Interactive Light Canvas of LEDs by Cellular Automata

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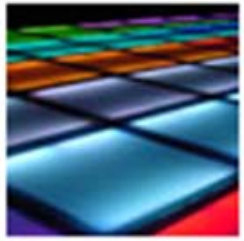
LED Lighting Installations

All Architectural Lighting Installations


111 Buckingham Palace Road


27 Knightsbridge


33 Restaurant & Lounge


Amara Beach Resort


Aspire Tower


Ben Franklin Bridge


Berkeley Homes Tower at Tabard Square


Boathouse Row


Boston Residence


Boston Symphony Hall


Brooklyn Borough Hall, Con Edison


Brunswick Zone


Caisse Des Depots Et Consignation


Capitol Mall


Casa Grijalva

“the big picture” Lighting Installation

- Xuanwu Lake Park in Nanjing, China
- 560 000 LEDs
- Italian International Light Sculpture Art Festival

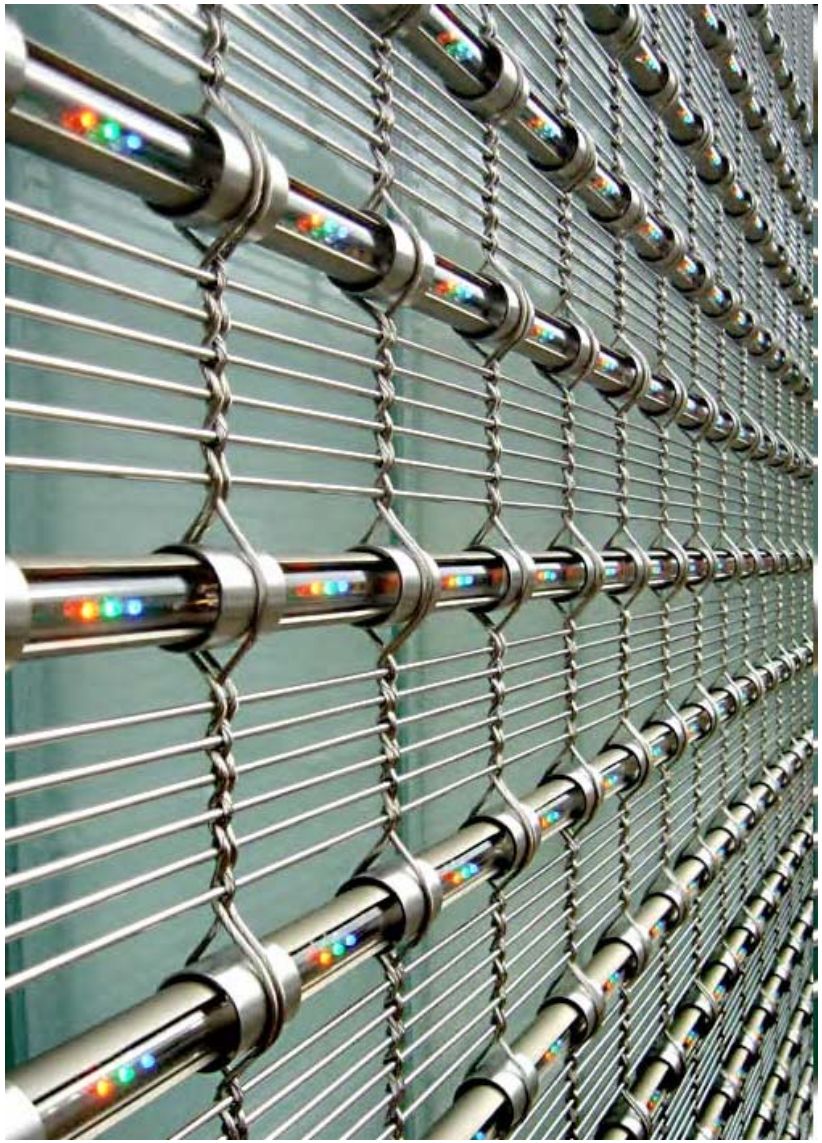
LED Light Tunnel

- National Gallery of Art in Washington DC, “LED light tunnel”
- “The custom designed software also has an element of chance built into it, so it’s unlikely that anyone will see the same routine twice.”

GreenPix, China

- GreenPix – Zero Energy Media Wall
  - uses thousands solar photovoltaic capture cells
  - an array of **computer-controlled LEDs**.
  - constructed for visitors attending the 2008 Beijing Olympics,
  - located in the Xicui entertainment complex, near the site of the games.

The Grand Indonesia Tower (Jakarta, Indonesia.)



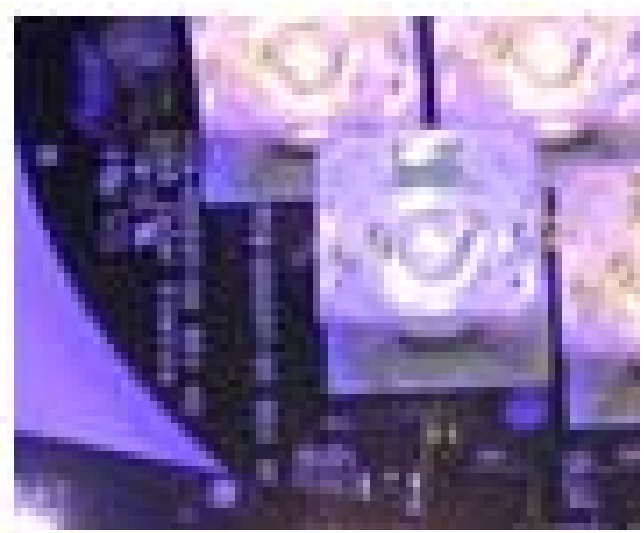
Power Station, Brussels

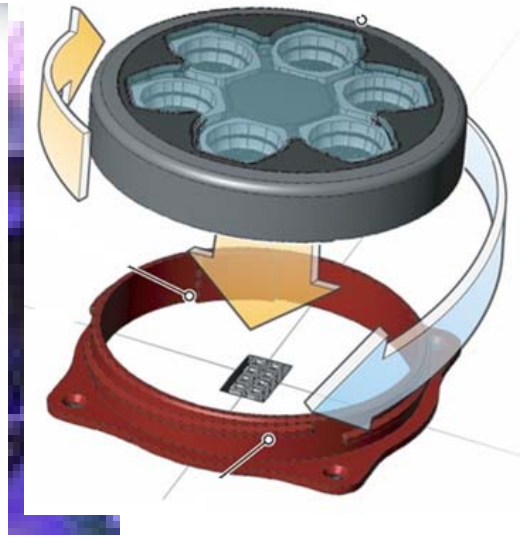
Rockefeller Center, NY

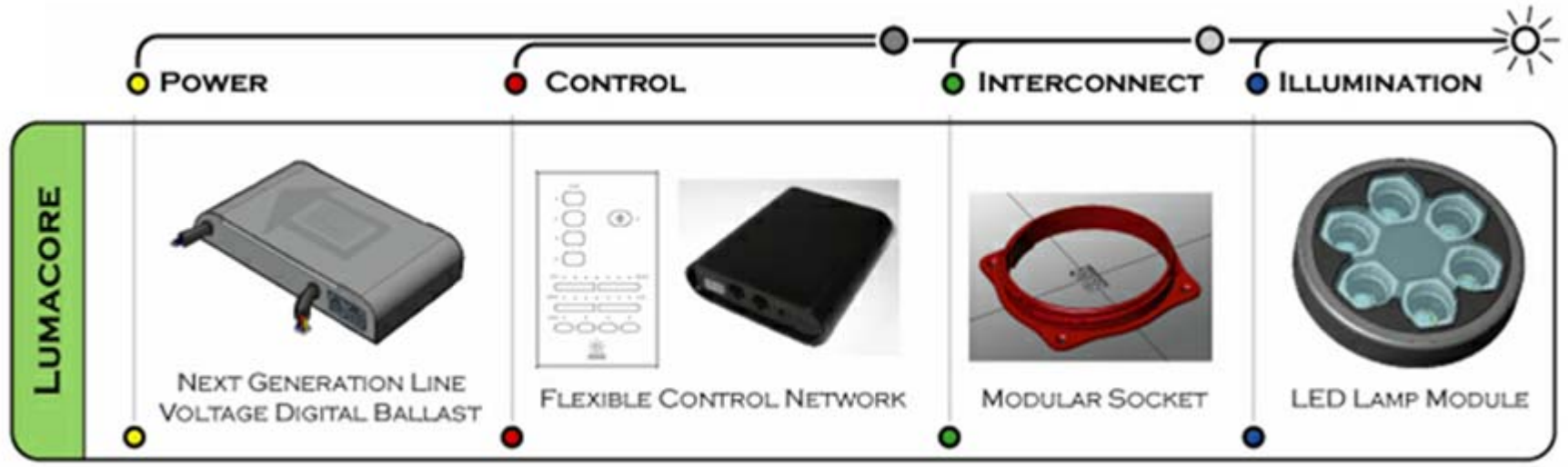
More

Further more

LED Lighting System





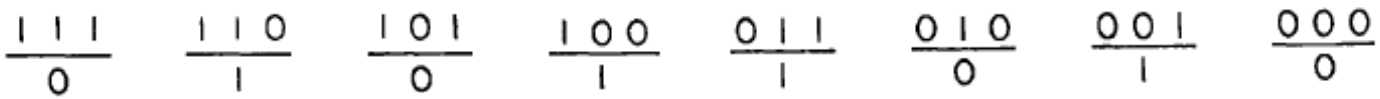


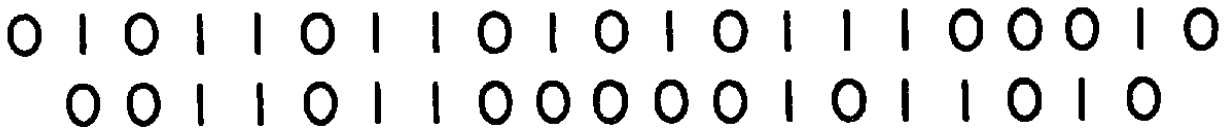
Characteristics of Cellular Automata (CA)

- They consist of a discrete lattice ("array") of sites ("cells")
- They evolve in discrete time steps
- Each site takes on a finite set of possible values
- The value of each site evolves, simultaneously, according to the same deterministic rules
- The rules for the evolution of a site depend only on a local neighborhood of sites around it.

1-dimension CA example

- Elementary CA:
  - Site values: 1 or 0 (“base 2”)
  - “neighborhood”: the site itself and the sites immediately adjacent to it on the left and right
- **Modulo 2 rule case**
  - A rule: Sum modulo 2 of its two neighbors



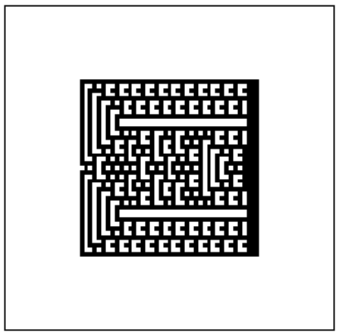


General rules for 1-dimension CA example

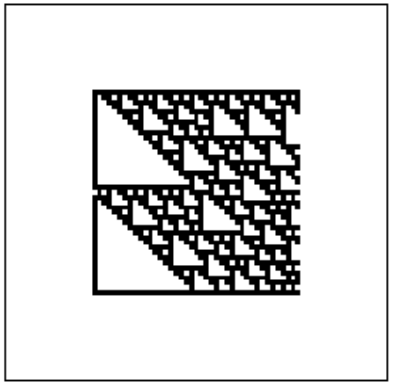
- A rule is described by 8-digit binary numbers

111	110	101	100	011	010	011	000
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	0
.....							
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0

- There are 2^8=256 possible distinct CA rules



y_{FRAME}

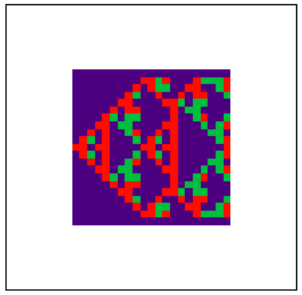


y_{Ts}

1-dim CA with 3 site values (0,1,and 2)

- A Simple Rule

SUM: 6 5 4 3 2 1 0
x_{t+1} : 2 1 0 1 2 1 2 (Example)



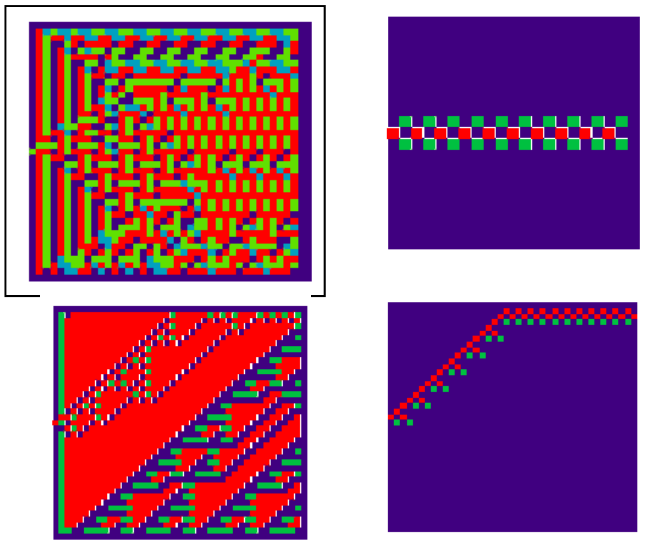
y_{Ts}

- General Rules

222 221 220 212 211 210 202 201 200 122 121 120 112 111 110 102 101 100 022 021 ...

2 2 2 2 .....
.....
0 0 0 0

If we ignore the current site's status in the rule formation, it reduces to:
22 21 20 12 11 10 02 01 00 (9 kinds)
2 2 2 2 2 2 2 2 2
0 0 0 0 0 0 0 0 0
Then, there are only 3^9 = 19683 possible rules.



1-d CA with 4 site values (0, 1, 2, and 3)

- General Rule

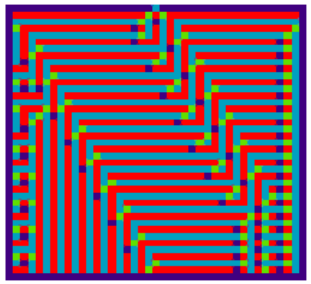
If we ignore the current site's status in the rule formation, it reduces to:

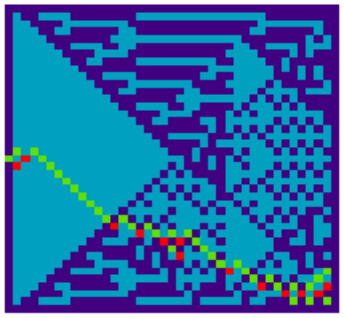
33 32 31 30 23 22 21 20 13 12 11 10 03 02 01 00 (16 kinds)

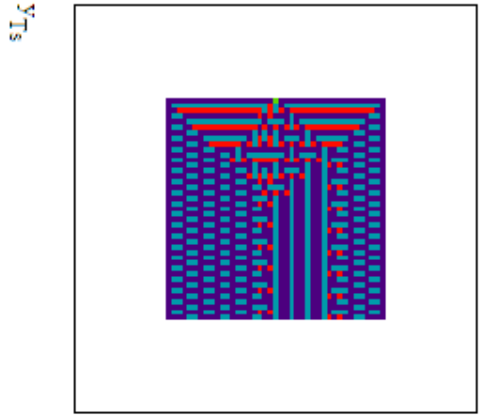
3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Then, there are only 4^16 is close to 4.3 billion possible rules.

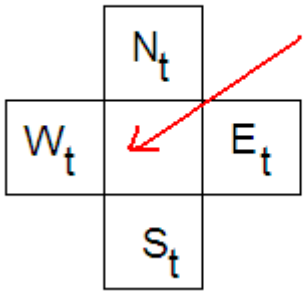






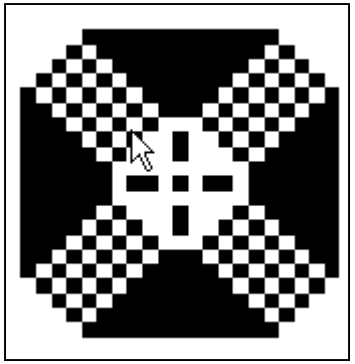
2-dim CA with 2 possible values (0,1)

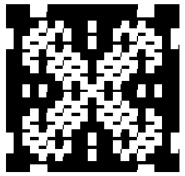
- **Simple rule by Sum:**

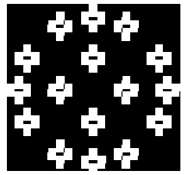


$State_{t+1}$

```
for xx ∈ 0..N
  for yy ∈ 0..N
    SUM ← West_xx,yy + East_xx,yy + North_xx,yy + South_xx,yy
    ZZ_xx,yy ← 0
    ZZ_xx,yy ← 1  if  SUM = 0 ∨ SUM = 3
x_t+1 ← ZZ
```



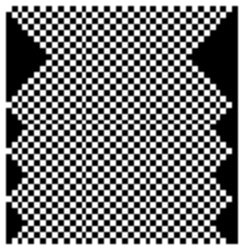


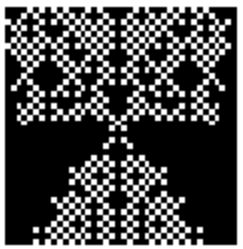


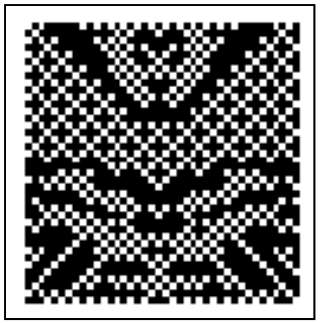
- **General Rules**

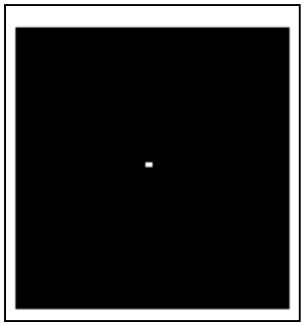
Therefore, there are: 2^16 rules (=65536 rules)

1111	1110	1101	1100	1011	1010	1001	1000	0111	0110	0101	0100	0011	0010	0001	0000
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

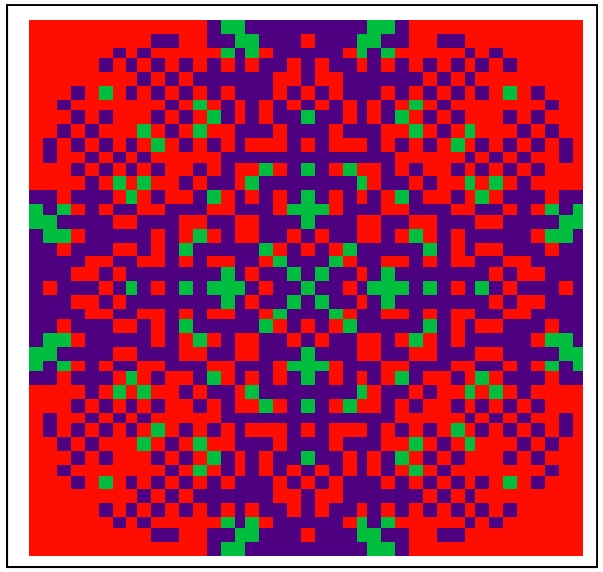


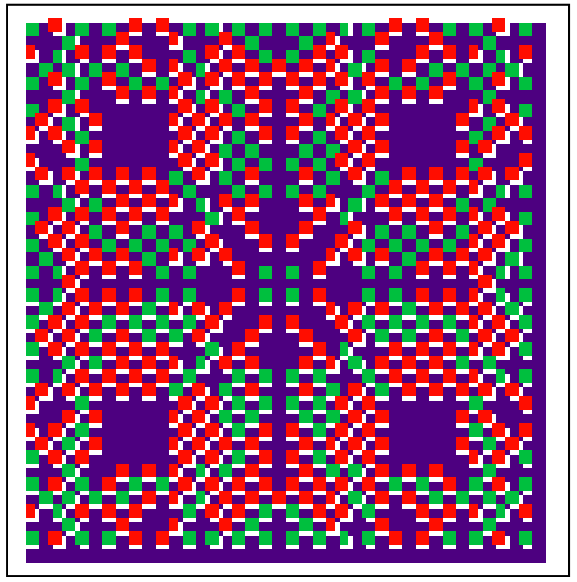


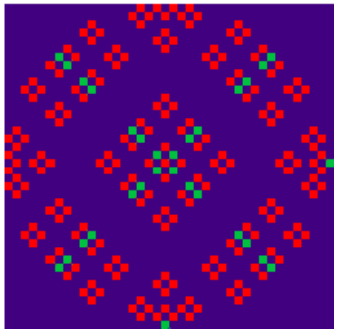


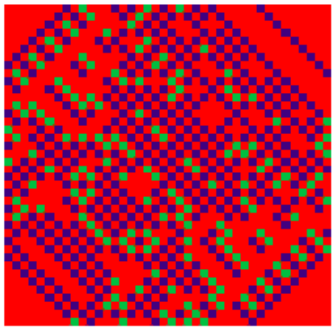


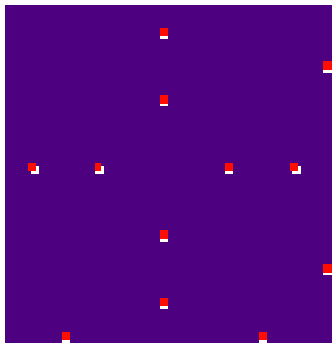
2-dim CA with 3 values (0,1,2)

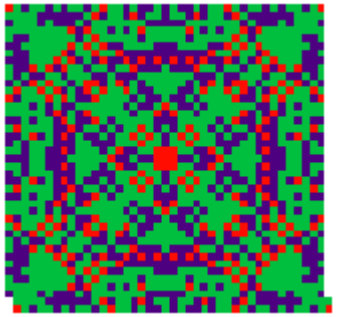








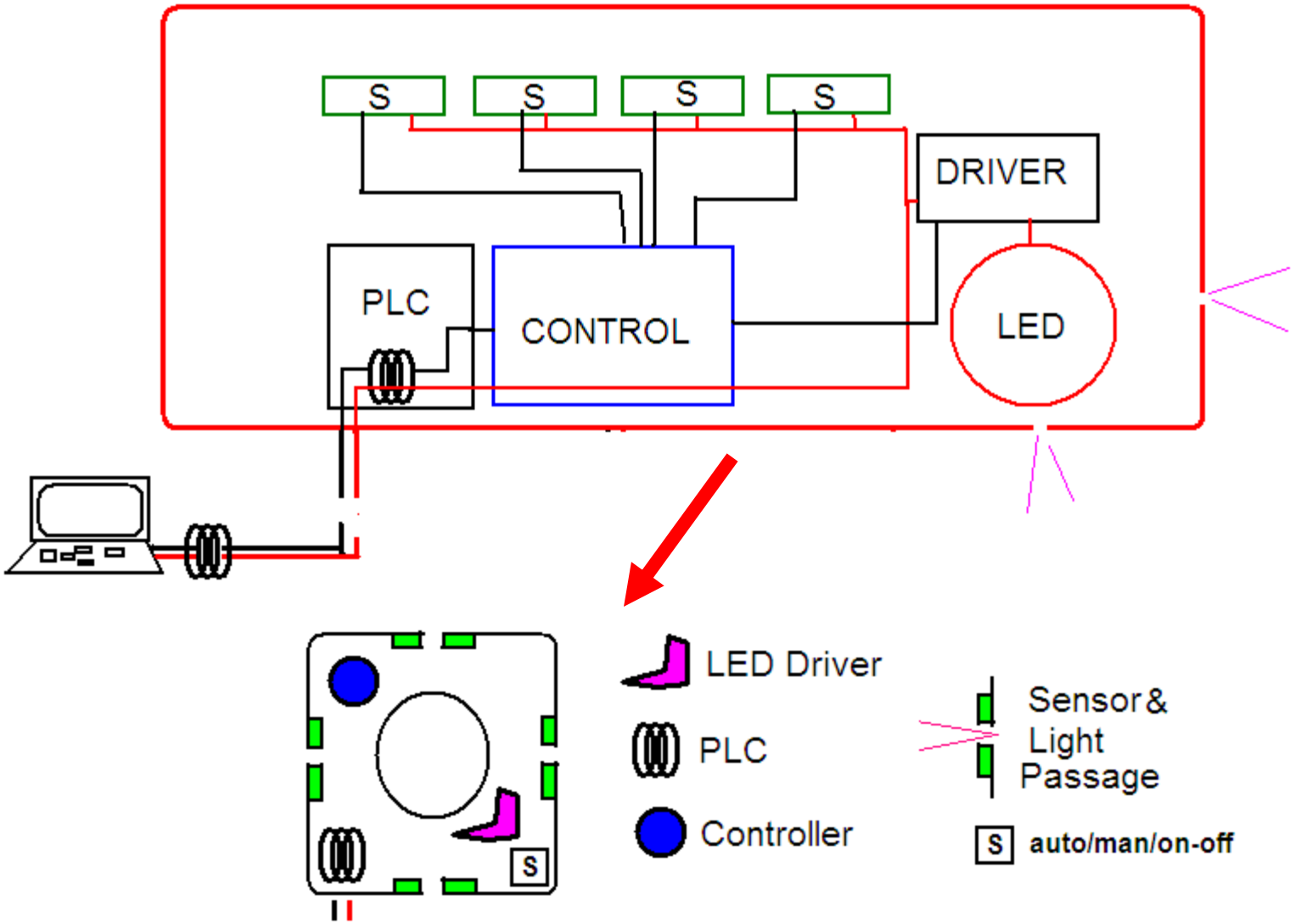




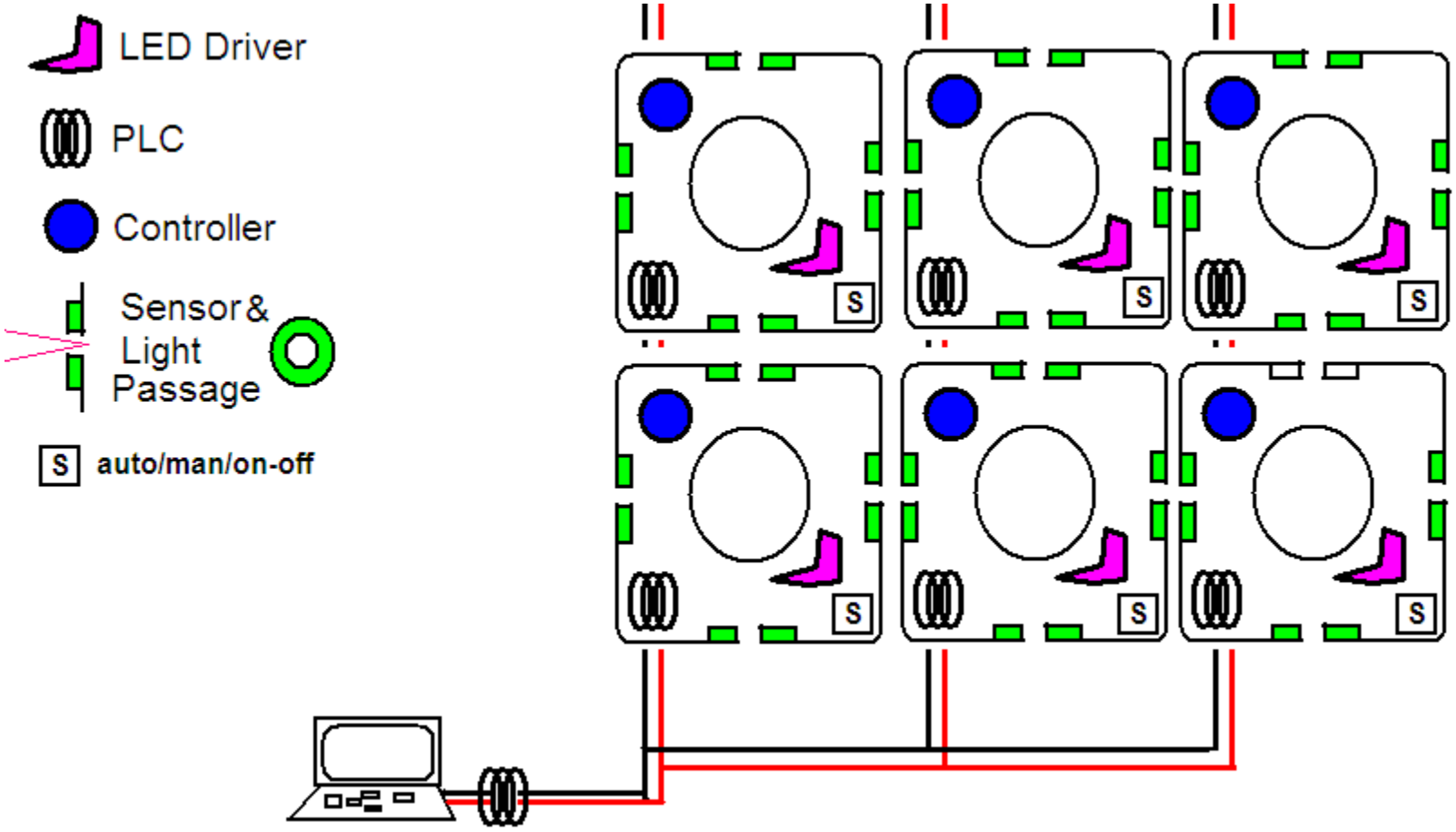
CA Implementation for LED Array Control

- **What are needed?**
- **1. Rule Generation and Execution and Synchronization**
  - Microcomputer
- **2. Rule Change and Rule Broadcast to all (without using control wire)**
  - Power Line Carrier Modem (communication over the DC line which powers LEDs)
- **3. Detection and Recognition of Neighbors**
  - Photo/Color Sensors
  - Power Line Communication Modem for Sensor-less Approach – Communication is used to know the status of neighbors
- **Components Needed in each LED Fixture**
- 1. LED and LED driving circuit (LED fixture)
- 2. Microprocessor
- 3. Power Line Carrier Modem
- 4. Photo/Color Sensors (optional)

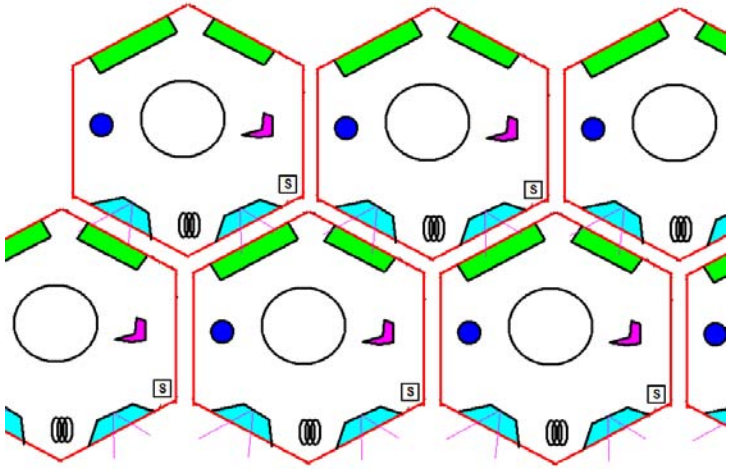
Schematics for one LED Lighting Unit (Color Sensor Option)



2-dim CA Implementation Schematics (Color Sensor Option)

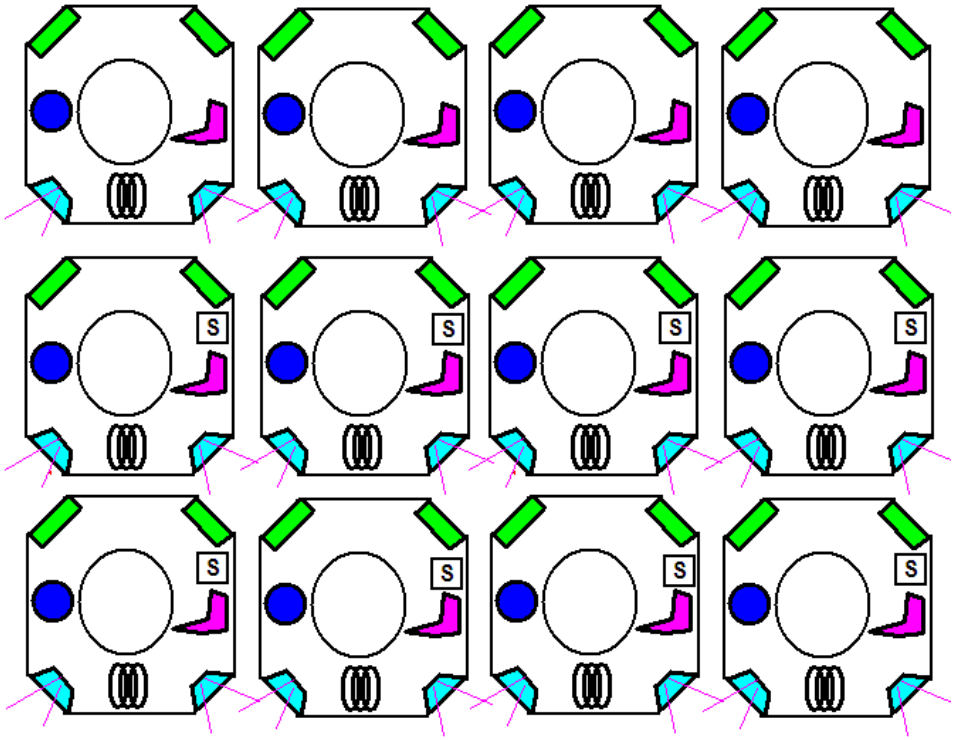


1-dim CA Implementation Schematics (Color Sensor Option)

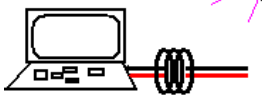


Hexagon Shape

Square Shape

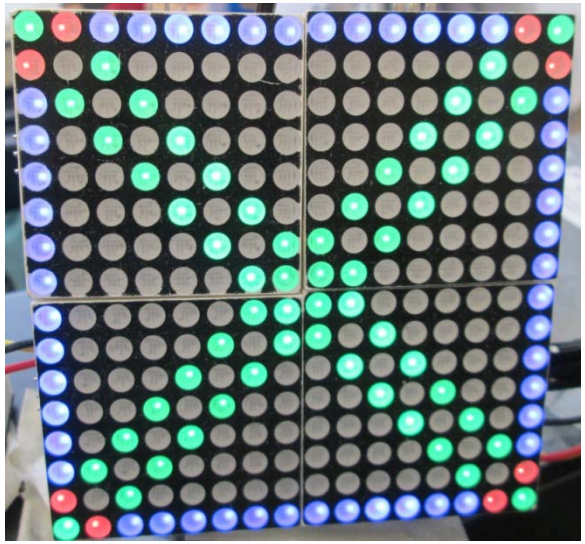
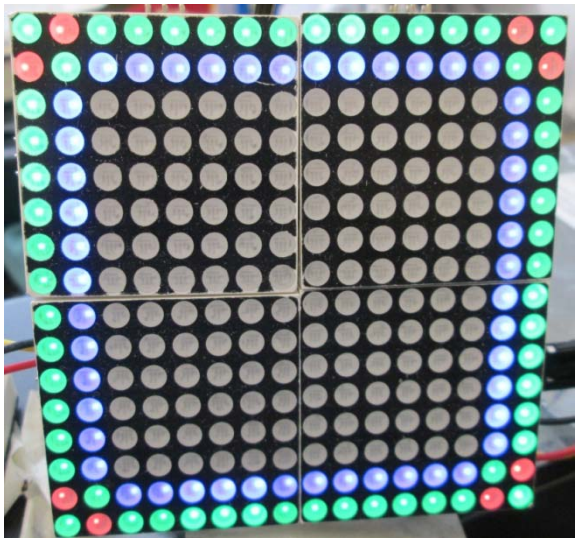
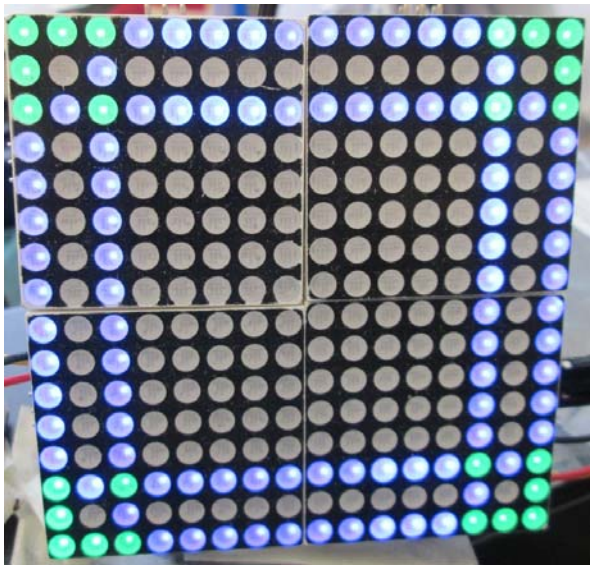
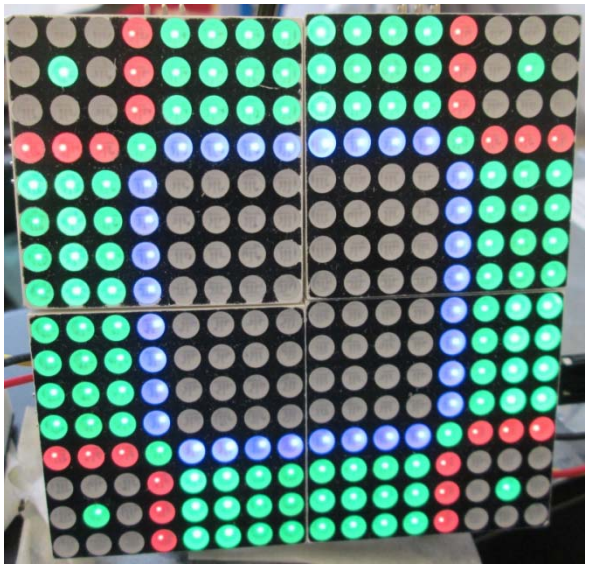
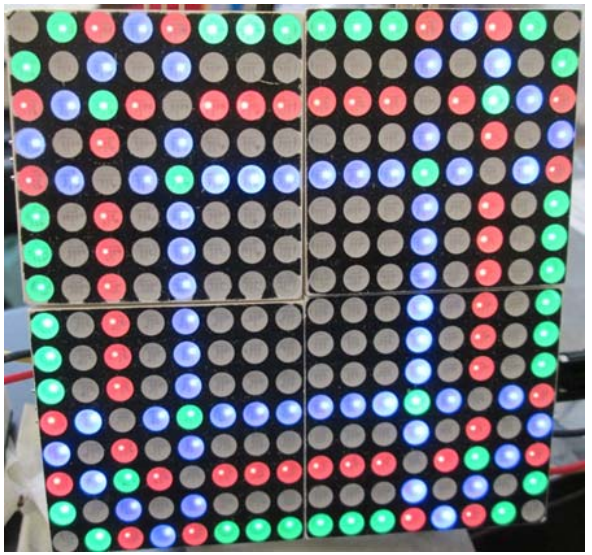


- **Sensors** upward, and **Light-Passage** downward



S auto/man/on-off

Pattern Transition Simulation Example

Applications

- Architectural Lighting
  - No heavy and bulky wires
  - No heavy structures for the wires/controllers, nor controllers
- Light Artist Community
- Advertisement and Signage Lighting
  - Advertisement and customer attraction
  - Special events
- Design Pattern Code Generation (similar to Smartphone App's) for Light Installers and Manufacturers and Artists

- Interactive 5-side light canvas
- People can select Cellular Automata rules for the canvases via Bluetooth communication
- Good engagement