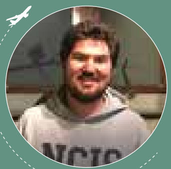


Göksel Keskin
Junior Researcher, Department of Biological Physics, Eötvös Lorand University / Glider Pilot

Bio-Inspiration in Various Types of UAVs

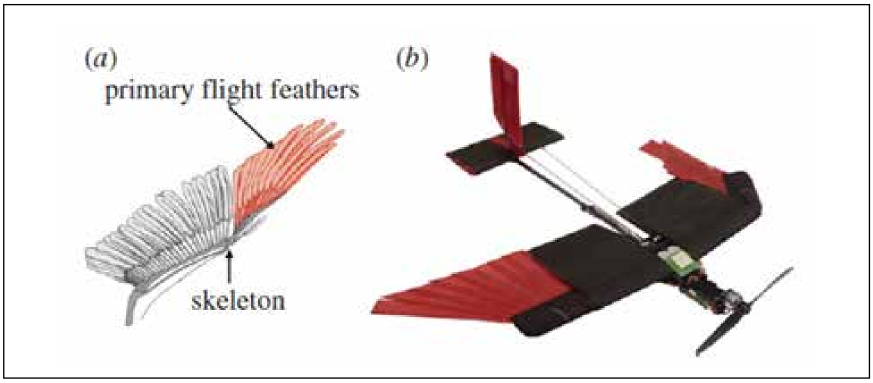
The design community is rapidly adopting biologically inspired concepts as a valuable paradigm to enhance mission capability. The general concept notes that biological systems are often able to perform manoeuvres that cannot be duplicated by engineered systems based on traditional designs; consequently, the aspects associated with that capability for biological systems can be incorporated into engineered systems. Natural systems are used to inspire engineered systems in their modes of locomotion, manoeuvres, and control systems.

In flight especially, both marine and aerial biological systems inspire vehicle configuration studies. The chemical processes used in nature, such as energy and reproduction, are being studied but remain challenging however, the issues of shape changing and mass distribution through morphing that is used in nature are often realizable in aircraft using off-the-shelf technology. A set of UAVs are developed and flown that directly incorporate biologically inspired morphing through articulated wings with shoulder and elbow joints along with twisting. One paper introduces a biologically inspired concept from pterosaurs to enhance mission performance; specifically, an aircraft is designed that incorporates a variable-placement vertical tail which is similar in nature to the cranial crest of the pterosaur were actually the first vertebrates to achieve flight which occurred about 225 000 000 years ago. This design allows the vertical tail to move back in a traditional airplane configuration and move forward in a pterosaur-inspired configuration. The flight dynamics are analysed using computational aerodynamics to observe the variations in static stability and unique modes that evolve. Finally, moving the vertical tail over the nose is shown to have an adverse effect on both static and dynamic stability but can reduce the turn radius by 14%.

Morphing wings that change the shape and configuration of an aircraft can expand the flight capabilities of a flying vehicle to fulfill opposing requirements. This capability is particularly important for small drones, also known as micro air vehicles (MAVs), that can navigate in close proximity to obstacles. These MAVs should be highly manoeuvrable in order to rapidly change course with a small turn radius: for a given weight of the aerial vehicle, a small turn radius is obtained by maximizing the wing surface and the lift coefficient of the wing. However, wings with a large surface are very sensitive to wind; while, wings with a small surface generate less frictional drag allowing an aerial vehicle to fly faster and keep a constant forward ground speed in comparatively stronger headwinds. A wing with a morphing surface could adapt its aerial surface to optimize aerodynamic performance to specific flight situations. Novel wing morphing mechanism inspired by the folding mechanism of bird feathers was introduced by a group of researchers. Similar to birds, the outermost part of the wing is equipped with artificial feathers that can be folded to actively change the surface of the wing. This morphing mechanism can not only improve aerodynamic performance for manoeuvrability and wind resistance, but also provide roll control with asymmetric folding of the two wings. In this study,

the mechanical design of the bio-inspired wing was proposed for integration in a small drone, and the aerodynamic design of the wing used a novel bird-like aerofoil.

Computational simulations show the benefits of surface morphing for high-speed flight and manoeuvrability. In agreement with the computational results, wind tunnel characterization of a foldable wing prototype shows high lifting capabilities when fully deployed and a drag reduction up to 48% when the wing is fully folded. In this example, the effectiveness of asymmetric surface morphing is used to controll the roll dynamic of a morphing wing prototype. Asymmetric surface morphing has been compared to conventional ailerons using a computational model. In agreement with computational results, wind tunnel tests show that asymmetric folding is comparable to conventional ailerons for roll control in low-speed flying conditions. Finally, as a proof of concept, the researchers validated the roll control authority of the proposed design with outdoor flights of a small drone with morphing wings.



The design of a morphing aircraft structure is highly dependent on the size, weight, and expected role of the flight vehicle. This suggests that there exist no universal morphing solution, and that each approach to morphing will depend entirely on the vehicle itself. For instance, a supersonic morphing fighter aircraft is likely to be entirely different in shape and characteristics than a high-endurance UAV platform. Although the very concept of morphing is to bridge the gap between two very different flight regimes, there are a variety of physical constraints that will limit such transitions. Morphing aircraft structures are likewise dependent on this relationship, as the choice of actuator or skin material will be intrinsically dependent on the size of the aircraft. The approach suggested in this paper is limited to a morphing concept for a small UAV with a size, flying speed, and weight comparable to a variety of birds. With such close similarities, it is reasonable to draw on biological inspiration in structure and shape.

The possible benets of morphing become evident by studying even basic aerodynamic and aeronautical formula. Concepts such as telescoping wings, variable chord, and variable aspect ratio have a direct bearing on the performance of the aircraft. Gull-wing morphing has an effect on the flight dynamics of a micro air vehicle, and a simple morphing strategy based on biological inspiration has been identified and has been used successfully on a 24-inch aircraft. The results show promise in the ability of the morphing device to alter the vehicle's aerodynamic performance.

Changes in the geometry of lifting surfaces provide better flight performance in different flight modes. However, previous trials on full-scale aircraft showed that it's really worth applying variable geometry to commercial or off-the-shelf technology. With the development of low-cost UAVs, we have been seeing similar types of applications more often and will continue to see this trend in the future.