Birds flying through laser light reveal faults in flight research

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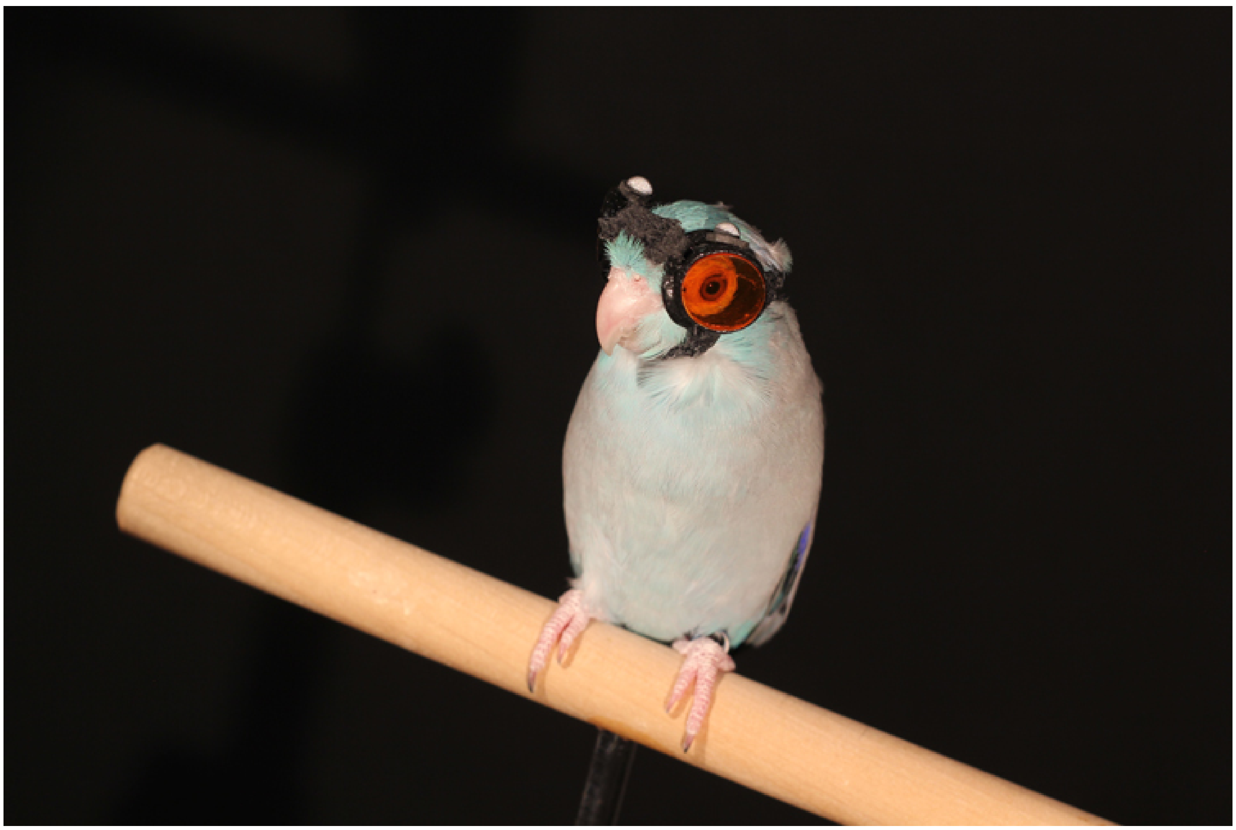

Obi the parrotlet wearing protective goggles. Credit: Eric Gutierrez

The protective goggles are tight, the chin strap secure. Conditions are calm and the lasers are ready; the air is infused with tiny aerosol particles that are primed to scatter and track at the slightest disruption. Wait for the signal.The researcher points. The bird flies!

It's just another day at the office for a parrotlet named Obi.

As a graduate student working with Stanford mechanical engineer David Lentink, Eric Gutierrez trained this member of the second smallest parrot species in order to precisely measure the vortices it creates during flight. Their results, published in the Dec. 6 issue of *Bioinformatics and Biomimetics*, help explain the way animals generate enough lift to fly and could have implications for how flying robots and drones are designed.

"The goal of our study was to compare very commonly used models in the literature to figure out how much lift a bird, or other flying animal, generates based off its wake," said Diana Chin, a graduate student in the Lentink lab and co-author of the study. "What we found was that all three models we tried out were very inaccurate because they make assumptions that aren't necessarily true."

Scientists rely on these models, developed to interpret the airflow generated by flying animals, to understand how animals support their weight during flight. The results are commonly referenced for work on flying robots and drones inspired by the biology of these animals. Bio-inspired robots are a specialty of Lentink - his students developed the first flapping robot that can take off and land vertically like an insect and a swift-like robot with wings that deform as it swoops and glides.

Birds wearing goggles

For this experiment, Gutierrez, the study's lead author and former graduate student in the Lentink lab, made parrotlet-sized goggles using lenses from human laser safety goggles, 3D-printed sockets and veterinary tape. The goggles also had reflective markers on the side so the researchers could track the bird's velocity. Then he trained Obi to wear the goggles and to fly from perch to perch.

Once trained, the bird flew through a laser sheet that illuminated nontoxic, micron-sized aerosol particles. As the bird flew through the seeded laser sheet, its wing motion disturbed the particles to generate a detailed record of the vortices created by the flight.

Those particles swirling off Obi's wingtips created the clearest picture to date of the wake left by a flying animal. Past measurements had been taken a few wingbeats behind the animal, and predicted that the animal-generated vortices remain relatively frozen over time, like airplane contrails before they dissipate. But the measurements in this work revealed that the bird's tip vortices break up in a sudden dramatic fashion.

"Now, whereas vortex breakup happens far away behind the aircraft - like more than a thousand meters - in birds, it can happen very close to the bird, within two or three wingbeats, and it is much more violent," said Lentink, who is the senior author on the paper.

Taking on three theories

The question was whether models of lift based on an inaccurate idea of an animal's wake were valid.

The team applied each of the three prevailing models to the actual measurements they recorded and from that generated three different estimates of the amount of lift Obi generated with each wingbeat. They then compared those calculated estimates of lift to the actual lift measured in a previous study carried out using a sensitive device developed by the Lentink lab. (The instrument, an aerodynamic force platform, is so sensitive that it nearly broke when they tested a prototype by popping a fully inflated balloon inside, said Lentink.)

What they found is that to varying degrees, all three models failed to predict the actual lift generated by a flapping parrotlet.

New models needed

This research highlights challenges in developing flying robots based on what's known about animal flight. The differences between the three models, plus the variety of animals involved in earlier studies, including other bird species, bats and insects, makes comparison within the literature extremely challenging. As shown by the problematic performance of the current options, a completely new model may be the answer.

"Many people look at the results in the animal flight literature for understanding how robotic wings could be designed better," said Lentink. "Now, we've shown that the equations that people have used are not as reliable as the community hoped they were. We need new studies, new methods to really inform this design process much more reliably."

Lentink believes that the new technique developed by his lab - the one for measuring force directly - could be combined with detailed flow measurements to better dissect and model the aerodynamic phenomena involved in animal flight.

Provided by Stanford University

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