CAN SQUARES BE SMARTER THAN YOU?

Exploring the link between dynamics and computation in Cellular Automata

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Meet Steve!

:)

Steve is a cell

Steve is either **alive** or **dead**

Steve has **neighbours**

And **evolves** depending on them

Steve also has a lot of friends

They form a **grid** and evolve together

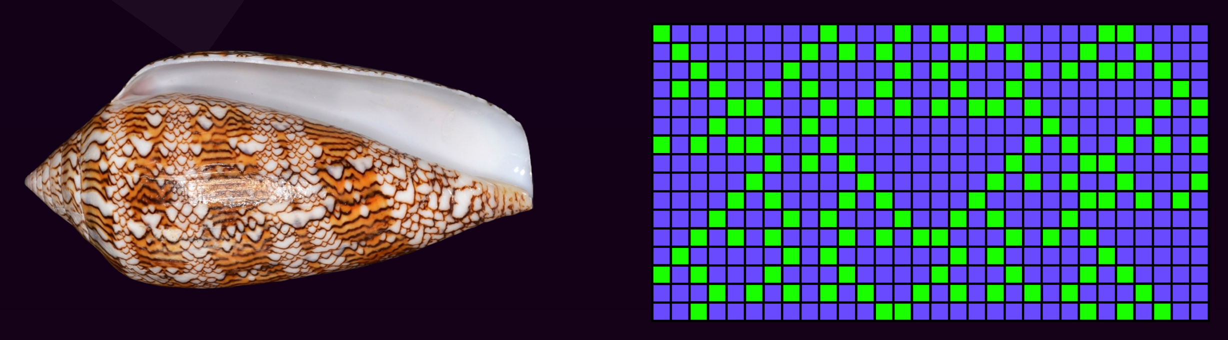
That's a **Cellular Automaton**!

Introduction

A **Cellular Automaton (CA)** is a dynamical system whose behaviour at any time is dependent upon previous states of the system and is determined by a simple local rule.

Scientists use Cellular Automata as compact models for describing complex physical and biological processes.

Figure 1 : Cellular Automata in Nature



On the left, the Conus textile exhibits a Cellular Automaton pattern on its shell.
On the right, Cellular Automaton '18', which behaviour resembles the pattern found on the shell.

Objective

Cellular Automata can be explored both through their dynamics and their computational abilities. **Dynamically**, one may ask: what do they look like after many steps? **Computationally**, the question is how 'intelligent' they are: can they compute as much as your computer can?

The aim of this work is to bring these perspectives together and explore **under which dynamical properties Cellular Automata can simulate each other**. In doing so, we get very close to understanding when these little squares can be smarter than you, and even your computer.

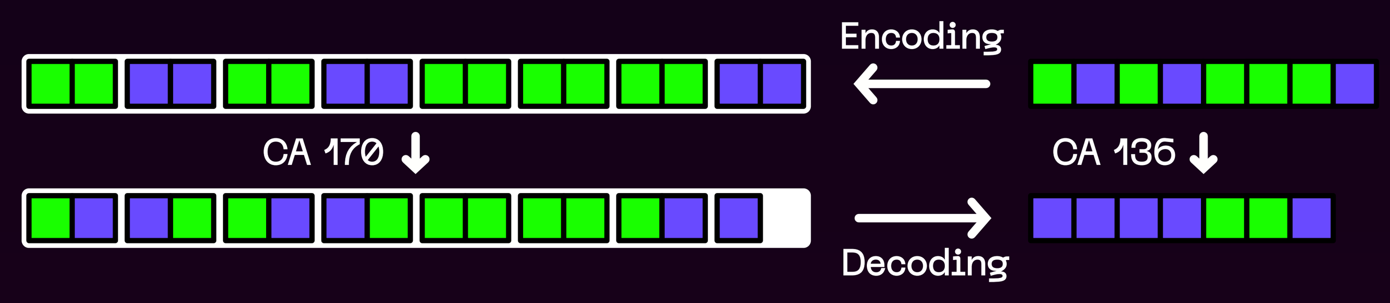
LET'S KEEP IN TOUCH! :)

Methodology

The work began with a systematic study of the dynamical properties of Cellular Automata, leading to a **classification framework** for comparing them.

This framework was then used to **investigate their computational power**, the main question being: what dynamical properties, if any, a Cellular Automaton must, or must not, possess in order to be able to simulate any other Cellular Automaton with the same dimension?

Figure 2 : Simulation of Cellular Automata



Cellular Automaton '170' can simulate Cellular Automaton '136': By encoding a pattern, updating it with CA '170', and then decoding, we get exactly the same result as one step of CA '136'.

Results

Our research shows that Cellular Automata that display a variety of dynamical properties such as surjectivity, transitivity, chaos, and mixing can simulate Cellular Automata outside of their dynamical class. This suggests that **computational power** may not be confined to a narrow class of dynamics but can **coexist with highly diverse structural properties**.

Conclusion

This work highlights that **Cellular Automata capable of complex computation might manifest in many different dynamical settings.** This suggests that dynamics and computation should be studied as complementary perspectives, and that the richness of Cellular Automata lies precisely in the diversity of ways these two aspects interact.

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