Dynamic Aero-Adaptation: A Biomimetic Approach to Active Vehicle Wings

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This research explores a biomimetic adaptive spoiler that dynamically adjusts individual panels to optimize vehicle aerodynamics. Inspired by bird feathers and fish fins, the spoiler consists of 12 servo-controlled panels that tilt based on driving conditions, improving stability and traction. When a car turns, centrifugal force shifts the center of mass outward, reducing grip on the inner wheels. The collected data shows that selectively tilting panels can counteract this effect by applying downforce to only one side of the car, enhancing cornering performance. Using SimScale, computational fluid dynamics (CFD) simulations were conducted to compare two panel designs: one rectangular and one with rounded logarithmic curves. The rectangular panels generated 3,086 N of drag and 1,642 N of downforce, whereas the rounded panels produced 2,228 N of drag and 1,872 N of downforce. The improved aerodynamic efficiency of the rounded design led to its selection for the final prototype. Further simulations demonstrated that when the spoiler lifted on one side, downforce increased on the wheels beneath it, confirming the system's effectiveness in redistributing load for improved traction. The spoiler is programmed to react to inputs from a set of wheel and pedals, with servos adjusting panel angles in real time. By refining downforce distribution, this system enhances high-speed maneuverability and braking efficiency. Beyond motorsports, this technology has potential applications in energy-efficient vehicles and emergency vehicle safety. By integrating biomimicry with adaptive aerodynamics, this study contributes to the development of more efficient and high-performance transportation technologies.

Awards Won: