Scientists study hummingbirds flight to develop self-propelled surveillance devices

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The secret to the flight of the hummingbird and other tiny birds and insects lies in the looping, swirling flow of air, called a vortex, that their flapping wings create.

These aerodynamically unconventional flows are the inspiration behind new research by a University at Buffalo scientist who hopes to understand the nature of the three-dimensional vortex formation process so that it can be optimized.

The UB research is motivated by the need to gather real-time intelligence in particularly challenging environments; these include remote caves and tunnels or complex building corridors in cities, neither of which can easily be penetrated by conventional, unmanned aircraft or spy satellites. One solution being explored is the design of tiny, flying surveillance devices called micro-air vehicles that are bio-inspired, based on lessons drawn from the behavior of insects and birds.

"In surveillance applications, these small, autonomous or remote-controlled vehicles would be ideal because they would be able to penetrate these complex kinds of terrain and gather first-hand, real-time intelligence," says Matthew Ringuette, PhD, assistant professor in the Department of Mechanical and Aerospace Engineering in the UB School of Engineering and Applied Sciences.

But developing flying devices on the scale of just a few inches requires a much greater understanding of the propulsion systems of tiny birds and insects.

"When you get down to such small sizes and slow speeds, conventional aerodynamics no longer apply," explains Ringuette.

Instead of the streamlined flow that occurs when air flows over the wing of a jet, for example, fluid dynamics at the much smaller scales of hummingbird wings are characterized by swirling flow and vortex formation, similar to that which is created by canoe paddles as they are pushed through the water.

"Animals, such as insects and birds, take advantage of this vortex formation to achieve flight and outstanding maneuverability," he explains.

Ringuette's research is designed to discover how vortex growth and development scales with wing size, motion and shape, so that the wing of a micro-air vehicle can be optimized for maximum propulsive force and efficiency. He notes that this work is fundamental to three-dimensional vortex formation in general, which occurs in a variety of settings, from cardiovascular flows to wind-energy applications.

He will conduct experiments using a robotic, flapping-wing model that will propel itself through a 13-foot by 4-foot by 3-foot water tank in his Vortex Dynamics and Bio-Inspired Propulsion Lab at UB. In water, these flapping wing models can produce at larger scales vortex formation similar to that exhibited by birds and insects. Ringuette will be making quantitative measurements of wing flow velocity and the forces at work during propulsion, supplemented by dye visualization to obtain a picture of the three-dimensional flow.

Ringuette is conducting this research as a result of his Young Investigators Research Program award from the Air Force Office of

Scientific Research.

Provided by University at Buffalo