MSc in Computational Cognitive Neuroscience

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Can Dust Clouds Perform Computations? Insight from Modelling Izhikevich Neuron with Cellular Automata

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Introduction

According to arguments (Putnam 1988, 121–125; Searle 1992, 207–208) in philosophy of mind, computation is observer-relative and every physical system performs any possible computations or at least very large number of computations.

Searle proposed that labeling physical system with 0s and 1s is what constitutes being a computer and any object can be described in a way that maps with formal structure of some program, implying even ordinary wall could be considered a computer given one can map pattern of molecular movements in a wall to the formal structure of a program. Putnam Supports more moderate but still strong thesis that any open physical system can implement any finite automaton.

Echoing claims by Putnam and Searle, Greg Egan's dust theory suggests that we can always find a mapping from the states of particles in a randomly dispersed dust cloud to any kind of Alogithm, including including algorithms our brain implements. In reality where causal structure is irrelevant to computation even particles of dust would give a rise to a myriad of states like mind and consciousness.

Izhikevich Neuronal Model

Izhikevich Neurons (Izhikevich, 2003) are more complicated than basic IAF neurons and can produce range of behaviour because of more flexible parameter settings. Izhikevich Neurons are controlled by four parameters a, b c and d that can dynamically reproduce spiking behaviours of bursting, fast spiking, regular and irregular spiking.

Mapping Izhikevich Model to Cellular Automata Rules

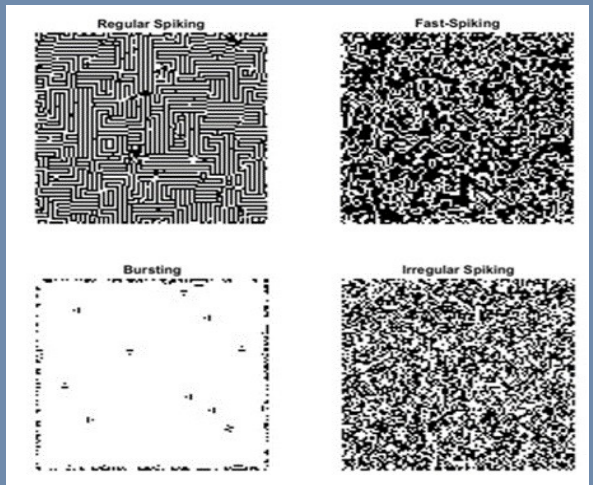
Excitation rule for fast spiking was is excite if number of active cells =4. Bursting rule is inhibitory rule that tells cell to inhibit when if number of nearby active cells >=4 and <=5, visually it looks like raping succession followed by a period of equilibrium. Fast spiking is simulated via increasing excitatory conditions, as for irregular firing I introduced random variable to change a rule of excitation and inhibition randomly.

Methods and Results

1. Izikevich Neuron Model can exchibit four different firing patterns.

These patterns were simulated with cellular automata:

- First, standard Izhikevich Neuron is simulated in MATLAB showcasing different spiking behaviours.
- Same is repeated with cellular automata with specific excitation rules where activation state of a neuron is dependent excitation/inhibition patterns of neighbouring cells.
- Real life dispersed particles, like one of intergalactic medium, do not interact directly over long distances. State of one particle is dependent on the states of particles around it.
- For a dust cloud to simulate mind, particles should interact dinamycally with states of neighbouring particles in a similar way Izhikevich neurons interact. Arbitrary mapping does not suffice.



.Chalmers (2022) Reality +, Virtual Worlds and Problems of Philosophy, Hilary Putnam (1988) Reality and Representation, John Searle (1980) The rediscovery of Mind,