Project Ananke: A Beginning

Solomon Saleh, Winston Vo, and You?

Abstract—This document details what Ananke means and entails: its goals and values. We explore the connection between Project Ananke and cellular automata, its applications in the world and major scientific realms, and potential areas of research. The goal of this paper is to lay the foundations for Project Ananke, providing a starting point upon which we can form and base ideas on.

Index Terms—Cellular automata, object-oriented programming, Turing-completeness, Turing machine, quantum mechanics, string theory

1 A Brief Introduction to Project Ananke

1.1 History, Etymology, and Meaning of "Ananke"

In Greek mythology, the goddess Ananke embodies inevitability, compulsion, and necessity. Her birth signaled the end of Chaos and the beginning of the cosmos. Her name comes from the term ἀνάγκη, used in Ancient Greek literature to mean ”fate” or ”destiny” [1].

Beyond the myths and antiquated language, and into our tangible world, the name Ananke reflects this project's founding values. Project Ananke is not a mission that we merely dream of, nor is it a means to attain our selfish desires; rather, it is our destiny that we inevitably share as comrades drawn forth to a common cause—the mission to which Fate compels us forth, for good or ill, for honor and camaraderie. It is destiny that we met and equally destiny that assembles us together for a fated mission—be it the end of an era or the beginning of many.

And just her birth once shone the dawn of the cosmos, Project Ananke's birth shall hereafter issue forth the dream of a new frontier: the entirety of world. Through Ananke, we shall together tip it, changing it little by little, improving it bit by bit.

1.2 Description of Project Ananke

Project Ananke is a doctoral research project on one word: **Cellular Automata** (or two?).

2 What is Cellular Automata?

Cellular automata[1] (henceforth referred to as CA) are ”discrete, abstract computational systems.” Throughout the scientific realm, in several major scientific fields, it has found use as representations of complex, non-linear dynamics and has long been utilized as a way to specifically represent ideas. Essentially, CA operate on a simple set of rules as a function of the information in the elements surrounding each cell. From simple rules arises complexity, and it grows into a complex dynamic system that can evolve into essentially digital lifeforms in a discrete time and space, each cell in the system evolving in parallel [2].

The cells can have information embedded in them following some abstraction; they don't necessarily need to be some strict 1 or 0, allowing for infinitely more possibilities of modelling and simulating our reality. We can use object-oriented programming[2] concepts to further abstract some rules.

Cellular automata reframe modern approaches to scientific research and innovation. Traditionally, we look at modern science in a top-down approach, where we describe what we observe with mathematical models first and then determining their underlying fundamental components after. On the contrary, CA favors a bottom-up approach,

1. Singularly referred to as cellular automaton.
2. A programming paradigm that views data in terms of objects and abstractions.

generalizing reality based off of fundamental models and rule-sets. This change in approach may radically change how we view science.

2.1 Brief History of Cellular Automata

Cellular automata was originally discovered by John von Neumann and Stanis Ulam in the 1940s. As a two-dimensional CA and a Turing-complete system[3], Conway's Game of Life popularized it beyond academia in the 1970s. In the 1980s, Stephen Wolfram studied one-dimensional CA, calling it elementary cellular automata [3]. In 2002, he applied his research in CA to physics in his book *A New Kind of Science*, claiming that these complex systems[4] can computationally describe "all of the physical world" [4].

As people continue researching, modelling, and implementing cellular automata through modern technologies, we have discovered many things about the world around us and many different applications for it.

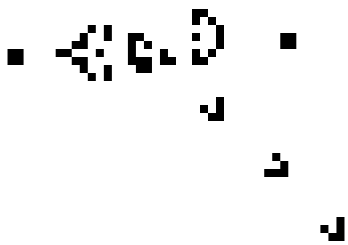

Figure 1. Conway's Game of Life, depicted as gliders.

2.2 Applications of Cellular Automata

Cellular automata can be used in image processing such as a blur effect—or in flocking, in which multiple cells belong to some flock that abides by pre-defined behavior.

More complicatedly, CA has been used alongside biology and neural networks in a form known as neural CA. It sees cells as physical cells that have potential for growth and repair. In image processing, it can provide the foundations for an algorithm that grows image cells that can regenerate when destructed (real-time image repair) [5].

Fluid and sand can also be simulated using CA. Probabilistic CA has been used to model things in physics such as fluid and heat flow [6]. Even within the game of life, there are patterns emerging that allow for Turing completeness. Objects such as the glider, reflector, and eater allow us to create AND OR NOT gates, further allowing us to perform basic logic design to build a Turing machine or even a modern computational machine [3].

CA are most useful in application for systems that have emerging complexity from a fundamentally basic process or rule. It has found use in modelling "dynamical systems occurring in all range of organized behavior, such as statistical physics, biology, medicine, ecology, and socioeconomic interaction" [6].

3. A Turing-complete system is a system that can simulate capabilities of a real-world computer.
4. Wolfram essentially claimed to have created a computational "theory of everything."

From the transmission of pandemics to quantum mechanics, to string theory, to our very cosmos, from the human mind down to its very neurons, from the dawn of time perhaps to even the ends of time, everything from our day-to-day realities to the concepts we may only dream of—these looming possibilities for research in CA are endless and endlessly applicable. These are the core beliefs and theories upon which Project Ananke is founded.

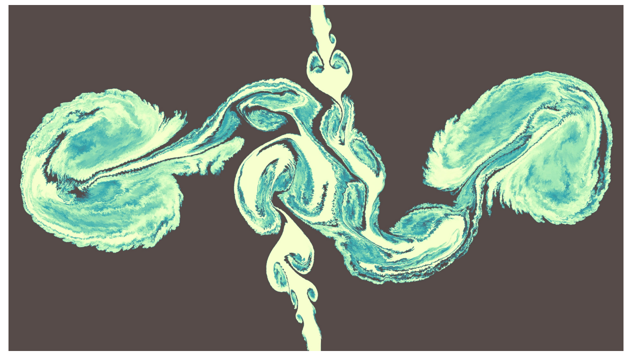

Figure 2. Computational fluid simulation using Navier-Stokes equations.

3 Project Ananke and Cellular Automata

Considering the variety of applications for CA, for our project, we must then define which complex systems most require a model. The economy, quantum mechanical systems, human behavior, chaotic fluid flow, cosmic phenomena, and the emergent intelligence and sentience from neurons are prime candidates.

Quantum mechanical systems may be discarded, as it would be unfeasible and inefficient to simulate quantum mechanics without quantum computing. However, this does not completely rule out theoretical physics, as research is underway to *interpret* developing theories such as quantum mechanics and even string theory [7].

If one were to design a rule-set or some function that simulates the emergence of intelligence, this intelligence would then be some form of abstract human-like Turing machines[5], as any problem readable by an intelligence would be solved by an intelligence constituting an intelligent being. This can solve any problem that is difficult or impossible to solve by a computer not simulating neurons—such as image detection—through sentient, intellectual, and computational neuron simulation.

As for physics, an emergent complex system is chaotic fluid flow—perhaps defining known parameters of already known fluid systems and tweaking them as initial conditions or a rule-set, then analyzing and optimizing the given complexity from the system to approach that of a chaotic system, such as turbulence. This would thus allow us to properly define the cause of this chaos.

Another idea would be to simulate the emergence of failure within Einstein's theory of General Relativity: that

5. A mathematical model describing an abstract machine capable of computation according to rules—essentially being able to implement any algorithm [8].

is, his equations would be used to solve for the gravitational behavior of large galactic structures as cells in flocks, eventually leading to failure as there is not enough mass in even our own galaxy to justify its structure. Analyzing where, when, and how this model fails would allow us to see what exactly is causing a failure within the theory.

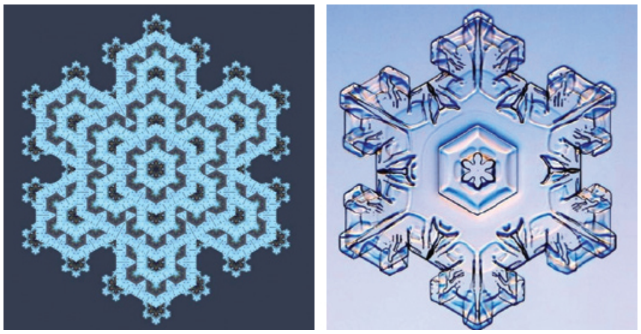

Figure 3. Water droplets attract other water molecules when falling, the hexagonal edges reaching out more so they attract more molecules. This process can be simulated in CA modelling snowflakes [9].

3.1 Potential Ideas with Big Picture Questions

1) Simulate the emergent intelligence of a system of neurons simulated by CA. Then, use the results to formalize what intelligence is, perhaps the concept of intelligence being some generalization of the concept of the Turing machine. What fundamentally causes and creates intelligence?
2) Simulate complex systems such as galactic formations to analyze where, why, and how Einstein's model "fails." Why does relativity fall apart at galactic scales?
3) Simulate fluid flow to the highest and most performant precision available to the information known for a single cell. Optimize the initial conditions to produce the chaotic results in, for instance, turbulence—to then solve for what exactly is causing this chaotic behavior. (There has been research in measuring chaos within CA, just not to this extent [10]). What fundamentally is causing chaos within fluid systems?

4 Conclusion

Cellular automata is a growing field that has considerable influences on modern and future research, and it has the potential to fundamentally revolutionize science. More importantly, it is the field which we have chosen to lay our foundations upon. Now, the options and ideas are laid out before us. From these, we will collectively decide what we are going to work on. Should none of them be satisfactory, simply suggest an idea, for Project Ananke is the inevitable team project that requires unanimous agreement and intellectual pursuit.

Now, will you take the red pill and join us on the journey for greatness? Or will you resign to ignorance and be doomed to eternal despair? The choice is yours.

References

[1] Wikipedia. "Ananke". (2022), [Online]. Available: https://en.wikipedia.org/wiki/Ananke.
[2] F. Berto and J. Tagliabue, "Cellular Automata", in *The Stanford Encyclopedia of Philosophy*, E. N. Zalta, Ed., Spring 2022, Metaphysics Research Lab, Stanford University, 2022.
[3] Wikipedia. "Cellular automaton". (2022), [Online]. Available: https://en.wikipedia.org/wiki/Cellular_automaton.
[4] M. v. Sivers, *Wolfram physics project seeks theory of everything; is it revelation or overstatement?*, Apr. 2020. [Online]. Available: https://hackaday.com/2020/04/30/wolfram-physics-project-seeks-theory-of-everything-is-it-revelation-or-overstatement/.
[5] J. Fernandez, *Connecting biology and ai: Growing neural cellular automata*, Jun. 2022. [Online]. Available: https://towardsdatascience.com/connecting-biology-and-ai-growing-neural-cellular-automata-fd53f2834ee2.
[6] A. Agapie, A. Andreica, and M. Giuclea, "Probabilistic cellular automata", *Journal of Computational Biology*, vol. 21, no. 9, pp. 699–708, Sep. 2014. DOI: 10.1089/cmb.2014.0074. [Online]. Available: https://doi.org/10.1089/cmb.2014.0074.
[7] G. '. Hooft, *The cellular automaton interpretation of quantum mechanics*, 2014. DOI: 10.48550/ARXIV.1405.1548. [Online]. Available: https://arxiv.org/abs/1405.1548.
[8] Wikipedia. "Turing machine". (2022), [Online]. Available: https://en.wikipedia.org/wiki/Turing_machine.
[9] *Fueling Innovation and Discovery*. National Academies Press, Jul. 2012. DOI: 10.17226/13373. [Online]. Available: https://doi.org/10.17226/13373.
[10] W. Ewert, W. Dembski, and R. J. Marks, "Algorithmic specified complexity in the game of life", *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, vol. 45, no. 4, pp. 584–594, 2015. DOI: 10.1109/TSMC.2014.2331917.