Utilizing Nonlinear Oscillator Arrays as Physical Reservoir Computers

Ayush Gupta*[1] and Vipin Agarwal*†[1]

[1]Department of Mechanical Engineering, University of Memphis – United States

Abstract

This work introduces a nonlinear multi-oscillator array as a physical reservoir computer, proposing a novel approach to computational tasks by leveraging the intrinsic dynamics of coupled oscillators. Unlike traditional reservoir computing, which relies on recurrent neural networks (RNNs) as computational reservoirs, a physical reservoir directly utilizes a physical system's inherent dynamics. The nonlinear behavior of oscillators makes them highly suitable as a computational medium, providing flexibility and depth for data processing. By adjusting parameters such as stiffness, damping coefficients, and inter-oscillator coupling, we can fine-tune the reservoir's properties, including vibration frequencies, amplitude, and equilibrium points, allowing precise control over its dynamic behavior. The interactions among oscillators introduce complexity, enabling synchronized and chaotic behaviors that capture intricate temporal dependencies in signal processing. Input signals are transformed into high-dimensional outputs through the oscillations of individual oscillators, where each oscillator represents a unique dimension within the state space. This high-dimensional representation is then utilized in neural network models for applications such as temporal data classification and time series prediction. The proposed multi-oscillator reservoir thus offers a versatile and customizable framework for advancing physical reservoir computing.

*Speaker

†Corresponding author: vipin.a@memphis.edu