Instituto Politécnico Nacional
Escuela Superior de Cómputo
Evolutionary Computing Genetic Algorithm
Student: Rodríguez Coronado Ricardo Professor: Jorge Luis Rosas Trigueros
Realization: 14/jun/20 Delivery date: 16/jun/20

1. Theoretical framework

Cellular automata

Cellular automata were originally introduced by von Neumann and Ulam (under the name of “cellular spaces”) as a possible idealization of biological systems (von Neumann, 1963, 1966), with the particular purpose of modelling biological self-reproduction.

Cellular automata are mathematical idealizations of physical systems in which space and time are discrete, and physical quantities take on a finite set of discrete values. A cellular automaton consists of a regular uniform lattice (or “array”), usually infinite in extent, with a discrete variable at each site (“cell”). The state of a cellular automaton is completely specified by the values of the variables at each site. A cellular automaton evolves in discrete time steps, with the value of the variable at one site being affected by the values of variables at sites in its “neighborhood” on the previous time step. The neighborhood of a site is typically taken to be the site itself and all immediately adjacent sites. The variables at each site are updated simultaneously (“synchronously”), based on the values of the variables in their neighborhood at the preceding time step, and according to a definite set of “local rules.” [1]

Conway's Game of Life

Is a cellular automaton of zero-player game, meaning that its evolution is determined by its initial state, requiring no further input. One interacts with the Game of Life by creating an initial configuration and observing how it evolves. It is Turing complete and can simulate a universal constructor or any other Turing machine. [2]

Although cellular automata have origins dating from the 1950s, widespread popular interest was not created until John Conway’s “Game of Life” cellular automaton was initially revealed to the public in a 1970 Scientific American article. The single feature of his “game” that probably caused this intensive interest was the discovery of “oscillators” (periodic forms) and “gliders” (translating oscillators). [3]

Rules

The universe of the Game of Life is an infinite, two-dimensional orthogonal grid of square cells, each of which is in one of two possible states, live or dead, (or populated and unpopulated, respectively). Every cell interacts with its eight neighbors, which are the cells that are horizontally, vertically, or diagonally adjacent. At each step-in time, the following transitions occur:

1. Any live cell with two or three live neighbors survives.

2. Any dead cell with three live neighbors becomes a live cell.
3. All other live cells die in the next generation. Similarly, all other dead cells stay dead. [2]

Patterns

Many different types of patterns occur in the Game of Life, which are classified according to their behavior. Common pattern types include *still lifes*, which do not change from one generation to the next; *oscillators*, which return to their initial state after a finite number of generations; and *spaceships*, which translate themselves across the grid. [2]

Minecraft

Minecraft is a sandbox video game developed by Mojang Studios. Created by Markus "Notch" Persson in the Java programming language and released as a public alpha for personal computers in 2009, the game was officially released in November 2011, with Jens Bergensten taking over development around then.

In Minecraft, players explore a blocky, procedurally generated 3D world with infinite terrain, and may discover and extract raw materials, craft tools and items, and build structures or earthworks. Depending on game mode, players can fight computer-controlled "mobs", as well as cooperate with or compete against other players in the same world. Game modes include a survival mode, in which players must acquire resources to build the world and maintain health, and a creative mode, where players have unlimited resources. Players can modify the game to create new gameplay mechanics, items, and assets. [4]

2. Material and equipment:

- Golly 3.3
- PC or Laptop with Windows 7+/Linux/MacOS X

Optional:

- Java: Java 6+.
- Minecraft Java Edition.

3. Practice development

The objective of the practice is to generate a new rule based on the last digit of the student's number and find the different patterns that can be generated on the Golly software simulation board.
In this case the digit to use is 3, so the rule B2 / S34 will be used, which means:
Any live cell with three or four live neighbors survives.

1. Any dead cell with two live neighbor becomes a live cell.
2. All other live cells die in the next generation. Similarly, all other dead cells stay dead.

So the first step is to enter the rule in the software, for this select the option "Control" in the top menu, followed by choosing "Set Rule ..." as it can see in Image 3-1 Set Rule in Golly.

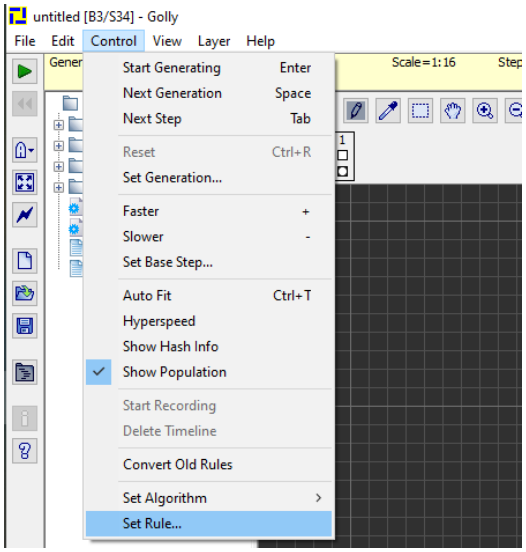


Image 3-1 Set Rule in Golly

A new window will be displayed in which the new rule is entered, then press the "OK" button, as shown in Image 3-2 - Enter a new Rule

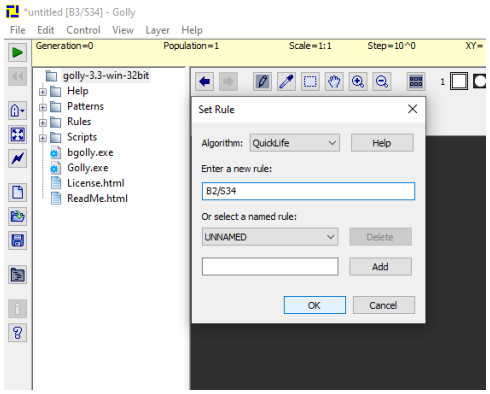


Image 3-2 - Enter a new Rule

Once this is done, different patterns can be drawn on the board, pressing the left mouse button to set a cell to live, as shown in Image 3-3 - Painting patterns

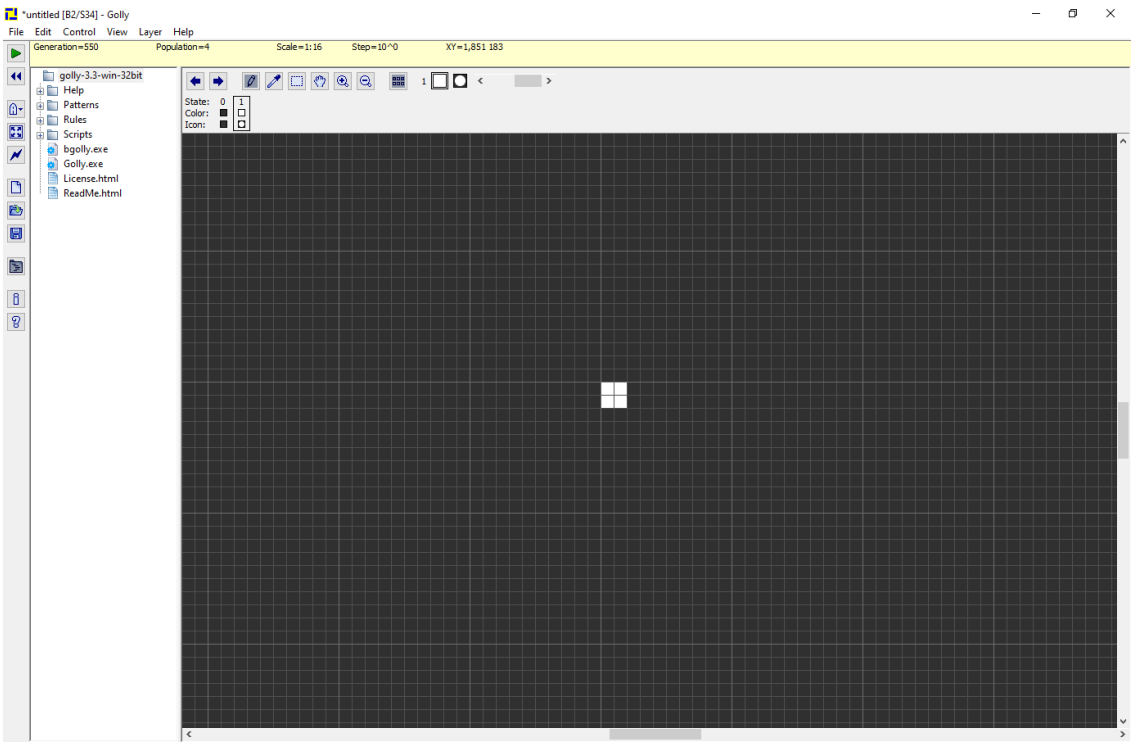


Image 3-3 - Painting patterns

Pressing the button with the green arrow symbol; Located almost in the upper-left corner of the program, it is possible to see the evolution of the cells in the dashboard, it is possible to stop it with the now button with a red square symbol, as shown in Image 3-4 - Start generating

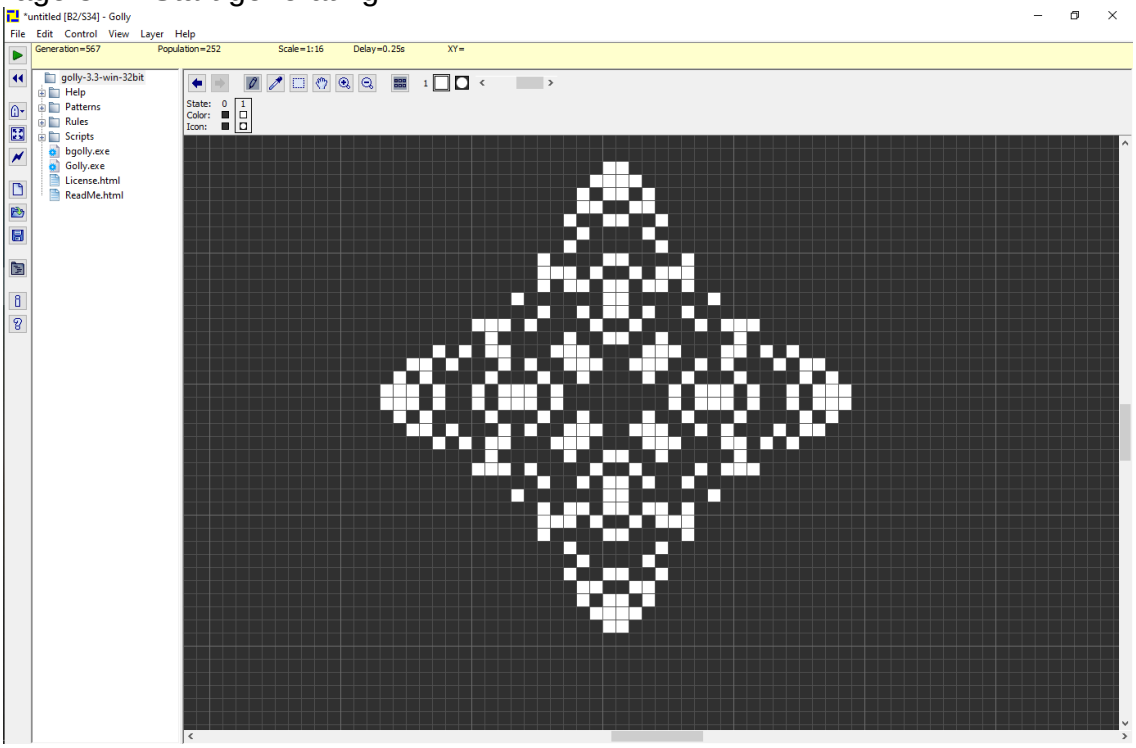
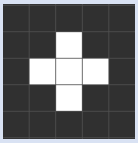
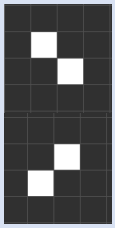
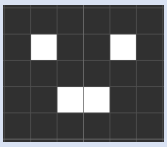
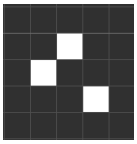
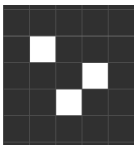
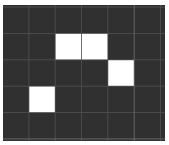


Image 3-4 - Start generating

To reduce the speed of the generations, press the '-' key, as well as its opposite '+' to increase it.

Patterns

Table 3-1 Patterns shows the different patterns that were found with the new rule, categorized in Still lifes, Oscillators and Spaceships.

Still lifes	Oscillators	Spaceships
	Period 2: 	
	Period 2  	

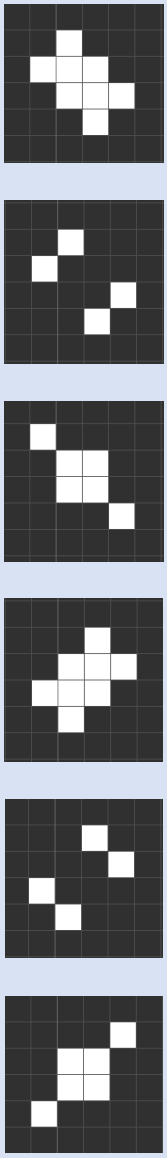
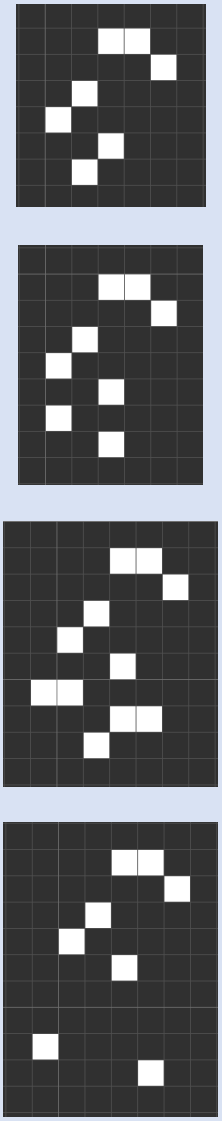
	Period 6	Period 3:
		

Table 3-1 Patterns

4. Extra

The minecraft video game has become popular among different themes due to its nature, which consists of cubes. Due to this, different types of work have been carried out, such as digital design, from calculators to processors. In this case it is possible to observe how certain behaviors within the vanilla game are related to cellular automata.
Because one of the milestones is to destroy / put blocks, it is possible to make different patterns, Image 4-1 Sierpinski carpet.

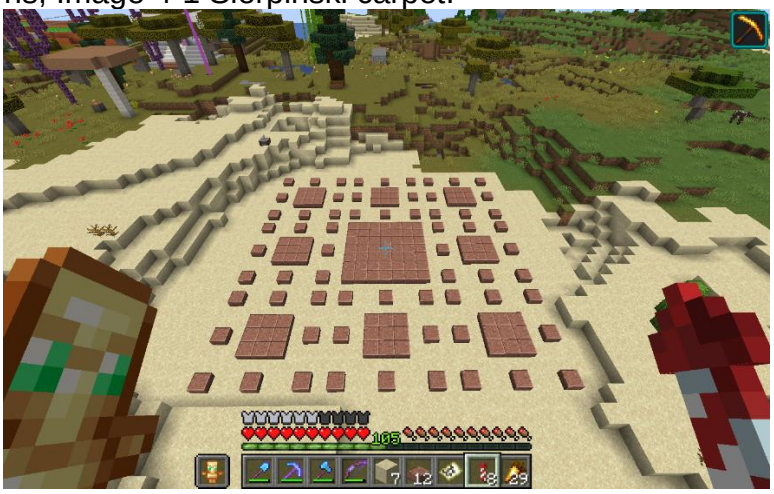


Image 4-1 Sierpinski carpet

The water and lava in the game have a behavior such that:

- If water and lava touch, a new block is created called obsidian; dark purple
- If water and a remnant of lava touch, a new block is created called stone; gray color

This can be seen in the image Image 4-2 Water and lava behavior.

Image 4-2 Water and lava behavior

Fire affects various elements; or blocks, from the game, wood and leaves as well, that is why it can be observed a cellular automaton behavior when starting a fire in a forest, as be shown in Image 4-3 Fire in a forest

Image 4-3 Fire in a forest

This effect can also be seen in dimension 2, Image 4-4 Fire in 2-Dimension

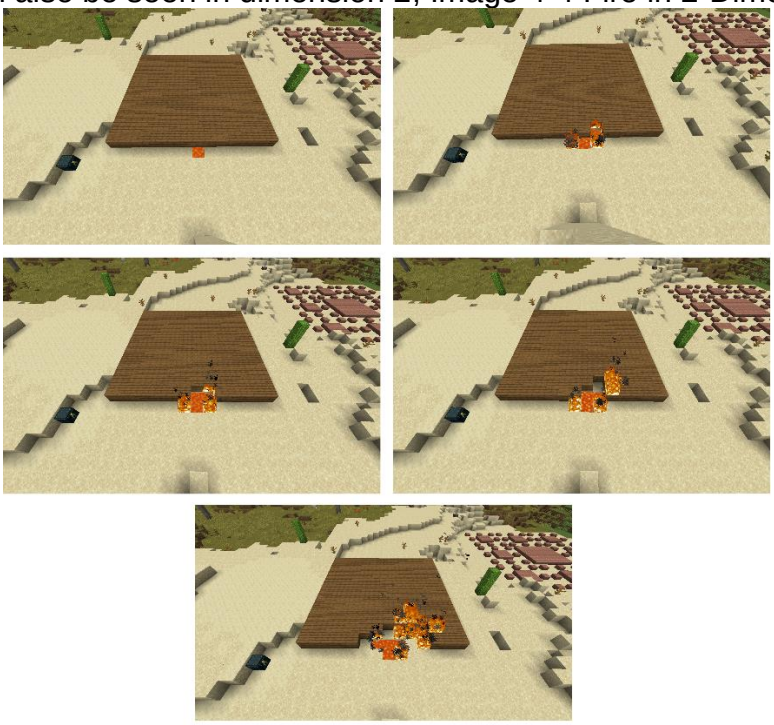


Image 4-4 Fire in 2-Dimension

Minecraft allows the use of commands, which allows the programming of different behaviors of the game; This game mode is called creative. Image 4-5 Wolfram 22 shows an example of the rule wolfram 22.

Image 4-5 Wolfram 22 [5]

Conclusions

Although the main idea of cellular automata is simple, they are very rough in what can be done with them, it can range from simulating basic aspects of how the universe works; and therefore in some ways useful in video games, even making a model of chaos.

Bibliography

[1] S. Wolfram, Cellular automata and complexity collected paper, Boca Raton, FL: CRC Press, 2018.

[2] Wikipedia, «Conway's Game of Life,» 02 Jun 2020. [Online]. Available: https://en.wikipedia.org/wiki/Conway's_Game_of_Life. [Last access: 16 Jun 2020].

[3] A. Adamatzky, Game of Life Cellular Automata, London: Springer, 2010.

[4] Wikipedia, «Minecraft,» 13 Jun 2020. [Online]. Available: https://en.wikipedia.org/wiki/Minecraft. [Last access: 15 Jun 2020].

[5] R. Jazz, «Elementary Cellular Automaton In Minecraft,» Youtube, 27 Mar 2017. [Online]. Available: https://www.youtube.com/watch?v=zBIb-bwSoSQ. [Last access: 15 Jun 2020].