Drawdown Automata, Part 4: A Few Good Rules

With the bezillions of possible rules, how do you find ones whose pattern sequences are rich in attractive and interesting patterns suitable for weave design?

There are several problems here. "Attractive" and "interesting" are subjective. "Suitable for weaving" is easier to get a handle on, although it, too, is subject to a variety of interpretations. For thread-by-thread drafts, one issue is structural integrity — there cannot be long sequences of white or black cells that translate into unacceptable floats. For patterns to be used for profile drafting, however, this is not a concern.

Another consideration is what to use as a starting pattern to which a rule is applied. In the Game of Life and studies of the evolutionary aspects of cellular automata, there is emphasis on what happens starting with a single "live" cell (state 1) in an otherwise "lifeless" sea of cells (state 0). While many fascinating results can be obtained in this way, this approach is, if nothing else, the hard and long way to get patterns for weave design.

A better approach is to start with an interesting pattern and see what happens when a rule is applied to it. Of course, there are many millions of interesting patterns, each one of which may produce a different sequence of patterns.

In this article, we'll use two starting patterns to illustrate typical results. The first starting pattern is shown in Figure 1. There is nothing special about this pattern; we just picked it from a large number of candidates at hand. This starting pattern has several significant properties, however.

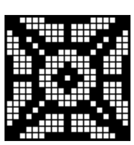

Figure 1. The Starting Pattern One

In the first place, it is symmetric under rotation in increments of 90°, as well as horizontal, vertical, and diagonal flips. While symmetry is not essential to attractiveness, it is a big help. Furthermore, rules, such as totalistic rules, that are insensitive to the relative locations of cells in the neighborhood, preserve symmetry.

This starting pattern is 19-by-19 cells. This is large enough to allow a wide variety of pattern sequences, yet not so large as to be overwhelming (or take inordinate amounts of computational time).

The number 19 may seem a bit strange, but what we have in mind is repeating the patterns, trimming cells on off (say) the right side and bottom to avoid artifacts at the edges. This gives 18 × 18 motifs. Figure 2 shows the results of repeating the first starting pattern in this manner.

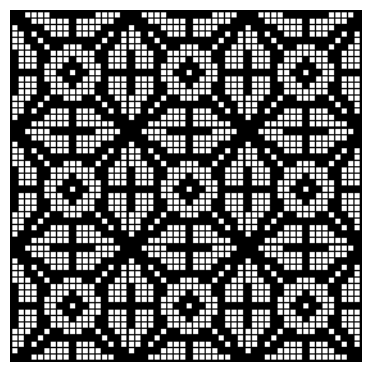

Figure 2. Starting Pattern One Repeated

The second starting pattern, shown in Figure 3, is asymmetric but of the same size as the first starting pattern.

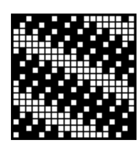

Figure 3. Starting Pattern Two

A Few Bad Rules

Many rules are clearly useless — for generating sequences of patterns or for most other purposes. Obvious examples are the following rules that depend only on the value of the core cell:

C = 0
C = 1
C = C
C = ~C

The first rule produces a pattern in which all cells are zero, while the second produces a pattern in which all cells are 1. The third rule leaves the pattern unchanged, while the fourth inverts black and white on successive applications.

There are many rules that do not have as obvious and stark results as these but nonetheless are nearly are useless. These rules include those that have short sequences and especially ones that tend to increase the number of black or white cells on successive applications. These include the standard Game of Life [1], which generally causes small patterns to disintegrate (see Figure 4), and the voting rule [2], for which patterns usually devolve into all-black or all-white patterns quickly (see Figure 5). The fascinating 1-of-8 rule [2], which produces beautiful patterns, does so quickly and results in a terminal pattern rather than going on to other patterns (See Figure 6).

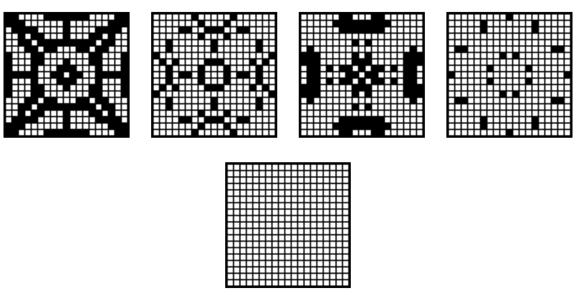

Figure 4. The Game of Life

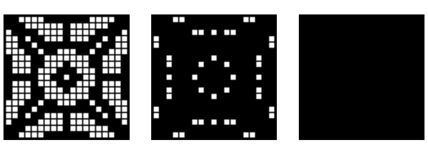

Figure 5. The Voting Rule

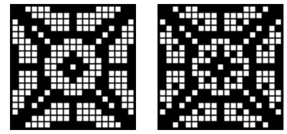

Figure 6. The 1-of-8 Rule

The results are somewhat different for other starting patterns, but these are typical.

A Few Good Rules

It might seem like most rules must be useless in the senses described above. Surprisingly, however, of the 64 totalistic rules for the von Neumann neighborhood more than half produce sequences of length 8 or longer for the starting pattern shown in Figure 1. Many sequences are very long; so long we haven’t been able to determine their length in a reasonable amount of time. And at least 25 rules produce sequences of interesting and useful patterns.

We therefore have a great embarrassment of riches. On the other hand, one good rule can produce more interesting patterns than there is time to evaluate, much less actually use.

The situation is somewhat analogous to the Game of Life, in which many thousands of enthusiasts have devoted massive amounts of their time and no doubt millions of hours of computer time in the search for interesting results. When one of them finds something new, the word is passed along and recorded, but most of the ”territory”, albeit probably mostly barren, remains unexplored.

We have found four rules that produce long sequences of useful patterns: The parity rule [2] for both the von Neumann and Moore neighborhoods, and two variations on the Game of Life [1]. There certainly are many other rules, but if you are interested in finding patterns for weave design, as opposed to becoming a drawdown pattern explorer, these rules probably will do. Be aware, however, that different rules produce patterns with different characteristics.

Figures 7 and 8 show the beginning of the very long sequences of patterns that the von Neumann parity rule produces.

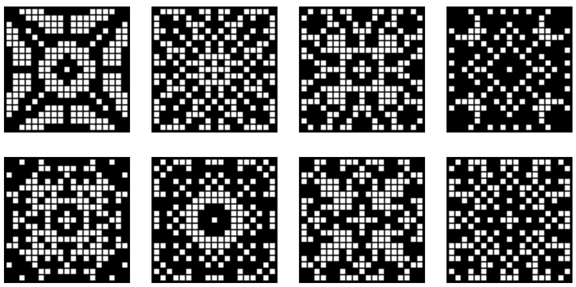

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Figure 7. Von Neumann Parity Rule Sequence for Starting Pattern One

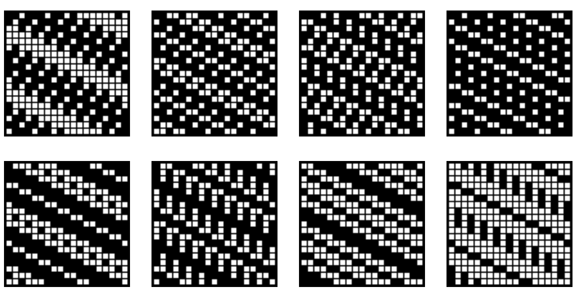

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Figure 8. Von Neumann Parity Rule Sequence for Starting Pattern Two

Figures 9 and 10 show the sequences for the parity rule with the Moore neighborhood.

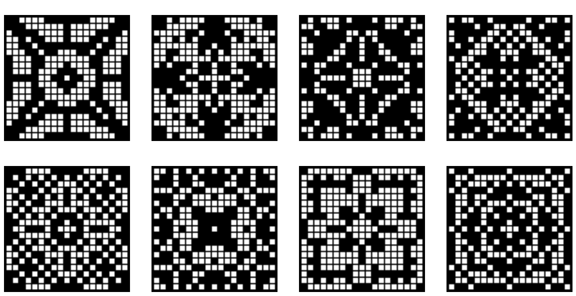

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Figure 9. Moore Parity Rule Sequence for Starting Pattern One

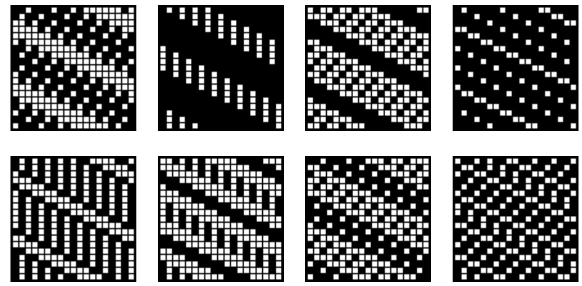

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Figure 10. Moore Parity Rule Sequence for Starting Pattern Two

Figures 11 through 114 show the beginnings of the pattern sequences for the two variations on the Game of Life. Note that for the second starting pattern, the sequence for the Life rule /123 is short and repeats with the second pattern after pattern five.

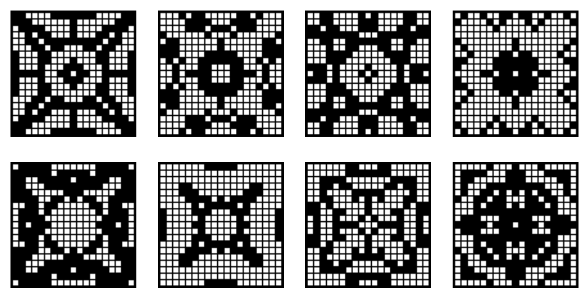

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Figure 11. Life /123 Sequence for Starting Pattern One

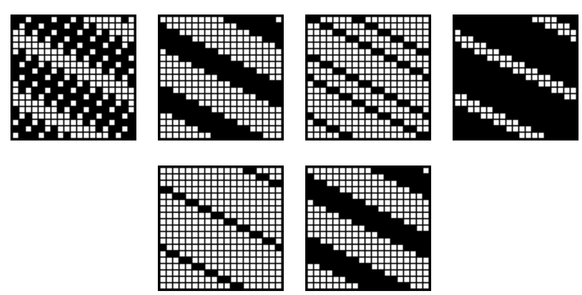

Figure 12. Life /123 Sequence for Starting Pattern Two

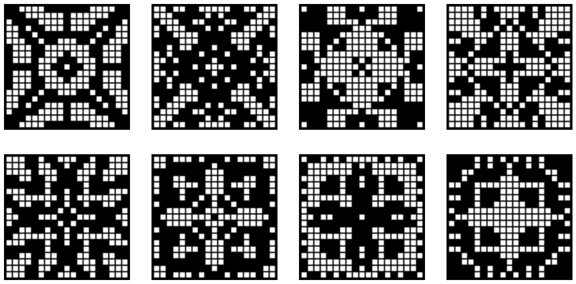

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Figure 13. Life /234 Sequence for Starting Pattern One

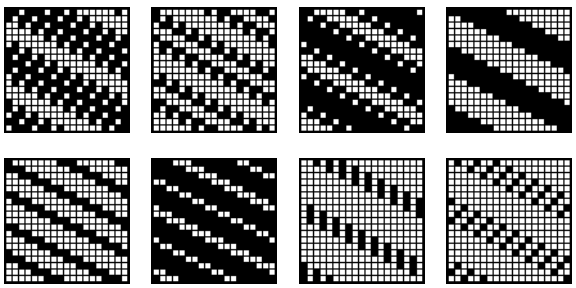

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Figure 14. Life /234 Sequence for Starting Pattern Two

If you choose to be a Drawdown Pattern Explorer, rather than just using one of the rules suggested here, let us know what you find.

References

1. *Drawdown Automata, Part 3: Pattern Sequences*, Ralph E. Griswold, 2004: http://www.cs.arizona.edu/patternsweaving/webdocs/gre_dda3.pdf

2. *Drawdown Automata, Part 1: Basic Concepts*, Ralph E. Griswold, 2004: http://www.cs.arizona.edu/patterns/weaving/webdocs/gre_dda1.pdf

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