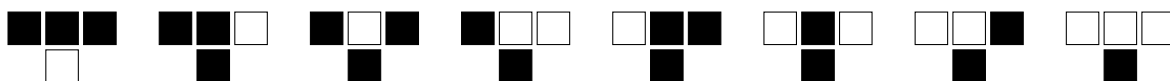


Read: Chapter 4.1: Global dynamics emerging from local interactions: agent-based modeling for the life sciences. By D. Gammack, Elsa. Schaefer, and H. Gaff, pp. 105–113.

1. Find an applet or program that can simulate a cellular automata. One such example is <https://elife-asu.github.io/wss-modules/modules/1-1d-cellular-automata/>. Carry out the following steps for ECA Rules 54, 73, 137, and one more “interesting” rule of your choice. Make the grid size be several hundred; not too big, and not too small (the specific size for which it “looks best” will depend on the specific rule).
 - (a) Explore the dynamics of the elementary cellular automaton (ECA) rule using both a single black square as a starting state, and using a random state. Include a screenshot of your findings.
 - (b) Which of the four Wolfram classes do you think this rule belongs to, and why?

2. Consider the ECA rule defined by the following *truth table*:



Here, white = 0, black = 1, and each 4-box diagram represents a three-bit input vector $(x_{i-1}(t), x_i(t), x_{i+1}(t))$ and the corresponding output $x_i(t+1) = f(x_{i-1}(t), x_i(t), x_{i+1}(t))$.

- (a) Find the decimal form of this rule. It should be a number between 0 and 255.
 - (b) Write the function $f(x_{i-1}, x_i, x_{i+1})$ as a *polynomial* over $\mathbb{Z}_2 = \{0, 1\}$, by replacing $x \wedge y$ with xy , $x \vee y$ with $x + y + 1$, and $\neg x$ with $1 + x$, and reducing modulo 2.
 - (c) Write the local function $f(x_{i-1}, x_i, x_{i+1})$ as a Boolean logical expression (that is, using \vee , \wedge , and \neg).
3. For each of the following, express the ECA rule four different ways: by its truth table, in decimal form, using Boolean logic, and as a polynomial over \mathbb{Z}_2 .
 - (a) the rule that translates its initial state one position to the right;
 - (b) the rule that models traffic flow to the left,
 - (c) the *logical OR* function: $f(x_{i-1}, x_i, x_{i+1}) = \text{OR}(x_{i-1}, x_i, x_{i+1})$.
 - (d) the negation of the logical or function, $f(x_{i-1}, x_i, x_{i+1}) = \text{NOR}(x_{i-1}, x_i, x_{i+1})$.
 - (e) the *parity function*, $f(x_{i-1}, x_i, x_{i+1}) = x_{i-1} + x_i + x_{i+1} \pmod{2}$.
 4. Go to <https://www.netlogoweb.org/> to access NetLogo, which can be run online or downloaded. Find two agent-based models that we did not try out in class. Adjust one of the parameters until you find a “threshold” between two distinct types of behaviors. Describe your findings in a paragraphs, including the approximate value of the threshold, and print out a screen shot (in color, if possible).