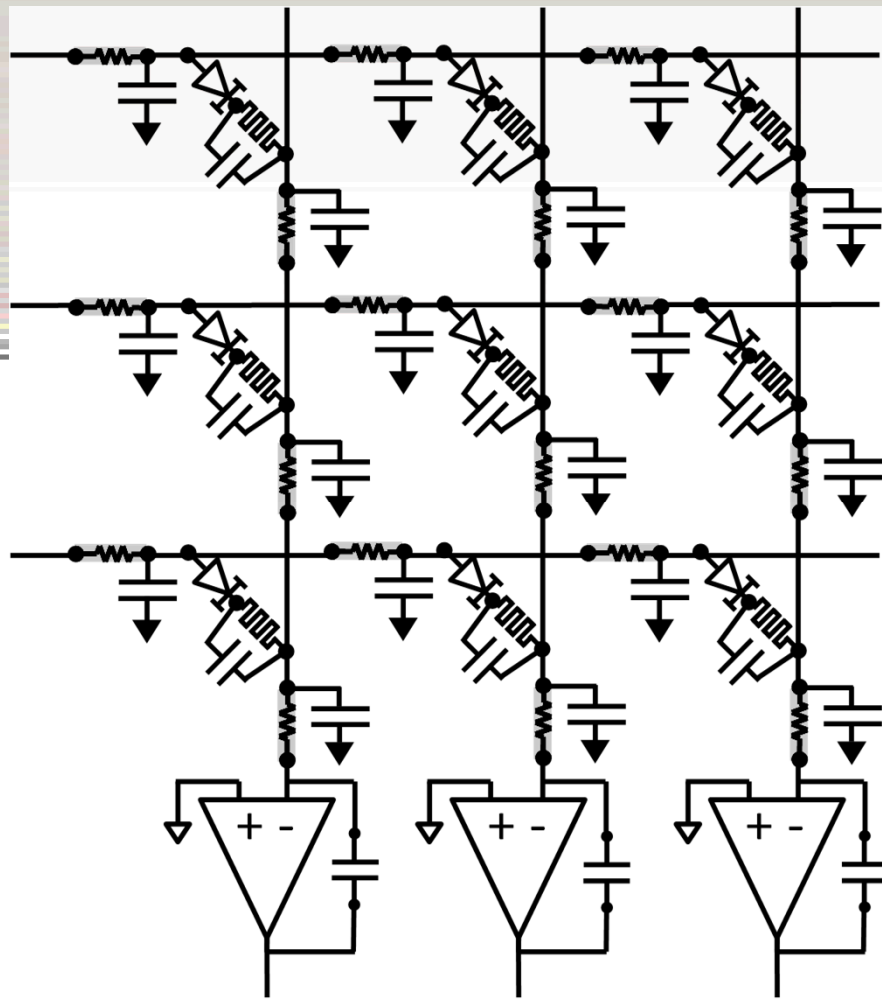


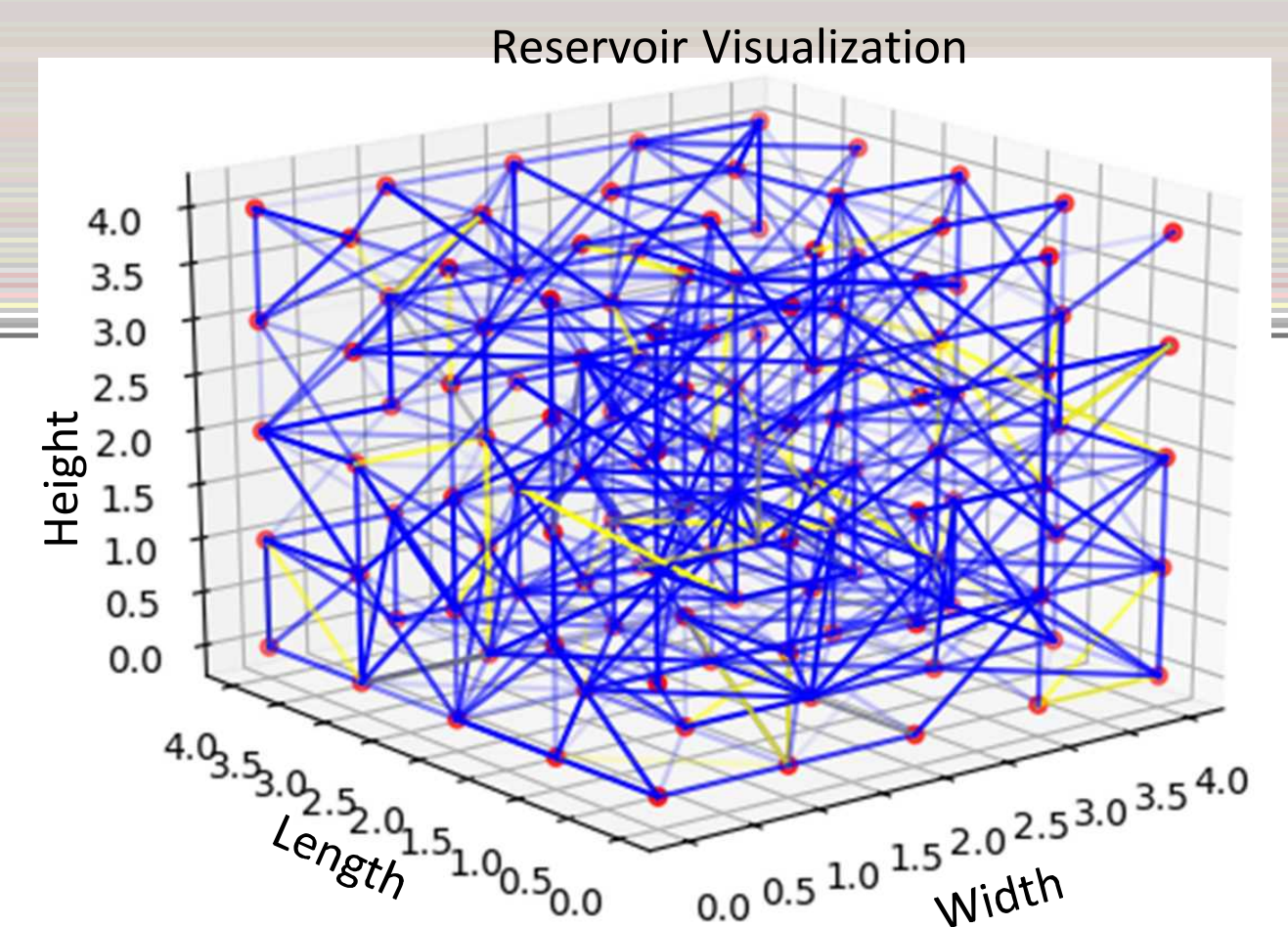
OPTIMIZING LIQUID STATE MACHINES ON ANALOG RESISTIVE CROSSBAR ACCELERATORS

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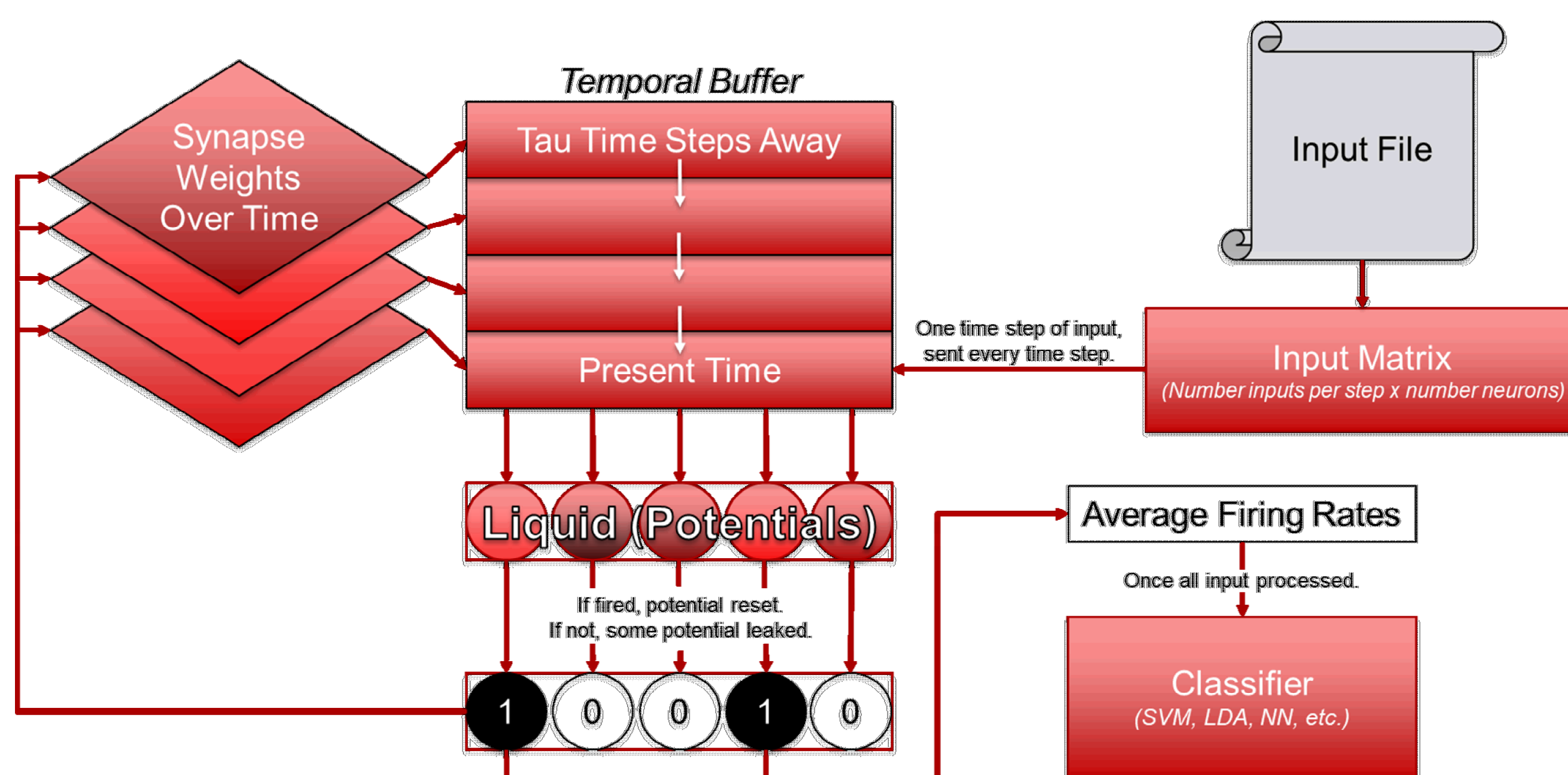


Introduction

Analog resistive crossbars accelerate vector matrix multiplication, reducing energy and latency by 2-3 orders of magnitude when compared to an optimized digital accelerator. However, being analog, crossbars are limited by read noise. The effect of this noise on the Liquid State Machine (LSM) neural net algorithm was simulated with CrossSim, an open source analog crossbar simulator. Several ways to mitigate the effect of noise were studied.

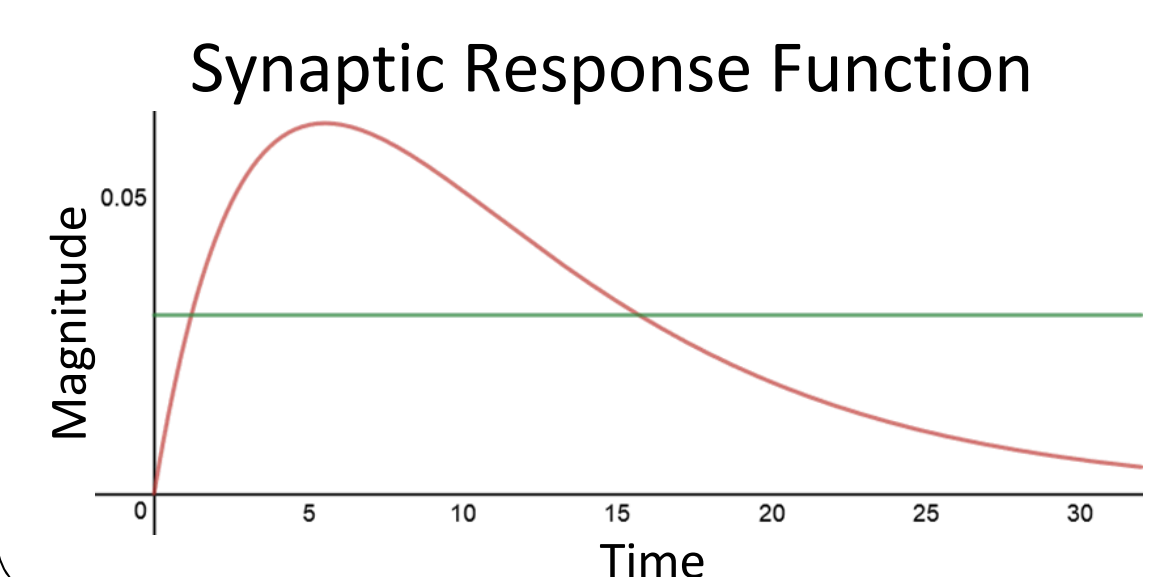


LSM & STPU Architecture



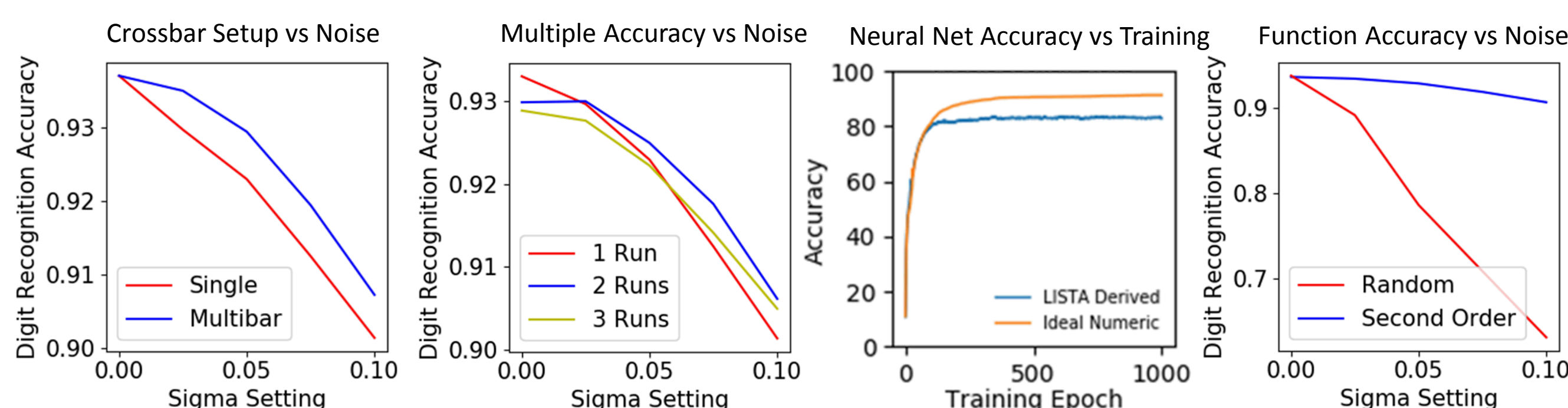
Early Tests

- SVM vs LDA Classifiers
- Inhibitory Neurons vs Synapses
- Optimal Synaptic Response Length
- Overflow
- Flat Synaptic Response
- Second Order Synaptic Response



Results

- Using multiple redundant crossbars consistently improved performance by ~.5%. The error from multiple noisy readings average out.
- Duplicating the training data with many noisy runs helps, but only when noise is very significant, otherwise the classifier may overfit.
- Optimized accelerated neural net classifier's peak accuracy was 91% at 5% noise.
- Randomized synaptic response functions hurt performance.
- Weighting the input by a time function greatly improves net performance. Frontloaded input improved accuracy 6-8% (most digits have the same ending).



Noise Hardening

- Multiple Crossbar Setup
- Multiple Runs
- Neural Net Classifiers
- Random Response Functions

Summary & Future Work

- Peak accuracy of 93-94%.
- Can retain 90+% accuracy with past 10% read noise.
- Multiple viable noise hardening techniques can be combined.
- Training the reservoir.
- Classifying off firing history.
- Optimizing net and classifier hyperparameters.
- Learning input weighting.