

# Cellular Automata and Computational Universality

July 14, 2018

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## Abstract

Cellular automata are discrete models with the ability to not only give rise to beautiful, intricate patterns, but also to be used as powerful tools of computation, with applications in cryptography, error-correction coding, and simulation of computer processors, to name a few. They also raise profound questions about the nature of our reality, asking whether our universe could be one such automaton. This paper provides a discussion into these automata, exploring the various power and limitations of a number of specific rule sets, covering John Conway's well-known "Game of Life" to the more obscure "Langton's ant" and "Wireworld". In particular, it explores the notion of computational universality, or Turing completeness, an automaton's ability to simulate any conceivable computation, and considers their potential in the context of solving two specific problems, the Firing Squad Synchronization Problem and the Majority Problem. Existing solutions to these problems are explored, and their existing avenues for optimization are discussed. In order to fully appreciate the complex structures that can arise from such simple beginnings, this project also presents software to visualize and probe further into the nature of the automata highlighted.