A Review of the Reservoir Concept in Reservoir Computing

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Abstract

Reservoir Computing is a computational framework in which a dynamical system, known as the *reservoir*, casts a temporal input signal to a high-dimensional space, and a trainable *readout layer* creates the output signal by extracting salient features from the reservoir. A suitable reservoir must possess the property of *fading memory* in order to process inputs. The foundations of Reservoir Computing are the independently proposed Echo State Networks and Liquid State Machines, both of which use a randomly connected artificial recurrent neural network as the reservoir. Since the inception of the field, researchers have looked for ways to optimize the selection of reservoir construction parameters. Hierarchical reservoirs reimpose a degree of topological structure on reservoir connectivity by breaking the monolithic reservoir into loosely connected sub-reservoirs. The realization that dynamical systems besides neural networks could act as reservoirs has caused increasing interest in alternative reservoir substrates using biological, chemical, and physical dynamical systems.

1 Introduction

Reservoir Computing (RC) is a relatively new approach to machine learning in which the inner dynamics of a recurrently connected system, the *reservoir*, are harnessed to cast temporal inputs into a high-dimensional space, enhancing their separability. A *readout layer* generates the output from a linear combination of the states of reservoir nodes. Figure **??** shows the components of a reservoir computing system. The idea of reservoirs as a new type of architecture for Recurrent Neural Networks (RNNs) was proposed independently in 2001, under the name Echo State Networks (ESNS) [**?**], and in 2002 as Liquid State Machines (LSMs) [**?**]. The recurrent connections of a RNN cycle information back to the internal nodes, allowing them to possess *state*, or memory, which makes them suitable for sequential tasks such as speech recognition.