Geremias Montano, Eduardo Martínez, Jason Whitlow, Rajan Sidhu

Dr. Thanos

CSCI 154

05/09/2023

Conway’s Game of Life Report

Abstract

The Conway’s Game of Life is a cellular automation model that analyzes rich emergent properties and has potential applications in numerous fields. Among these fields are biology, physics, and computer science. The purpose of this paper is to explore and discover “The Game of Life’s” rules, properties, interesting objects, and potential applications. This implementation of the Game of Life is written in Python programming language using the following libraries to make the most efficient clean and well written simulation: “Tkinter”, “NumPy”, “Pygame”, and “Random'' for visualization and user interaction of this simulation. The emergent complexity, identification of interesting objects, and discussion of possible real-world applications were analyzed during the experimentation and observational phase. The findings of this project highlight the value of cellular automata and the Game of Life as tools for understanding complex phenomena and real-world applications.

1. Introduction

Cellular automata can be defined as a very powerful model of simulation with a limitless number of applications across many different fields. Conway’s Game of Life is a clear example of this one that can be used to represent the behavior of cellular automata in different studies. One of the examples of the uses of cellular automata could be population simulation among others. Throughout this report the different aspects and components of Conway’s Game of Life will be addressed and explain to understand better the concepts behind this one and the potential use of this modeling example.

1. Problem Statement

The goal for this project is to realize a detailed analysis of Conway’s Game of Life by changing the starting patterns and the rules then examining its emerging properties. The results of this analysis can provide us with more insight of how populations can grow based on the effects that everyone.

1. Related Work and Background Material

John von Neumann first introduced cellular automata in the 1940s, while John Horton Conway developed the Game of Life in 1970. The Game of Life consists of a grid of cells, each of which can be in one of two states: alive (1) or dead (0). The state of each cell evolves based on the states of its eight neighboring cells and follows four simple rules:

Underpopulation: A live cell with fewer than two live neighbors die.

Overpopulation: A live cell with more than three live neighbors dies.

Survival: A live cell with two or three live neighbors survives.

Reproduction: A dead cell with exactly three live neighbors becomes alive.

1. Approach

We decided to use Python for this project since it had the easiest graphic libraries to work with. The libraries that were chosen were Pygame and NumPy for the bare bones implementation of Game of Life. The reason we chose NumPy over a regular 2D array is because several sources claim that NumPy can be anywhere from five to one hundred times faster than a regular 2D array because of the library being implemented using the C language. This was a simple way of increasing speed since we did not implement any algorithms that would help with efficiency. After all cell states were calculated based on the rules provided, all the cells that were flagged as “alive” were displayed on screen.

Once the base game implementation was created, some extra libraries were included mostly for decoration and convenience. The random library was imported to make use of Pygame color functionality which allowed us to change the color of every cell individually, giving it a sort of rainbow effect. A control panel was later added to help with the experimentation process.

As for the simulation, we grew tired of just trying to find interesting patterns and found out that some of the patterns found on the internet only worked under different rules than the classic “Game of Life” rules. This led us down a rabbit hole of changing the conditions of which a cell dies, remains alive, or reproduces. This led to more interesting results that were not as documented on the internet.

1. Experiment set-up (including Metrics, Benchmarks, Data collection)

Several initial configurations are used to demonstrate different properties and objects in the Game of Life, such as still life, oscillators, spaceships, and guns. Metrics for analyzing complexity include the number of generations, pattern sizes, and interactions among patterns. Data is collected through observation and experimentation with various initial configurations.

1. Results and Discussion

Experiments with different initial configurations show a wide range of emergent complexity, such as patterns forming, stabilizing, and interacting with other patterns. Interesting objects identified in the Game of Life include still life (e.g., Block, Beehive), oscillators (e.g., Blinker, Toad), spaceships (e.g., Glider, Lightweight Spaceship), and guns (e.g., Gosper Glider Gun). Also, the patterns that we were able to discover by manipulating the original rules that were shown in the presentation such as: the brain rule, block rule, pattern rule, and spark rule.

The Game of Life's emergent complexity and self-organization have potential applications in modeling natural systems, simulating computations, and studying artificial life. For example, the Game of Life has been used to model population dynamics, investigate the properties of Turing machines, and explore the emergence of artificial life in simple rule-based systems.

1. Contributions and Conclusions

This project successfully explores the Game of Life by implementing it in Python, investigating its emergent complexity, interesting objects, and potential applications. The study highlights the value of cellular automata and the Game of Life as tools for understanding complex phenomena and real-world applications.

Future work could explore other cellular automata or extensions of the Game of Life or investigate novel applications in interdisciplinary research. Additionally, more advanced visualization techniques and user interfaces could be developed to enhance the exploration and understanding of the Game of Life's properties. Overall, our findings contribute to the growing body of knowledge surrounding cellular automata and their potential applications in various fields. Being said, some of the areas that could be improved in the future work would be the delivery and the structure of how this project was presented, such as more precise information about the structure and implementation of the project, more testing to develop more interesting patterns and more objects, and implementation of the model in a different field.