Behaviors and Patterns in Low Period Oscillators in Life

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I. Abstract

There are natural occurring cellular automatons seen everywhere in the world, yet there is little known about how these patterns behave. This summer for ten weeks I participated in a research experience that will increase the knowledge known about cellular automata. This paper introduces common patterns and behaviors among minimal period oscillators. Through the program Golly we have been able to analyze a small set of oscillators using the game of life rule set. For each oscillator in our set we looked as it cycled through its different patterns and noted what kind of patterns and behaviors we saw. Along with common patterns and behaviors we looked at the overall density of the oscillator and the density of each pattern the oscillator contained. In this paper we will show some of the common behaviors and patterns we found in minimal period oscillators.

II. Introduction

A Cellular Automaton is a infinite grid of cells used to represent artificial life. Each cell has a finite number of states and a set of neighbors. Cellular automatons behaviors and properties are determined by the rule set that is applied to the cellular automata. The most common rule set is Conway's Game of Life. Life uses a two dimensional with cells that have two states, alive or dead. The neighborhood of a cell in game of life consists of the cell and the eight closest cells to it, including the top, left, right, bottom, and four. Life uses four basic rules to simulate life and death of cells. The rules are applied simultaneously to all cells.

1. Any live cell with one or less neighbors dies from underpopulation.
2. Any live cell with four or more neighbors dies from overcrowding.
3. Any live cell with two or three neighbors stays alive.
4. Any dead cell with three neighbors come alive.

Conway's Game of Life is the most known CA but is not often seen in nature, however there are rule set that are seen in nature. In life there are many different types of patterns, all of which have different outcomes. The main patterns we looked at in our research were oscillators. Oscillators are an arrangement of live cells that cycle through a set number of configurations and returns back to its original arrangement. The number of different patterns an oscillator goes through is known as its period. Other patterns that were relevant to our research were:

Still Lifes- pattern that does not change over generations

Spaceship- repeating pattern that moves to a new location after a finite number of generations

Gun- a stationary pattern that creates spaceships

Currently there are algorithms to create oscillators with period fifty-eight or greater, but it is unknown how to create minimal period oscillators. Presently there are seven oscillators with periods less than fifty-eight that are unknown. To increase our knowledge of cellular automata we must first increase our knowledge of Conway's Game of Life. Through our research we will increase our knowledge of oscillators in hope of being able to learn more about game of life and other cellular automata.

III. Data Analysis

The oscillators we analyzed during our research consisted of oscillators with periods two through fifty-seven. With the limited time available we were only able to look at one oscillator for each period. We determined which oscillator for each period to look at based on the minimal number of live cells. We chose to look at the smallest oscillators for each period in hopes of finding commonalities in density. For a select few periods we did look at a couple extra oscillators. All of the oscillators we analyzed were non-trivial oscillators. A trivial oscillator is an oscillator that is made up of two or more smaller oscillators that do not have any extra live cells in any of the generations.

We observed each oscillator using the program Golly. Golly is an open source cross platform application and is the main accepted program used for Conway's Game of Life and study of cellular automata. Golly allowed us to change the speed at which the oscillators cycled and the magnification of the oscillators. Golly already had many of the oscillators we needed for our data analysis and provided the game of life rules already programed. For the oscillators Golly did not have we were about to import into the program from an online database of known oscillators. Golly provides other rule sets that are related to game of life and rule sets not related to life, which will provide helpful in future research of cellular automata.

For each periodicity oscillator we examined every patter of it cycle and documented common sub-patterns and still life. We also looked at the behavior of the oscillator in hope of classifying them into groups and finding commonalities. For each pattern in the cycle of an oscillator we recorded the density. For calculating density we took the bounding box of the oscillator and divided it by the number of cells in the oscillator. We also kept track of the average number of cells changing for each oscillator, known as the heat. We did our observations manually by watching each oscillator as it ran on Golly and recorded them in a journal. We later examined the records and tried to group the oscillators by common behaviors.

IV. Results

We were able to find some common behaviors and shapes in many of the low period oscillators we analyzed. There were a select few sub-patterns and still lifes that were seen in a large number of the oscillators we studied. Some of the behaviors we recorded were the number of symmetrical lines, whether the oscillator was composed of two smaller oscillators, number of cells changing, area of cells changing, expansion, and movement.

The most common sub-patterns we found were still lifes. For all of the minimal period oscillators we were able to find still lifes except for the period fourteen oscillator. For some oscillators we had to go outside of our data set and look at other instances of such oscillators, though we did have to observe oscillators outside of our data set it was for very few periods. The two most common still lifes seen and documented were the block, loaf, and eater one.

For about ninety percent of our oscillators we were able to find an identifiable behavior. We hope to continue looking into all known oscillators so we can find more behaviors and classifications. Listed below are the six main behaviors we were able to find.

1. Oscillators composed of two or more smaller oscillators.
2. Oscillators that have less than 25% average change.
3. Oscillators with two lines of symmetry.
4. Oscillators made up of identical sub-patterns with each sub-pattern rotated.
5. Oscillators with one line of symmetry.
6. Oscillators with identical sub-patterns with each rotated and a different pattern in the middle.

For each pattern of each oscillator we calculated the density by dividing the number of live cells by the bounding box. From our analysis we were unable to find any kind of commonality among the densities. From identifying common sub-patterns and behaviors we had hopes of being able to find oscillators for the remaining unknown periods. Unfortunately with the time we had we did not have a chance to finish creating a program to generate oscillators with our restraints.

V. Future Works

In the future we hope to be able to continue our research on oscillators in cellular automata using Conway's Game of Life. We would like to be able to collect enough information so that we could find non-trivial oscillators for the remaining unknown low period oscillators. The more we are able to learn about oscillators in Conway's Game of Life the more we will be able to understand the rest of game of life and eventually other cellular automatas.

There are people who are currently working on cellular automatons, though many of them are working with them as a hobby. This makes it hard to find current and accurate research on cellular automatas and game of life. We hope we will be able to continue our research and be able to encourage others to study cellular automata's and those currently working with CA's to better document their work in hopes of expanding what is known.

VI. My Experience

This summer was a true learning opportunity, not only was I able to learn new things related to my field but I was able to learn about graduate school and the process of applying. Participating in research is completely different from being an undergraduate student. With research, specially theoretical research, you have to make yourself sit down and work the amount you need to work during the day, unlike undergrad where you are required to attend class to get a good grade. With research if you do not put in the time you will not finish your work and will have nothing to show for it.

I felt that this summer really gave me a chance to experience what graduate school would be like. I feel that if I had not had this experience I would not have made the best decisions regarding graduate school. This summer also increases my chances of getting into graduate school and has supplied me with many useful contacts.

VII. Acknowledgements

VIII. References

[1]Conway's Life. Johnston, Nathaniel. January 2012. Retrieved June 2012. http://www.conwaylife.com/.

[2] Game of Life Status page. Summers, Jason. March 2012. Retrieved July 2012. http://entropymine.com/jason/life/status.html#oscper.

[3]Golly. Trvorrow, Andrew, Rokicki, Tom. June 2012. Retrieved July 2012. http://golly.sourceforge.net/

[4] Oscillators. June 2012. Retrieved July 2012. http://conwaylife.com/wiki/Oscillator.