Feedback control on a morphing A320 reduced scale wing towards aerodynamic performance increase

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ABSTRACT

Innovative wind design has been particularly performed in the recent years to increase aerodynamic performances for aeronautics systems. Using smart-materials able to deform a structure, an electroactive morphing wind prototype has been designed at reduced scale in the Smart Morphing and Sensing project [1]. Both low-frequency camber control and high frequency vibrating trailing edge (HFVTE) serve as actuators for the wing. In the present study, the HFVTE actuators have been used for the feedback control of the trailing-edge wake downstream the model [1,2]. Pressure taps are also located upstream to the trailing edge on the upper surface to measure the state of the flow in real-time and to perform feedback control.

The design of the closed-control laws was first based on reduced-order models of the flow [3]. Two nonlinear Van der Pol oscillators were considered for this objective: unperturbed and with the pulsation perturbed by a random signal, to generate a more realistic representation of the measured signal, with a broadband spectrum. Adaptive feedback controllers are therefore designed, based on the minimization of a cost function: $J = \sum_{sensors} \sigma_{yy}$, with σ_{yy} the pressure fluctuations variance. Different control laws were considered for the stabilization of the Van der Pol oscillators to prove the efficiency of adaptive control for the optimization of the controllers' parameters [4]. For the experimental morphing wing, simple control laws based on a gain K and a delay τ were implemented: $u(t) = K\, p(t - \tau)$. Then, adaptative control adapts the set $\{K, \tau\}$ for the minimization of J. Online optimizations of the gain and delay show a cost function reduction gain $\Delta J / J_0$, with J_0 the cost function without control, between 4 and 11%, with optimal parameters found $\{K^*, \tau^*\} \approx \{1.2, 0.04\ s\}$.

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