Feathered robotic wing paves way for flapping drones

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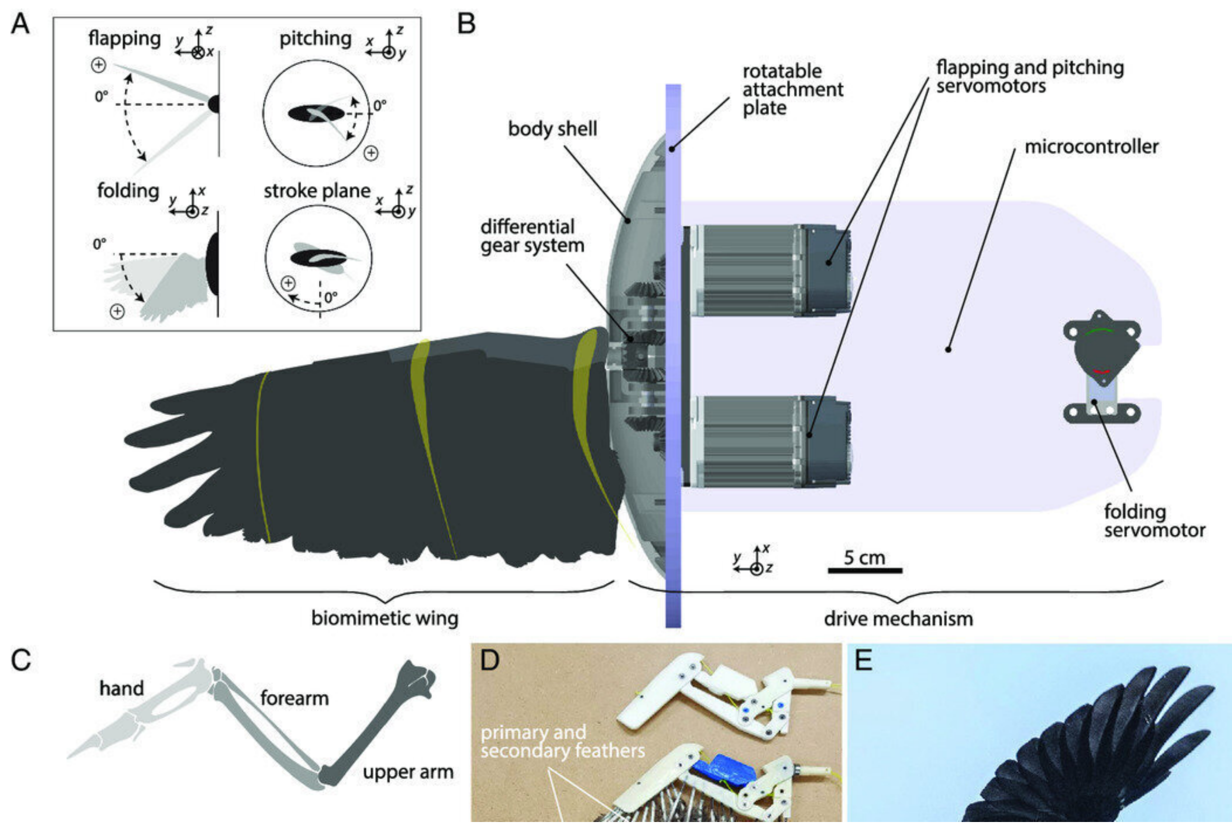

Mechanical design and working principle of the biomimetic wing and the drive mechanism. A) The robotic flapper allows the active control of flapping, pitching, and folding angles, while the stroke plane angle can be changed manually by rotating the circular attachment plate. B) The robotic flapper consists of two main parts: the biomimetic, undercambered wing made from real feathers (local airfoil given in transparent yellow) and the drive mechanism containing a differential gear (covered by the transparent mock-up body), the three servo motors, and a microcontroller. C) The bird wing skeleton (top) was used as an inspiration for the bar linkage skeleton (middle and bottom) of our artificial wing, consisting of five bones (b1−b5) and seven joints (j1−j7), which can be extended through tendon (t1) and closed though tendon (t2). D) Three construction steps of the biomimetic wing: skeleton (top), skeleton with primary and secondary feathers (middle), and the final wing with the silicone membrane and the covert plates (bottom). E) We mimicked the wing of the jackdaw (Coloeus monedula). Photo: Arend Vermazeren, used under a Creative Commons license 2.0 F) Exploded view of the gear setup containing seven bevel gears (g1−g7) and the support that holds gears g1−g3 together. G) To flap the wing, the servo motors are counter-rotating. To pitch the wing, the motors are corotating. H) The folding servomotor is rotated clockwise to extend and counterclockwise to fold the wing. Credit: *Advanced Intelligent Systems* (2022). DOI: 10.1002/aisy.202200148

Birds fly more efficiently by folding their wings during the upstroke, according to a recent study led by Lund University in Sweden. The results could mean that wing-folding is the next step in increasing the propulsive and aerodynamic efficiency of flapping drones.

Even the precursors to birds—extinct bird-like dinosaurs—benefited from folding their wings during the upstroke, as they developed active flight. Among flying animals alive today, birds are the largest and most efficient. This makes them particularly interesting as inspiration for the development of drones. However, determining which flapping strategy is best requires aerodynamic studies of various ways of flapping the wings. Therefore, a Swedish-Swiss research team has constructed a robotic wing that can achieve just that—flapping like a bird, and beyond.

"We have built a robot wing that can flap more like a bird than previous robots, but also flap in way that birds cannot do. By measuring the performance of the wing in our wind tunnel, we have studied how different ways of achieving the wing upstroke affect force and energy in flight," says Christoffer Johansson, biology researcher at Lund University.

Previous studies have shown that birds flap their wings more horizontally when flying slowly. The new study shows that the birds probably do it, even though it requires more energy, because it is easier to create a sufficiently large forces to stay aloft and propel themselves. This is something drones can emulate to increase the range of speeds they can fly at.

"The new robotic wing can be used to answer questions about bird flight that would be impossible simply by observing flying birds. Research into the flight ability of living birds is limited to the flapping movement that the bird actually uses," explains Christoffer Johansson.

The research explains why birds flap the way they do, by finding out which movement patterns create the most force and are the most efficient. The results can also be used in other research areas, such as better understanding how the migration of birds is affected by climate change and access to food. There are also many potential uses for drones where these insights can be put to good use. One area might be using drones to deliver goods.

"Flapping drones could be used for deliveries, but they would need to be efficient enough and able to lift the extra weight this entails. How the wings move is of great importance for performance, so this is where our research could come in handy," says Christoffer Johansson.

More information: Enrico Ajanic et al, Robotic Avian Wing Explains Aerodynamic Advantages of Wing Folding and Stroke Tilting in Flapping Flight, *Advanced Intelligent Systems* (2022). DOI: 10.1002/aisy.202200148

Provided by Lund University