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TURBULENCE CONTROL – BETTER, FASTER AND EASIER WITH MACHINE LEARNING

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Closed-loop turbulence control has current and future engineering applications of truly epic proportions, including cars, trains, airplanes, jet noise, air conditioning, medical applications, wind turbines, combustors, and energy systems. A key feature, opportunity and technical challenge is the inherent nonlinearity of the actuation response [1]. For instance, excitation at a given frequency will affect also other frequencies. This frequency cross-talk is not accessible in any linear control framework.

Recently, Artificial Intelligence (AI) / Machine Learning (ML) has opened a game-changing new avenue: the automated model-free discovery and exploitation of unknown nonlinear actuation mechanisms directly in the plant [2]. We present numerical and experimental demonstrations of machine learning control (MLC) in turbulent shear-flows. Examples include drag reduction of a car model and mixing optimization of a turbulent jet with distributed actuation. In dozens of experiments and simulations, MLC has consistently outperformed existing optimized control methods [3].

We will outline a new path to understanding the nonlinear actuation mechanisms with datadriven control-oriented reduced-order modeling. Methods of machine learning are a disruptive technology which can be expected to catalyze rapidly accelerating progress in turbulence control-both for performance and for physical understanding.

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