Augmented Autoencoders for Interpretable Physical Reservoir Design

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Predicting and controlling the behavior of nonlinear dynamic systems is a clear priority for the AF mission, as these phenomena sit at the forefront of potentially new operational capabilities to exploit. One particularly promising application for these nonlinear dynamics is to use them as an unconventional computing resource. This effectively harnesses their nonlinearity to perform complex input-output mappings, which could simultaneously be leveraged to facilitate their control. However, nonlinear spatial-temporal dynamics can be quite challenging to optimally integrate into these computing model abstractions, due to i) the difficulty in identifying state variables that carry rich and distinct information, ii) the complexity of navigating the high dimensional space of design configurations and possible boundary conditions, and iii) the difficulty of identifying computing tasks that are operationally relevant for specific embodiments of physical computing sources. The goal of this LUCI project is to harness the dimensional reduction capability and increased interpretability of augmented-autoencoders to develop fundamental design strategies for physical reservoir computing implementation, benchmarking, and control using fluid dynamics as a model system.