

Universality of simple cycle reservoirs using dilation theory

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Reservoir computation models form a subclass of recurrent neural networks with fixed non-trainable input and dynamic coupling weights. Only the static readout from the state space (reservoir) is trainable, thus avoiding the known problems with propagation of gradient information backwards through time. Reservoir models have been successfully applied in a variety of tasks and were shown to be universal approximators of time-invariant fading memory dynamic filters under various settings. Simple cycle reservoirs (SCR) have been suggested as severely restricted reservoir architecture, with equal weight ring connectivity of the reservoir units and input-to-reservoir weights of binary nature with the same absolute value. Such architectures are well suited for hardware implementations without performance degradation in many practical tasks. We apply a novel technique from dilation theory to rigorously study the expressive power of SCR in the complex domain and show that they are capable of universal approximation of any unrestricted linear reservoir system (with continuous readout) and hence any time-invariant fading memory filter over uniformly bounded input streams.

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