Cellular automata and neural computation

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NDAC

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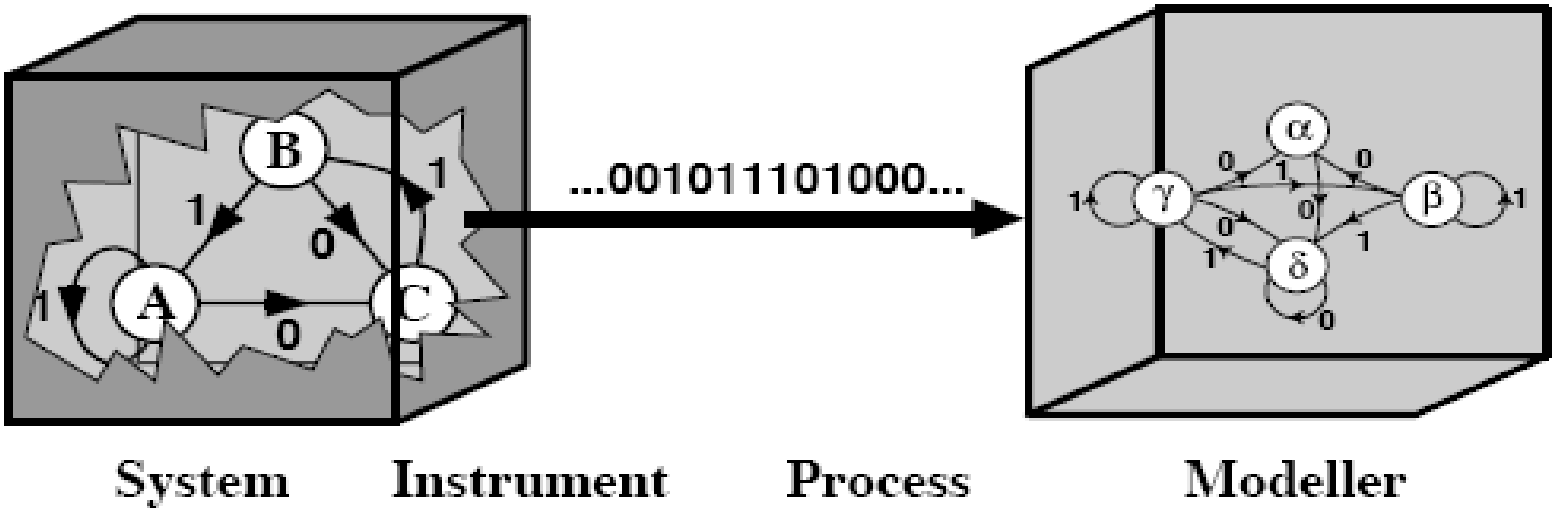
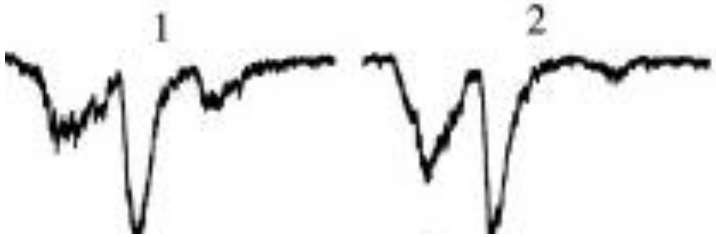
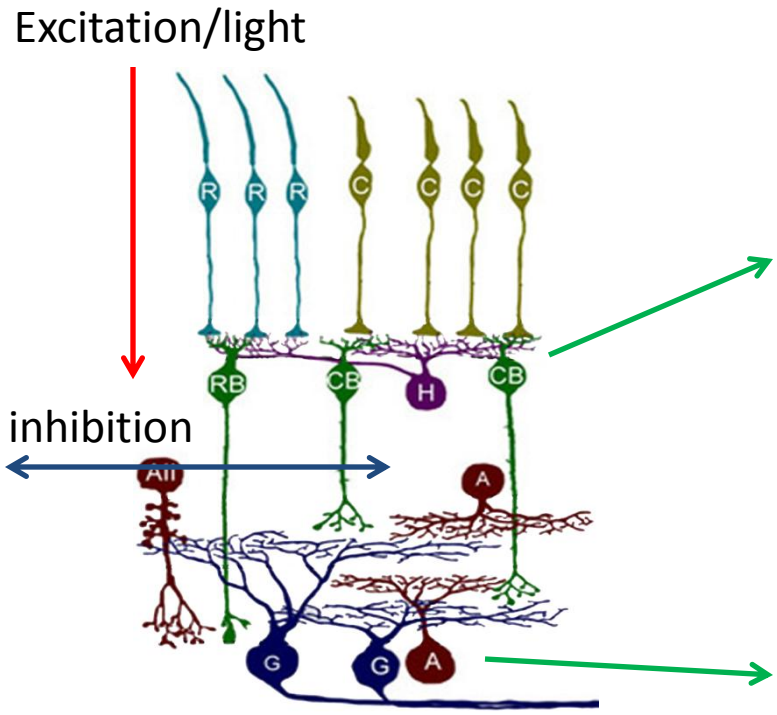
The brain is very large.

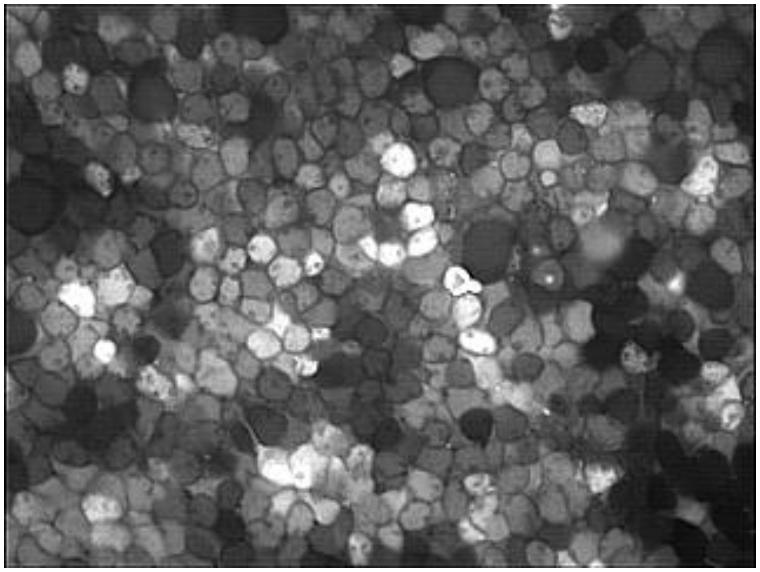


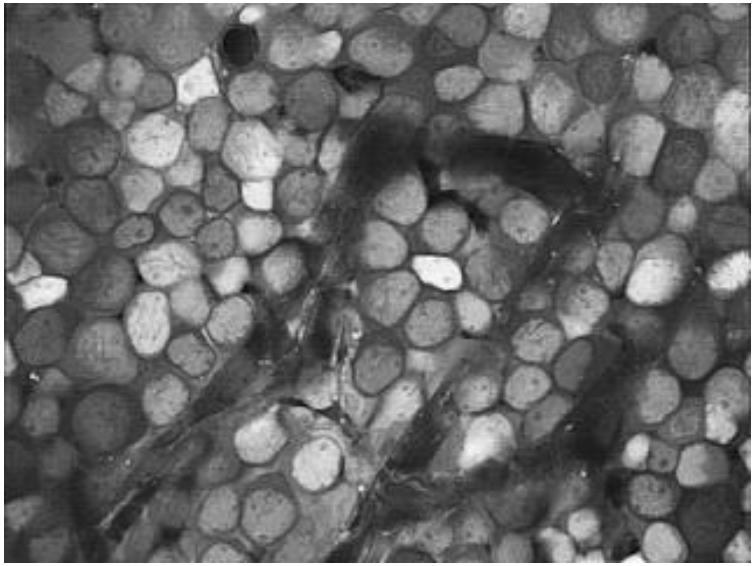


?

The retina is a relatively small brain.



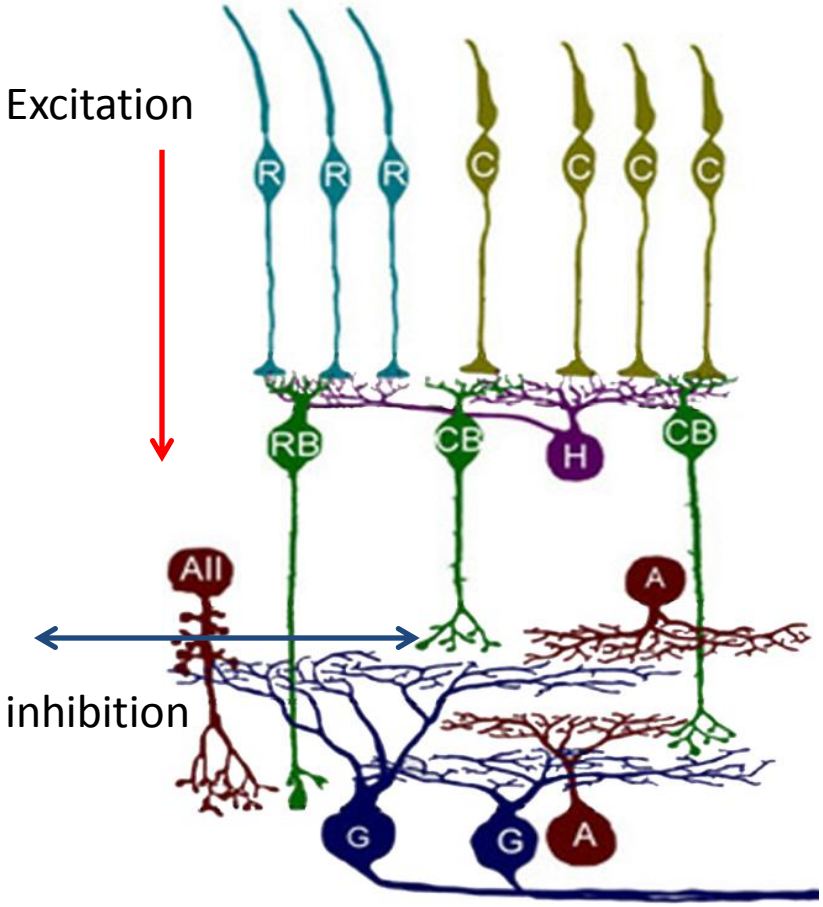


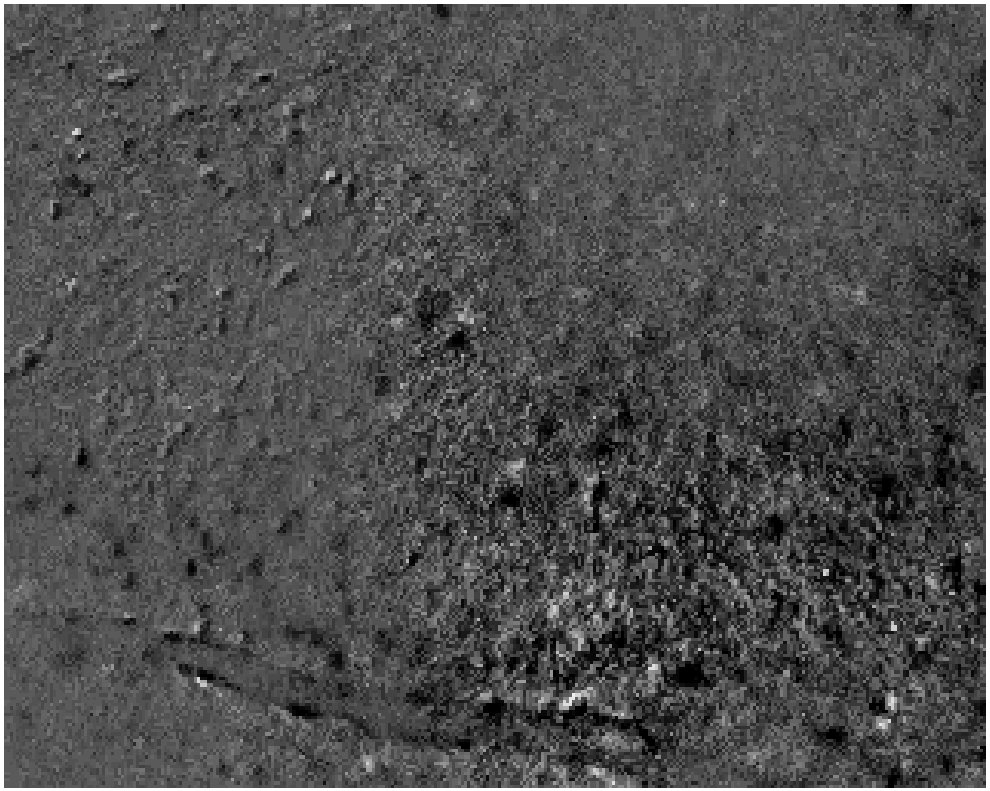


Neuron communication rules:

1. Spikes
2. Synaptic strength
3. Depolarization vs hyperpolarization

Retinal waves self-organize circuits.

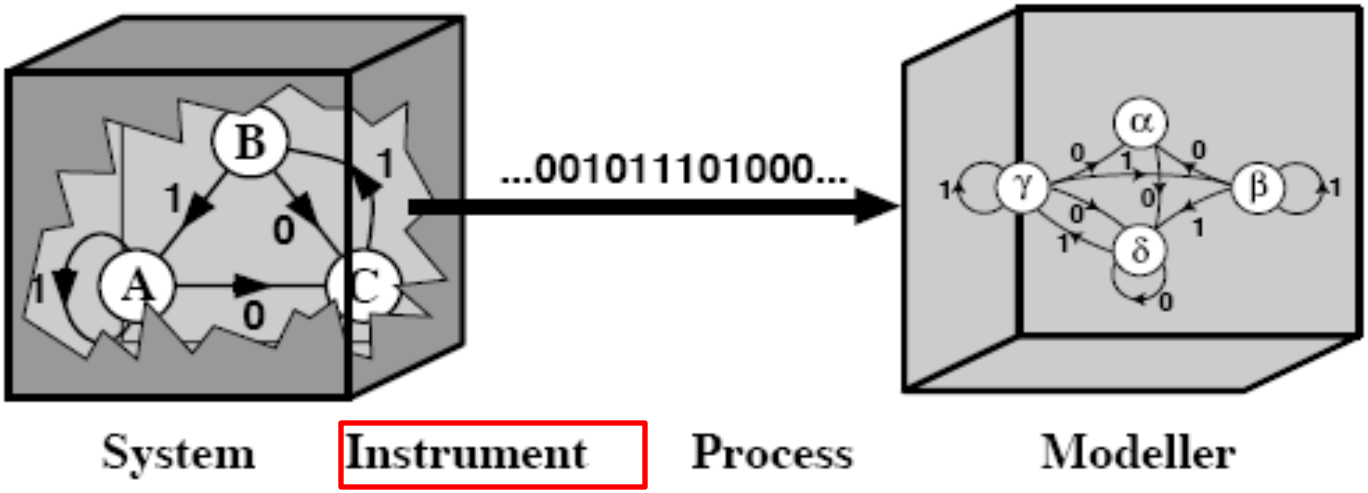




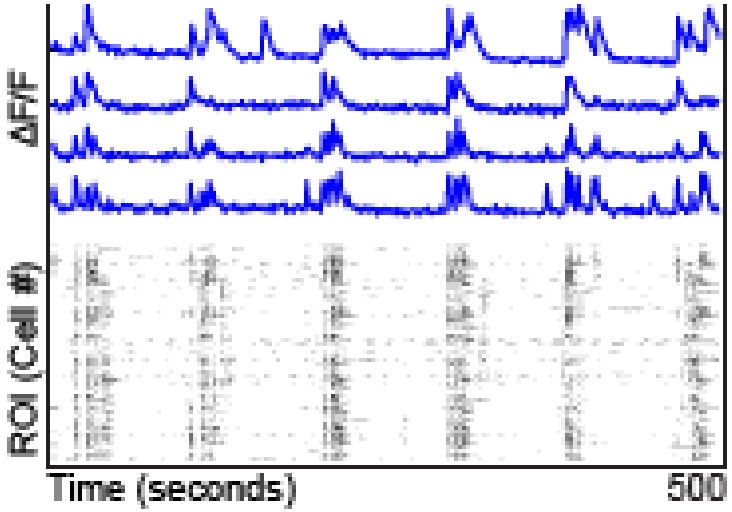
Spontaneous activity has also been studied in the following areas:

Hippocampus
Cortex
Brainstem
Cerebellum
Cochlea

How to quantify waves?



1. Microelectrode arrays
2. Fluorescent imaging
3. Electrophysiology of cell membranes



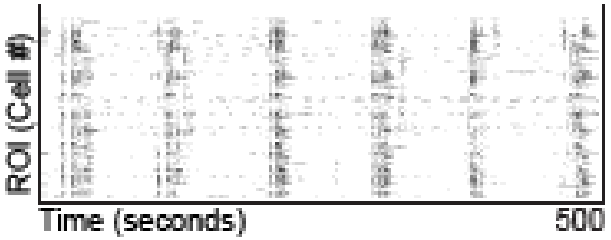
Two other questions.

1. What is the physical mechanism?

2. Models: what kinds of systems display self-sustaining spontaneous activity?

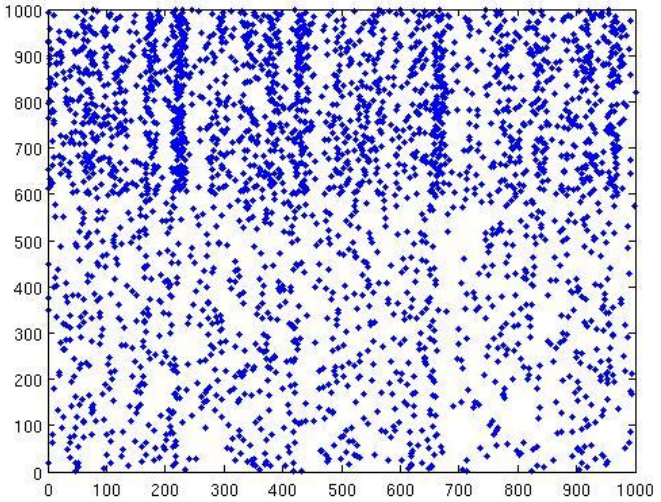
    - Recurrent networks
    - Excitatory/inhibitory networks
    - CAs

Excitatory/inhibitory Model

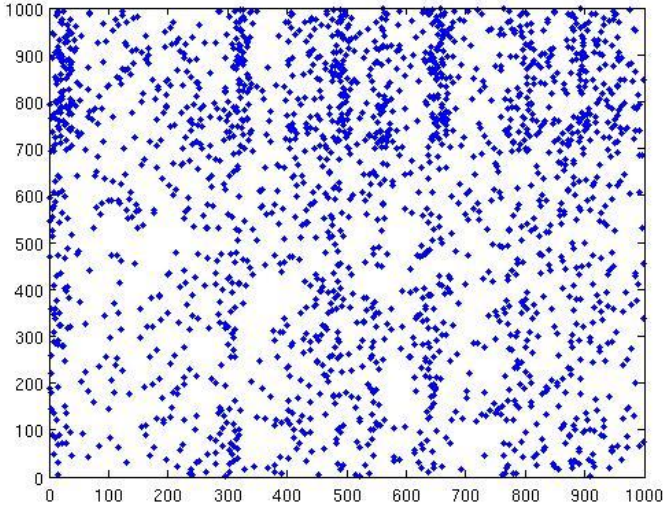


- Integrate and fire neurons
- Adjustable synaptic weights
- Adjustable number of synapses per cell
- Adjustable balance of excitation/inhib
- Constant noise input

Problem: balance issues, requires overdamping and constant noisy input



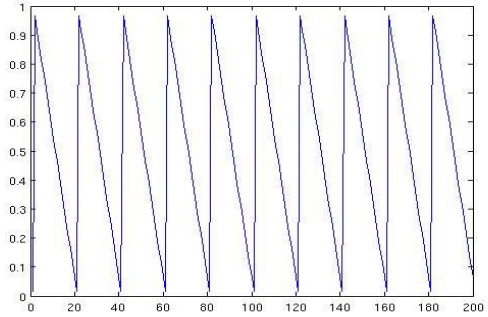
More excitation

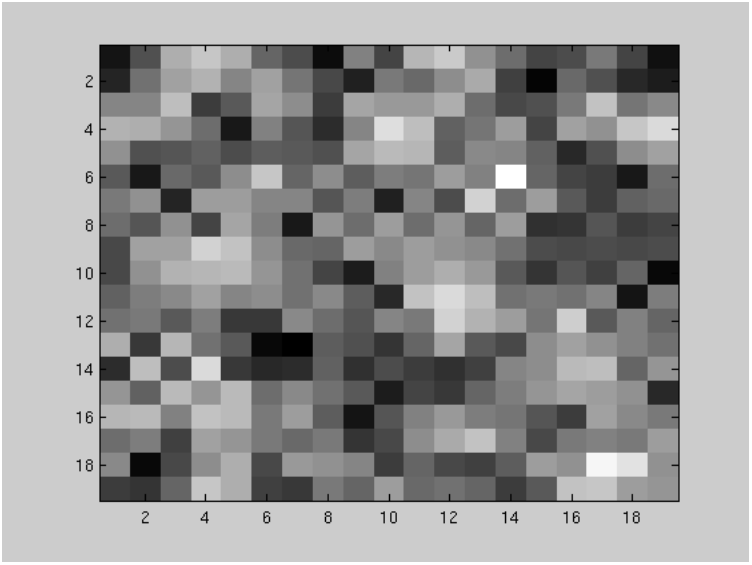


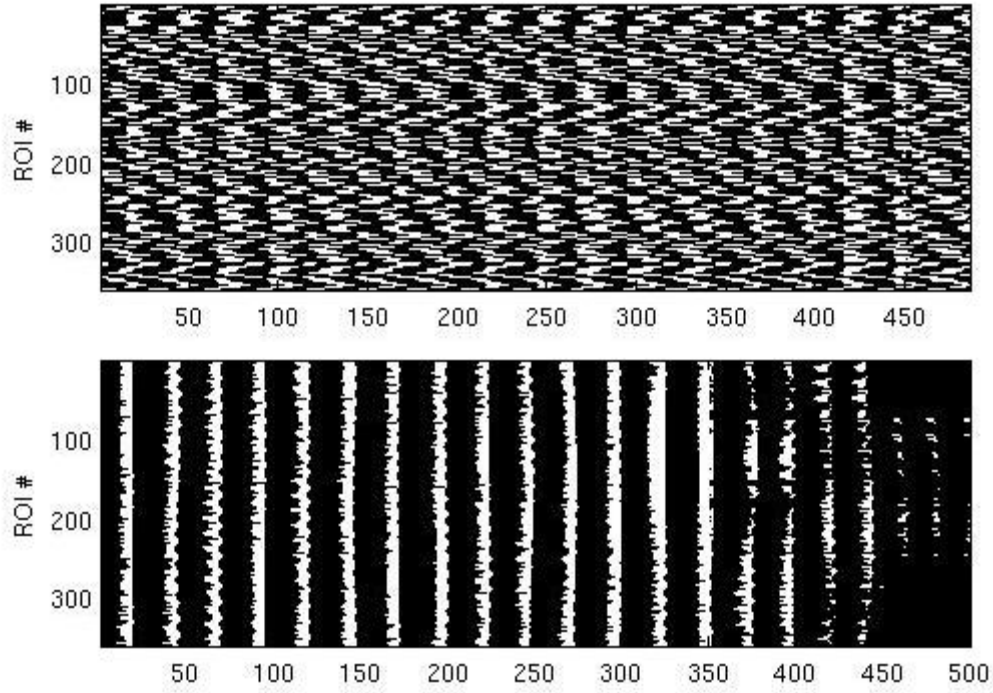
More inhibition

CA Model- linear circle map

- Neurons obey some internal function
- Adjustable coupling strength
- Adjustable number of neighbors per cell
- Adjustable balance of excitation/inhib







Where to go from here?

Strengths of CA models:

1. Freedom in the internal state
2. Self-sustaining
3. Naturally gives rise to spatiotemporal patterns

Many similarities to excitation/inhibition models without the same caveats.