Bio-Inspired High Speed Pupil-Tracking using a Dynamic Vision Sensor

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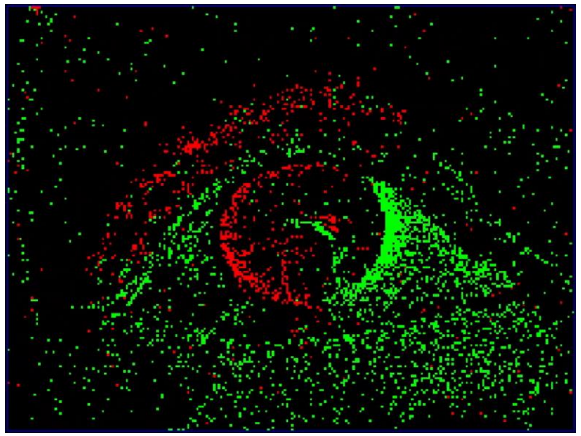
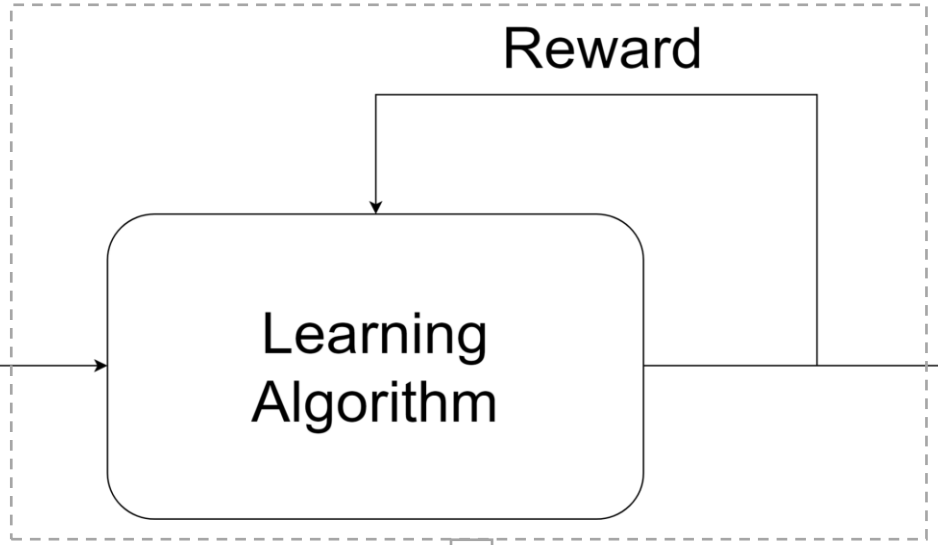
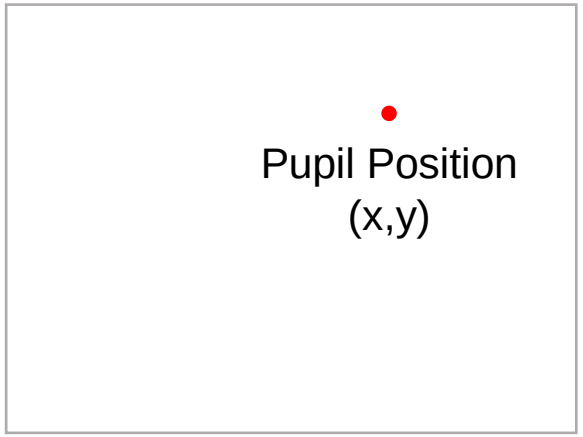
Algorithmic Framework

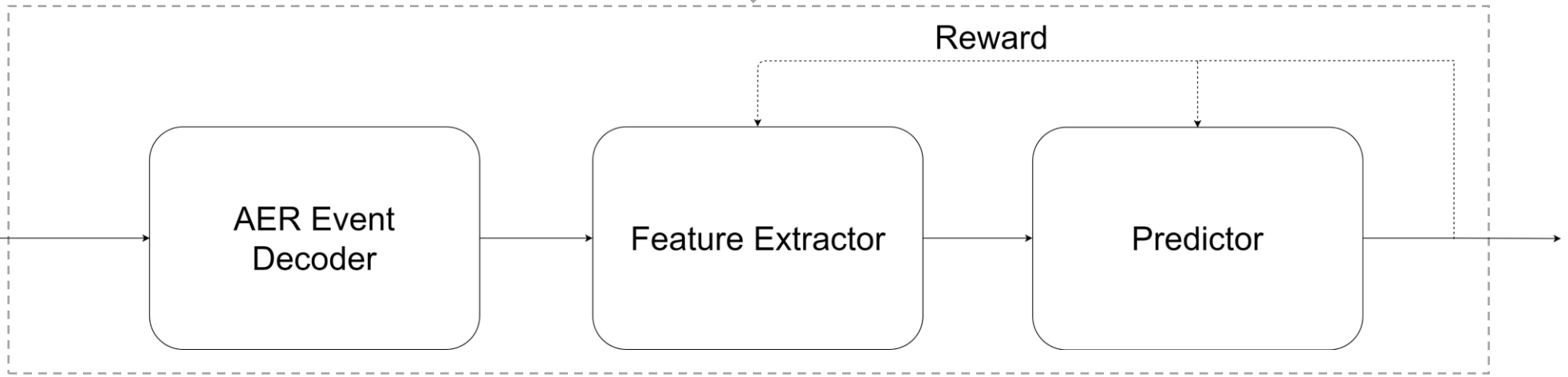


Input Event Data





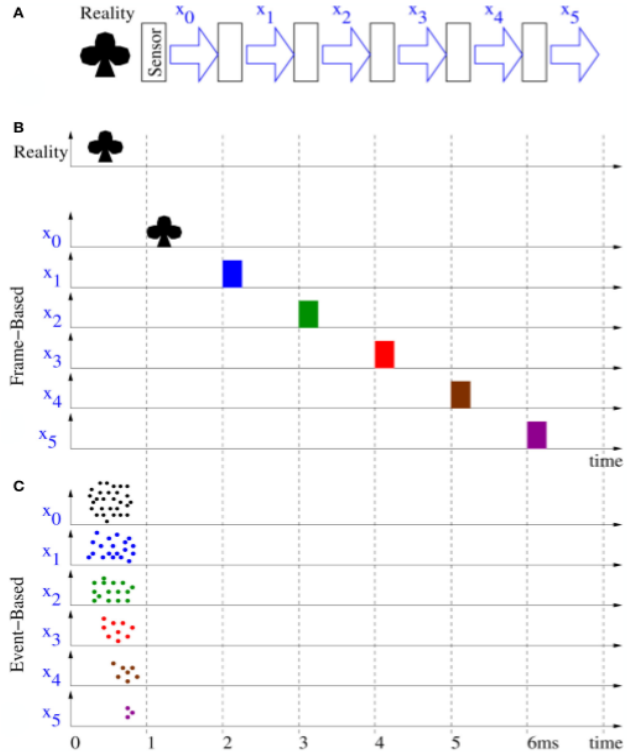
Output (x,y)

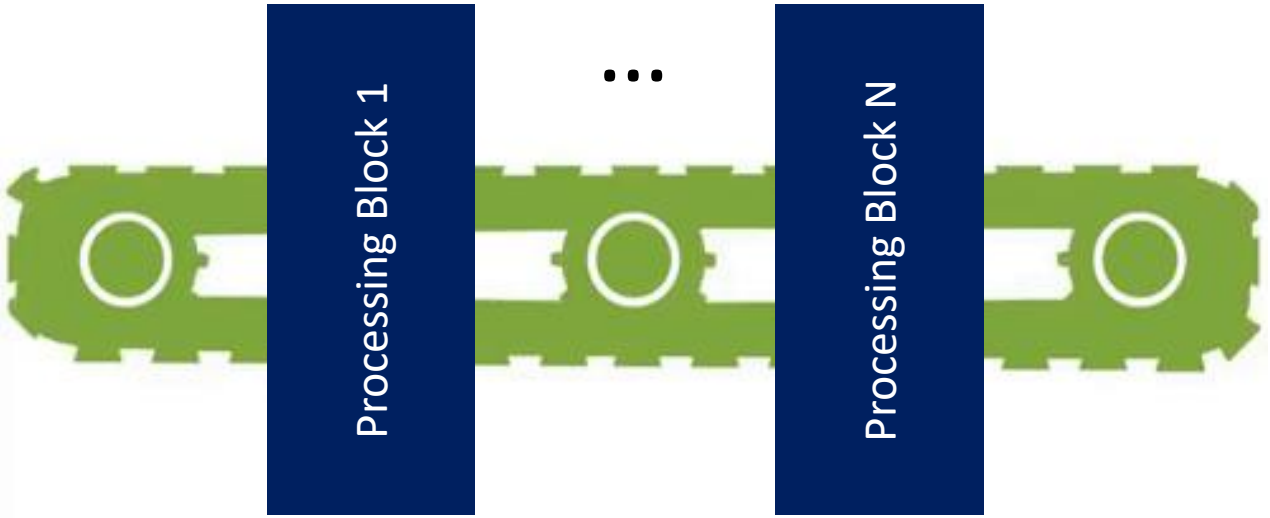


Asynchronous Processing

- Extremely high throughput required
  - Upto 2M input events/s
  - ~20K 'packets'/s

- Asynchronous > Synchronous
  - Better as can simultaneously consume & process data
  - No lag
  - No queue





Current Work

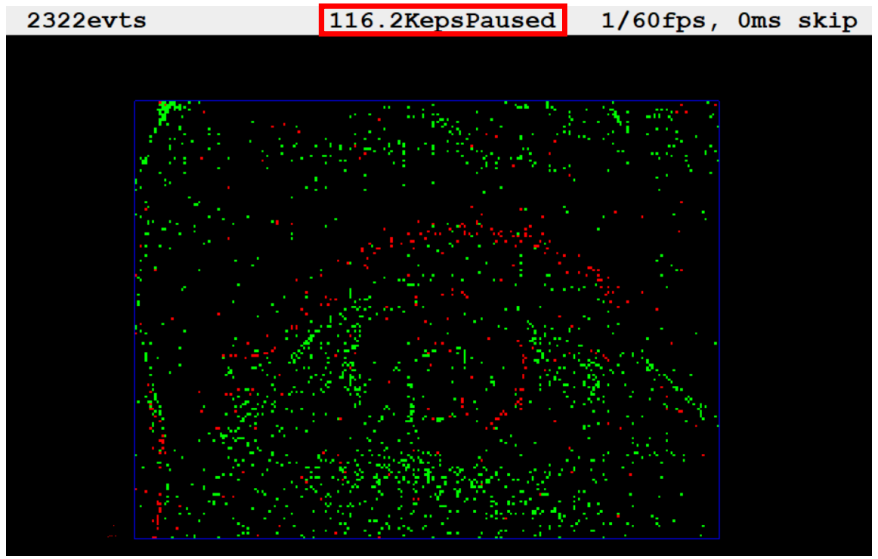
1. Live data acquisition from DVS Camera

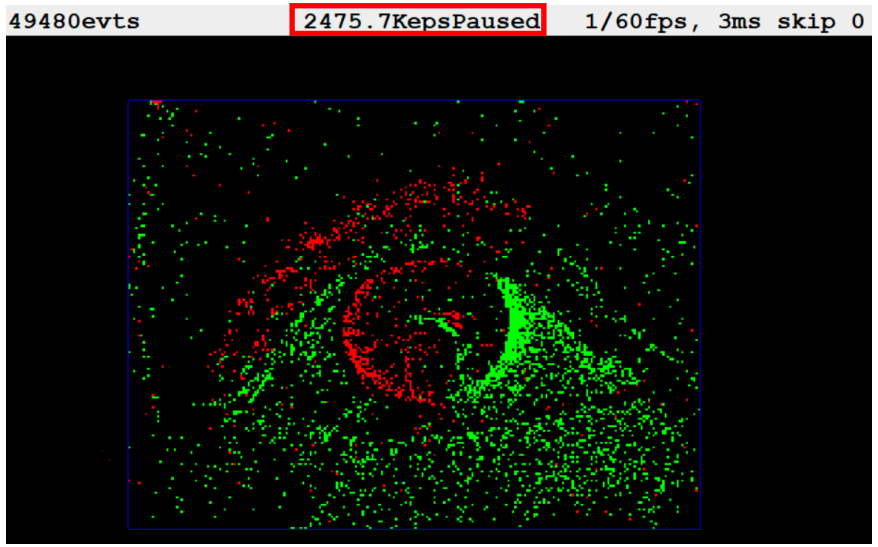
2. Ground Truth for supervised learning
   - Pupil-centre from frames

3. Feature extraction
   - SNN simulator

Current Work – Part 1

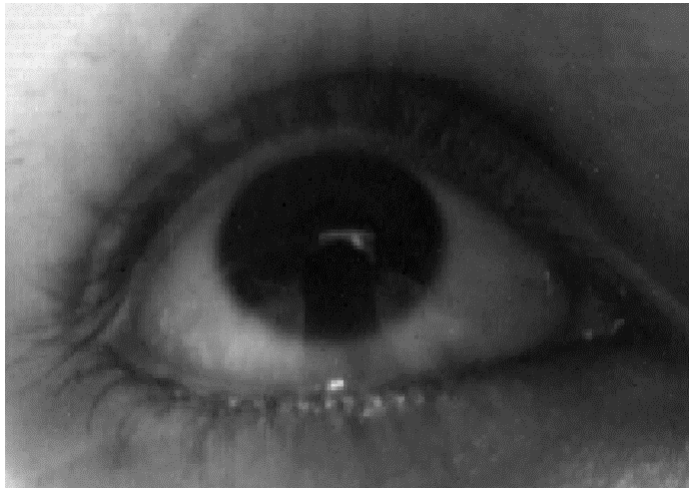
- Data acquisition from camera via USB2.0
- Want ***real-time, no latency***
- *Peak* event-rate output ~ 2M events/s
  - Each event = 8bytes
  - ~16MB/s
  - USB2.0 max transmission speed = 60MB/s
- cAER/libcaer
  - Framework for consuming data
  - Multi-thread

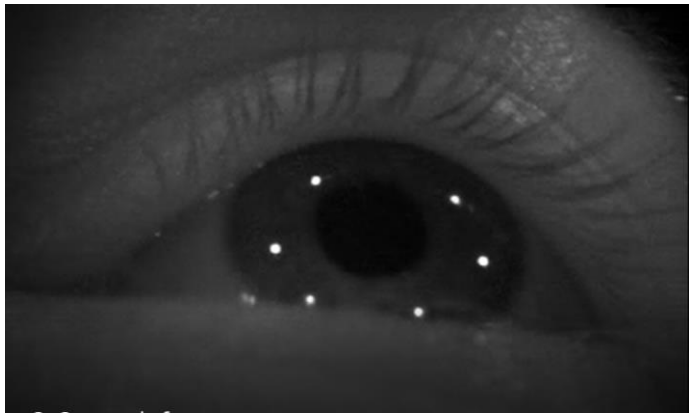


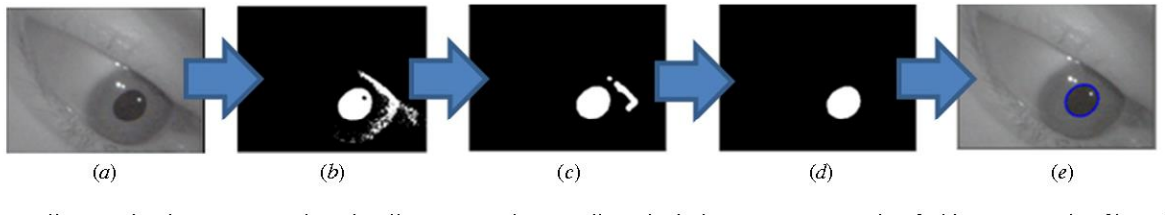


Current Work – Part 2

- Pupil detection (centre x,y)
  - Will be ground truth
- Needed for reward signal to network
- Abbott & Faisal pupil detection method
- Need IR light

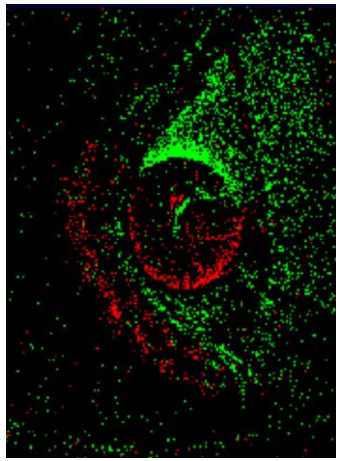






Abbott WW, Faisal AA. Ultra-low-cost 3D gaze estimation: an intuitive high information throughput compliment to direct brain-machine interfaces. *Journal of neural engineering.* 2012; 9 (4): 046016.

Current Work – Part 3



DVS CAMERA

Real-time Decoder

[Part 1]

AER EVENTS

LIF Neurons

Pixel 1

Pixel 2

Pixel N

t

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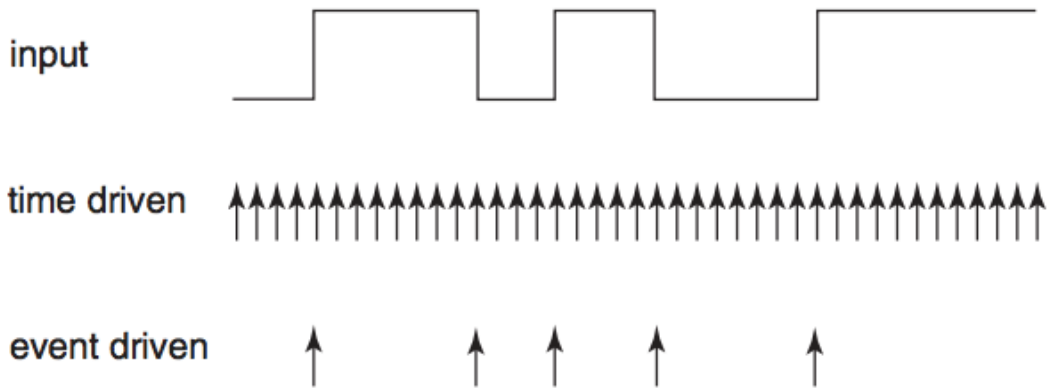
Spiking Network Simulators

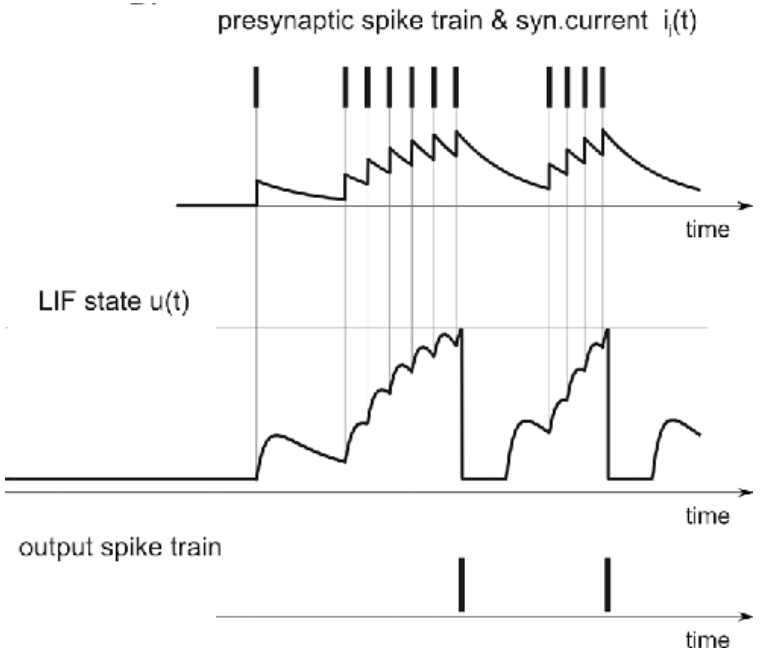
- Event-driven > Time-driven
  - More efficient

- MUST run live
  - DVS output upto 2M events/s
  - MUST be fast

- GPU Acceleration?



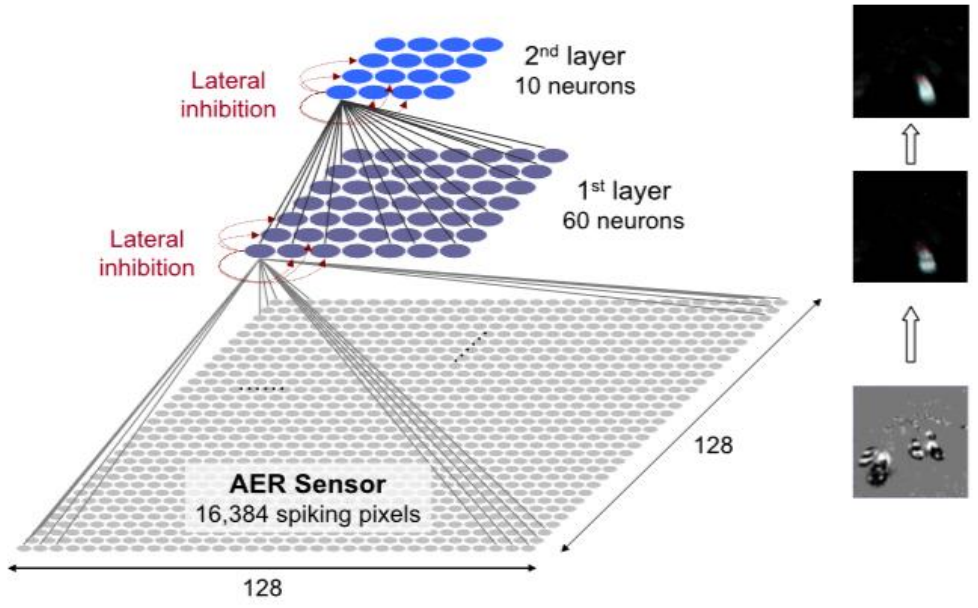
Source: Short K. VHDL for Engineers. Pearson Education (2009)

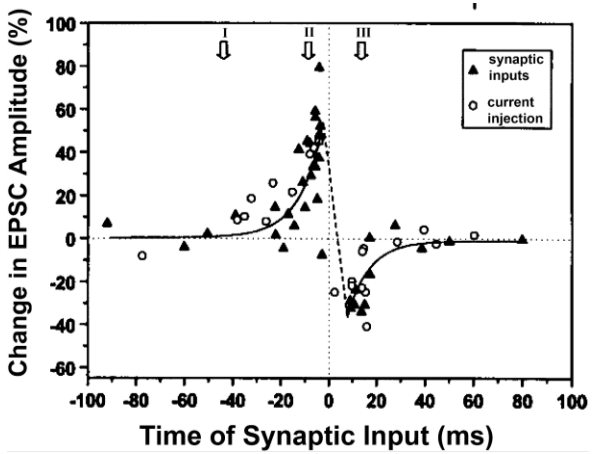


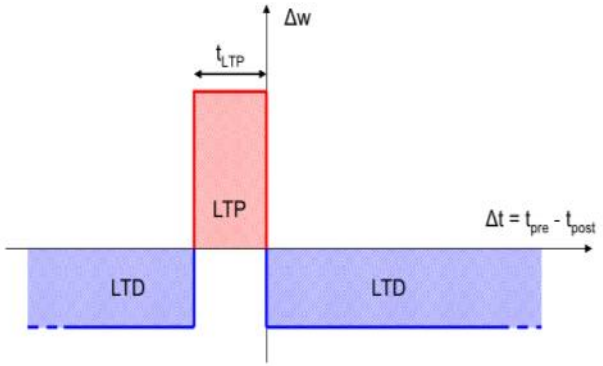
Ponulak F, Kasinski A. Introduction to spiking neural networks: Information processing, learning and applications. *Acta neurobiologiae experimentalis*. 2011; 71 (4): 409.

N2D2 Simulator

- Event-driven
- Customisable
- *Near real-time*
  - ~2M synapses
  - Learning included?
- CPU-based
- Currently compatible with DVS *offline* data







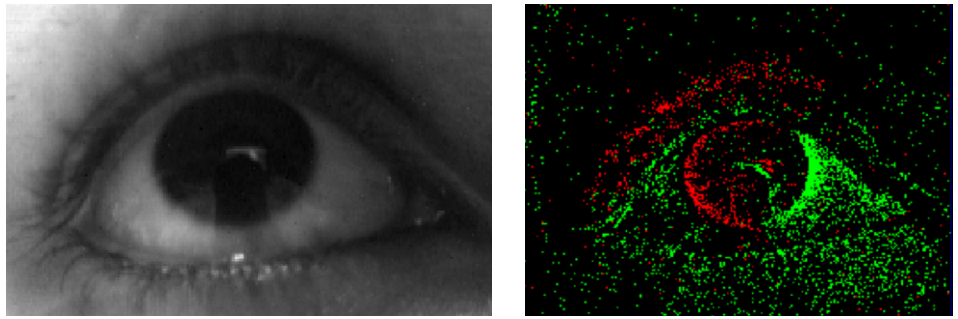
Bichler O, Querlioz D, Thorpe SJ, Bourgoin J and Gamrat C. Extraction of temporally correlated features from dynamic vision sensors with spike-timing-dependent plasticity. *Neural Networks.* 2012; 32 339-348.

Dan Y, Poo MM. Spike timing-dependent plasticity of neural circuits. Neuron. 2004; 30;44(1):23-30

Progress

Completed:

- Collected my own offline data



In progress:

- Collect live online data
- Pupil detection from frames
- Get N2D2 simulator running
  - Else find another simulator
  - Interface with my own event-data
- Create simple LIF network using N2D2
  - Test with offline data
  - Interface with online data stream