A coupled experimental-numerical framework for fluid-structure interaction studies: towards a pseudo-self-oscillating vocal fold facility

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Voiced speech is a complex process that involves coupled interactions between expelled air and the vocal fold structure. Numerical simulations of this process are difficult due to the unsteady nature of the flow and boundary conditions, while experimental investigations are generally limited in the structural modeling. To bridge this gap, an experimental platform is investigated that couples a mechanical flow facility featuring instrumented and actuated walls, with a numerical structure solver. Specifically, a proof-of-concept experimental apparatus consisting of a flat plate oriented normal to a uniform jet is developed. The plate is instrumented with pressure sensors, which record the pressure distribution caused by the impinging jet. A real-time controller reads the pressure distribution and computes the integrated force on the plate. The resulting force is applied to a numerical structure model comprising a spring-mass-damper system, in which the dynamical parameters can be adjusted in software. The axial position and velocity of the plate are updated in real time based upon the numerical dynamics solution. In the future, this experimental facility will be extended to model two degrees of freedom asymmetric vocal fold motion with full fluid coupling. Pressure sensors distributed across the solid interface, as opposed to direct force sensors, will help explicate the effect of fluid-structure coupling on tissue loading and flow properties, thus allowing for more detailed validation and improvement of computational models.