Oscillators in Cellular Automaton

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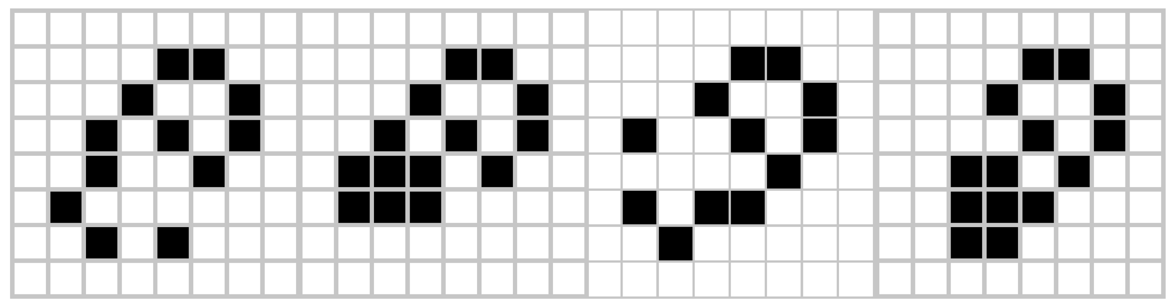
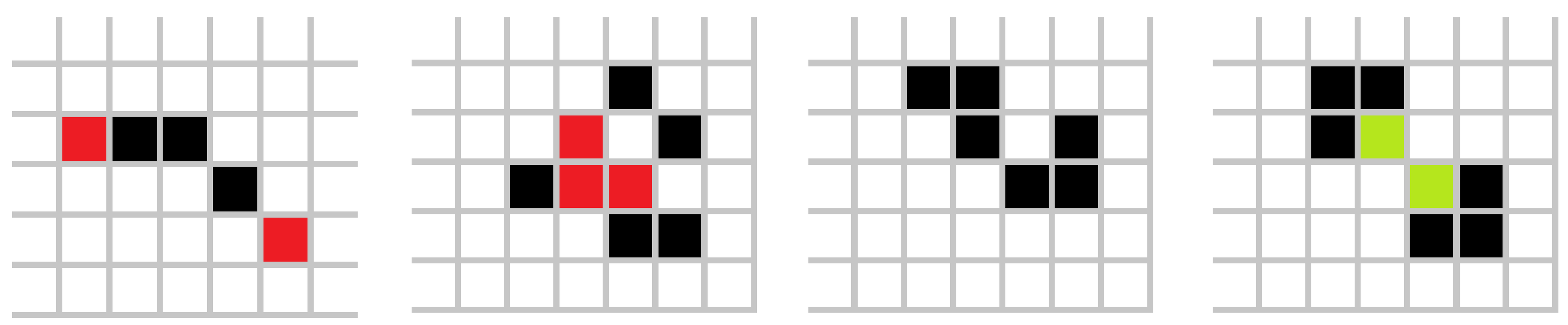
Introduction

The purpose of this research is to increase our knowledge of short period oscillators in cellular automata so we can learn how to create new oscillators.

Period 4 Oscillator



For this research we used a two dimensional grid that contained cells that had two states: white and black or alive and dead. We used Conway's Game of Life rule set which consist of four rules.



Under population Overcrowding Continued life Cell birth

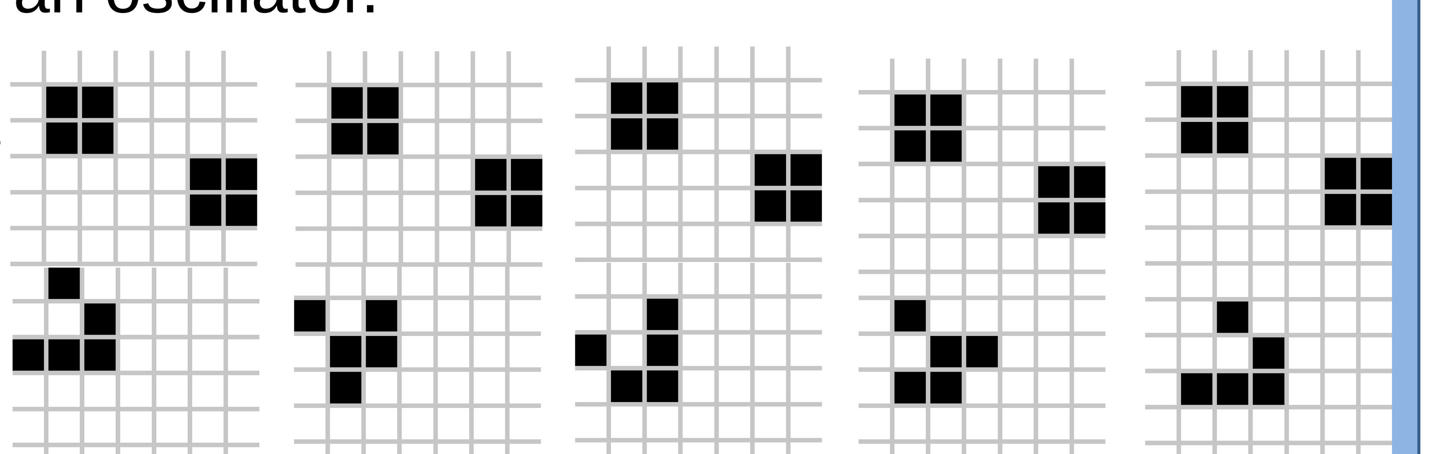
Background

Cellular Automata are infinite grids of cells that represent artificial life. Each cell has a finite number of states and a set of neighbors. A cell's neighborhood consist of itself and any surrounding cells you wish to include. For Game of Life the cells neighborhood consist of its eight closest neighbors. Based on a set of rules that are applied to the cell and its neighbors, the cell changes. Rules are applied simultaneously to each cell. Conway's Game of Life is just one rule set for cellular automata.

In the Conway's Game of Life patterns tend to end in four different scenarios:

1. The pattern dies out and no lives cells are left
2. The pattern ends in a stable figure that will not change anymore, also known as a still life.
3. The pattern creates shapes that move away from the pattern in an infinite direction.
4. The pattern ends in an infinite repeating patter, also known as an oscillator.

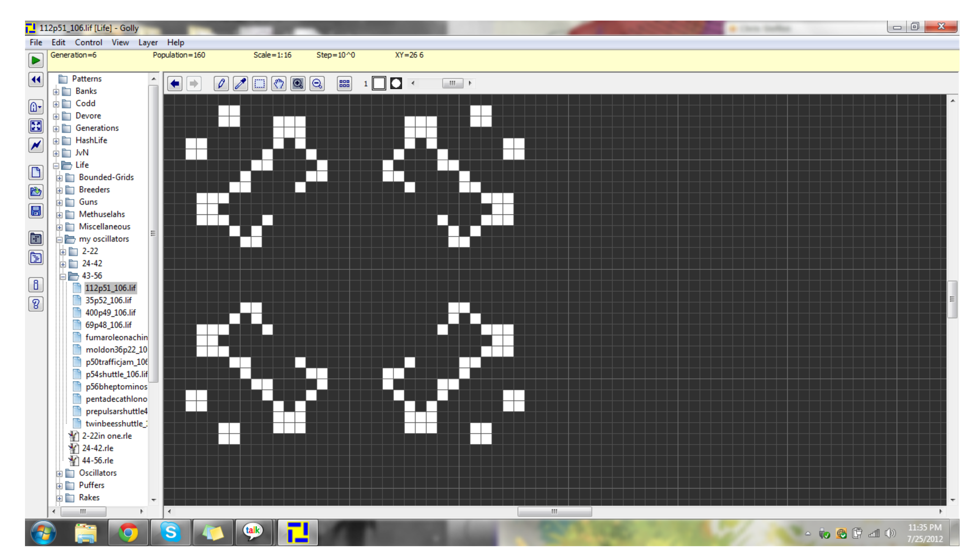
Five generations of a Still life and a Glider



Data

We studied a set sixty minimal oscillators with periods of two through fifty-seven. We used the program Golly, which is the main accepted program used for Conway's Game of Life and other cellular automata.

For each periodicity oscillator we examined every pattern of its cycle and documented common sub-patterns and still lifes. We also looked at the behavior of the oscillator in hopes of classifying them into groups and finding commonalities. For each patterns in the cycle of an oscillator we recoded the density. We also kept track of the average number of cells changing for an oscillator, known as the heat.

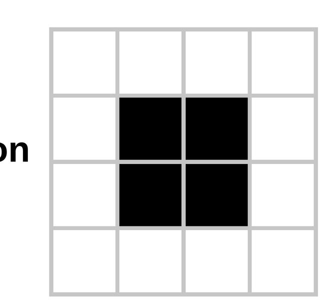


A period 51 oscillator in Golly

Results

For all but the period-14 oscillator we found a still life. The most common found was the block. Only a few distinct still lifes were found.

Block the most common still life.

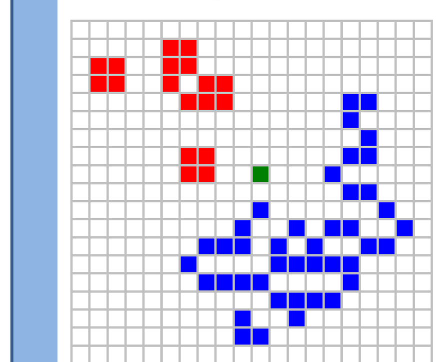


We found that it is possible to classify most oscillators into categories based on its behavior. The classifications include:

- Patterns with average blocks change less than 25%.
- Patterns with two lines of symmetry.
- Patterns created from a combination of smaller oscillators.
- Patterns with multiple identical shapes rotated and moved.
- Patterns with one line of symmetry.

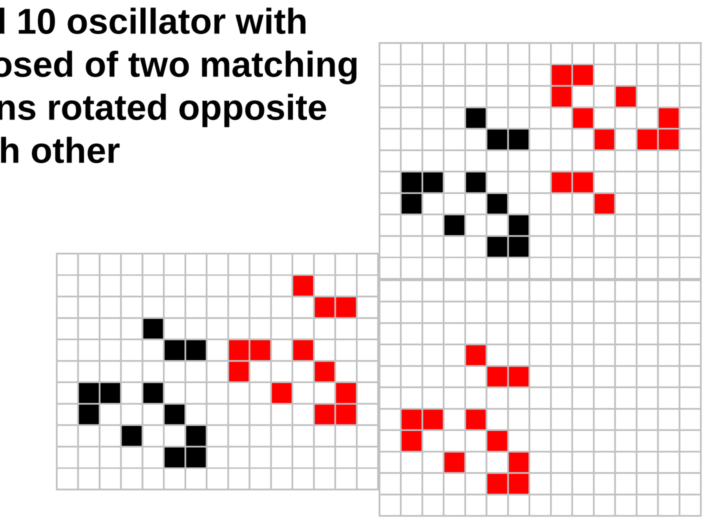
New Oscillators

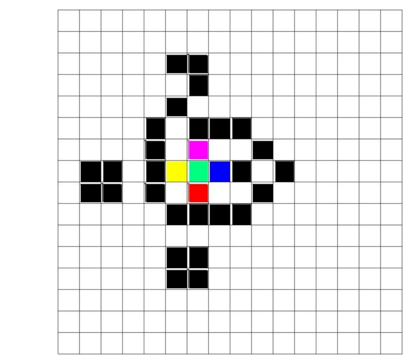
Not all oscillators created from a combination of smaller oscillators are accepted as non-trivial oscillators. For a oscillator to be considered non–trivial it must contain a live cell in once oscillation that is not in any of the other oscillations.



Period 42 Oscillator Composed of a period 6 and 7 oscillator. Green cells makes It non trivial.

Period 10 oscillator with composed of two matching patterns rotated opposite of each other





Period 7 oscillator with average block change of 0.05. Color cells are the only ones that change.

Discussion

These results provide us with common patterns and behaviors that we can apply when creating new oscillators, reducing the amount of patterns needed to test to find new oscillators. If we are able to find new oscillators in the Conway's game of Life using this information we will later be able to look at oscillators in different cellular automatons and create guidelines for creating oscillators.

Conclusion

Conway's Game of Life is the most well-known cellular automata, yet there is still much unknown about its behavior. Since the study of cellular automata only began in the 1940s, significant research and learning opportunities in this area remain. There are plans for the research presented in this poster to be continued at Tufts University.

References

- Conway's Life. Johnston, Nathaniel. http://www.conwaylife.com/.
- Game of Life Status page. Summers, Jason. http://entropymine.com/jason/life/status.html#oscper.
- Golly. Trvorrow, Andrew, Rokicki, Tom. http://golly.sourceforge.net/

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