetic systems. *Bioinsp. Biomim.* 3, 034001.
- [3] Ellington, C. P. (1984). The Aerodynamics of Hovering Insect Flight. V. A Vortex Theory. *Phil. Trans. R. Soc. B. Biol. Sci.* 305, 1122, 115-144.
- [4] Muijres, F.T., Spedding, G. R., Winter, Y. and Hedenstrom, A. (2011). Actuator disk model and span efficiency of flapping flight in bats based on time-resolved PIV measurements. *Exp. Fluids.* 51, 511-525.

## Processing Pipeline



### Post-processing

1. Create video showing stroke angle
2. Combine extracted data with synchronized force measurements to estimate induced power
3. Use wingbeat timings with footage from another camera to generate a time-lapse image of the entire flight

## Results

The processing steps were tested on videos of ascending, descending, and level flights of 3 different Pacific parrotlets. By adjusting a series of flight-specific parameters, stroke angles and all wingbeats were successfully extracted from 30 out of 31 flight videos.

