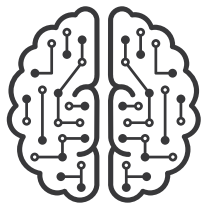
DANNA2:

Dynamic Adaptive Neural Network Arrays

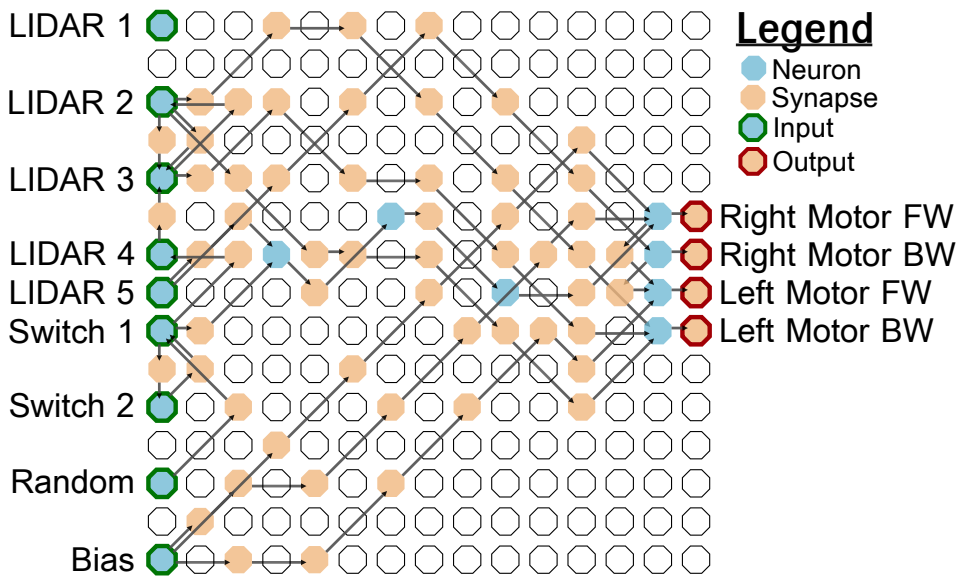
J. Parker Mitchell, Mark E. Dean, Grant R. Bruer,
James S. Plank, Garrett S. Rose



TENN LAB
NEUROMORPHIC
ARCHITECTURES. LEARNING. APPLICATIONS.

ICONS 2018 – July 24, 2018

Last Year – A Robot with DANNA



DANNA2 Model Overview

- Programmable Leaky Accumulate & Fire neurons
- Neurons include accompanying synapses (no synapse chains)
- Lookup based Synaptic Plasticity (STDP)
- Discrete integer time steps
- All fires at time t are simultaneous
- Two Array Types
  - Grid Arrays – A fixed grid of programmable elements with 5×5 nearest neighbor connectivity
  - Sparse Arrays – A directed graph of connected elements (not runtime configurable)

The DANNA2 Element

- Built of small components
  - Programming Interface
  - Delay/Distance Registers
  - Synapse Table
  - Synapse Units with plasticity
  - Accumulator
  - Compare and Fire
  - Sub-cycle Counter
- Configurable and Extensible
- Capable of running at 250MHz on FPGAs

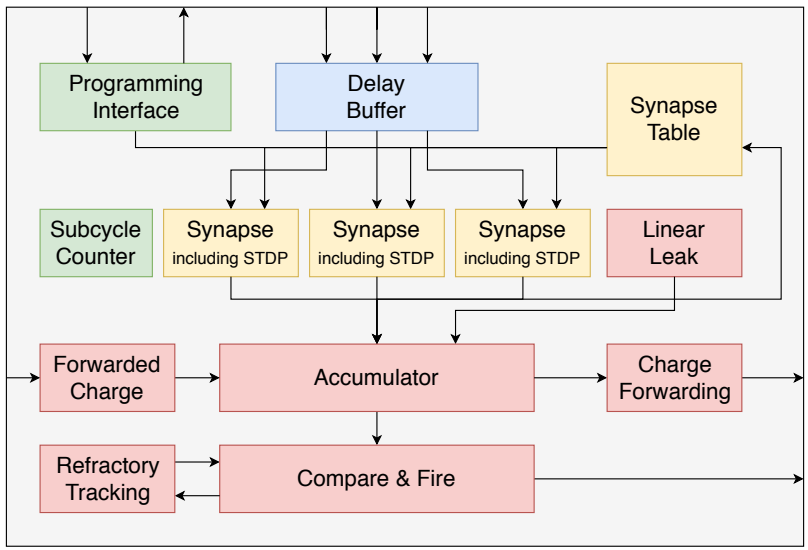


Figure 1: DANNA2 Element

Software Simulation

- Before simulation begins, create a network and queue inputs
- Check for incoming fires for time t
- Process internal fires for time t
- Schedule new fires after time t is fully processed
- Log fires from designated outputs
- Stop the simulation once desired time is reached

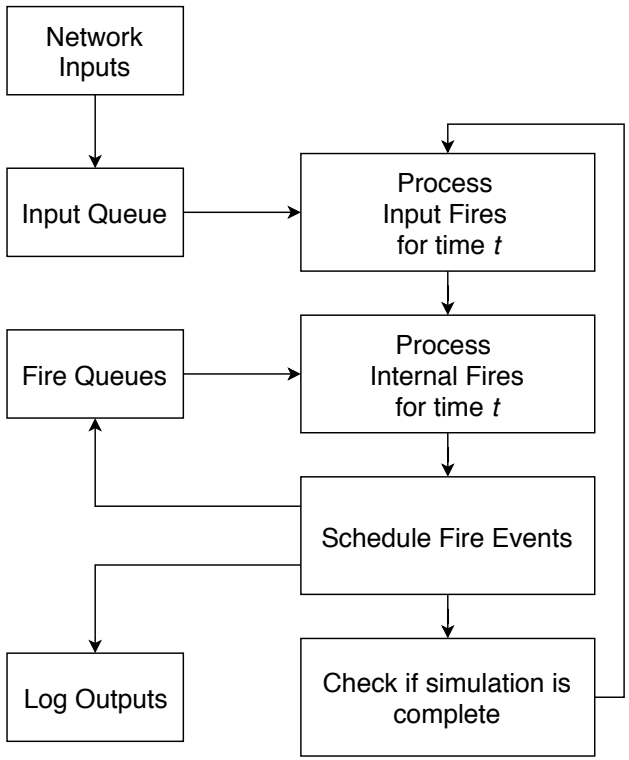


Figure 2: Simulation Flow

Performance Comparison

- Simple pass-through network to compare simulation performance
- Staggered firing pattern across all inputs
- Under 120 inputs, DANNA2 is $> 10\times$ faster than DANNA
- At 7500 inputs, DANNA2 is $4.8\times$ faster than DANNA

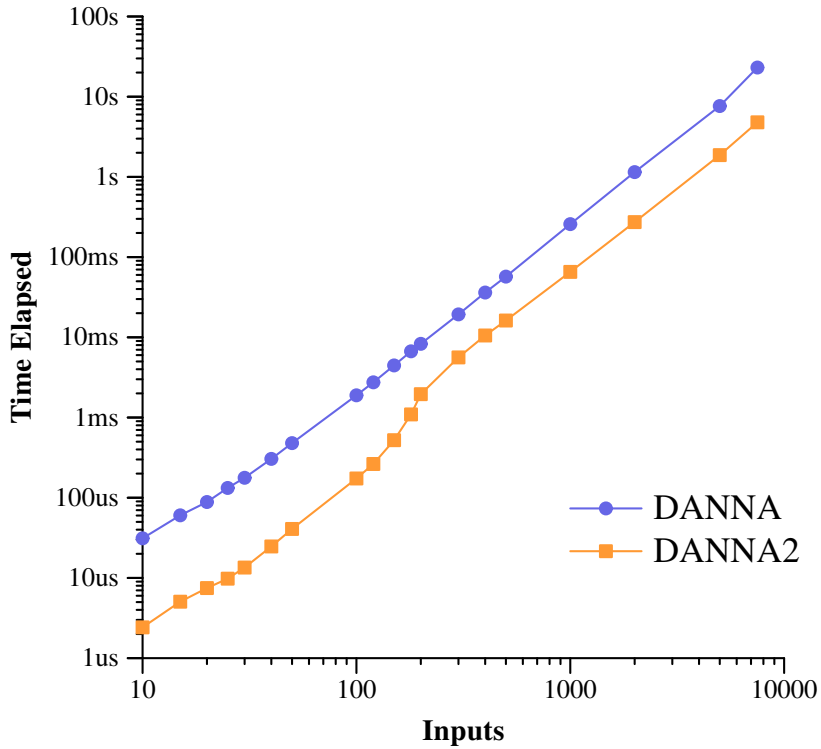
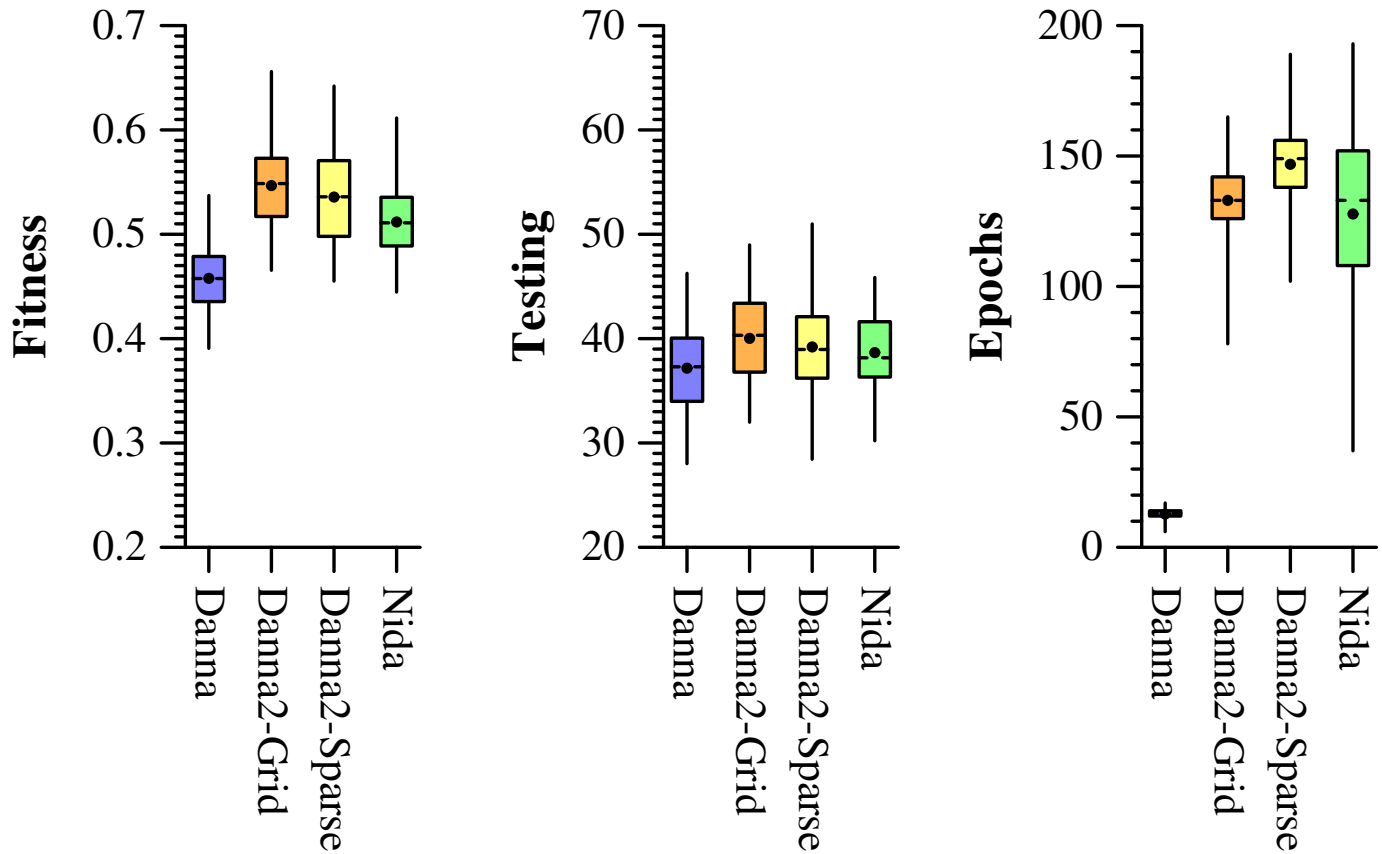


Figure 3: Benchmark Results

Example Application: Robonav



Future Work

- VLSI design and fabrication?
- Multi-chip scaling of arrays
- Embedded robotic deployment – NeoN 2
- Investigation of leak and learning parameters
- Examine importance of precision in parameters
- Development of other hardware implementations including an event driven processor

Conclusion

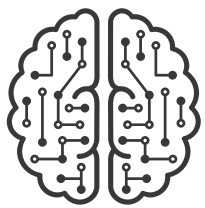
- DANNA2 delivers an order of magnitude higher execution speed than DANNA in both hardware and software
- Additional speed and capability can be utilized to improve training performance
- Improves effective density compared to DANNA
  - 60% more usable neurons than DANNA on the same FPGA
  - Sparse arrays allow for optimized deployments
- Designed to be scalable and allow for new implementations

Acknowledgments

DANNA2:

Dynamic Adaptive Neural Network Arrays

J. Parker Mitchell, Mark E. Dean, Grant R. Bruer,
James S. Plank, Garrett S. Rose



TENN LAB
NEUROMORPHIC
ARCHITECTURES. LEARNING. APPLICATIONS.

ICONS 2018 – July 24, 2018