ICNEM

International Conference on Nonlinear Elasticity in Materials

Contribution ID: **41** Type: **not specified**

Optimising Ultrasound-Based Physical Reservoir Computing with Nonlinear and Viscoelastic Media

Thursday 17 July 2025 11:50 (20 minutes)

Physical reservoir computing (PRC) offers a promising path toward low-energy, brain-like computing by harnessing the inherent dynamics of physical systems. We present a novel ultrasound-based PRC system that exploits nonlinear acoustic wave propagation for classification tasks. As a proof of concept, we demonstrate performance comparable to state-of-the-art neural networks on a handwritten digit classification benchmark. These results highlight the potential of PRC to significantly reduce the energy and computational costs associated with training conventional neural networks. We investigate how key reservoir properties, nonlinearity, memory, and heterogeneity, influence performance through spatiotemporal wave transformations. Our results suggest that nonlinear and viscoelastic media, with intrinsic memory, can enhance reservoir dynamics, better suited for complex temporal tasks such as spoken digit recognition.

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Session Classification: Theoretical developments in nonlinear wave propagation

Track Classification: Theoretical developments in nonlinear wave propagation