TemporaLSM: A Simulation Framework for Temporal Neural Liquid State Machines

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***Abstract*—Liquid state machines (LSMs) are a type of reservoir computer that aim to construct more biologically plausible neural network architectures than artificial counterparts. Rather than purposely constructing neurons in particular arrangements, an LSM self-organizes its neurons into a 'liquid', which is read out to perform a task. Many arguments against LSMs stem from this difficult-to-control random procedure, and due to their complicated setup, current LSM designs are not well explored.**

Through this work, we present TemporaLSM, a simulation framework for liquid state machines using good-for-hardware temporal neuron designs. Furthermore, we analyze a series of liquids generated by TemporaLSM to determine how different hyperparameters affect the construction of the liquid, and attempt to identify similarities between liquids on differing tasks.

***Index Terms*—liquid state machines, temporal neural networks**

I. Introduction

II. Network Construction

This work mainly follows the temporal neuron as defined in [1]. As such, this section presents an overview of the network construction process and the individual (hyper)parameters of a constructed network.

A. Overview

B. Seed Configuration

C. Neuron Activation Function

D. Network Training

III. Problem-Specific Analysis

A. Amazon Product Reviews (Text Classification)

B. MNIST Handwritten Digits (Image Classification)

IV. Conclusions

A. Notes on Network Organizations

B. Future Work

References

[1] H. Nair, J. P. Shen, and J. E. Smith. "A Microarchitecture Implementation Framework for Online Learning with Temporal Neural Networks." *IEEE Computer Society Annual Symposium on VLSI (ISVLSI)* (2021).

[2] W. Maass. "Liquid State Machines: Motivation, Theory, and Applications." *Computability in Context: Computation and Logic in the Real World* (2011).

[3] H. Hazan, L. M. Manevitz. "Topological Constraints and Robustness in Liquid State Machines." *Expert Systems with Applications* (2012).