Conway's Game of Life

Science Talent Search

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For my Science Talent Search I have written a “Conway’s Game of Life” program in Visual Basic. Conway’s Game of Life is a Cellular Automaton.

What is a Cellular Automaton?

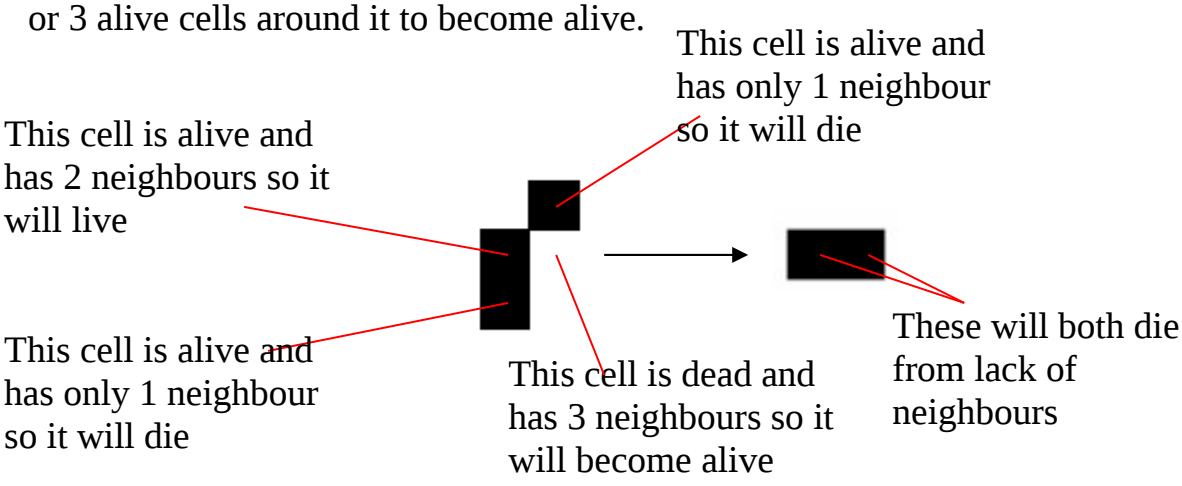
A Cellular Automaton is a grid of cells that extends infinitely in every direction. Different Cellular Automatons allow the cells to be different values, the cells in Conway’s Game of Life are either ‘dead’ or ‘alive’, and have new values calculated by a rule which is applied to each cell. Rules are usually based on how many neighbours of a particular value the cell has.

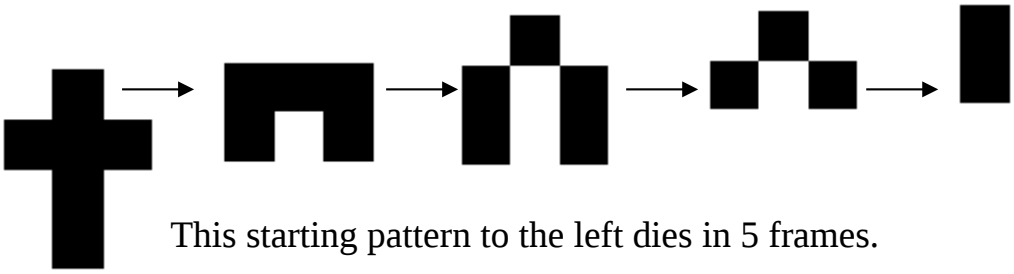
For any particular Cellular Automaton, the cells are given values and then all at once by each cell having the rule of that Cellular Automaton applied to it they all change to their new values. This is a new ‘frame’. These new valued cells will then have new values calculated for them. You can watch the Cellular Automaton for 1000’s and 1000’s of frames if you would like thanks to computers being able to calculate the new frame very quickly.

There has been allot of interest recently in Cellular Automata which is now a field of mathematics.

The Game of Life rules

Each cell in the Game of Life is either ‘dead’ or ‘alive’. Each cell has 8 neighbours. If a cell is dead, it needs to have 3 alive neighbours to become alive its self on the next frame. If a cell is alive, it needs to have 2 or 3 alive cells around it to become alive.





This starting pattern to the left dies in 5 frames.

What is the Game of Life?

John Conway invented the Game of Life in 1970. After trying different rules he came up with the ones he did because the alive cells don't die out to quickly and they don't just spread everywhere in a few frames. The Game of Life is a very simple Cellular Automaton. Cellular Automata have been designed to simulate systems in the real world. Conway says the Game of Life simulates the distribution of a species over an area. An alive group of species represented by 1 cell will only continue to be alive if it has enough neighbour groups to mate with but also does not have too many neighbours to take all the resources (2 or 3 will keep it alive). A dead cell will only become alive if the conditions are perfect (3 surrounding cells). Some have taken the idea further and say that each alive cell is like an animal moving and killing off others. An idea that never really went anywhere was that the Game of Life actually created some form of artificial life. There have been plenty of variations of the Game of Life involving counting more than just 8 neighbours or having 2 different competing species on the grid at one time.

The Game of Life is interesting because it shows how something incredibly complex can come from such a simple pattern with simple rules. It helps us to understand for example how the complex feint lines on our hand or the stripes on a zebra can arise from a small bunch of living cells all interacting with each other. How about the diversity of life on earth all evolving from a single celled organism? Of course we don't know all the rules for nature but we do know the rules for the Game of Life.

Sometimes the Game of Life looks intelligent and complicated like ant colonies gathering food but the rules of the Game of Life are quite simple and we see that possibly the ants are just following simple rules too.

My program

When you run Conway.exe two windows are displayed. One window is the grid (there are no lines). Just click a cell and it will become black. That cell is now alive. Place as many alive cells as you like then press Enter to start the game. The program will look at the value of each cell and will calculate what the new grid should look like and will display it in a second. Just push Enter again to stop the game when ever you want to. You can stop the game, add or remove alive cells and then start it again.

Changing the delay

The time delay between each frame can be changed in the Options window or by pressing the A and Z keys. The speed is in 1000ths of a

second so 1000 = 1 second which is the default. “Make changes” must be clicked to confirm to changes (unless you use A and Z).

Changing the size of the grid

If you make the grid to big the computer will have trouble calculating the new values at high speeds. Any cell on the edge of the grid will die so try not to let alive cells get that far. If they do then the results will not be accurate because of course the grid is meant to extend infinitely in every direction. Just make the grid bigger if are going to need allot of space. The default size is 40 by 40 cells. “Make changes” must be clicked to confirm to changes.

Clearing the grid

To clear the grid so you can make a fresh new pattern, just click the “Clear the Grid” button in the options window. If the game was running it will be stopped.

Changing the rule

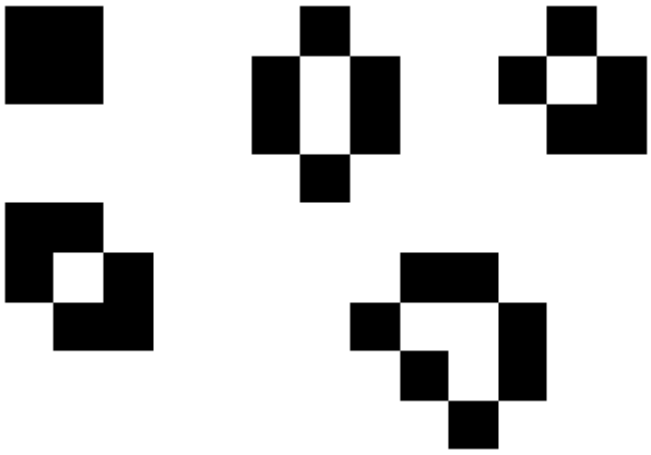
You can if you want, not use Conway’s Game of Life rule. Change the numbers in the box and then click “Make Changes”. Click “Set to Conway’s Rule” to change it back.

2 Species mode

2 Species mode is an experimental mode where 2 species interact with each other on the same grid. I will explain this later. Clicking the button clears the grid!

A “Still Life”

It is quite common for patterns to emerge that have a “Still Life”. This means that frame after frame the pattern will stay the same. No new cells become alive and none die. Here are a few



Of course other alive cells can come crashing into these “Still Life” objects and set them off and that happens all the time during complex constructions.

Oscillators

An Oscillator is similar to “Still Life”. It’s a pattern that changes but gets back to what it started out as eventually.

This is the simplest Oscillator. It is called a “period-2 oscillator” because it takes 2 frames to reach its original state. These pop up everywhere

Lining up 10 alive cells will turn into a period-15 oscillator called a pentadecathlon.

Things to try

Just muck around. Place random alive cells and watch it go! Try these when you’re sick of that.

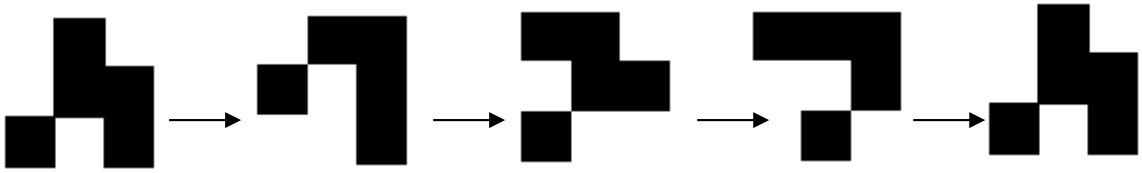
R-pentomino

Conway didn’t have a computer and used to use a “Go” board and pieces to invent his Game of Life. This pattern is called the R-pentomino and was the first pattern Conway tried that was just too hard on a “Go” board.

This 5 celled pattern gets very complex very quickly. It takes 1103 frames to become “stable”. A stable pattern is one that is made up entirely of “Still Life”, oscillators and easily predictable patterns such as gliders (see below). Once a pattern is “stable” it is considered to be over.

Glider

The Glider is also a 5 celled pattern which “moves” diagonally across the screen. It would be a period-4 oscillator if it didn’t move.



(Does not move in a straight line)

Pulsar

This is one of my favourites.
It becomes a period-3 oscillator.

My 2 Species mode

As an experiment, I have modified the standard Conway's Game of Life rule to allow 2 different species on the same grid. Each of the two different species works the same as in the normal Life game except that if an alive cell has more of the other species as neighbours than it does its own then it dies.
In 2 Species mode, use left click to place Species 1 and right click to place Species 2.
It was my original plan to have one species the predator and the other the prey but I couldn't work out a rule that followed the rules of a Cellular Automaton (working out each cell at once) that was realistic. I might have come up with something if I had had more time to work on it. I spent almost all my time writing the program.

The CD

Conway.exe – The Program
Conway Source - The Visual Basic source files are here if anyone wants to see them
Conway.doc – This word file
msvbvm60.dll – a required runtime dll file

Closing words

It is debatable wether or not the Game of Life has much of a practical use except that it can be used to help better understand other fields of maths and science. For example it is possible to build a computer within a very large grid. Very complex patterns could perform all the functions of a CPU and ram. Glider type things could send signals around. This has never been done but a simple sort of computer has been made which works out prime numbers. It is said to be possible that patterns can be built that will construct other patterns, even replicate them selves with slight modifications. That's a little bit scary really.