

Turbulence Control—Better, Faster and Easier with Machine Learning

B.R. Noack^{*1,2}, **G. Cornejo Maceda**¹, **F. Lusseyran**¹, **N. Deng**³, **L. Pastur**³,
R. Li⁴, **L. Cordier**⁴, **J. Borée**⁴, **D. Fan**⁵, **Z. Wu**⁵, **Y. Zhou**⁵,
M. Morzynski⁶, **E. Kaiser**⁷ and **S.L. Brunton**⁷

¹ LIMSI-CNRS, Orsay, France, <http://BerndNoack.com>

² TU Berlin, Germany

³ ENSTA, Paris, France,

⁴ Harbin Institute of Technology, Shenzhen Graduate School, China

⁵ Institute PPRIME, Poitiers, France

⁶ Poznań University of Technology, Poland

⁷ University of Washington, Seattle, WA, USA

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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 data-driven 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.

References

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