
MMAE SEMINAR

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Closed-Loop Feedback Control of the Turbulent Flow over a Wing

The flow over a NACA-4412 airfoil is experimentally used as a means for demonstrating a practical closed-loop feedback control based on low dimensional representations of the flow. The aim is to delay the separation of the flow and therefore the stall of the wing using input from surface pressure measurements only, as the angle of attack is increased using a smart, cost-efficient and autonomous actuation. Proper Orthogonal Decomposition (POD) lets us reduce the order of the complex turbulent system and extract from the flow only the most energetic features fundamental for control. Estimated measurements of the state of the flow are taken through the modified Linear Stochastic Measurement (mLSM) using the multiple pressure measurements along the chord only. The amplitude of the leading edge zero net-mass flow actuation is controlled by the flow itself: as the angle of attack increases, the structures convected over the wing grow larger, the estimated POD/mLSM coefficients increase along with the actuation amplitude accordingly. Initial exciting results from such a simple feedback control will be presented. The next step for a more elaborate control involves the development of a model or plant for our system. To do so, we are developing a set of ODEs for the POD coefficients. The form of the ODEs is guided by a Galerkin projection of the NS equations. In this case however, we train this system with experimental data in order to get the final form of the time-evolution equations for the POD coefficients. In this talk the early results of the dynamical system will also be presented and some ideas on how to incorporate such a system into feedback flow control discussed.