Nature-Based Problems in Cellular Automata

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More than half a century ago John von Neumann had become interested in the question of whether computing machines can construct copies or variants of themselves, whether artificial self-reproducing structures exist. He started to investigate the logic necessary for replication and found one of the cornerstones in the theory of automata. He employed a mathematical device which is a homogeneously structured multitude of interconnected finite-state machines operating in parallel to form a larger machine, a cellular automaton. John von Neumann showed that there are cellular automata which can replicate itself ad infinitum. Inspired by these ideas and results cellular automata became a famous model to investigate further nature-based problems.

For example, we will address the French Flag Problem that came up with the question whether one can achieve regulative global polarity in organisms without polarity in individual cells. In connection with the simulation of pigmentation patterns on the shells of sea-snails it is supposed that glands stop their action synchronously at the same time, even though their number was growing during the synchronization process. This inspired the investigation of synchronization in growing cellular automata. Another phenomenon occurring in nature is obliviousness. In order to be economic, information that has not been used for a certain time is of little importance and may be forgotten. So, obliviousness can be studied as an additional property of cellular automata. Furthermore we consider fault-tolerant computations in the context of the Early Bird Problem. computations.