

Towards a Biologically Inspired Supercritical Airfoil Adapted for Gliding Cross-Domain Vehicles

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Abstract : Growing research on cross-domain vehicles (CDVs) has addressed the requirement to balance airfoil efficiency in air and water. No existing airfoil is specifically developed to adapt to the large Reynold's number range CDVs operate in. This research proposes a supercritical airfoil biologically inspired by Atlantic Puffins. The initial airfoil is parameterized with the composite Karman-Trefftz method, optimized with a series of multi-stage gradient descend procedures, and compared with other airfoils with Xfoil. Results from Xfoil are also validated via Fluent and experiment considering curvatures on the designed airfoil might affect the accuracy of Xfoil. The results indicate that while CFD and Xfoil results closely align, Xfoil produces results closest to the experimental value. The bionic airfoil demonstrates superior performance in the range $Re = 2 \cdot 10^4$ to $Re = 2 \cdot 10^5$ compared to other studied airfoils, satisfying design requirements. This airfoil and its future counterparts are probable solutions to be implemented on fixed-wing CDVs desiring to glide in the given working conditions, providing an efficient and structurally simple pathway.

Keywords : fluid dynamics, airfoil design, biomimicry, cross domain vehicle

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