A Technique for Describing and Transforming Images Based on the Evolution of Cellular Automata

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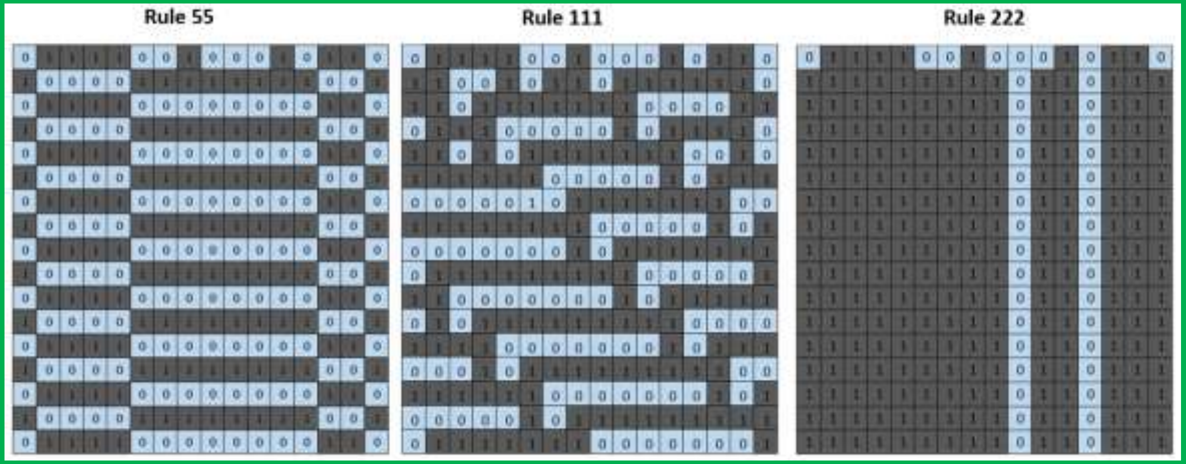
Evolution of Elementary CA

«Transition Rule 111 for ECA

The state of the cell $a_i(t)$ at the next time step	Neighborhood cells state at the previous time step $a_{i+1}(t)$, $a_i(t)$, $a_{i-1}(t)$
1	000
1	001
1	010
1	011
0	100
1	101
1	110
0	111

Evolutions of ECA behavior for **rules 55, 111, 222** and for identical initial states of cells of cellular automata



Identification algorithm

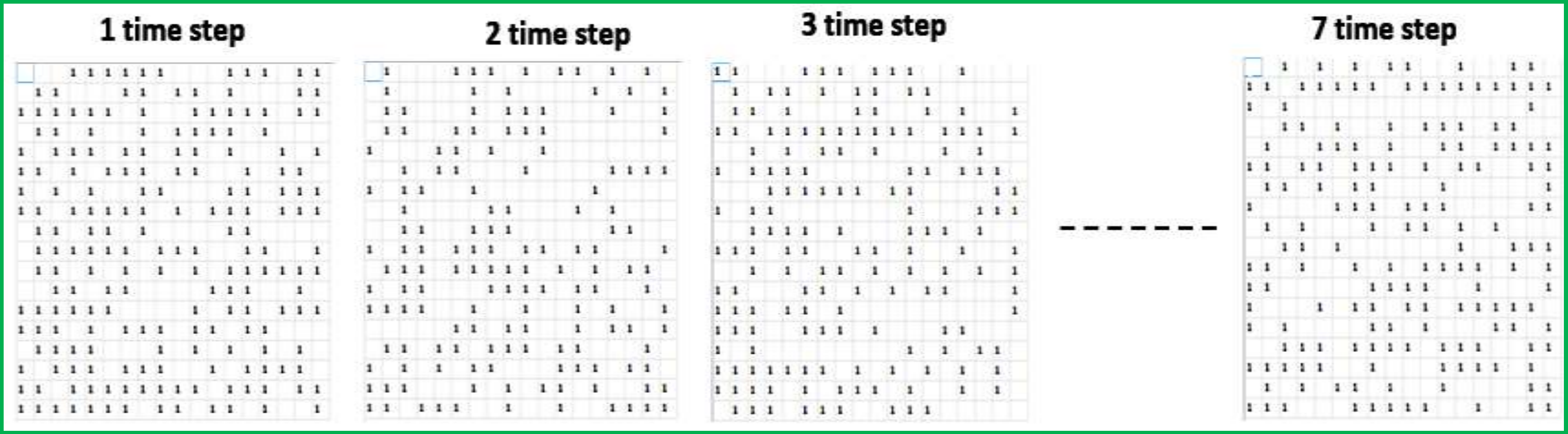
Evolution of an elementary cellular automaton with a sequential and repeating combination of **rules 55→111→222** for the initial conditions

0	1	1	1	1	0	0	1	0	0	0	1	0	1	1	0	initial states
1	0	0	0	0	1	1	1	1	1	1	1	1	0	0	1	**55**
1	0	1	1	1	1	0	0	0	0	0	0	1	0	1	0	**111**
1	0	1	1	1	1	1	0	0	0	0	1	1	0	1	0	**222**
1	1	0	0	0	0	0	1	1	1	1	0	0	1	1	1	**55**
0	1	0	1	1	1	1	1	0	0	1	0	1	1	0	0	**111**
1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	0	**222**
0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	**55**
0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	**111**
0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	**222**
1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	**55**
1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	**111**
1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	**222**
0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	**55**
1	1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	**111**
1	1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	**222**
0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	**55**

Rules

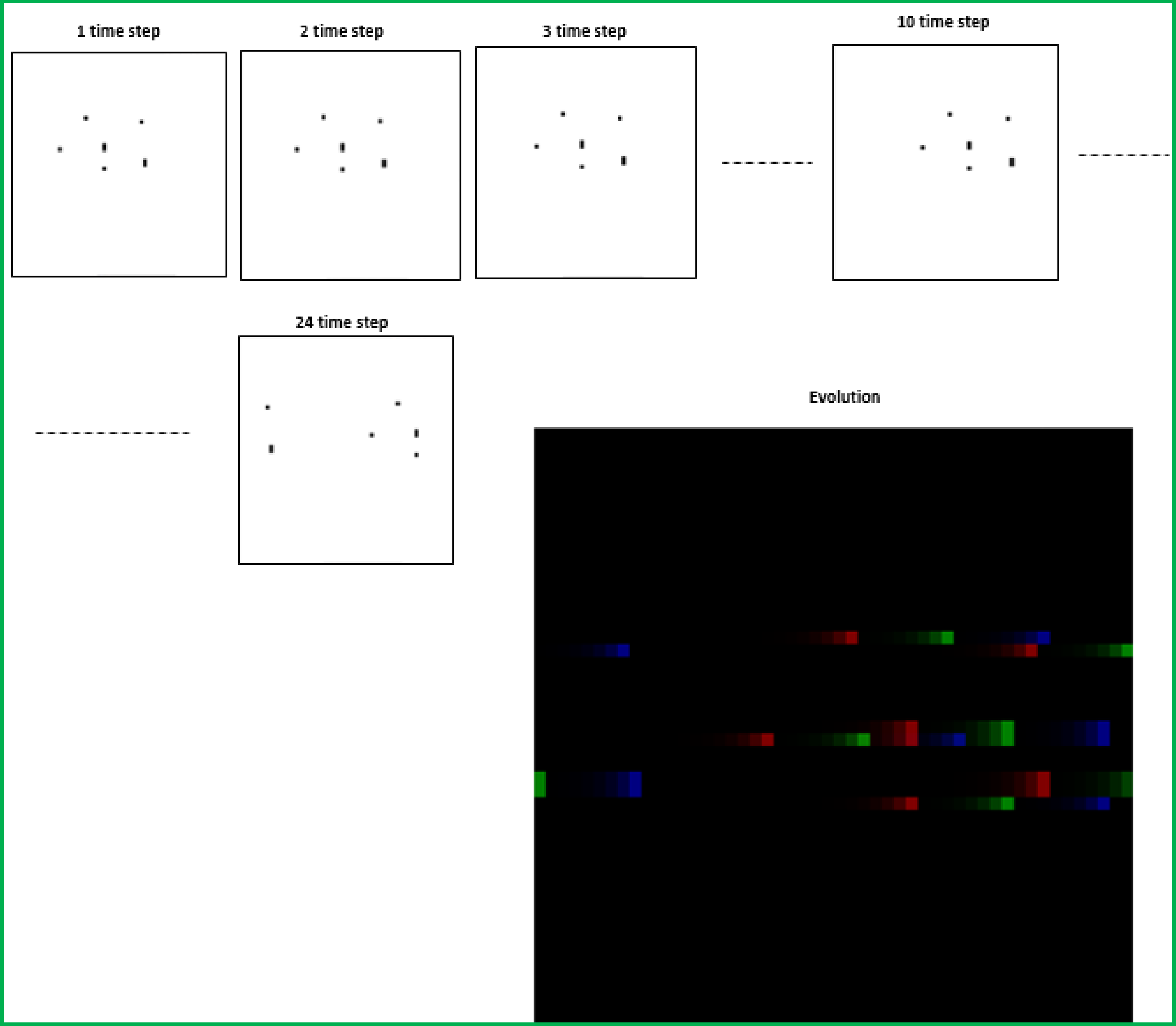
New Forms of Evolution of Two-Dimensional Cellular Automata

An example of TCA evolution in the form of a sequence of two-dimensional pictures



New Forms of Evolution of Two-Dimensional Cellular Automata

An example of TCA evolution on one two-dimensional array

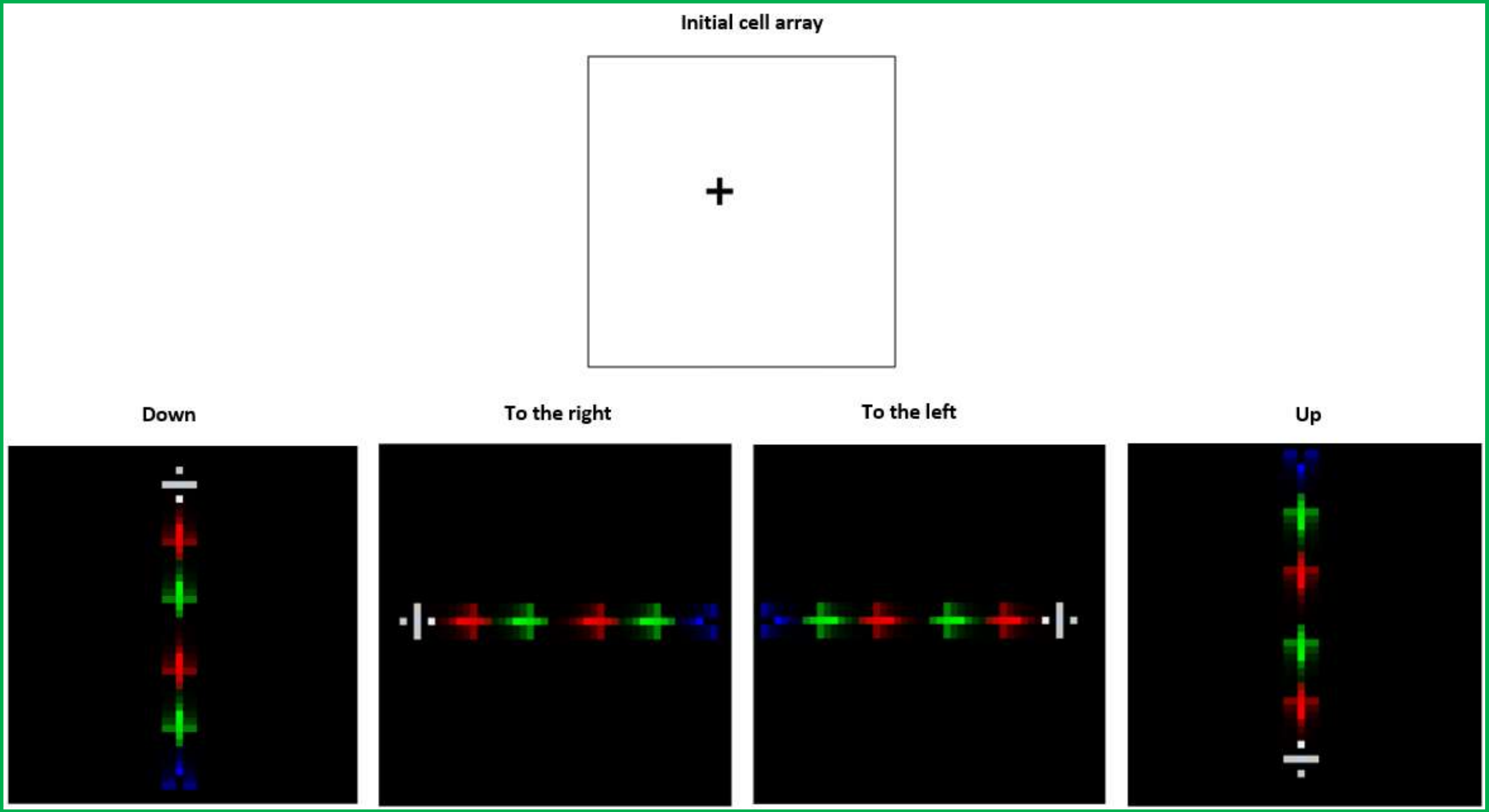


New Forms of Evolution of Two-Dimensional Cellular Automata

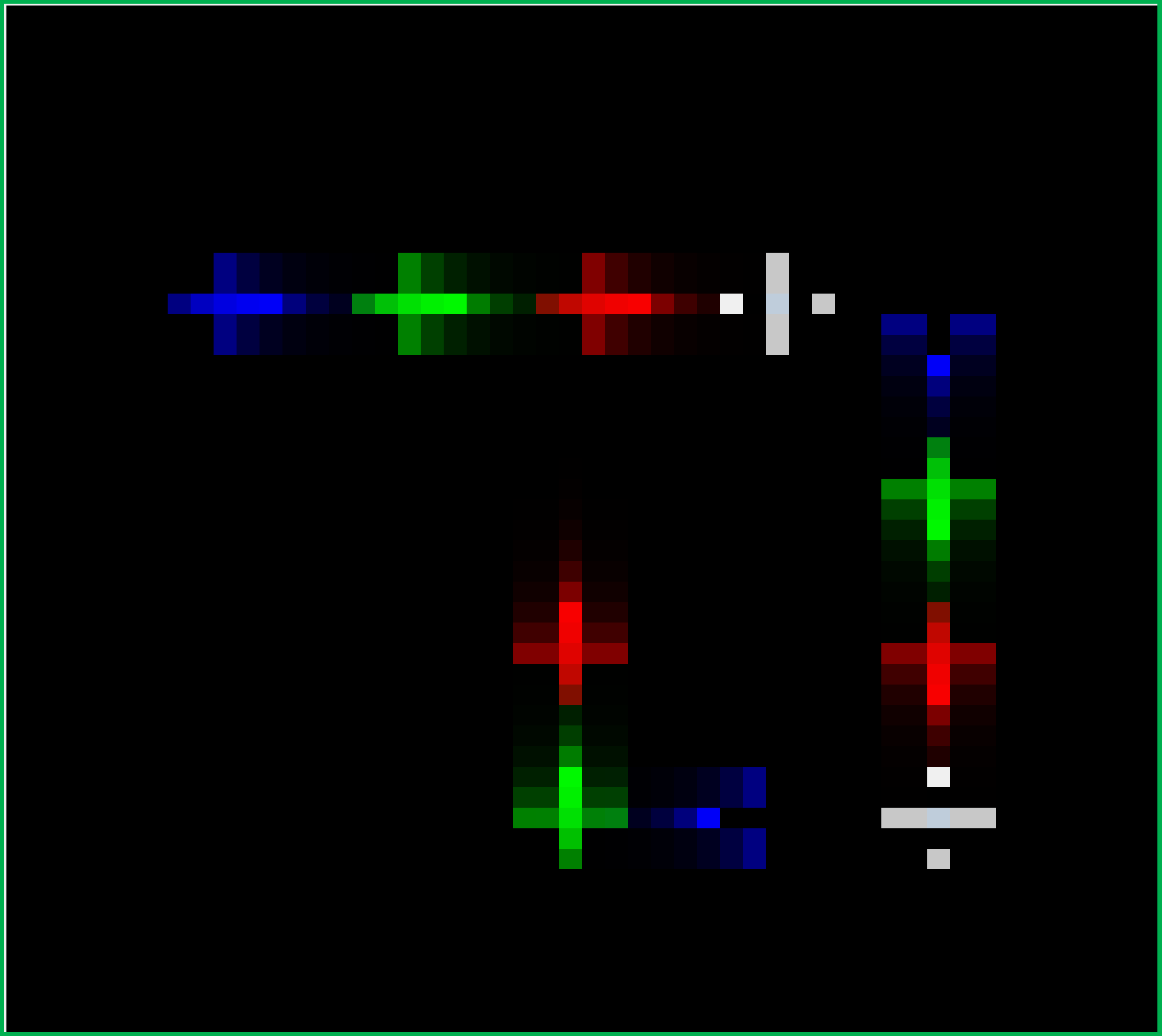
Transition rules 43690, 65280, 52428, 61680 for TCA

The state of the neighborhood cells at time t at the next time step				Shear direction (rule)			
a_4(t)	a_3(t)	a_2(t)	a_1(t)	down (43690)	right (65280)	left (52428)	up (61680)
0	0	0	0	0	0	0	0
0	0	0	1	1	0	0	0
0	0	1	0	0	0	1	0
0	0	1	1	1	0	1	0
0	1	0	0	0	0	0	1
0	1	0	1	1	0	0	1
0	1	1	0	0	0	1	1
0	1	1	1	1	0	1	1
1	0	0	0	0	1	0	0
1	0	0	1	1	1	0	0
1	0	1	0	0	1	1	0
1	0	1	1	1	1	1	0
1	1	0	0	0	1	0	1
1	1	0	1	1	1	0	1
1	1	1	0	0	1	1	1
1	1	1	1	1	1	1	1

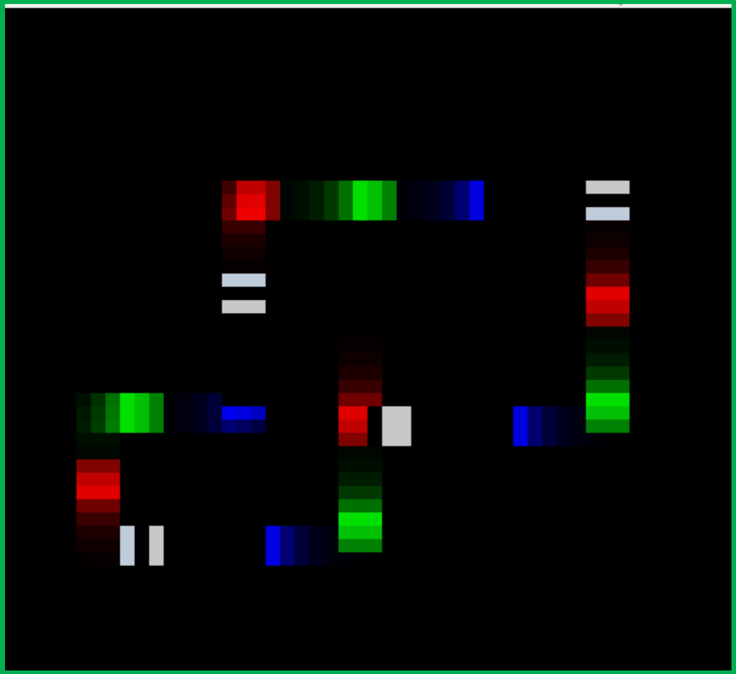
An example of applying the rules presented in Table. According to the initial state, the shifts are carried out down, right, left and down



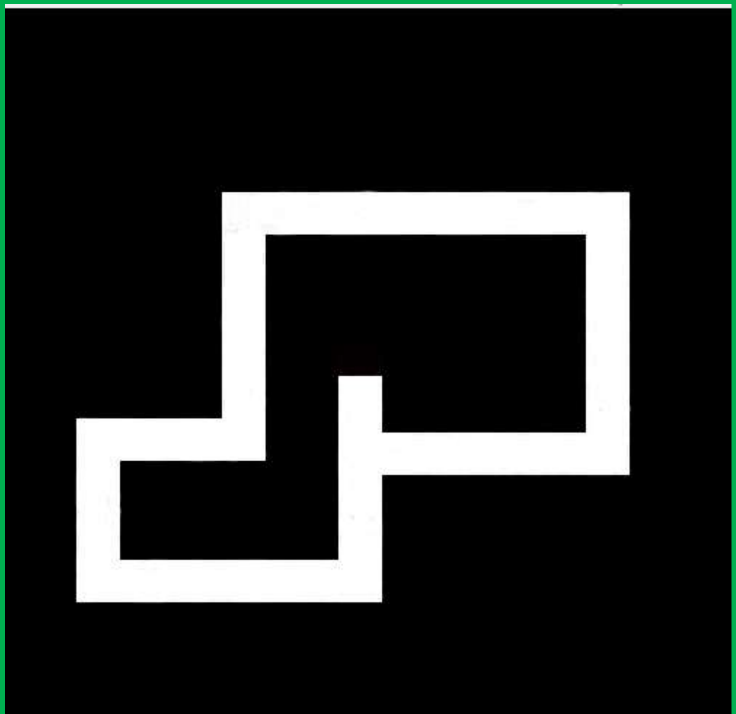
Evolution of TKA with the sequential application of four rules 43690, 65280, 61680, 52428 (the initial image consists of nine ones cells)



An example of the evolution of a CA for constructing a trajectory of motion. The trajectory is described by a 3 × 4 square



The final formation of the trajectory according to the evolution of the TCA shown in Figure



Conclusion

The paper considers the forms of representation of the evolution of elementary and two-dimensional cellular automata. Approaches are described that allow the formation of both binary and color images. The advantages of the evolution of two-dimensional cellular automata, which make it possible to form color images of any complexity, are shown. Using a sequence of rules based on Wolfram coding simplifies imaging processes and simplifies their preprocessing operations. To solve the problem of image recognition, images are described by a sequence of rules that also form the base of standards. It is shown that for different forms of neighborhoods there are different rules that perform the same operation. This form of representation of the evolution of two-dimensional cellular automata makes it possible to simulate various dynamic processes in a field of the same dimensions.

In future studies, the author plans to research and analyze, as well as the interaction of all rules for solving problems of describing and recognizing images.