Family of Fungal automata[1]

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Fungi are iniquitous creatures capable of adaptation in hush environments. Recently there is a growing intelligence of the fungi comparable with that of slime mould and plants and that fungi sense and process information in a highly efficient way. To formalise information processing in fungi we developed several classes of fungal automata which constitute the family. The talk will analyse the structure of the family, problems solved on the particular classes of the family and complexity issues.

1D Fungal Cellular Automata. This is cellular automaton (CA) models of information dynamics on a single hypha of a fungal mycelium. Such a filament is divided in compartments (here also called cells) by septa. These septa are invaginations of the cell wall and their pores allow for flow of cytoplasm between compartments and hyphae. The septal pores of the fungal phylum of the Ascomycota can be closed by organelles called Woronin bodies. Septal closure is increased when the septa become older and when exposed to certain environmental conditions. Thus, Woronin bodies act as informational flow valves. The 1D fungal automata is a binary state ternary neighbourhood CA, where every compartment follows one of the elementary cellular automata (ECA) rules if its pores are open and either remains in state '0' (first species of fungal automata) or its previous state (second species of fungal automata) if its pores are closed. The Woronin bodies closing the pores are also governed by ECA rules. We analyse a structure of the composition space of cell-state transition and pore-state transition rules, complexity of fungal automata with just few Woronin bodies, and exemplify several important local events in the automaton dynamics.

2D Fungal Sandpile Automata. The 2D fungal automata are 2D CA where communication between neigh- bouring cells can be blocked on demand. We demonstrate computational universality of the fungal automata by implementing sandpile cellular automata circuits there. We reduce the Monotone Circuit Value Problem to the Fungal Automaton Prediction Problem. We construct families of wires, crossovers and gates to prove that the fungal automata are P-complete.

3D Fungal Colony Automata. The automata are derived from the geometrical structure of real fungal colonies. Z-stacks of imaged micro-colonies are made using hundreds of slices. The hyphal structure of the colony is extracted using image processing and converted into a graph structure. This Euclidean graph is transformed into an automaton network by assigning each edge (or node) a set of finite states and imposing the state transition rules based on local neighbourhoods. Each node in the graph takes three states—resting, excited and refractory. All nodes update their states simultaneously and by the same rule. Two rules are considered: the threshold rule—a resting node excites if it has at least one excited neighbor, and the narrow excitation interval rule—a resting node excites if it has exactly one excited neighbor. The distributions of transient periods and lengths of limit cycles are analyzed. We speculate on

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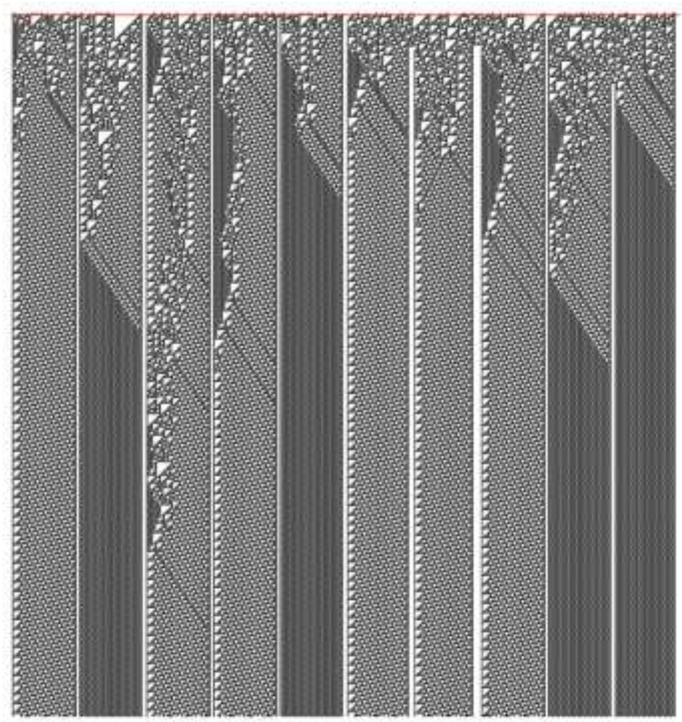
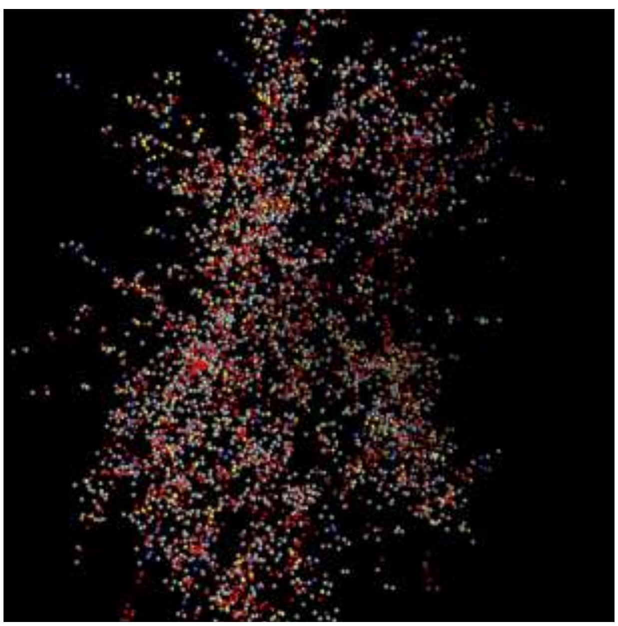
how limit cycles can be used to store information in fungal colonies.



(a)



(b)

Fig 1. Fungal automata. (a) Space-time dynamics of 1D Fungal Automata, (b) 3D view of the Fungal Colony Automata.

References

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