The goal of this experiment is to study the dynamics of cellular automata. Cellular automata are discrete models composed of cells that govern their replication and destruction. These systems can model naturally occurring patterns. Cells in these systems can occupy a certain number of states (in a binary case, either 0 or 1), and predetermined rules dictate how cells transition between such states. The rules acting on individual cells depend on the configuration of their neighboring cells. Thus, local interactions between neighbors translate to global changes in the system. This project will examine how factors, such as grid size, rule choice, and initial grid state tend to drive models to chaos and others to stability.

In this experiment, we study the evolution of cellular automata under two-dimensional rules. Our cellular automata is a grid system made of two sublattices, denoted as A and B. Each cell in the grid starts in an initial state of zero or one and updates itself according to a self-assigned rule. We condition these rules on the number of neighbors that a cell has. “A” cells all have “B” cells as neighbors and vice versa. Cells update by flipping their state to either 0 or 1 when their neighbor count satisfies a condition. We define a cell's neighbors as their immediate neighbors to the north, east, west, and south. Systems exhibit varying behavior when left to evolve under these rules. A measure used to keep track of this behavior is the recurrence time (period) of these systems, the iteration where the grid returns to its initial state. Systems with long periods can be considered chaotic.

In this experiment, we examine four different rules on a grid system. The rules are when the neighbor count is equal to one, equal to two, greater than or equal to one, and a neighbor count of greater than or equal to two. The graphs of damage on the system show similarities between rules with the same target number. However, the rules for greater than or equal to the target have a smaller radius of impact. When the rule is greater than or equal to one the disturbance is localized, and there is no prominent shockwave.

In general, the log of recurrence times increases in frequency until they reach a maximum value. From this point, the frequency of recurrence times decreases. Relatively long periods occur with less frequency. When the target number is two, periods seem to have a normal distribution when plotted in log scale. When the target number is one, the rules are less predictable behavior. The values on the right tail of the mean value appear normally distributed, but values to the left of the mean are more sporadic. Some periods that one would expect to see along the distribution do not occur.

The graphs of damage on the system show similarities between rules with the same target number. However, the rules for greater than or equal to the target have a smaller radius of impact. When the rule is greater than or equal to one the disturbance is localized, and there is no prominent shockwave.

Studying these grids gives us a better understanding of systems made of many interacting components.

References