3D Fractal Generated Worlds with Cellular Automata
Introducing

JHON HENRY AVILA PEREZ
Outline

• Introduction
• Automata
• Fractal
• Conway CA
• Wolfram Research on CA
• 1D CA Software
• 2D CA Software
• CA Experiments in 3D
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- Fractal
- Automata
- Conway CA
- 1D CA Software
- 2D CA Software
- CA Experiments in 3D
-**Mathematics** is the language of nature.

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Makes A Spiral

When we make squares with those widths, we get a nice spiral:

Do you see how the squares fit neatly together? For example 5 and 8 make 13, 8 and 13 make 21, and so on.
Fibonacci sequence:

The Fibonacci numbers are the sums of the "shallow" diagonals (shown in red) of Pascal's triangle.
INTRODUCTION

Sunflower pattern
The sunflower seed pattern: If you count the spirals in a consistent manner, you will always find a Fibonacci number (0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, ...). Below are the three most natural ways to find spirals in this pattern. Note that the black pattern is identical in all the images on this page. Only the colored lines indicating the selected spirals are different.
The rule: Most identities involving Fibonacci numbers can be proved using combinatorial arguments using the fact that $F_n$ can be interpreted as the number of sequences of 1s and 2s that sum to $n - 1$.

$$F_n = F_{n-1} + F_{n-2},$$
Chaos theory contends that complex and unpredictable results occur in systems that are sensitive to small changes in their initial conditions. This small changes effect is best illustrated and commonly known as the "Butterfly Effect" which states that the flapping of a butterfly's wings in the Amazon could cause tiny atmospheric changes which over a certain time period could effect weather patterns in New York.

Chaos Theory
http://www.science4all.org/wp-content/uploads/2013/03/orbit.gif

Solar system orbital patterns in time.
http://www.science4all.org/wp-content/uploads/2013/03/orbit.gif
Newton's method and Newton basin fractals
INTRODUCTION

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A fractal is a natural phenomenon or a mathematical set that exhibits a repeating pattern that displays at every scale. If the replication is exactly the same at every scale, it is called a self-similar pattern.
There is some disagreement amongst authorities about how the concept of a fractal should be formally defined. Mandelbrot himself summarized it as "beautiful, damn hard, increasingly useful. That's fractals."
If you have the coordinates basically you can replace pixels by anything you can imagine it can get as crazy as you want.
- Frost crystals occurring naturally on cold glass form fractal patterns.
- High voltage breakdown within a 4" block of acrylic creates a fractal Lichtenberg figure.
Applications in technology

**Fractal Antennas**[^51]
Fractal transistor[^52]
Fractal heat exchangers
Digital imaging
Urban growth[^53][^54]
**Classification** of histopathology slides
**Fractal landscape** or **Coastline complexity**
Enzyme/enzymology (**Michaelis-Menten kinetics**)
**Generation of new music**
**Signal** and **image compression**
Creation of digital photographic enlargements
**Fractal in soil mechanics**
**Computer and video game design**
**Computer Graphics**

And here is where it’s starts to make sense :D
Etymology
The word "automaton" is the latinization of the Greek αὐτόματον, automaton, (neuter) "acting of one's own will". This word was first used by Homer to describe automatic door opening,[2] or automatic movement of wheeled tripods.[3]

- Simple deterministic rules can create a vast amount of complexity.
- Automaton is simple abstraction of a logical machine that upon receiving an input it will generate an output governed by a deterministic rule.
A cellular automaton (pl. cellular automata, abbrev. CA) is a discrete model studied in computability theory, mathematics, physics, complexity science, theoretical biology and microstructure modeling. Cellular automata are also called cellular spaces, tessellation automata, homogeneous structures, cellular structures, tessellation structures, and iterative arrays.
1D - Cellular automata lab.
CELLULAR AUTOMATA

1D - Cellular automata lab.
CELLULAR AUTOMATA

1D - Cellular automata lab.

The generated patterns here is the result of the pattern simulator.

We can either choose to save a rule or load another one.
1D - Cellular automata lab.

- Of the system initial state, select a position in the initial array.
- Set the state of the array to a value different than 0.
- Virtual Piano has 128 possible notes; user must set a key note range for the pattern.
- User must close the window and press Start button.
- Load Rule once sound experimental option is selected.
1D - Cellular automata lab.
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, alive or dead. Every cell interacts with its eight neighbours, which are the cells that are horizontally, vertically, or diagonally adjacent. At each step in time, the following transitions occur:

Any live cell with fewer than two live neighbours dies, as if caused by under-population.

Any live cell with two or three live neighbours lives on to the next generation.

Any live cell with more than three live neighbours dies, as if by overcrowding.

Any dead cell with exactly three live neighbours becomes a live cell, as if by reproduction.
CELLULAR AUTOMATON – CONWAY GAME OF LIFE
After developing 1D cellular automata explorer, I decided to create a new program to let me explore the 2D cellular automata world. Here is a look of the Java implementation and the patterns I achieved.
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Once the right patterns according to my needs where identified I could start creating some applications for possible games.

- For example creating normal maps by using cellular 2d automaton can make up interesting bump textures like the following ones.

- In principle just stacking up 2D cellular automaton iterations can create interesting and unique 3D models.
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