Title: **Reservoir computing with physical limits**

Key words: reservoir computing, unconventional computing, artificial life, biological neural networks, echo state networks

Old one-liner: Is it possible to use physical substrates, such as electroneurological cell networks, in place of artificial neural networks?

Second attempt at one-liner: While artificial neural models show remarkable promise for time series forecasting, it is still uncertain how performance will translate to more unconventional computational mediums. In this paper, we examine the impact of common physical limitations: noise, inaccurate measuring equipment, partly observable states, and the degree of rigidity of the reservoir.

Abstract

The introduction of Echo State Networks (ESN) and Liquid State Machines (LSM) paved the way for the Reservoir Computing (RC) paradigm of computing with artificial recurrent neural networks (RNN). Key to this methodology is a randomly generated *reservoir,* most commonly an RNN that remains untrained, and a linear *readout* layer that is optimized to produce some desired function. Training recurrent neural networks is hard, making reservoir computing, with its random recurrent topology and simpler linear classifier, a promising area of research.

Interestingly, there is no need for the reservoir to be an artificial neural network; any physical computing substrate capable of intrinsic computation can be used. Such computation arises within high-dimensional, driven systems which exhibit complex dynamic behavior. A wide range of physical reservoirs have shown to provide state of the art performance, ranging from optical laser circuits and nanomagnetic assemblies to wetware biological neurons.

The physical limitations of such reservoirs affect performance, but the extent remains an open question. In this paper we examine the impact of four common limitations manifested in physical systems: How does the accuracy of our measuring instruments affect the quality of the reservoir? What if we can only observe parts of the reservoir? How does noise affect performance? What if we impose stricter neighboring rules, such as crystal structuring? Such fundamental properties of reservoirs are investigated in RNNs by imposing these physical restrictions on RC-driven predictions of Mackey-Glass time series and NARMA10 tasks.