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Improving linear embedding of complex nonlinear flow dynamics[1]

NIKOLAUS ADAMS, LUDGER PAEHLER, Technical University of Munich — We propose an improvement on the concept of linear embedding of nonlinear flow dynamics by a Koopman-mode encoding network. A solution representation of approximate Koopman modes enables a linear estimation of the time evolution on a reduced number of degrees of freedom. Lusch et al., Deep learning for universal linear embeddings of nonlinear dynamics. Nature Communication, 2018, have proposed an encoder-decoder deep learning approach of approximate Koopman projection, and have demonstrated application feasibility for dynamical systems with continuous spectra. The most complex flow considered by Lusch et al. is that of low-Reynolds-number incompressible 2D cylinder flow. The objective of our work is to obtain a better representation of latent dynamics in order to represent significantly more complex flow dynamics. The concept is to improve on the auto-encoding capability of the deep learning approach with a probabilistic objective and by including input information. We demonstrate feasibility of the approach for broad-band flow dynamics such as generated by 3D Taylor-Green vortex-flow transition. Also, we will consider the representation of compressibility effects in oscillating gas-bubble dynamics.

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Nikolaus Adams
Technical University of Munich

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