RESEARCH BRIEF

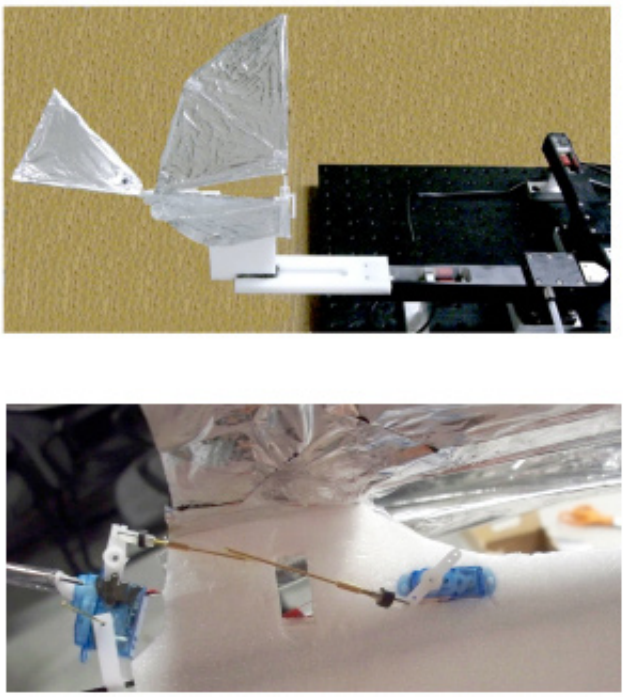
MICRO AIR VEHICLES WITH FLAPPING WINGS

The potential

Remote-controlled micro air vehicles (MAVs) that imitate birds are expected to play a big role in future U.S. military surveillance and reconnaissance missions.

When flying, larger birds like hawks or seagulls fold their wing on the upstroke. This slows their forward velocity to a near hover and enables them to carry food and other objects—two abilities highly desirable in a good surveillance MAV. Developing working folding-wing technology that will make slow flight and sensor payload possible is a large step forward in developing these aircraft.

Ornithopter MAVs also have an advantage of being more maneuverable for operations in constrained spaces than their fixed-wing or rotary-wing MAV cousins. In addition, ornithopters offer greater possibilities for miniaturization. Importantly, flapping wing MAVs are quieter than other types of tiny aircraft, and when the wings also can fold, maneuverability dramatically increases.



The jumbo bird, currently in development, features wings that maximize thrust and lift performance (top), and a new tail actuator design with rudder and elevator separately controlled (bottom).

The challenges

The vehicles should exhibit quiet flight and be able to execute advanced acrobatics. They should be capable of cruising, gliding nad hovering. Long endurance and highly efficient flight are necessary. The vehicles should be able to be controlled with many degrees of freedom. They need to be rugged for adverse weather flight capability and to be able of withstanding multiple crashed. Finally, the vehicles need a high payload to overall weight ratio.

The research

Professor S.K. Gupta and his students have developed new technology that makes possible a working "ornithopter" MAV that can flap and fold its wings like a real bird.

Until this breakthrough, lightweight ornithopters could only flap, not fold their wings. This is because wings that fold are heavier than those that don't. In the world of MAVs, the weight of everything matters: wings, batteries, the motor, the camera and the microphone. Previously, a lightweight surveillance ornithopter with folding wings was not able to fly or carry a payload.

Gupta realized that weight could potentially be shaved and efficiency improved by developing a lightweight, highly-efficient drive mechanism, or transmission. The transmission is critical because it transfers the power from a rotary motion motor to the flapping wings. His breakthrough is a new way to fabricate lightweight transmissions using multi-part molding, a technology Gupta has been developing and refining for the better part of a decade.

Multi-piece molding can manufacture geometrically complex structures. This scalable process not only molds parts, but assembles them inside the mold as well. With this technology, his team has developed a new, optimized lightweight drive mechanism for MAVs that minimizes moving parts by replacing them with biologically inspired compliant structures. The fewer mov-

ing parts minimize power loss, increasing the efficiency of the transmission. Gupta says that one day the in-mold assembly process could be refined to integrate electronics, batteries and actuators into the structures.

Gupta's team first developed transmissions for several nonfolding flapping-wing MAVs, and demonstrated their capacity to fly. Each of these aircraft was successively larger, so that increasingly heavy payloads could be carried. The largest are about the size of a crow and weigh 1.5 ounces. They can carry a video camera with a transmitter as well as its batteries, and stay aloft for 14 minutes in calm air. (Time aloft is determined by the capacity of the batteries.) The video camera's images can be stabilized via software.

The folding-wing MAV began flying in September 2008. This innovation allowed the aircraft to slow its flight velocity by 10 percent without any appreciable decrease in cargo capacity. This ornithopter, about the size of a pigeon, weighs 1.3 ounces with its batteries, and has a wing span of 22.5 inches. It is capable of carrying cargo (usually a surveillance camera) that weighs .35 ounces.

Importantly, Gupta's aircraft do not use wing-mounted propellers to "help" the wings. Such motors are too loud for reconnaissance purposes, forfeiting the element of stealth. "These MAVs are truly bird-inspired," Gupta says.

The research team is developing a "jumbo bird" that will be able to carry cargo weighing .70 ounces. This bird will be capable of flying along a course using an autopilot flight plan incorporating global positioning system software. The jumbo bird will be slightly smaller than a hawk, and will continue the incremental development of this promising technology.

Link

Videos of birds developed by Gupta's group can be seen at *www.enme.umd.edu/~skgupta/UMdBird/*

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