

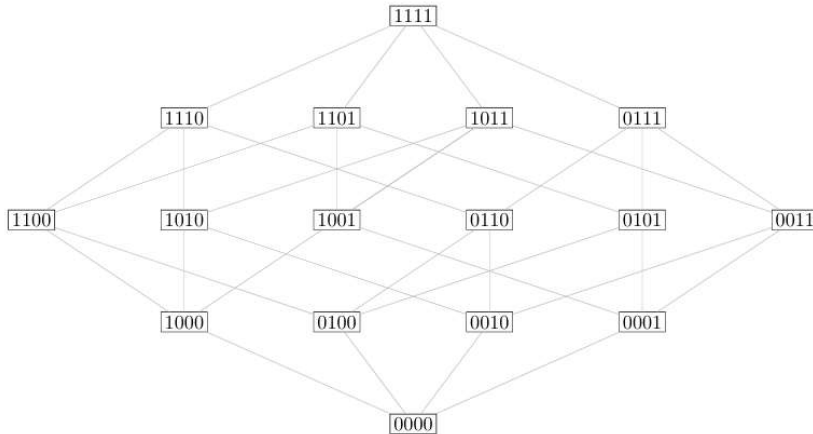
# HW5

Friday, October 25, 2024 1:32 PM

1. **Asynchronous automata.** Draw the asynchronous automaton the following Boolean model:

$$(f_1, f_2, f_3, f_4) = (x_2 \wedge \overline{x_3}, \overline{x_1}, x_3 \vee x_4, x_1 + x_2).$$

Then, partition the nodes into strongly connected components, and draw the acyclic directed graph formed by collapsing the SCCs into single nodes. Find the attractors and classify them by type: fixed point, cyclic attractor, or complex attractor. The Boolean lattice  $B_4$  is shown below.



```
import numpy as np

list = np.array([[1,1,1,1],
                 [1,1,1,0],
                 [1,1,0,1],
                 [1,0,1,1],
                 [0,1,1,1],
                 [1,1,0,0],
                 [1,0,1,0],
                 [1,0,0,1],
                 [0,1,1,0],
                 [0,1,0,1],
                 [0,0,1,1],
                 [1,0,0,0],
                 [0,1,0,0],
                 [0,0,1,0],
                 [0,0,0,1],
                 [0,0,0,0]])

#f1
#list[:,0] = list[:,1]*(1+list[:,2])%2

#f2
#list[:,1] = (1+list[:,0])%2

#f3
#list[:,2] = (list[:,2]+list[:,3]+list[:,2]*list[:,3])%2

#f4
#list[:,3] = (list[:,0]+list[:,1])%2

print(list)
```

f1

f2

f3

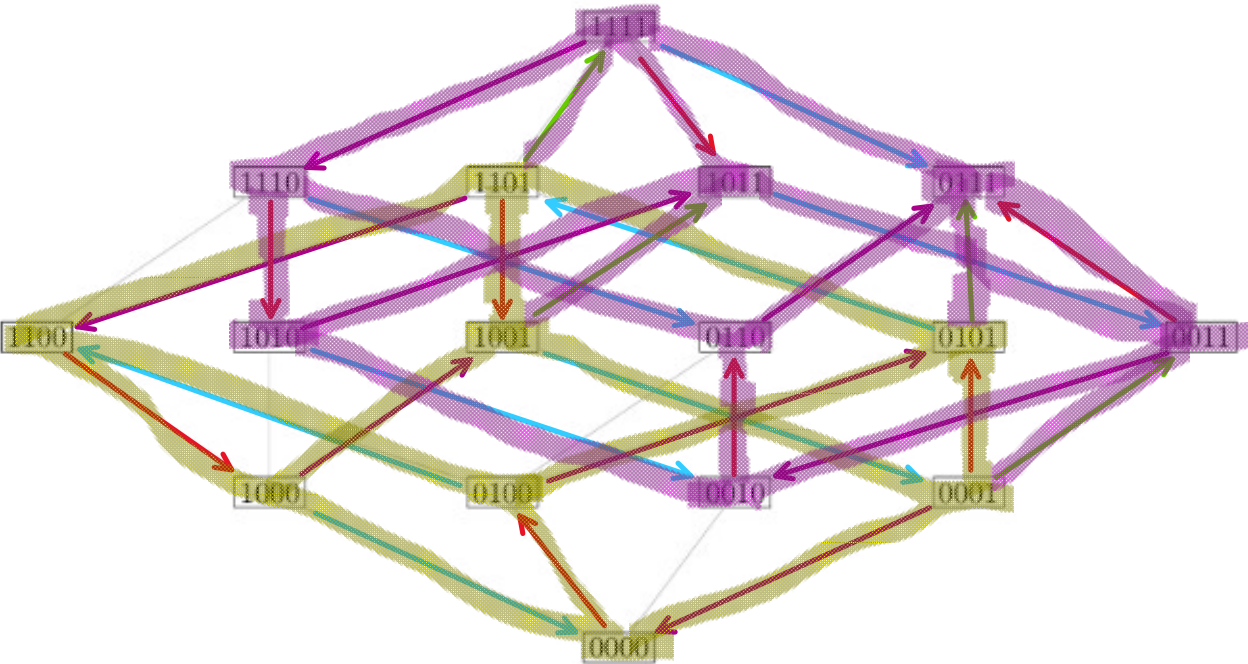
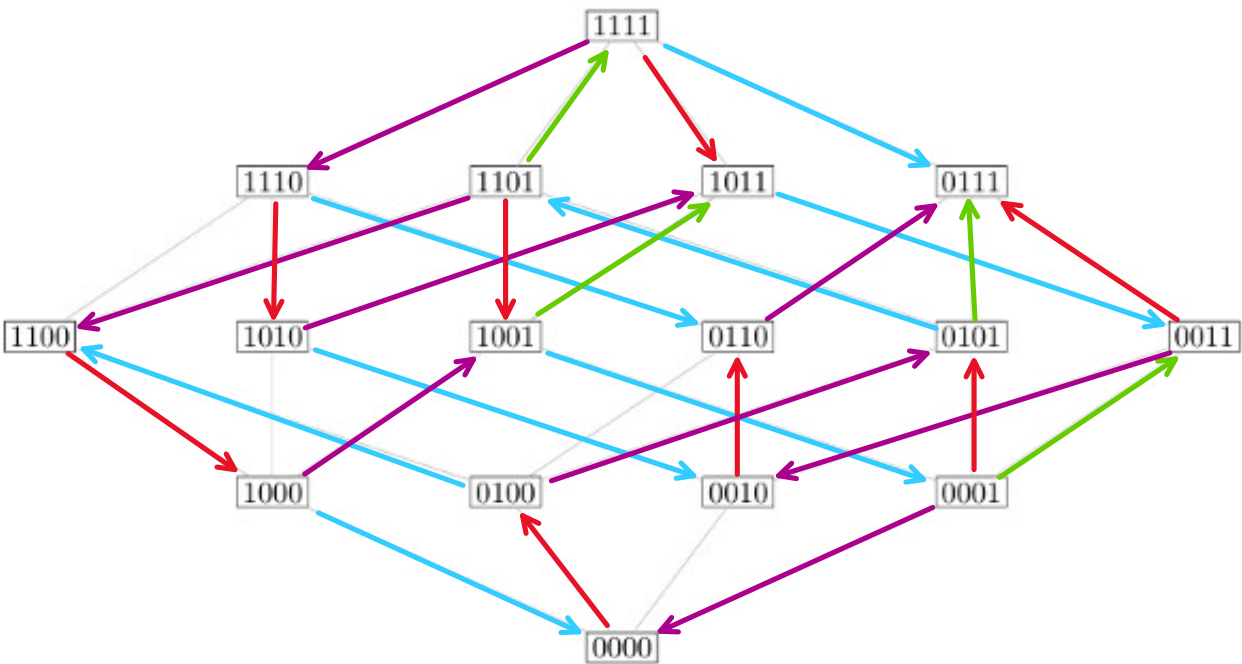
f4

<del>[[1,1,1,1],</del>	<del>[[0 1 1 1]</del>	<del>[[1,1,1,1],</del>	<del>[[1 0 1 1]</del>	<del>[[1,1,1,1],</del>	<del>[[1 1 1 1]</del>	<del>[[1,1,1,1],</del>	<del>[[1 1 1 0]</del>
<del>[1,1,1,0],</del>	<del>[0 1 1 0]</del>	<del>[1,1,1,0],</del>	<del>[1 0 1 0]</del>	<del>[1,1,1,0],</del>	<del>[1 1 1 0]</del>	<del>[1,1,1,0],</del>	<del>[1 1 1 0]</del>
<del>[1,1,0,1],</del>	<del>[0 1 1 0]</del>	<del>[1,1,0,1],</del>	<del>[1 0 1 0]</del>	<del>[1,1,0,1],</del>	<del>[1 1 1 1]</del>	<del>[1,1,0,1],</del>	<del>[1 1 1 0]</del>
<del>[1,0,1,1],</del>	<del>[0 0 1 1]</del>	<del>[1,0,1,1],</del>	<del>[1 0 1 0]</del>	<del>[1,0,1,1],</del>	<del>[1 0 1 1]</del>	<del>[1,0,1,1],</del>	<del>[1 0 1 1]</del>
<del>[0,1,1,1],</del>	<del>[0 0 1 1]</del>	<del>[0,1,1,1],</del>	<del>[1 0 1 0]</del>	<del>[0,1,1,1],</del>	<del>[1 0 1 0]</del>	<del>[0,1,1,1],</del>	<del>[1 0 1 1]</del>
<del>[1,1,0,0],</del>	<del>[0 0 1 0]</del>	<del>[1,1,0,0],</del>	<del>[1 0 0 0]</del>	<del>[1,1,0,0],</del>	<del>[1 0 1 0]</del>	<del>[1,1,0,0],</del>	<del>[1 0 1 1]</del>
<del>[1,0,1,0],</del>	<del>[0 0 1 0]</del>	<del>[1,0,1,0],</del>	<del>[1 0 0 0]</del>	<del>[1,0,1,0],</del>	<del>[1 0 1 1]</del>	<del>[1,0,1,0],</del>	<del>[1 0 1 1]</del>
<del>[1,0,0,1],</del>	<del>[0 0 0 1]</del>	<del>[1,0,0,1],</del>	<del>[1 0 0 1]</del>	<del>[1,0,0,1],</del>	<del>[1 0 1 1]</del>	<del>[1,0,0,1],</del>	<del>[1 0 0 1]</del>
<del>[0,1,1,0],</del>	<del>[0 0 0 1]</del>	<del>[0,1,1,0],</del>	<del>[1 0 0 1]</del>	<del>[0,1,1,0],</del>	<del>[1 0 1 1]</del>	<del>[0,1,1,0],</del>	<del>[1 0 0 1]</del>
<del>[0,1,0,1],</del>	<del>[0 0 0 1]</del>	<del>[0,1,0,1],</del>	<del>[1 0 0 1]</del>	<del>[0,1,0,1],</del>	<del>[1 0 1 1]</del>	<del>[0,1,0,1],</del>	<del>[1 0 0 1]</del>
<del>[0,0,1,1],</del>	<del>[0 0 0 1]</del>	<del>[0,0,1,1],</del>	<del>[1 0 0 1]</del>	<del>[0,0,1,1],</del>	<del>[1 0 1 1]</del>	<del>[0,0,1,1],</del>	<del>[1 0 0 1]</del>
<del>[1,0,0,0],</del>	<del>[0 0 0 1]</del>	<del>[1,0,0,0],</del>	<del>[1 0 0 1]</del>	<del>[1,0,0,0],</del>	<del>[1 0 1 1]</del>	<del>[1,0,0,0],</del>	<del>[1 0 0 1]</del>
<del>[0,1,0,0],</del>	<del>[0 0 0 1]</del>	<del>[0,1,0,0],</del>	<del>[1 0 0 1]</del>	<del>[0,1,0,0],</del>	<del>[1 0 1 1]</del>	<del>[0,1,0,0],</del>	<del>[1 0 0 1]</del>
<del>[0,0,1,0],</del>	<del>[0 0 0 1]</del>	<del>[0,0,1,0],</del>	<del>[1 0 0 1]</del>	<del>[0,0,1,0],</del>	<del>[1 0 1 1]</del>	<del>[0,0,1,0],</del>	<del>[1 0 0 1]</del>
<del>[0,0,0,1],</del>	<del>[0 0 0 1]</del>	<del>[0,0,0,1],</del>	<del>[1 0 0 1]</del>	<del>[0,0,0,1],</del>	<del>[1 0 1 1]</del>	<del>[0,0,0,1],</del>	<del>[1 0 0 1]</del>
<del>[0,0,0,0]</del>	<del>[0 0 0 1]</del>	<del>[0,0,0,0]</del>	<del>[1 0 0 1]</del>	<del>[0,0,0,0]</del>	<del>[1 0 1 1]</del>	<del>[0,0,0,0]</del>	<del>[1 0 0 1]</del>

Redlines  
are ones  
that didn't  
change

<del>[1,1,0,0]</del>	<del>[1,1,0,0]</del>	<del>[1,1,0,0]</del>	<del>[1,1,0,0]</del>	<del>[1,1,0,0]</del>	<del>[1,1,0,0]</del>	<del>[1,1,0,0]</del>	<del>[1,1,0,0]</del>
<del>[1,0,1,0]</del>	<del>[1,0,1,0]</del>	<del>[1,0,1,0]</del>	<del>[1,0,1,0]</del>	<del>[1,0,1,0]</del>	<del>[1,0,1,0]</del>	<del>[1,0,1,0]</del>	<del>[1,0,1,0]</del>
<del>[1,0,0,1]</del>	<del>[1,0,0,1]</del>	<del>[1,0,0,1]</del>	<del>[1,0,0,1]</del>	<del>[1,0,0,1]</del>	<del>[1,0,0,1]</del>	<del>[1,0,0,1]</del>	<del>[1,0,0,1]</del>
<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>
<del>[0,1,0,0]</del>	<del>[0,1,0,0]</del>	<del>[0,1,0,0]</del>	<del>[0,1,0,0]</del>	<del>[0,1,0,0]</del>	<del>[0,1,0,0]</del>	<del>[0,1,0,0]</del>	<del>[0,1,0,0]</del>
<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>	<del>[0,1,0,1]</del>
<del>[0,0,1,1]</del>	<del>[0,0,1,1]</del>	<del>[0,0,1,1]</del>	<del>[0,0,1,1]</del>	<del>[0,0,1,1]</del>	<del>[0,0,1,1]</del>	<del>[0,0,1,1]</del>	<del>[0,0,1,1]</del>
<del>[0,0,1,0]</del>	<del>[0,0,1,0]</del>	<del>[0,0,1,0]</del>	<del>[0,0,1,0]</del>	<del>[0,0,1,0]</del>	<del>[0,0,1,0]</del>	<del>[0,0,1,0]</del>	<del>[0,0,1,0]</del>
<del>[0,0,0,1]</del>	<del>[0,0,0,1]</del>	<del>[0,0,0,1]</del>	<del>[0,0,0,1]</del>	<del>[0,0,0,1]</del>	<del>[0,0,0,1]</del>	<del>[0,0,0,1]</del>	<del>[0,0,0,1]</del>
<del>[0,0,0,0]</del>	<del>[0,0,0,0]</del>	<del>[0,0,0,0]</del>	<del>[0,0,0,0]</del>	<del>[0,0,0,0]</del>	<del>[0,0,0,0]</del>	<del>[0,0,0,0]</del>	<del>[0,0,0,0]</del>

Change



The yellow part is a complex attractor  
0111 is a fixed point. The rest are transient

