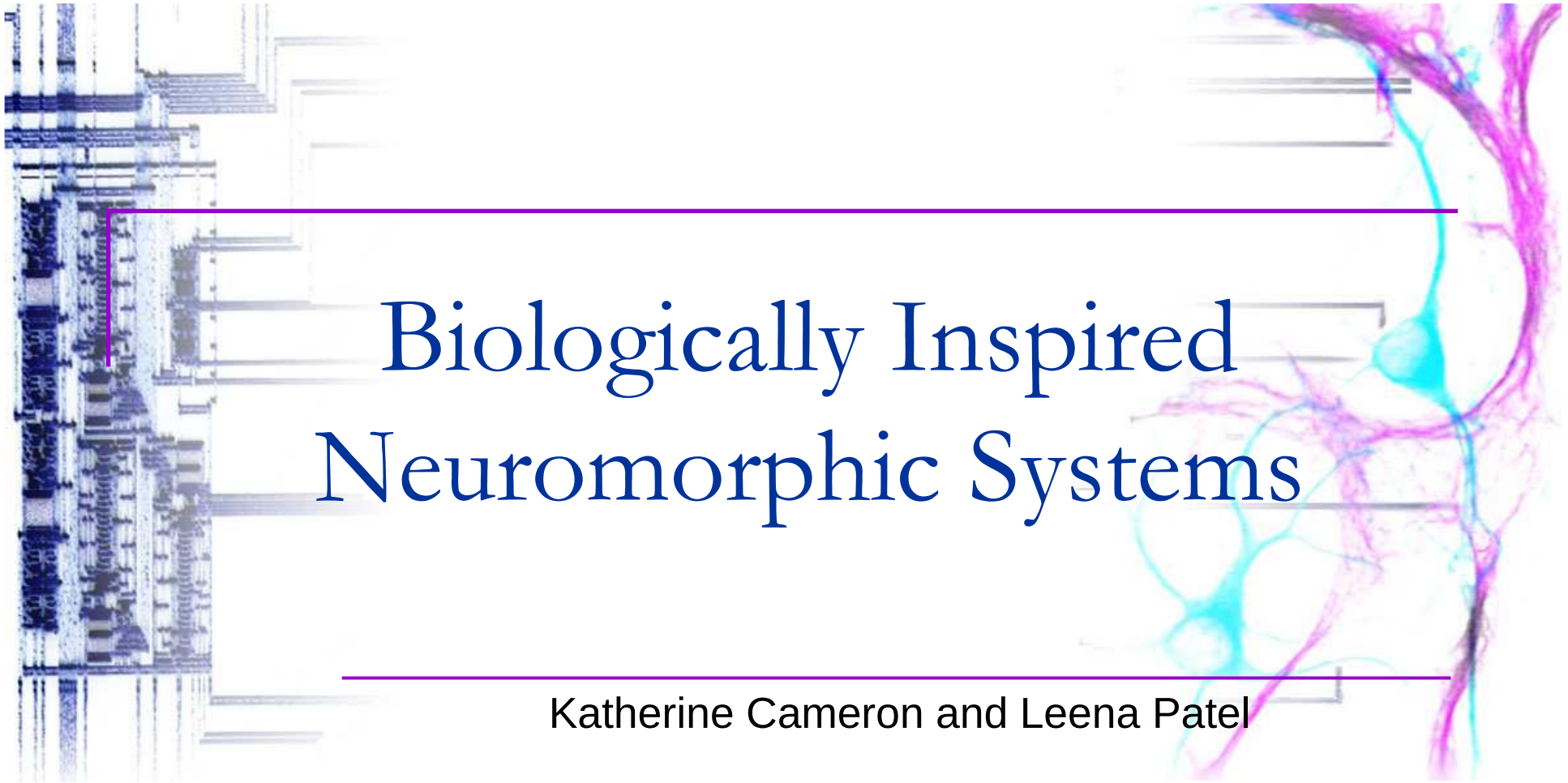


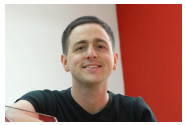
Biologically Inspired Neuromorphic Systems

Katherine Cameron and Leena Patel

The Neural Group



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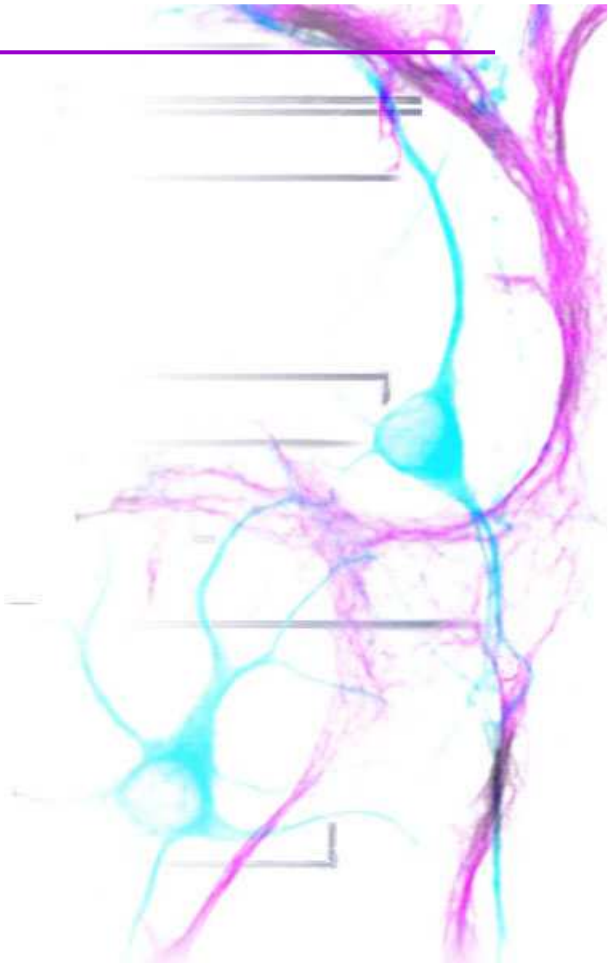
Katherine Cameron
Leena Patel
Tong-Boon Tang
Zhijun Yang
Simeon Bamford
Vasin Boonsobhak
Tom Clayton
Andrew Cogman
Juna Huo
Alex Kourkoulas-Chondrorizos
Hugo Monteiro

Overview

- Neuromorphic Engineering
- Current projects – some examples
- Future directions



Neuromorphic Engineering

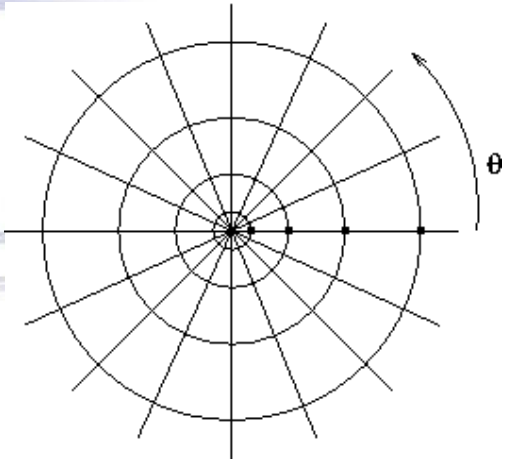
- Neuromorphic Electronics are those where the design principles are inspired by the biological nervous system

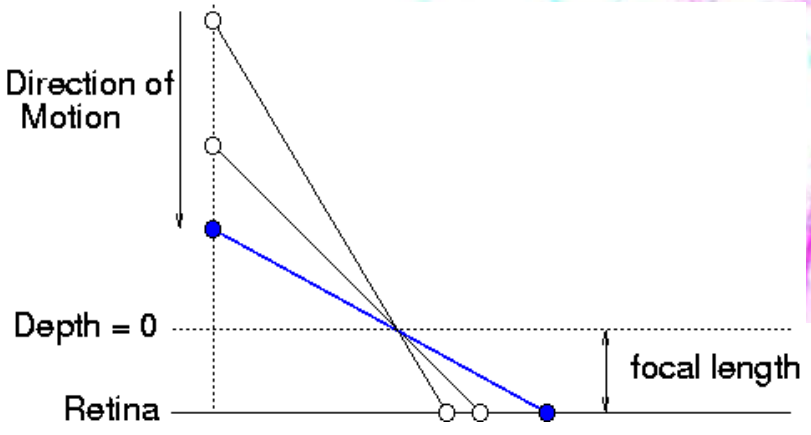
- Aims
  - Low power
  - Better interaction with the environment
  - Learn about some aspect of the nervous system
  - Interact with the nervous system
  - Use the brain's inherent robustness to inspire new design avenues

NSILL

Zhijun Yang & Hugo Monteiro

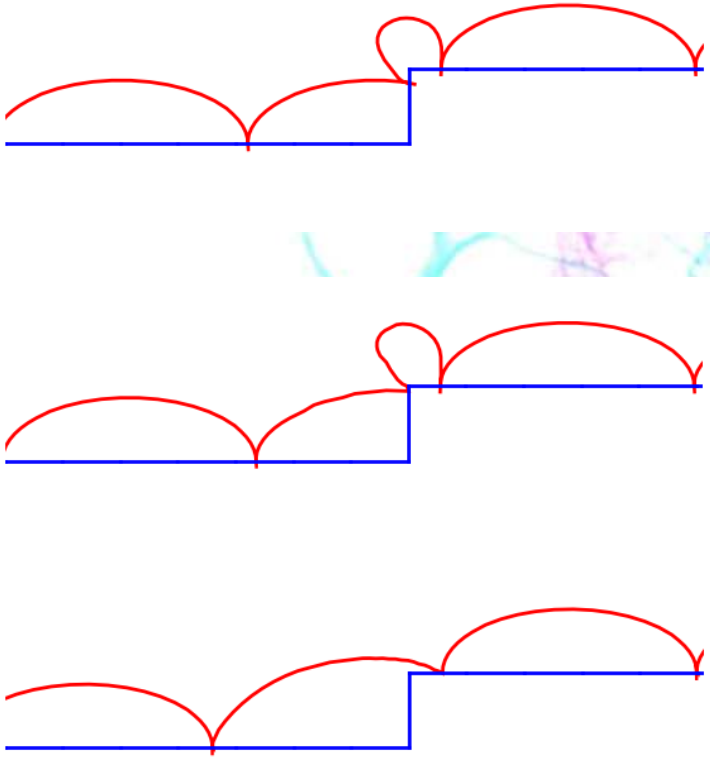
- Neuromorphic Sensorimotor Integration for Legged Locomotion (with IPAB)
- Working on a vision chip to extract depth from motion





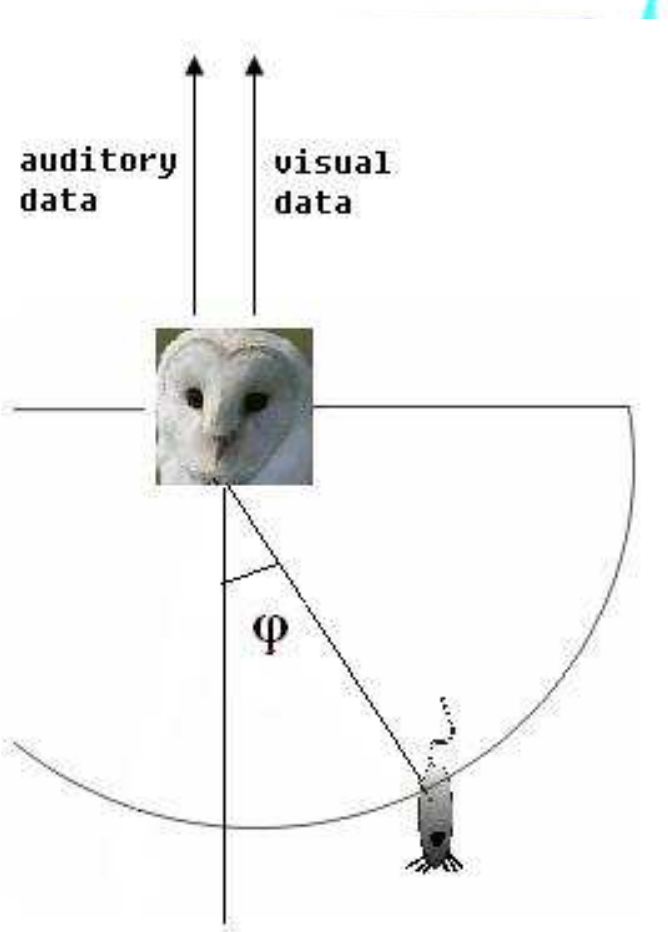
NSILL

- Depth information to be used as input to the 6 legged robot
- Robot being designed by William Lewinger
- Control System implemented by Hugo using ISO learning



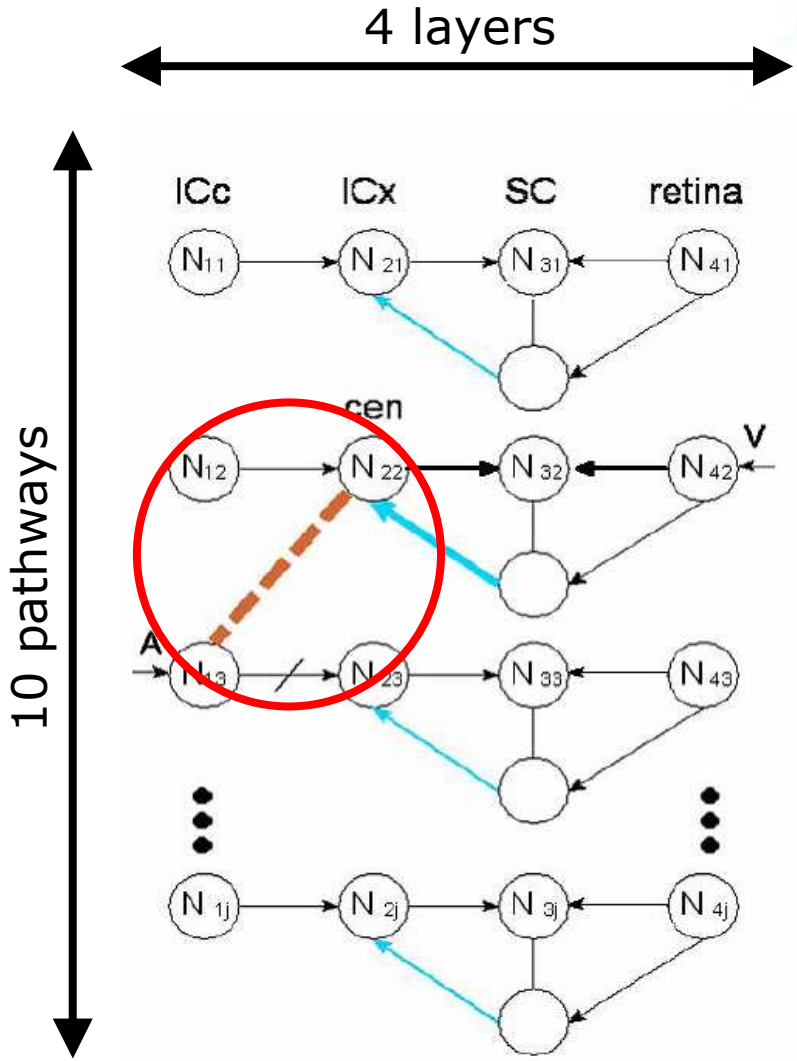
Sensory Map Realignment
Juan Huo

- Model of Barn owl auditory and visual system
- Prism experiment to misalign correlated visual and auditory stimulus
- Allow axon growth to realign map



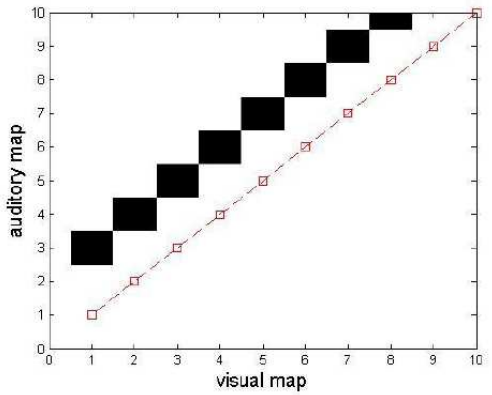
Sensory Map Realignment

- Integrate and Fire neuron
- Network
  - 4 layers
  - 10 pathways
  - each pathway represents 18° in azimuth
- Reconfigurable axon connection
  - Using neurotrophin model
  - Electrical growth signal



Sensory Map Realignment

- Map can be successfully realigned
- Model has been integrated into a robotics application using an E-puck robot

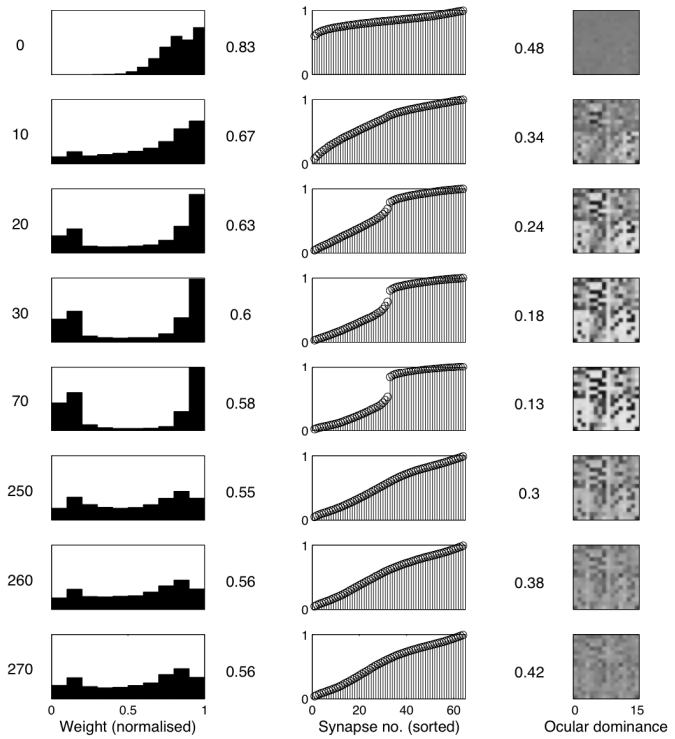


Topographic Map Formation
Simeon Bamford

- Topographic Map Formation can be observed from the retina to the optic tectum in the African Clawed Toad
- A neuromorphic VLSI chip with two methods for formation was designed
  - STDP
  - Synaptic Rewiring
- A new version of AER protocol was also designed

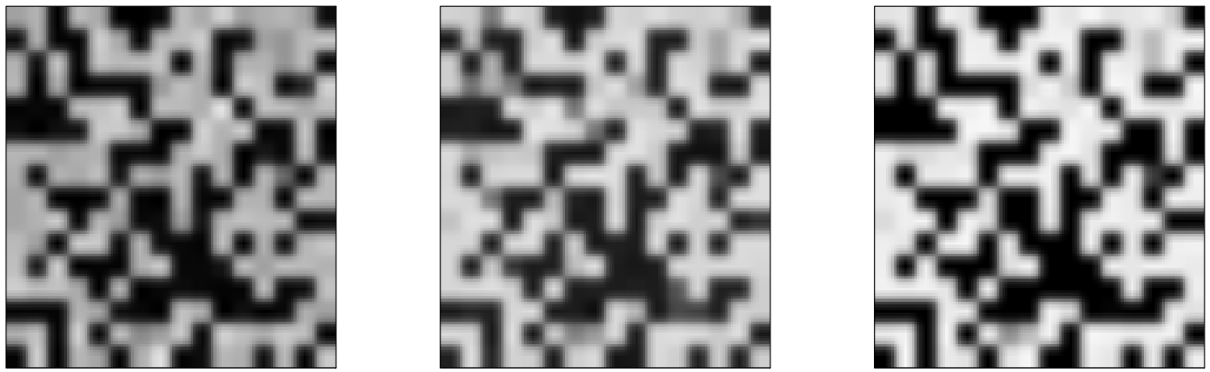
Topographic Map Formation

- Two highly correlated inputs flashed at input layer for 240s
- Weight Change only
- Weight distribution tends to bipolar
- Ocular dominance patterns form
- Input turned off
- Over 30s weights return to random distribution



Topographic Map Formation

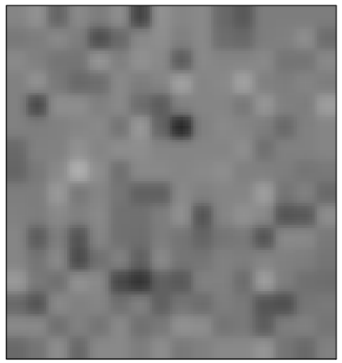
- STDP and Synaptic rewiring
- After 240s of learning
  - Combined ocularity measure better than STDP alone



Topographic Map Formation

- After 30s with no input
  - STDP weight shows no preference
  - Combined map still shows preference

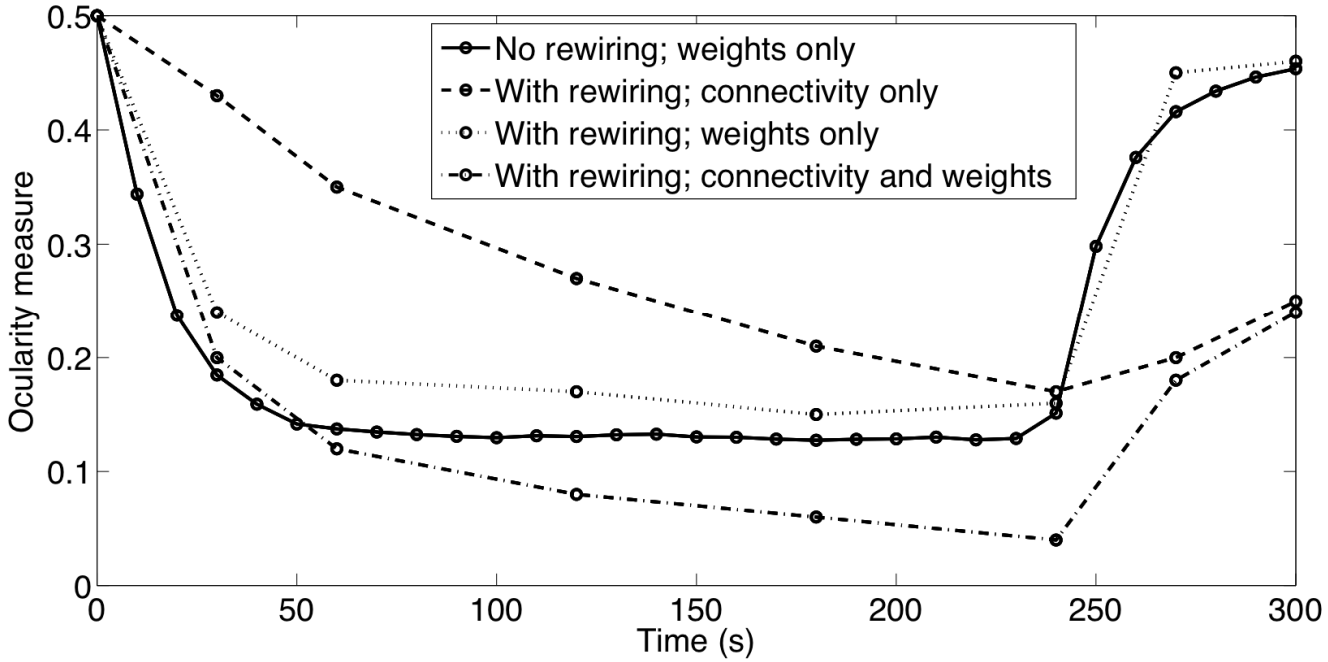
0.2



0.45

0.18

Topographic Map Formation



- STDP allows fast learning
- Synaptic re-wiring aids remembering

Other Projects

- Rapid Evaluation and Evolution of Neural Models
  - Tom Clayton
- Optimising power output of wave devices using GAs
  - Leena Patel
- Investigating the effect of noise in neural networks
  - Can intrinsic nano-scale noise be used to enhance performance?
    - Andrew Cogman & Tong-Boon Tang
  - How do you measure the performance enhancement?
    - Alex Kourkoulas-Chondrorizos

Future

- Self-assembling structures for processing and control
- Applications of adaptive spiking computation
- Reliable, robust computation using unreliable and faulty devices

Acknowledgements

- Neural Group
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