# Resolving Control Divergence in GPGPU with dynamic warps

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# Overview

# Table

- Information Flow :
  Presynaptic Axon → Active Synapse → Postsynaptic Neuron
- Axonal Delays
  - Stored at the Sending Neuron
  - Implemented at Receiving Neuron
- Propagation through router:
  x-direction → y-direction

syn.jpg

# Function Blueprint

- Chip Area 4.3 $cm^2$
- Tech Node 28 nm (Samsung)
- Power Density 20 $mW/cm^2$
- Memory 428 MBits

phy.jpg

# Real-time multiobject recognition on TrueNorth

The TrueNorth architecture was the programmed to perform pattern recognition on a pre-recorded data set (NeoVision 2 Tower Data)

- To detect people, bicyclists, cars, trucks, and buses that occur sparsely in images while minimizing false detection
- To correctly identify the object

exp.jpg

# Programming Methodology

- Input stream RGB 400x240 pixel (Converted to Spike Events)
- Orientation Selective Filters (Hubel and Wiesel)
- Data processing in the Visual Cortrex[1]
    - Ventral - Visual Identification of Objects
    - Dorsal - Visual Location of Objects
- Neurons trained offline to detect individual objects
- What and Where pathways are combined

[1]Mishkin et all Object Vision and Spatial Vision: Two cortical Pathways

# Power and Energy

pow.jpg

A. Network Topology (Node: Cores and Edge: Network Connection)
B. Total Power increases with both the Mean Spike Rate as well as the Active Synaptic Density
C. The total power decreases with increasing Synaptic Density

# Benchmarking the Performance

## Benchmarking Criteria

The performance of the chip has been evaluated in terms of energy per operation and against a state-of-the-art multiprocessor neuromorphic system[a].

[a] SpiNNaker, Manchester University, UK

## Results

Configuring TrueNorth as the SpiNNaker(48 chips with 18 processors each), it consumers 769 times less energy per synaptic event. Whereas, while running at its own configuration, it consumers 176,000 times less energy. SOPS (Synaptic Operations per Second) - 46 GSOPS per Watt (peak perf 400 GSOPS per Watt)[a]

[a] AMD 6850 (GPGPU) has a performance of 10 GFLOPS/W, Ref: A Custom processor for energy efficient Scientific computing, IEEE Transactions on computers, December 2012

# Issues and Discussion

While TrueNorth seems to be an important step towards building a true neuromorphic computer. Some of the issues have not been dealt by the authors.

- Demonstrating the need for a neuromorphic approach for Pattern Recognition
- Developing a programming paradigm for this class of machines
- Accelerated training and training time
- Comparing performance with existing machines (taking non-neuromorphic approaches)

References[2]

[2] Paul A. Merolla, John V. Arthur, Rodrigo Alvarez-Icaza1, Andrew S. Cassidy, Jun Sawada, Filipp Akopyan, Bryan L. Jackson, Nabil Imam, Chen Guo, Yutaka Nakamura, Bernard Brezzo, Ivan Vo, Steven K. Esser, Rathinakumar Appuswamy, Brian Taba, Arnon Amir, Myron D. Flickner, William P. Risk, Rajit Manohar, Dharmendra S. Modha