Avian Flight as an Inspiration for Drone Design

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Many organisms fly in order to survive and reproduce. I am fascinated by the mechanics of flying birds, insects, and autorotating seeds. Their development as an individual and their evolution as a species are shaped by the physical interaction between organism and surrounding air. It is critical that the organism's architecture is tuned for propelling itself and controlling its motion. Flying macroscopic animals and plants maximize performance by generating and manipulating vortices. These vortices are created close to the body as it is driven by the action of muscles or gravity, then are 'shed' to form a wake (a trackway left behind in the fluid). I study how the organism's architecture is tuned to utilize the fluid dynamics of vortices. Here I link the aerodynamics of insect wings to that of bat, maple seed and bird wings. The methods used to study all these flows range from robot fly models to maple seeds flying in a vertical wind tunnel to freeze dried swift wings tested in a low turbulence wind tunnel. The study reveals that animals and plants have converged upon the same solution for generating high lift: a leading edge vortex that runs parallel to the leading edge of the wing, which it sucks upward. Why this vortex remains stably attached to flapping animal and spinning plant wings is elucidated and linked to kinematics and wing morphology. While wing morphology is quite rigid in insects and maple seeds, it is extremely fluid in birds. Here I show how such 'wing morphing' significantly expands the performance envelope of birds during both gliding and flapping flight. Finally I will show how these findings have inspired the design of new flapping and morphing micro air vehicles.