Biomimetic self-replication of complex structures

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Mitosis is a complex biological process by which a eukaryotic cell separates the chromosomes in its cell nucleus into two identical sets, in two separate nuclei. It is generally followed immediately by cytokinesis, which divides the nuclei, cytoplasm, organelles, and cell membrane into two cells containing roughly equal shares of these cellular components. A satisfactory mathematical model of such a complex process should mimic these stages of cell reproduction and the membrane separation yielding structures that are identical to the parent one.

Cellular automata constitute paradigmatic models for complexity in nature, and can be used to model patterns of DNA bases, mollusc seashells, snowflakes, spiral waves in the BelousovZhabotinsky reaction, neural networks and the fundamental physical reality. They consist of a discrete lattice of sites, with a finite set p of possible values each. The site values evolve synchronously and deterministically in discrete time steps according to identical rules, being determined by the previous values on the sites of their neighborhood. The spatiotemporal dynamics of all deterministic cellular automata can be mathematically described by means of a universal map that has been recently formulated [1,2].

A 2D cellular automaton model is considered in which an arbitrary initial condition contained in a rectangle of side $p-1$ (with p being an odd prime number) surrounded by sites with value '0', produces in its spatiotemporal evolution a complex structure at $(p-1)/2$ time steps that, in turn, produces two copies of itself at $p+(p-1)/2$ time steps. A number of computational observations are formalized into a mathematical theorem which is then proved and which establishes this general result. This deterministic self-replication process happens in an entirely biomimetic way resembling mitosis [3] and allow stages of cell reproduction to be modeled as well. Such mechanism is robust and can be generalized to arbitrary number of dimensions and topologies. Mutations that are passed on from the parent structure to the daughter ones can also be mathematically modeled with this approach.

1. V. Garcia-Morales, *Phys. Lett. A*, **376**, 2645 (2012).
2. V. Garcia-Morales, *Phys. Lett. A*, **377**, 276 (2013).
3. V. Garcia-Morales, (submitted for publication, 2013).