

NKS 2006 Summer School

Rubens Zimbres



Favorite Rule: 661856526

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Favorite Rule: 661856526 (4 color, radius 1/2 Cellular Automaton)

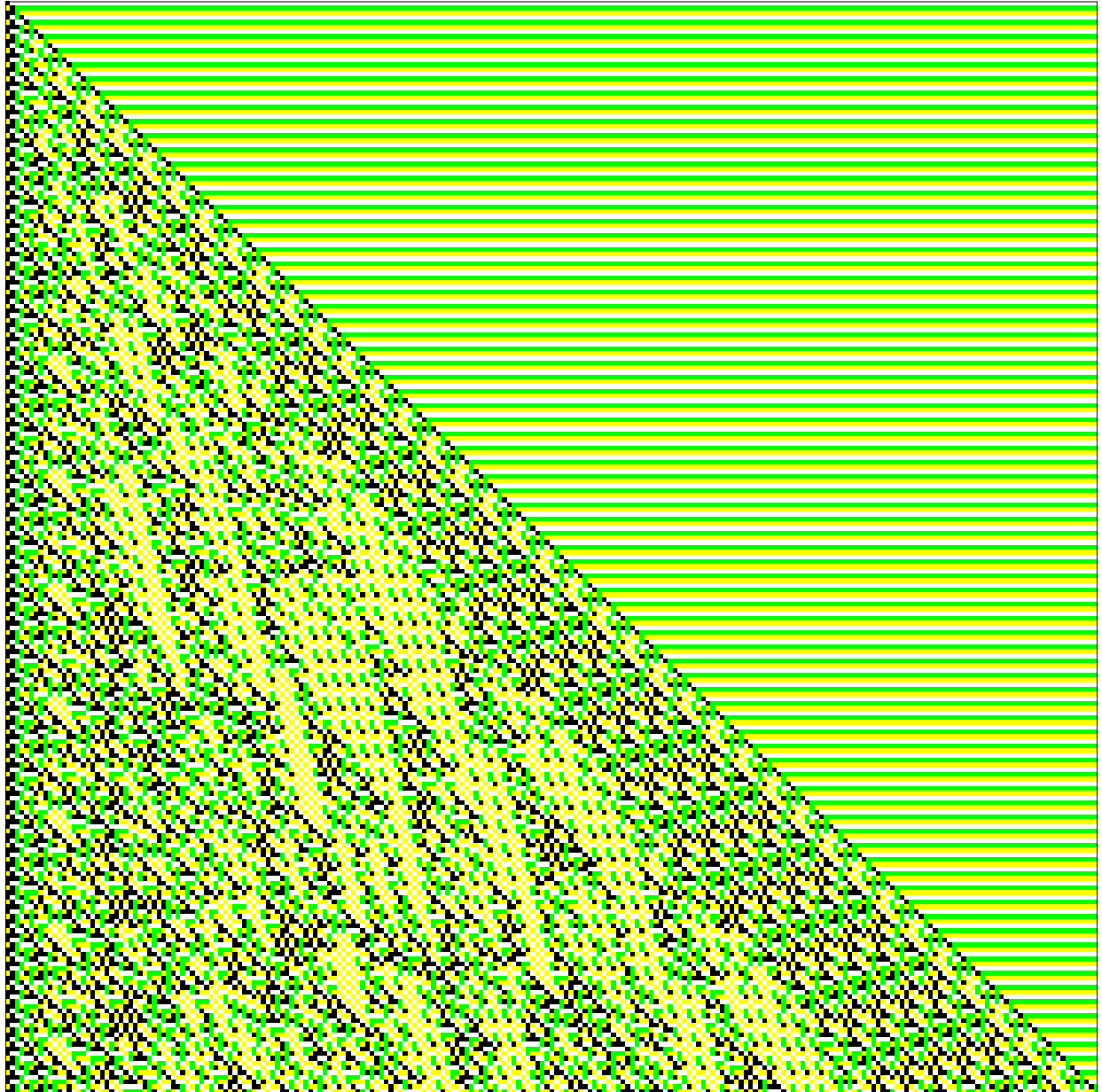
Initial state $\rightarrow \{\{1\},0\}$

Neighborhood $\rightarrow \{\{-1\},\{0\}\}$

`In[286]:=`

```
ArrayPlot[CellularAutomaton[{661856526, 4, {{-1}, {0}}}, {{1}, 0}, 230],  
ColorRules  $\rightarrow$  {0  $\rightarrow$  White, 1  $\rightarrow$  Black, 2  $\rightarrow$  Green, 3  $\rightarrow$  Yellow}, PixelConstrained  $\rightarrow$  2]
```

`Out[286]=`



Comments

Depending on initial condition and neighborhood, it shows a repetitive pattern (Class I) or complex pattern (Class IV) → flexibility

Inserts diversity

Repetitive horizontal pattern every 3 cycles

Repetitive vertical pattern that invades the CA (vertical and diagonal)

Gliders → simple structures that propagate, collide and fades away



Cycles → 8000

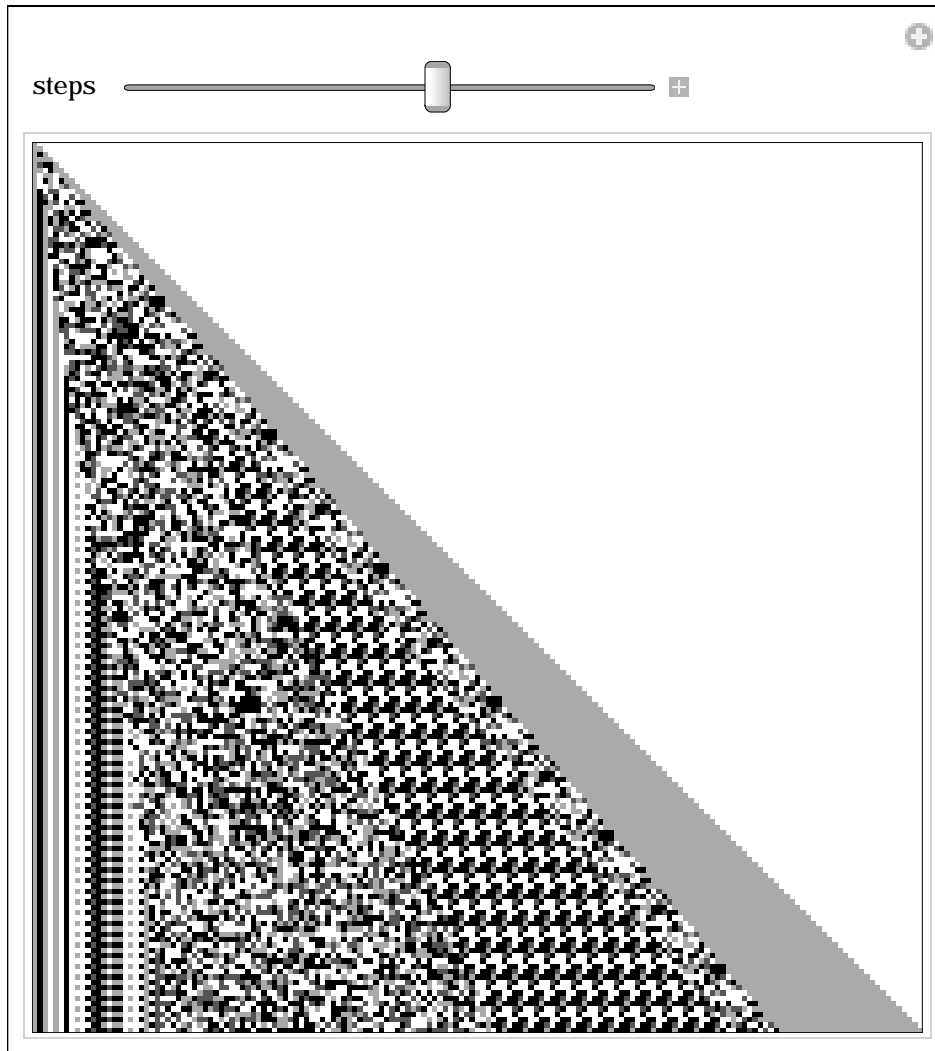
Steps → 16

Infinite background

In[221]:=

```
Manipulate[ArrayPlot[CellularAutomaton[{661856526, 4, {{-1}, {0}}}, {{1}, 0},  
  {0, 8000, steps}, {0, 8000, steps}], PixelConstrained → 2], {steps, 30, 60, 6}]
```

Out[221]=



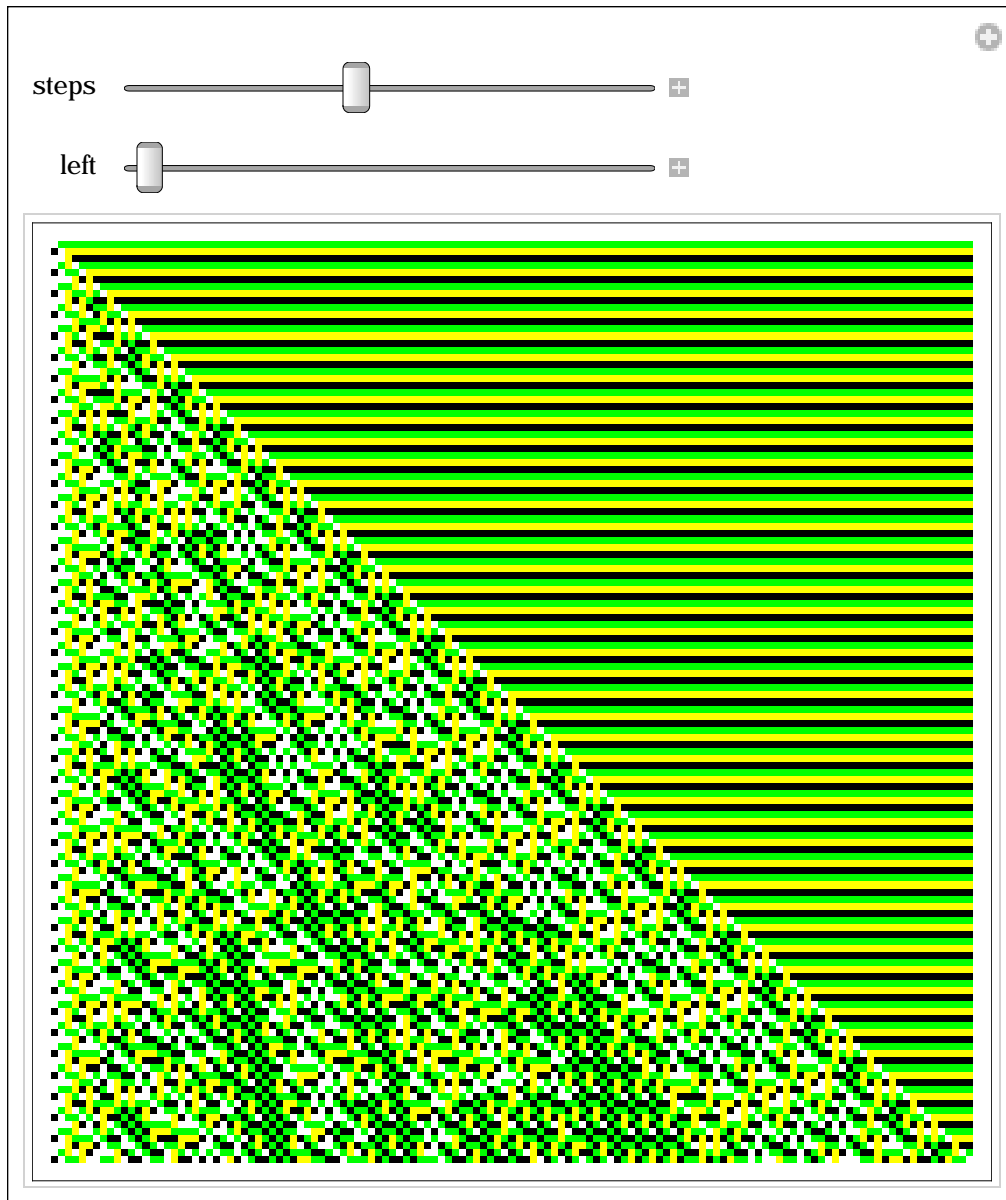
Comments

Depending on the step, black cells go different directions (30,36)



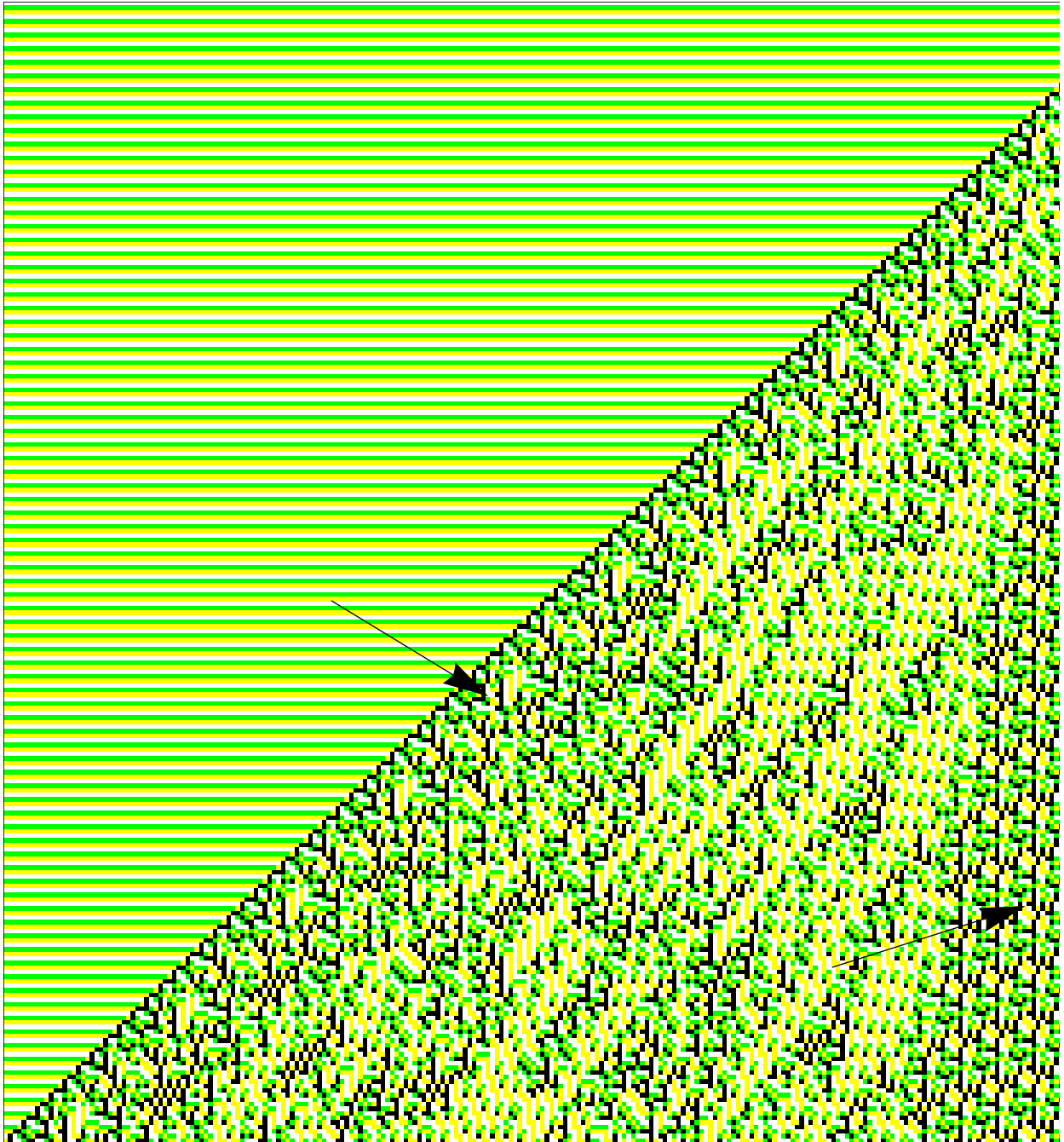
Manipulating the CA

```
Manipulate[ArrayPlot[CellularAutomaton[{661856526, 4, {{left}, {0}}], {{1}, 0}, steps],  
  ColorRules -> {0 -> Green, 1 -> White, 2 -> Yellow, 3 -> Black}],  
 {steps, 1, 300, 1}, {left, -1, -6, 1}]
```



Change in neighborhood $\rightarrow \{\{0\},\{1\}\}$

```
ArrayPlot[CellularAutomaton[{661 856 526, 4, {{0}, {1}}}, {{1}, 0}, 250],  
ColorRules  $\rightarrow$  {0  $\rightarrow$  White, 1  $\rightarrow$  Black, 2  $\rightarrow$  Green, 3  $\rightarrow$  Yellow}, PixelConstrained  $\rightarrow$  2]
```



Comments

Behaves like Class IV (complex pattern)

Inserts diversity

Generates an increasing repetitive pattern (arrows)

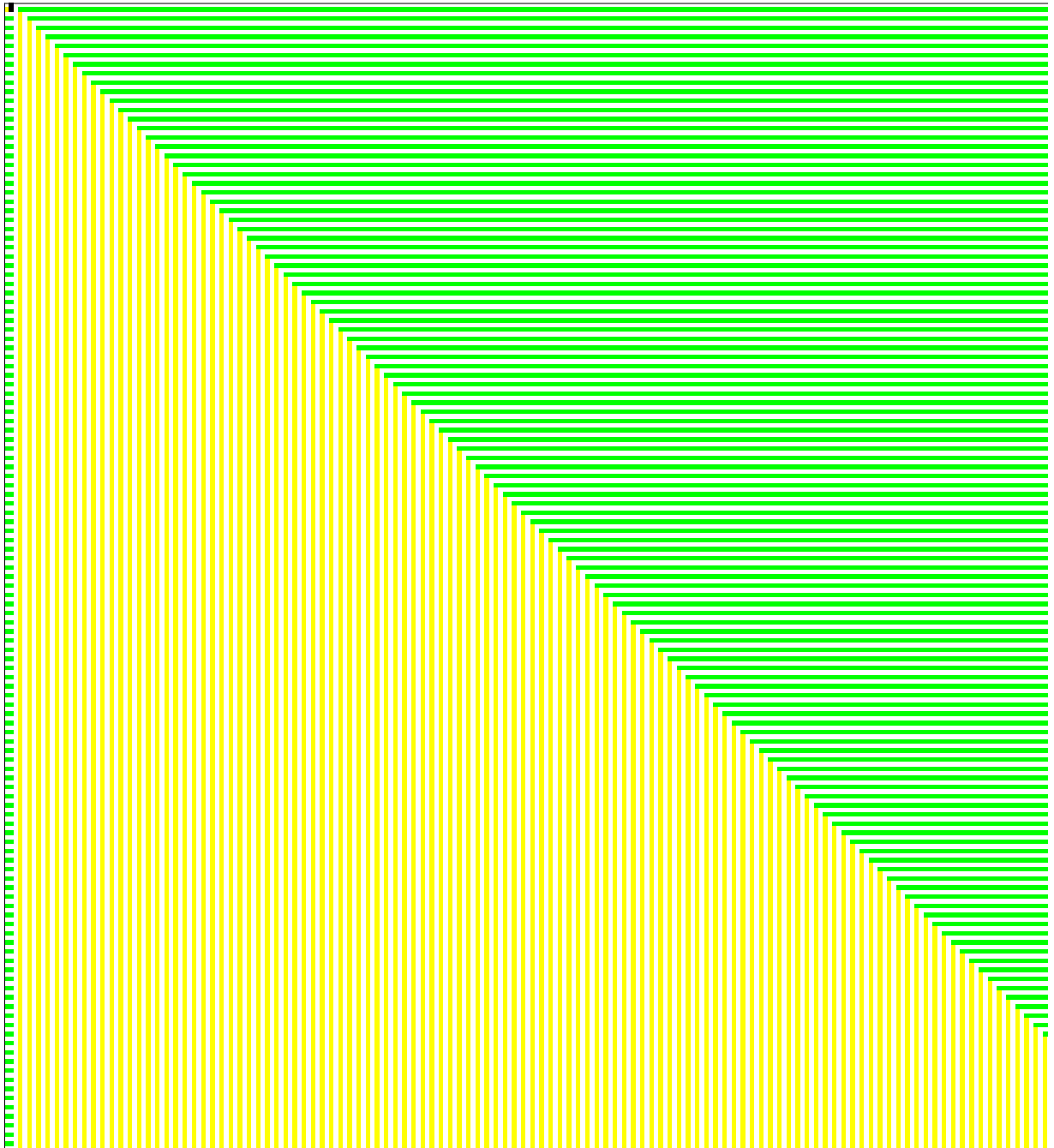
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Change in neighborhood $\rightarrow \{-1\},\{0\},\{0\}$

```
In[92]:= ArrayPlot[CellularAutomaton[{661856526, 4, {{-1}, {0}, {1}}}, {{1}, 0}, 250],  
ColorRules -> {0 -> White, 1 -> Black, 2 -> Green, 3 -> Yellow}, PixelConstrained -> 2]
```

Out[92]=



Comments

Behaves like Class I (repetitive pattern)



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Change in neighborhood $\rightarrow \{-1\}, \{0\}, \{1\}$ and

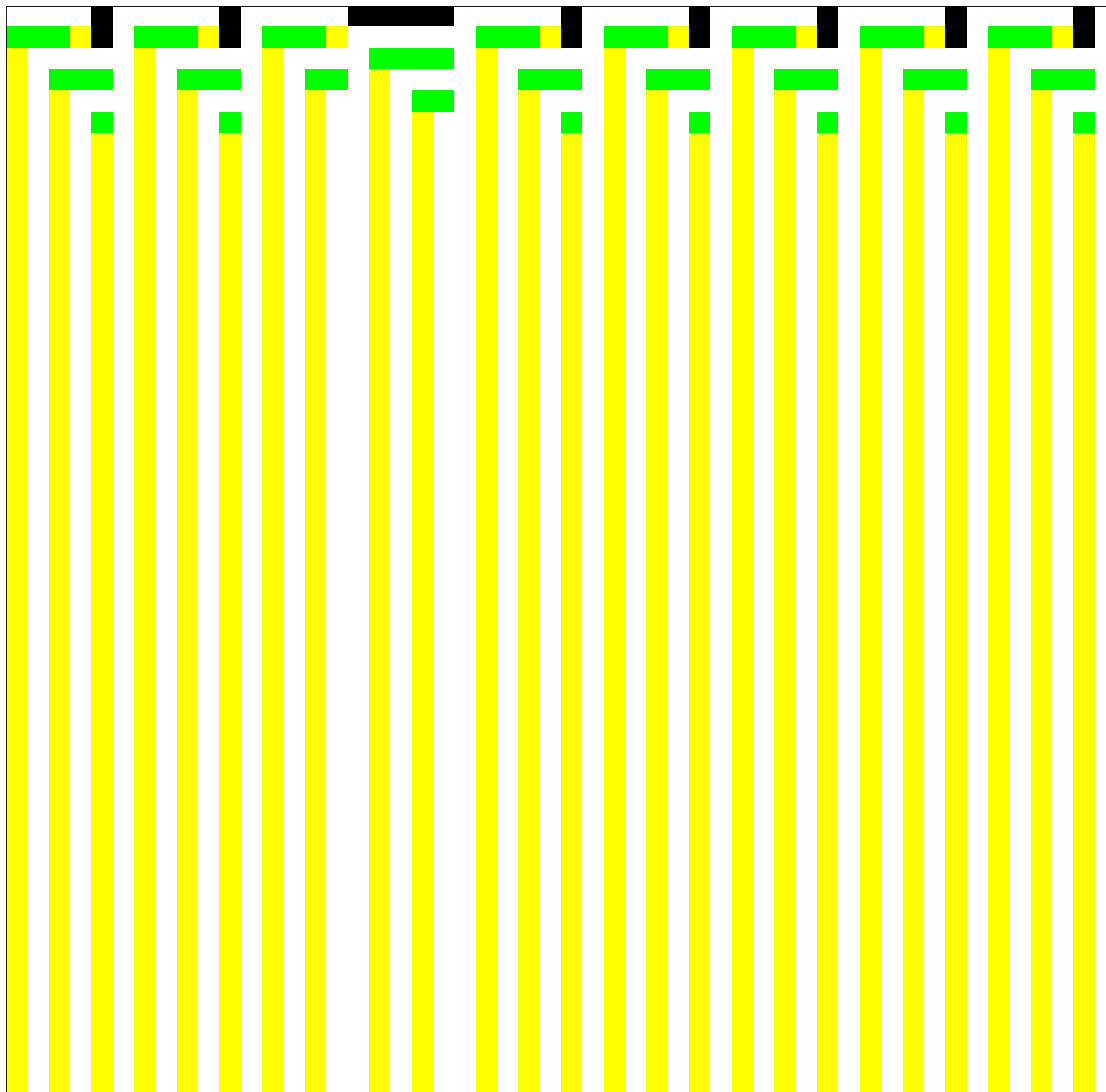
Initial state \rightarrow

$\{0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,0,1,0,0,0,0,0,0,1,0\}$

In[458]:=

```
ArrayPlot[CellularAutomaton[{661856526, 4, {{-1}, {0}, {1}}},
  {0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 0, 0, 0, 1,
  0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0}, 50],
  PixelConstrained  $\rightarrow$  8, ColorRules  $\rightarrow$  {0  $\rightarrow$  White, 1  $\rightarrow$  Black, 2  $\rightarrow$  Green, 3  $\rightarrow$  Yellow}]
```

Out[458]=



Comments

Behaves like Class I (repetitive pattern)

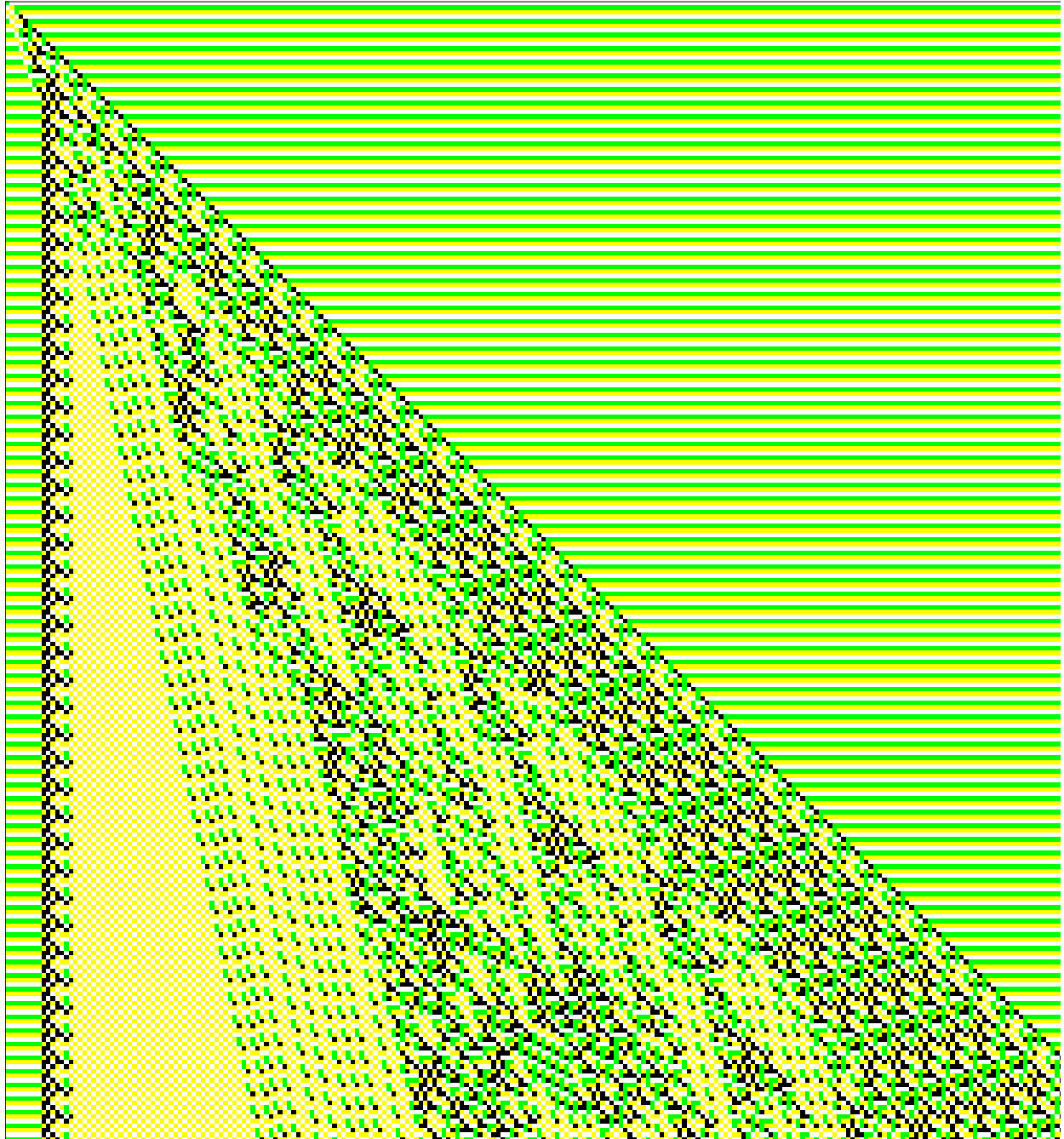
Inserts diversity



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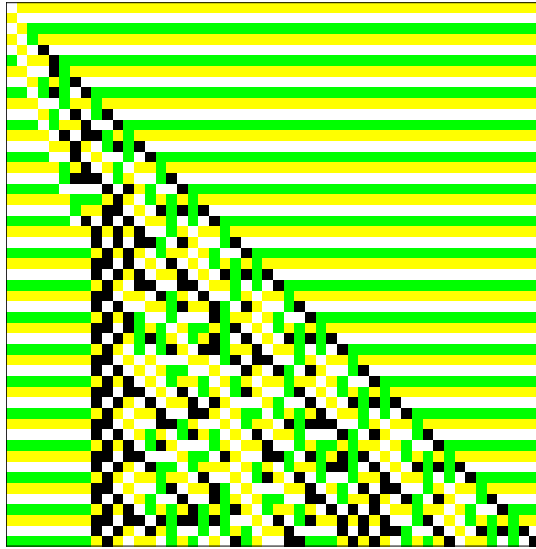
Change in initial state $\rightarrow \{\{2\},0\}$

```
ArrayPlot[CellularAutomaton[{661 856 526, 4, {{-1}, {0}}}, {{2}, 0}, 250],  
PixelConstrained  $\rightarrow$  2, ColorRules  $\rightarrow$  {0  $\rightarrow$  White, 1  $\rightarrow$  Black, 2  $\rightarrow$  Green, 3  $\rightarrow$  Yellow}]
```



```
In[246]:=
ArrayPlot[CellularAutomaton[{661856526, 4, {{-1}, {0}}}, {{3, 0}, {3}}, 50],
PixelConstrained -> 4, ColorRules -> {0 -> White, 1 -> Black, 2 -> Green, 3 -> Yellow}]
```

Out[246]=



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```
In[164]:=
aa = Flatten[
  {Table[Abs[RandomInteger[]], {2}], Table[0, {100}], Table[Abs[RandomInteger[]], {2}]}]
```

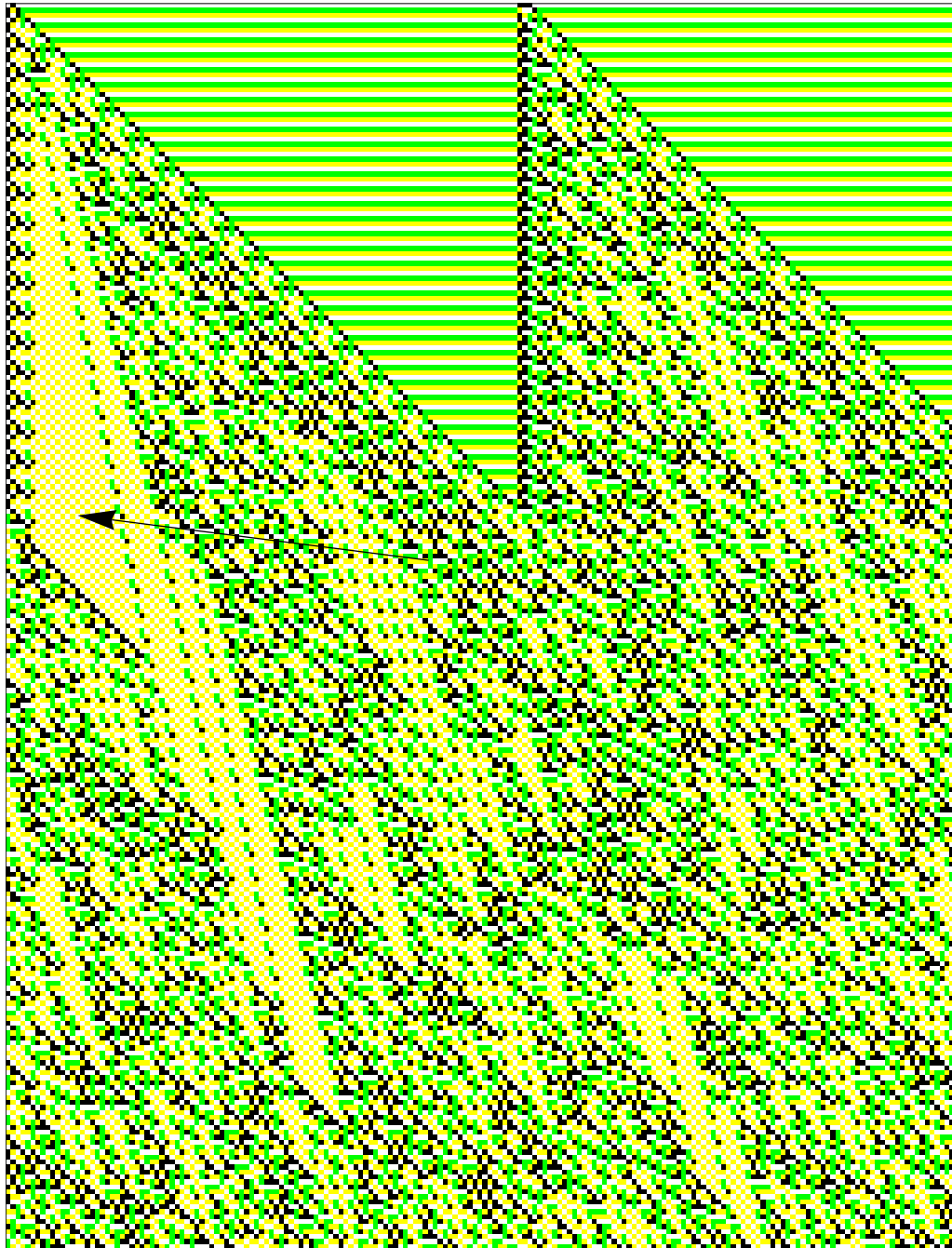
Out[164]=

```
{1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1}
```

In[165]:=

```
ArrayPlot[CellularAutomaton[{661856526, 4, {{-1}, {0}}}, {{0}, aa}, 250],
PixelConstrained -> 2, ColorRules -> {0 -> White, 1 -> Black, 2 -> Green, 3 -> Yellow}]
```

Out[165]=

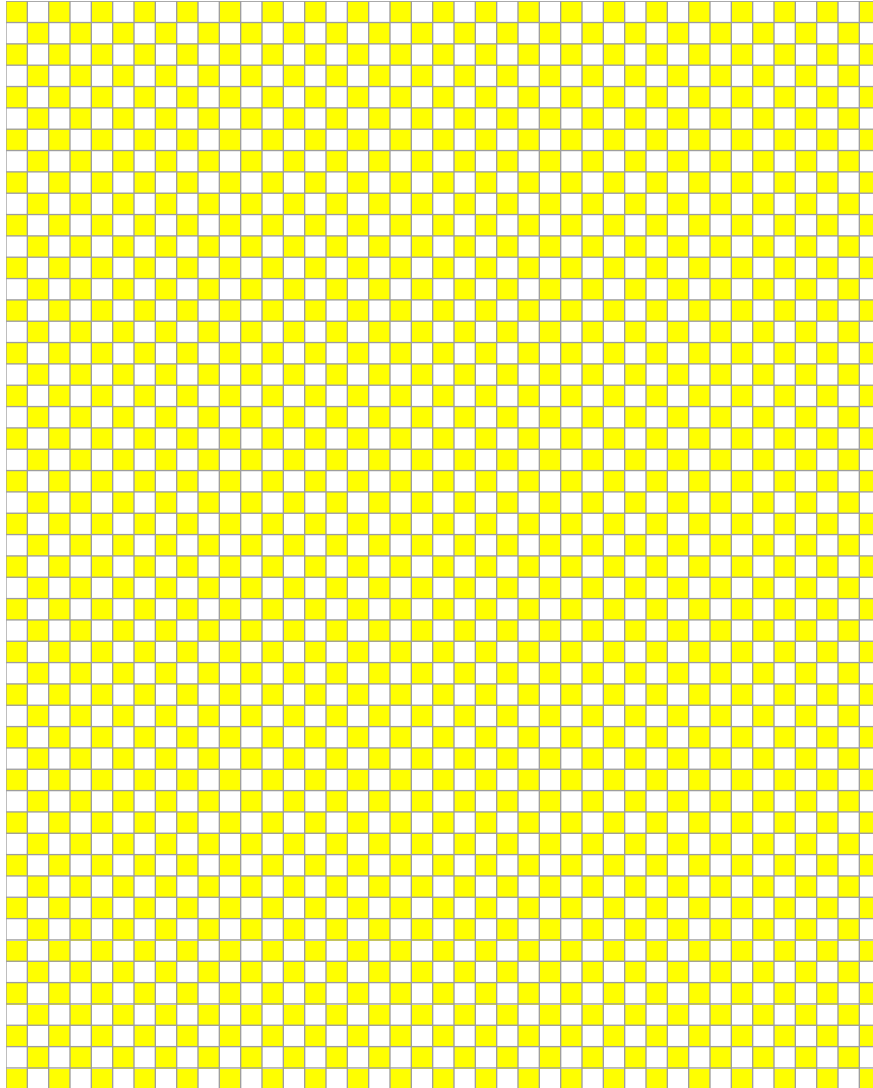


Background

In[224]:=

```
ArrayPlot[CellularAutomaton[{661856526, 4, {{-1}, {0}}},
  {{3, 0}, {3, 0, 3, 0, 3, 0, 3, 0, 3, 0}}, {{90, 140}, {10, 50}}, PixelConstrained -> 8,
  Mesh -> True, ColorRules -> {0 -> White, 1 -> Black, 2 -> Green, 3 -> Yellow}]
```

Out[224]=



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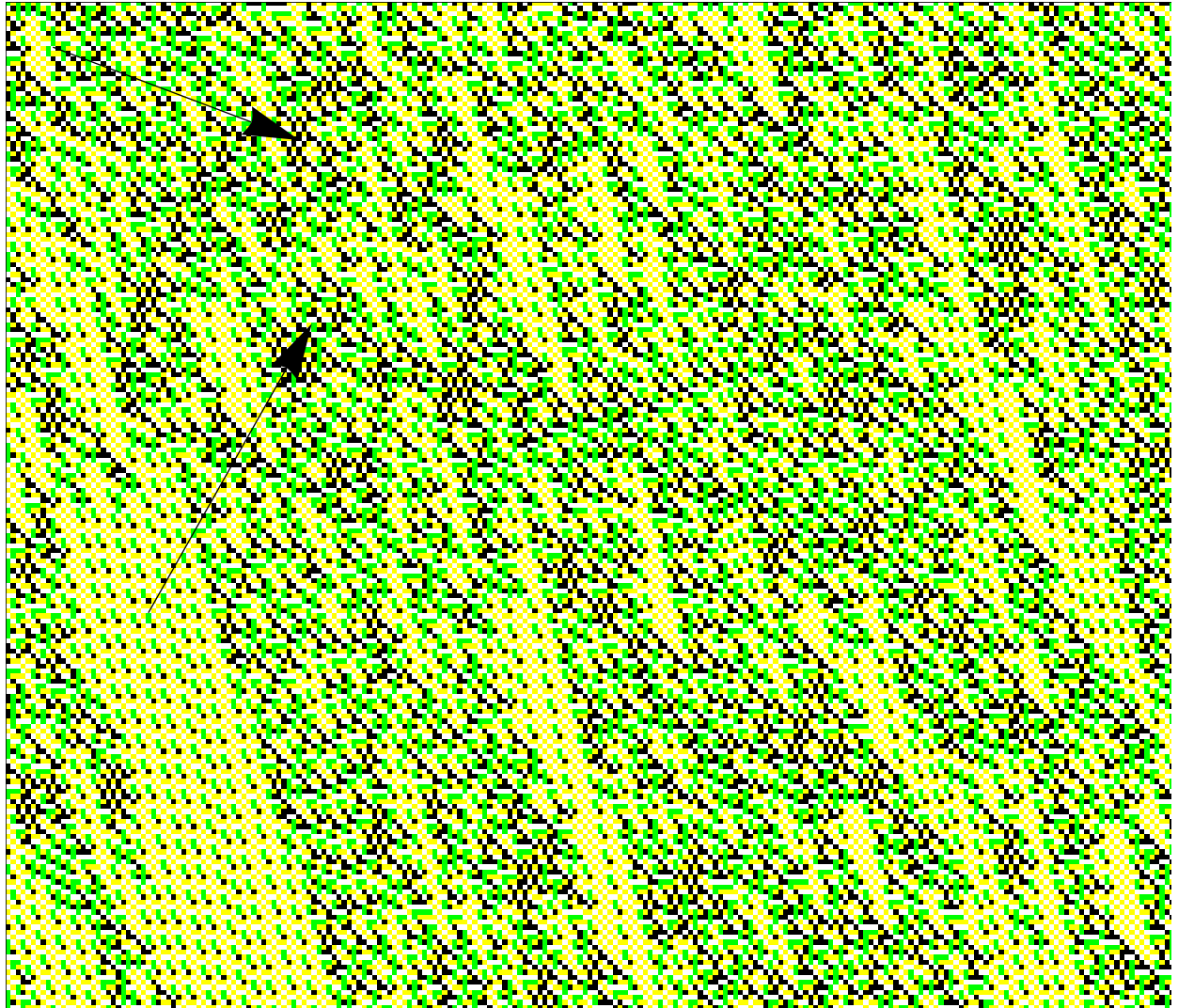


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Change in initial state → `RandomInteger[{0,3},280]`
background

Finite

```
ArrayPlot[
  CellularAutomaton[{661856526, 4, {{-1}, {0}}}, RandomInteger[{0, 3}, 280], 200],
  ColorRules -> {0 -> White, 1 -> Black, 2 -> Green, 3 -> Yellow}, PixelConstrained -> 2]
```



Comments

Structures that appear, spread and meet again

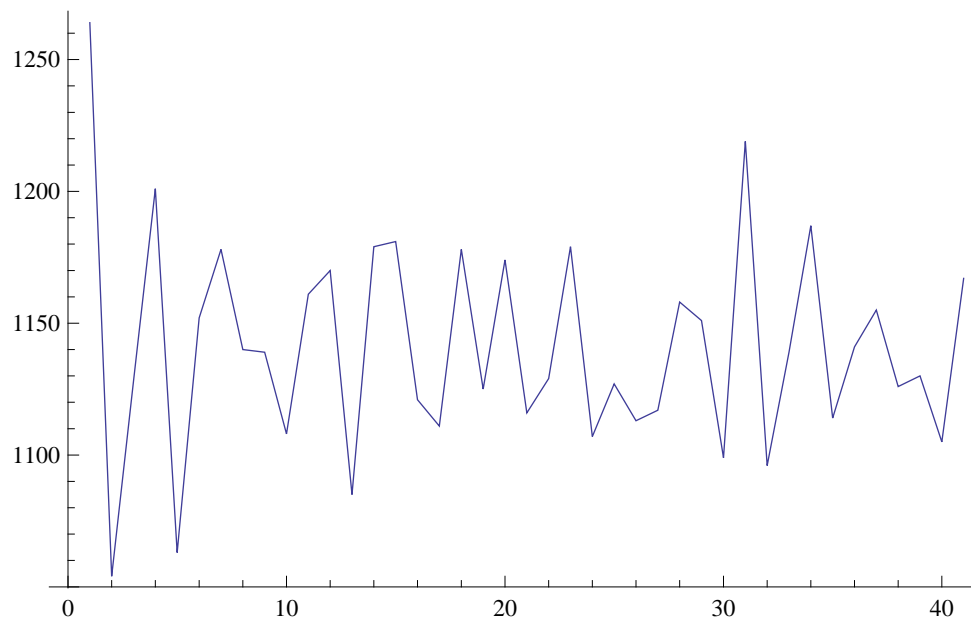


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CA Total (steady state)

Rule 661856526

```
ListLinePlot[
  Total /@ CellularAutomaton[{661856526, 4, {{-1}, {0}}}, RandomInteger[{0, 3}, 800], 40]
```



Comparing Wolfram's Classes of Cellular Automata

```
In[67]:= rules = {204, 232, 30, 110};
```

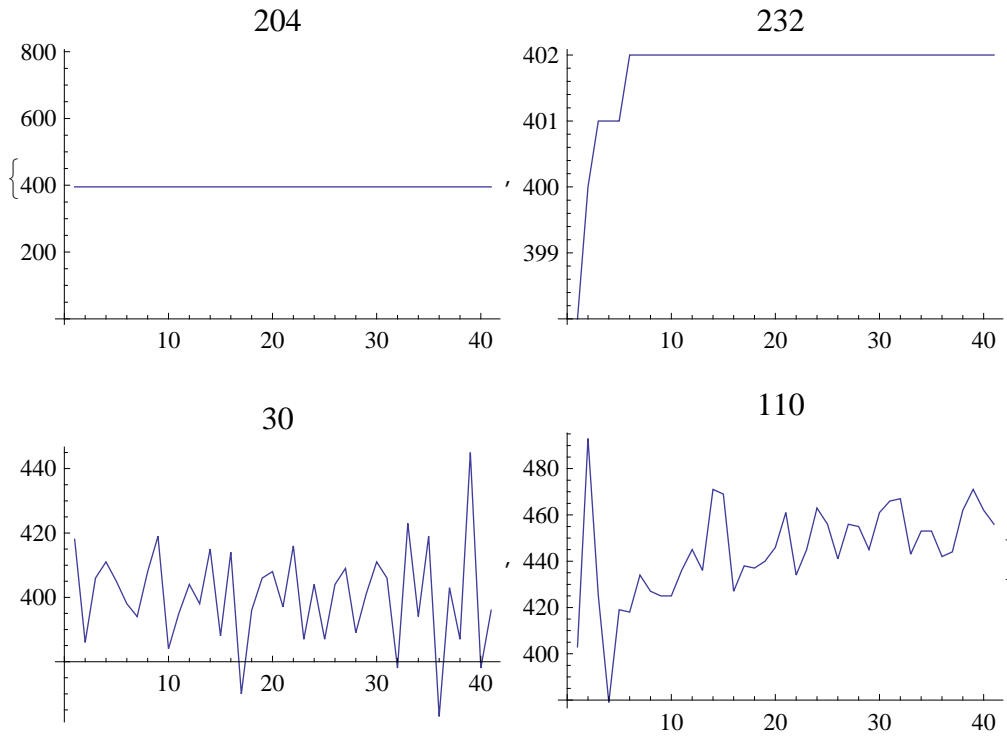
```
In[78]:= r = {"I", "II", "III", "IV"};
```

```
In[104]:=
```

```
graph[l_] := ListLinePlot[
  Total /@ CellularAutomaton[l, RandomInteger[{0, 1}, 800], 40], PlotLabel -> l]
```

```
In[105]:= graph /@ rules
```

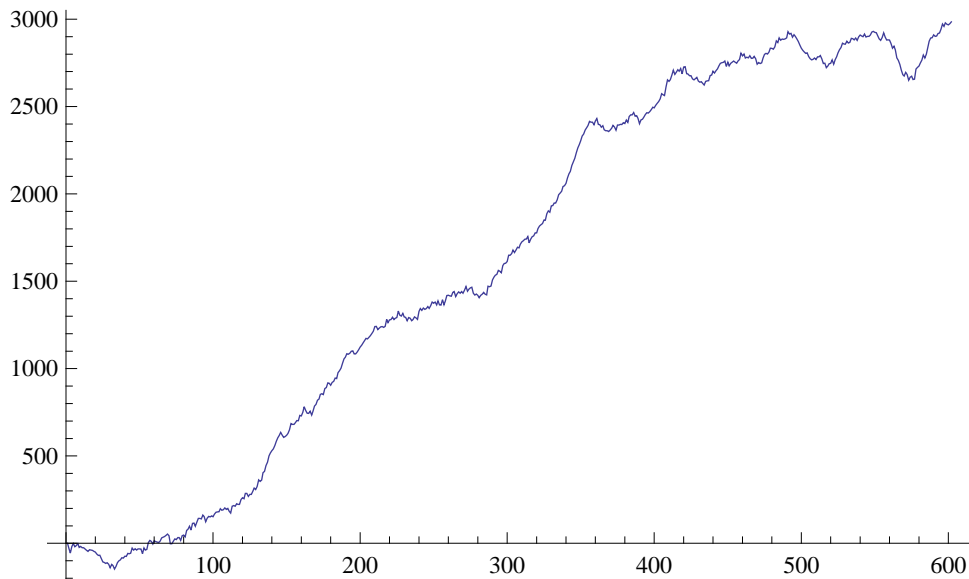
Out[105]=



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CA oscillations

```
ListLinePlot[FoldList[Plus, 0,
  Total /@ (CellularAutomaton[{661 856 526, 4, 1 / 2}, RandomInteger[{0, 3}, 100], 600] - 2 /.
    {-2 → -1, -1 → -2, 0 → 1, 1 → 2})]]
```



Transition Table

```
In[200]:=
```

```
q = Reverse@Tuples[{0, 1, 2, 3}, 2]
```

```
Out[200]=
```

```
{{3, 3}, {3, 2}, {3, 1}, {3, 0}, {2, 3}, {2, 2}, {2, 1},
 {2, 0}, {1, 3}, {1, 2}, {1, 1}, {1, 0}, {0, 3}, {0, 2}, {0, 1}, {0, 0}}
```

```
In[167]:=
```

```
IntegerDigits[661 856 526, 4, 16]
```

```
Out[167]=
```

```
{0, 2, 1, 3, 1, 3, 0, 3, 0, 2, 0, 1, 0, 0, 3, 2}
```

```
In[199]:=
```

```
final = {{0, 0}, {0, 2}, {0, 1}, {0, 3}, {0, 1}, {0, 3}, {0, 0},
 {0, 3}, {0, 0}, {0, 2}, {0, 0}, {0, 1}, {0, 0}, {0, 0}, {0, 3}, {0, 2}};
```

```
In[201]:=
MapThread[ArrayPlot[{{##}}, ImageSize -> 50, Mesh -> True] &,
  {q, final} /. {0 -> White, 1 -> Black, 2 -> Green, 3 -> Yellow}]
```

Out[201]=

