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Peer Review

Review of: "Data-Driven Nonlinear Modal Identification of Nonlinear Dynamical Systems with Physics-Constrained Normalizing Flows"

Christopher W. Curtis[1]

1. Mathematics and Statistics, San Diego State University, United States

In the following work, Normalizing Flows are used to develop a nonlinear modal decomposition technique complementing classic results from POD and more modern approaches such as Spectral POD. The authors are also able to generalize their method to provide future predictions from learned data. Particularly compelling are their results for fluid flows past cylinders, which show that their method can provide a markedly more accurate low-dimensional approximation than classic POD alone. In all, then, the authors' approach has real merit and could be of use in domains where dimensionality reduction is a critical concern.

That said, the paper does suffer from poor use of notation and terminology, such as the confusing choice to use (p,q) to denote position and velocity, or the use of the word "bijector" as opposed to just saying bijection or, even better, diffeomorphism. Further, key details are not explained well, such as exactly what a "Masked Autoregressive Flow" is or how they use Normalizing Flows to approximate the distributions in the Kullback-Leibler divergence, which is a critical point for understanding their results on Navier-Stokes.

In all, then, the paper presents a compelling method with strong support, but it is difficult to read and follow to the extent that it hampers understanding of the overall approach. It would do well to have a deep rewrite to enhance clarity, add detail, and provide more explanation of network architecture choices since this better points to future improvements.

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Declarations

Potential competing interests: No potential competing interests to declare.