BOUNDARY CONDITIONS IN CONWAY'S GAME OF LIFE

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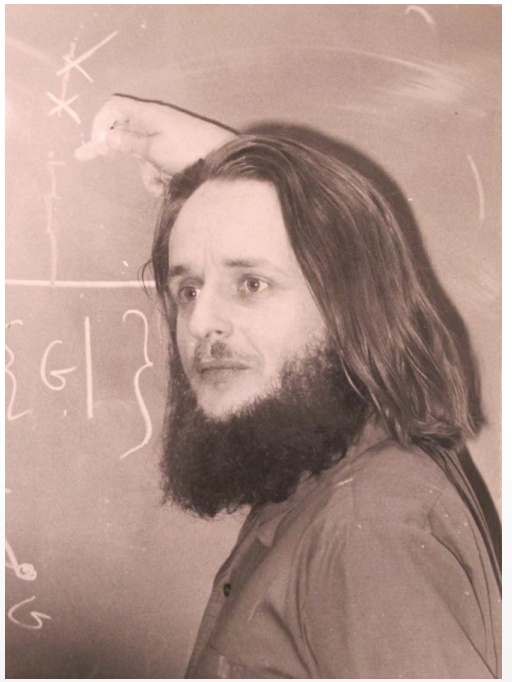
Conway's Game of Life (1970)

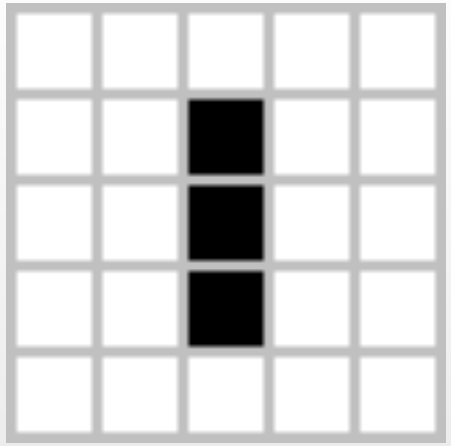
- A set of rules governing pixels on a grid
- These rules lead to patterns whose evolution is strikingly reminiscent of real life!
- Has led physicists to speculate that the "laws of nature" are not fundamental, but simply approximations to a deeper set of Conway-like rules on an underlying "spacetime grid"
- Are we living in the matrix?



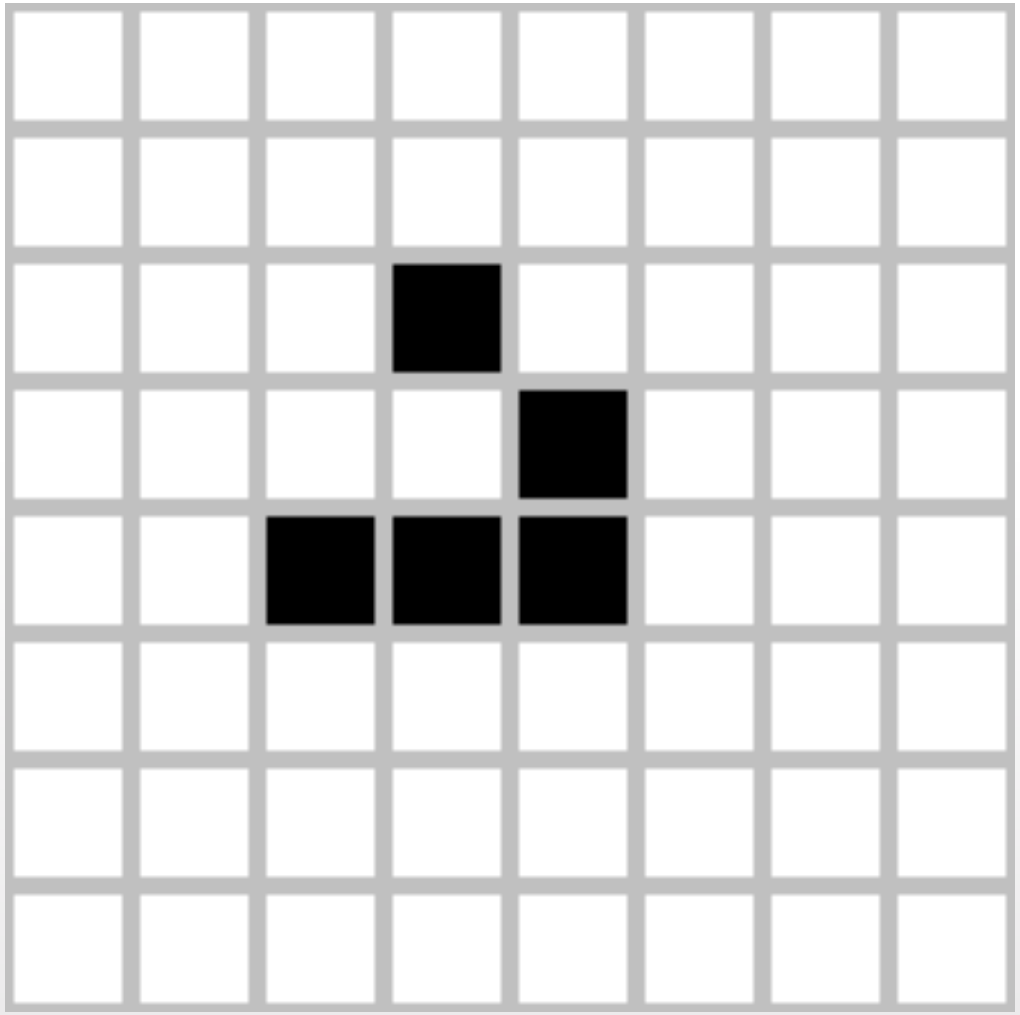
John Conway Circa 1969

Rules

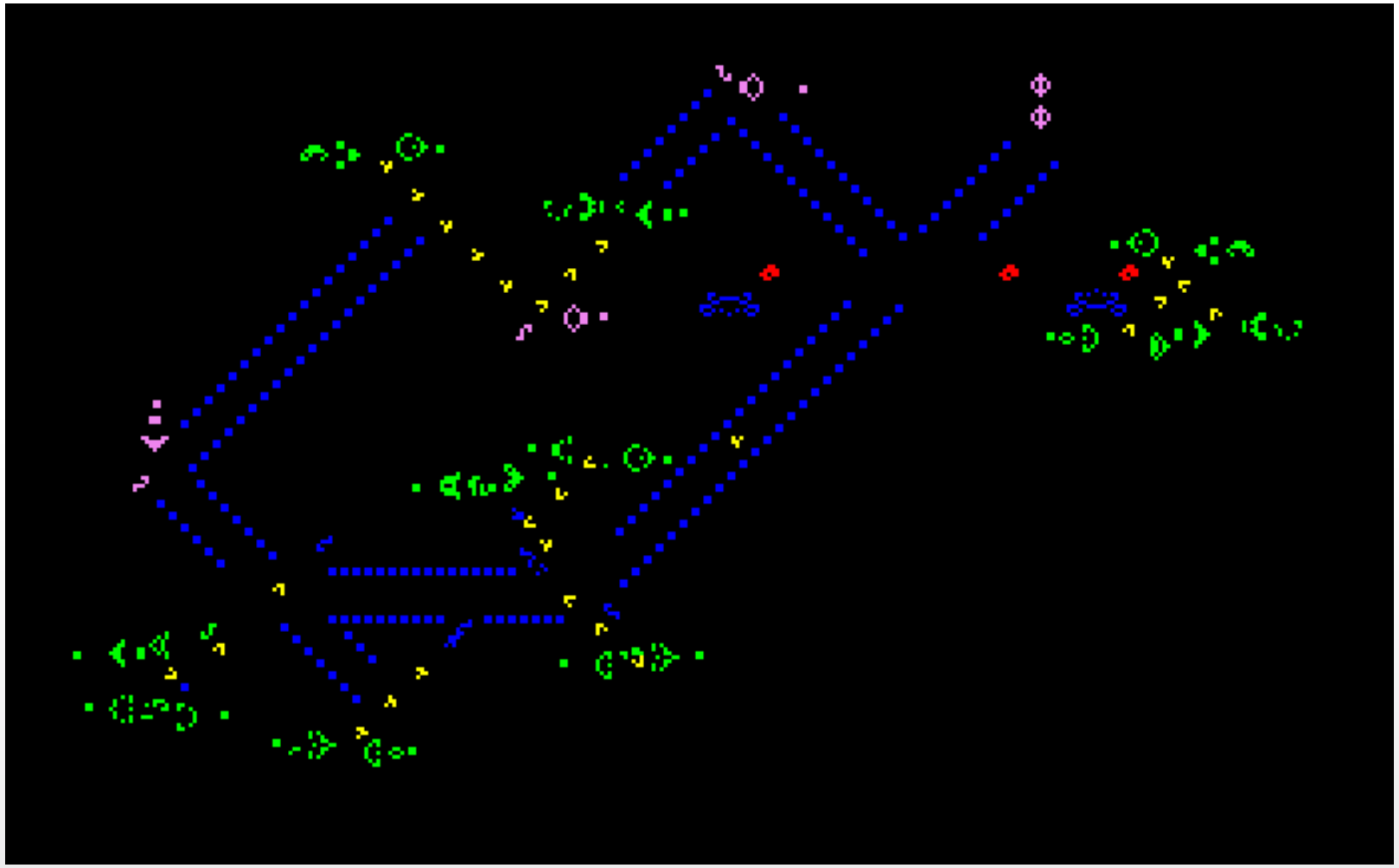
1. Any nonliving cell with 3 neighbors becomes alive next time step **(Birth)**
2. Any living cell with 2-3 live neighbors survives to the next time step **(Survival)**
3. Any living cell with > 3 live neighbors dies next time step **(Overpopulation)**
4. Any living cell with < 2 live neighbors dies next time step **(Underpopulation)**



Glider Example

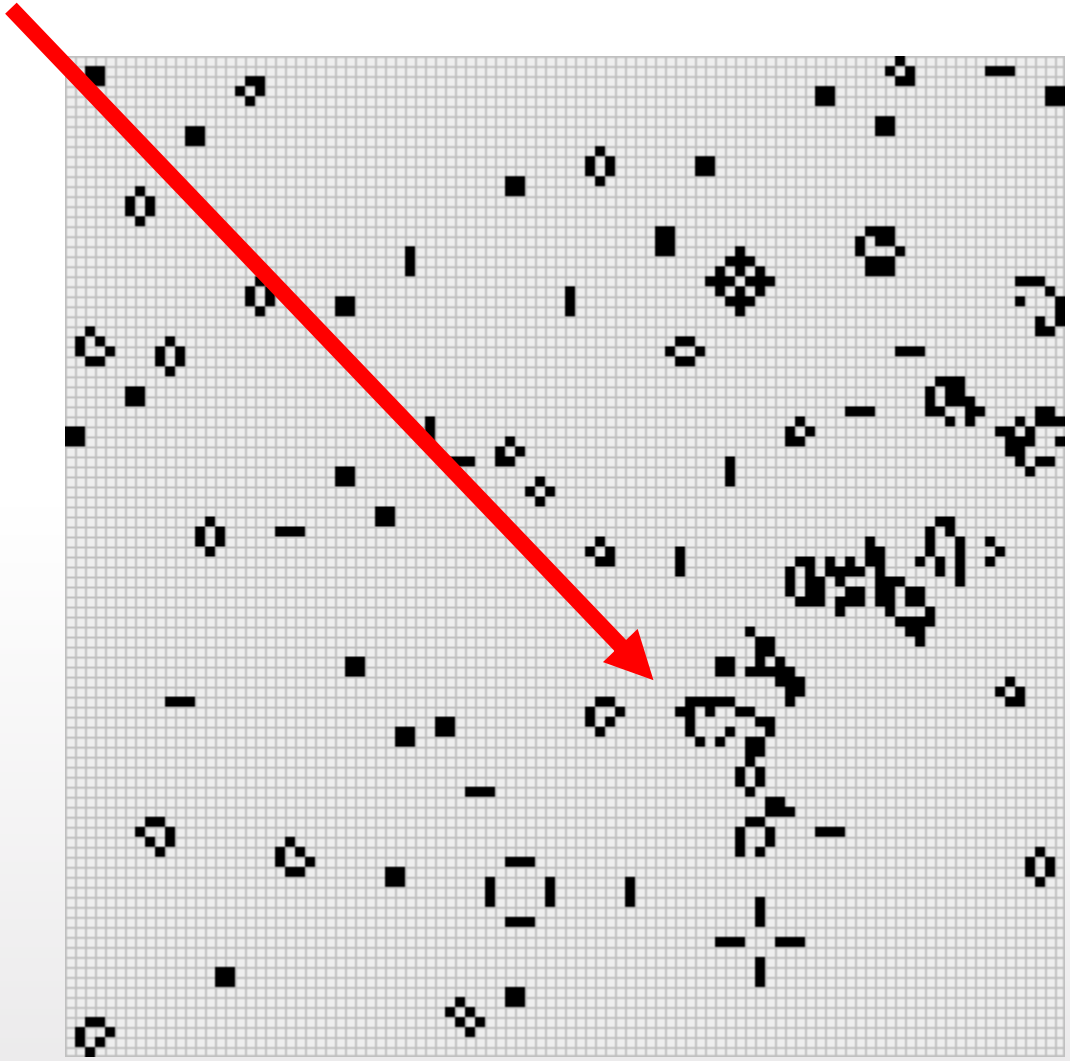


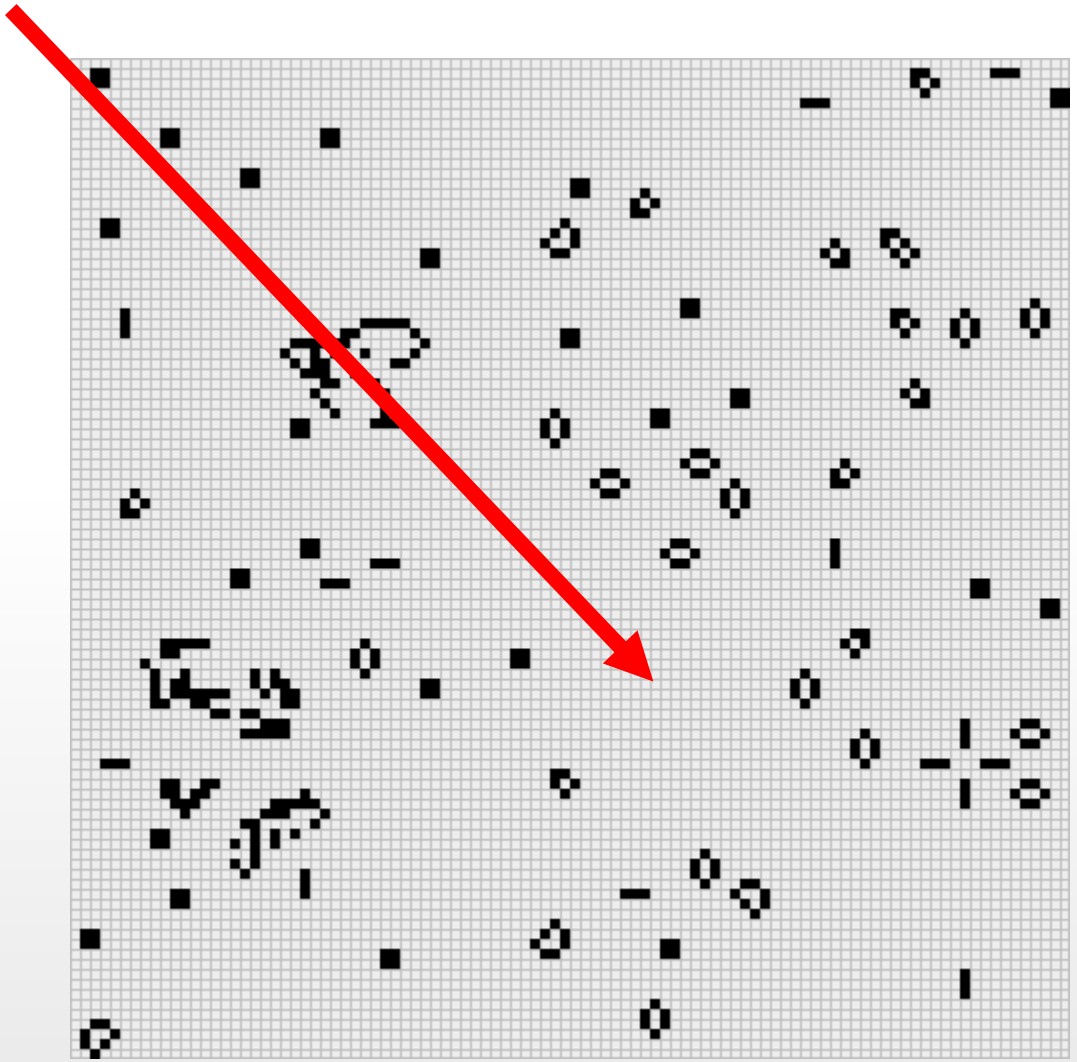
Slightly More Complicated Example



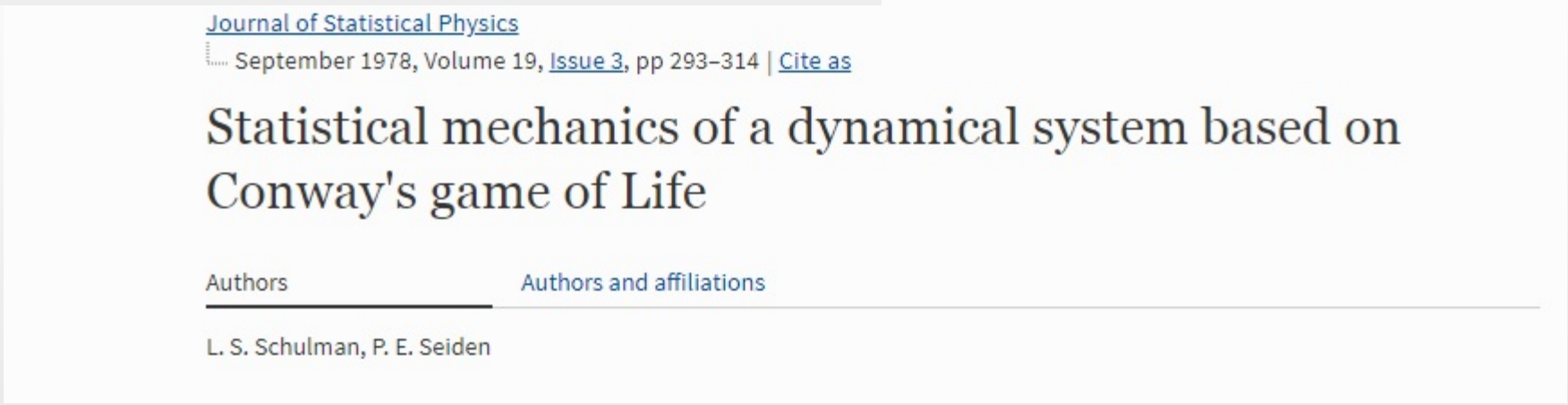
Racetrack (Featured Picture, Wikimedia Commons, February 6, 2011)

Small Variances Lead to Large Changes



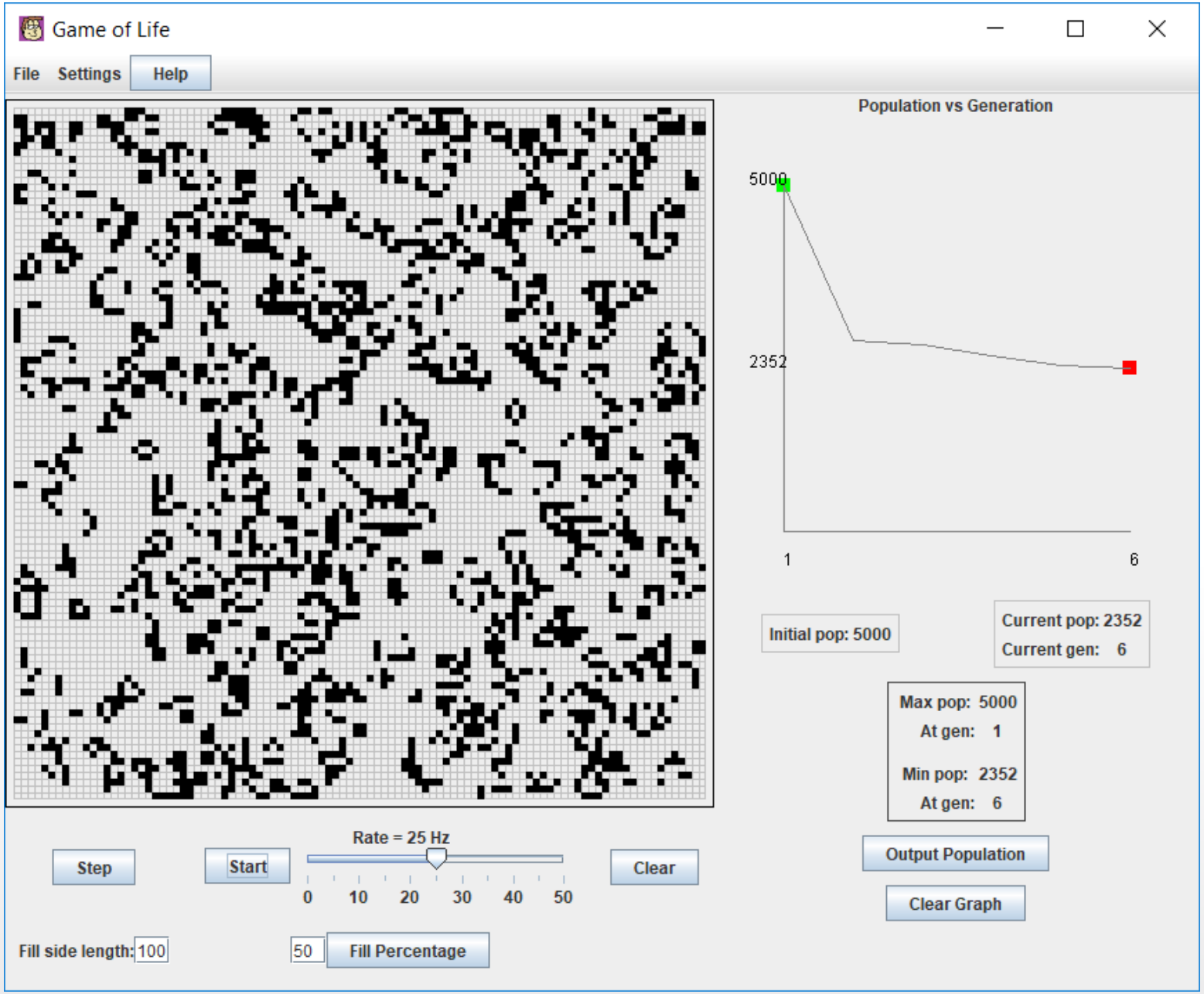


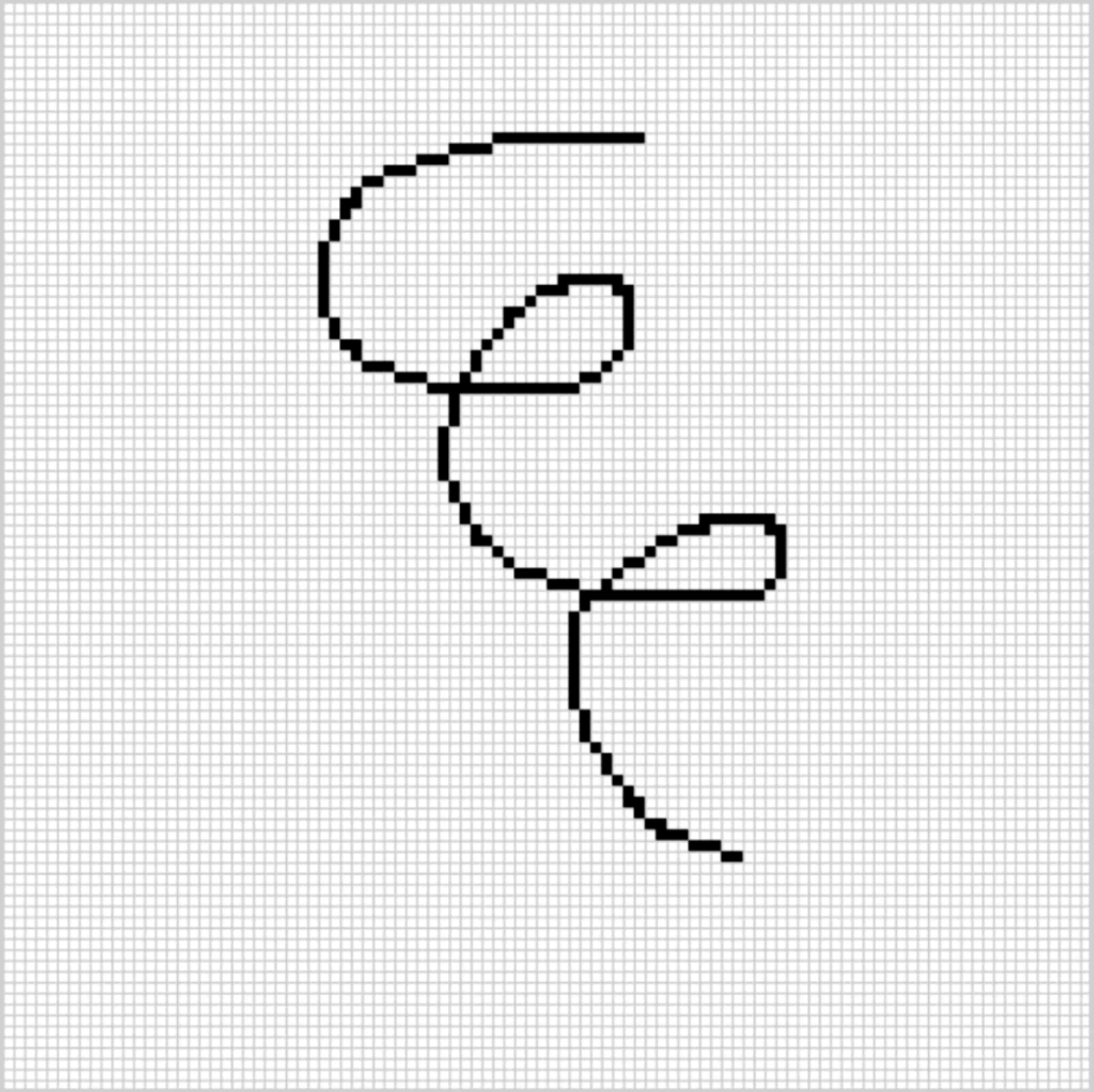
People Actually Study This?

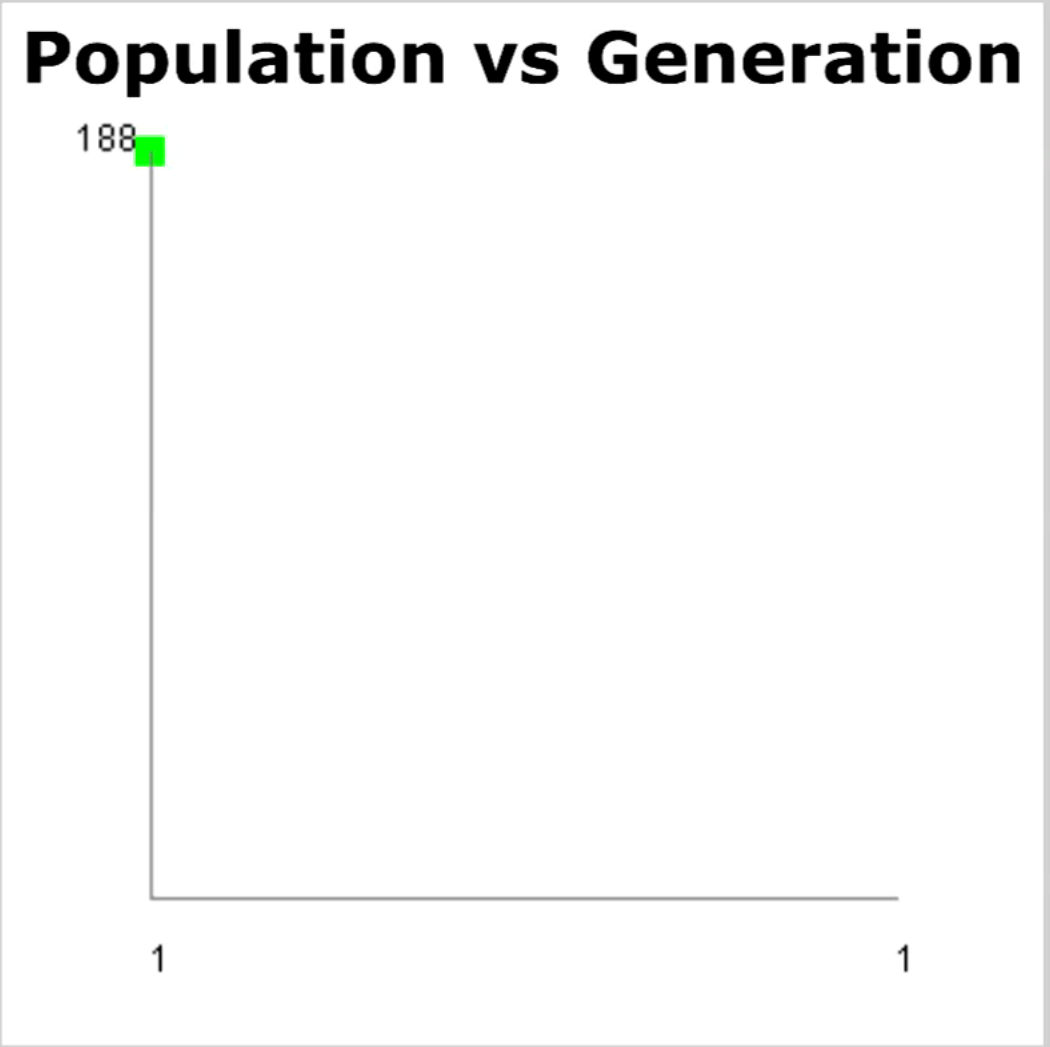


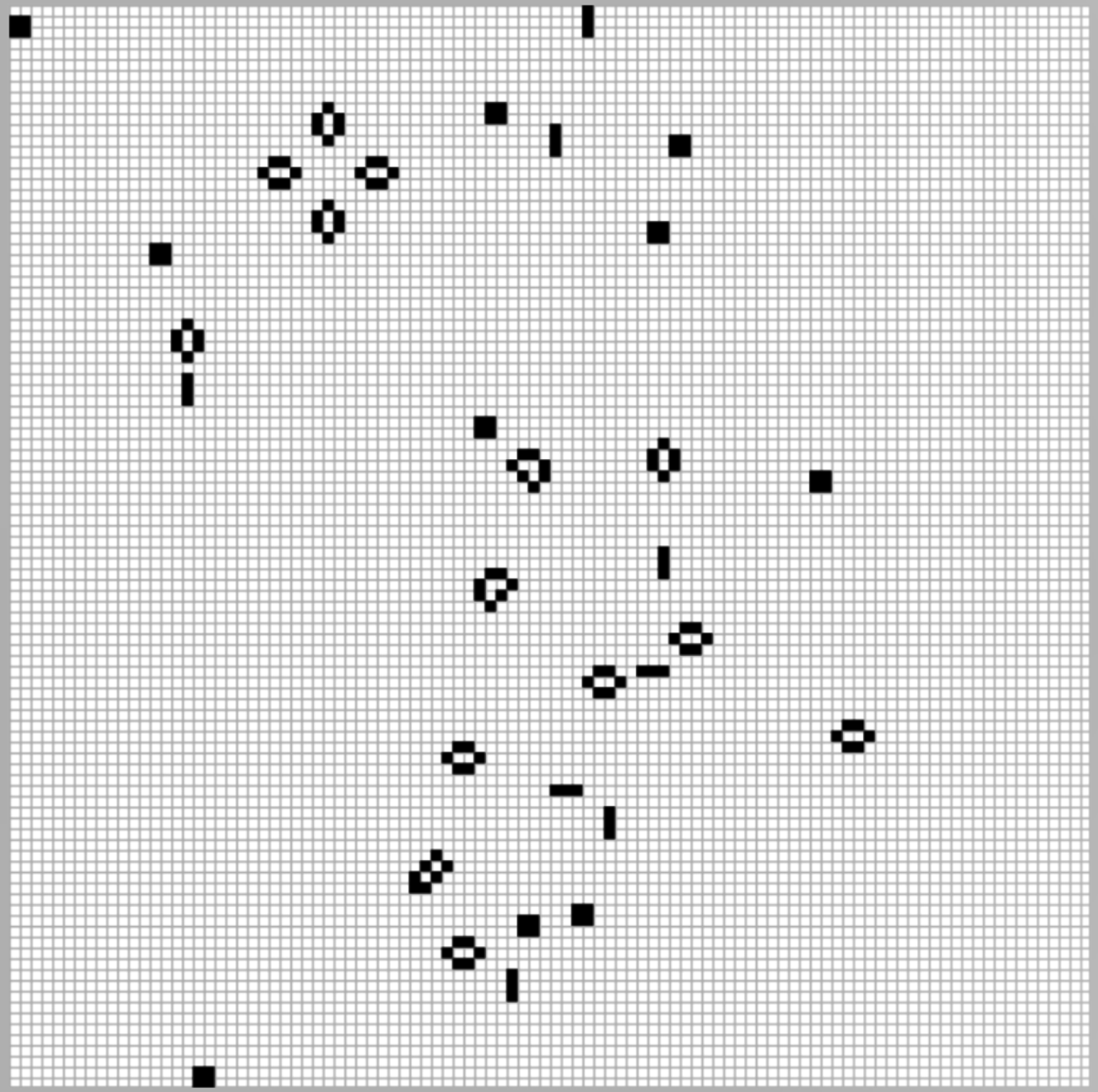
Implementation

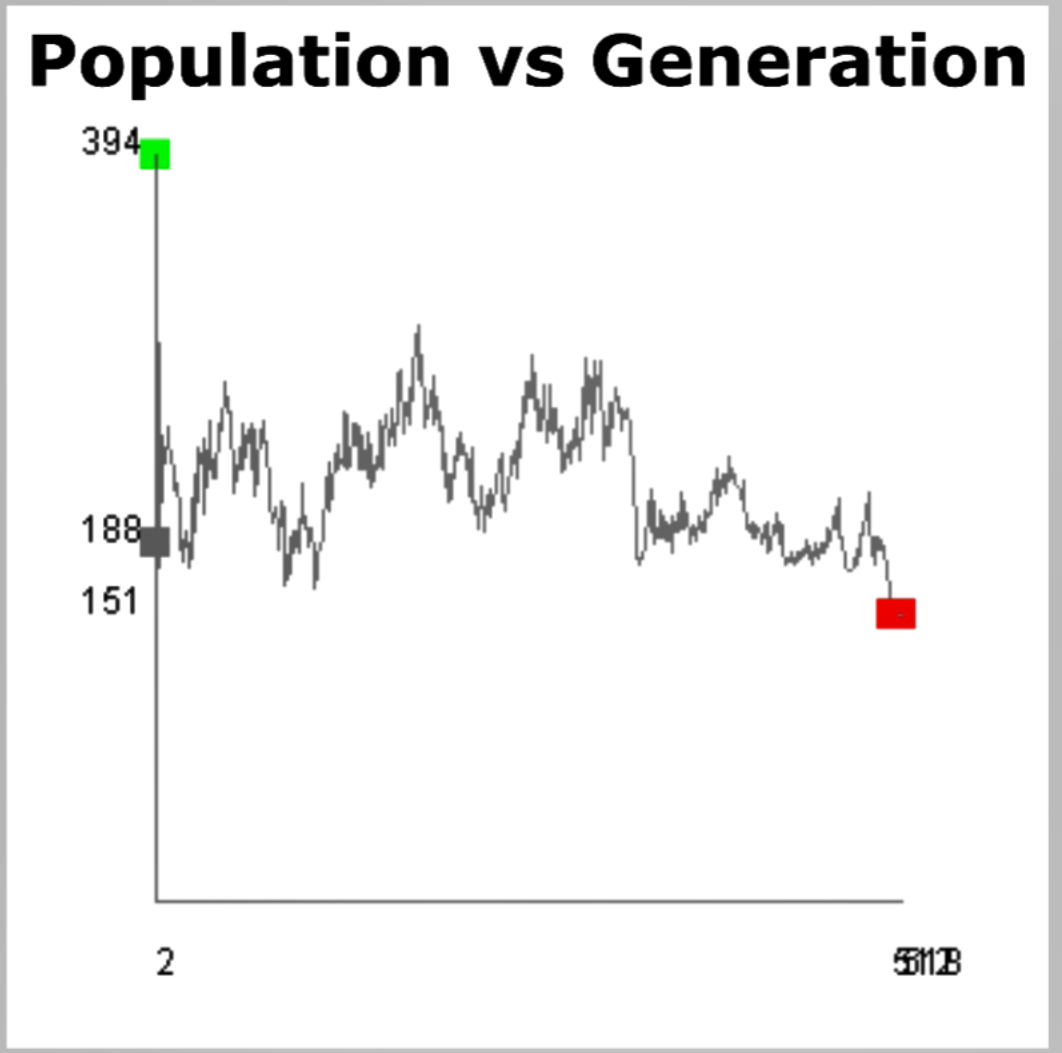
- Java-based program
- Features:
  - Graphical display
  - Population graph
  - Fill fraction
  - Resizable






Population vs Generation
188
1
1

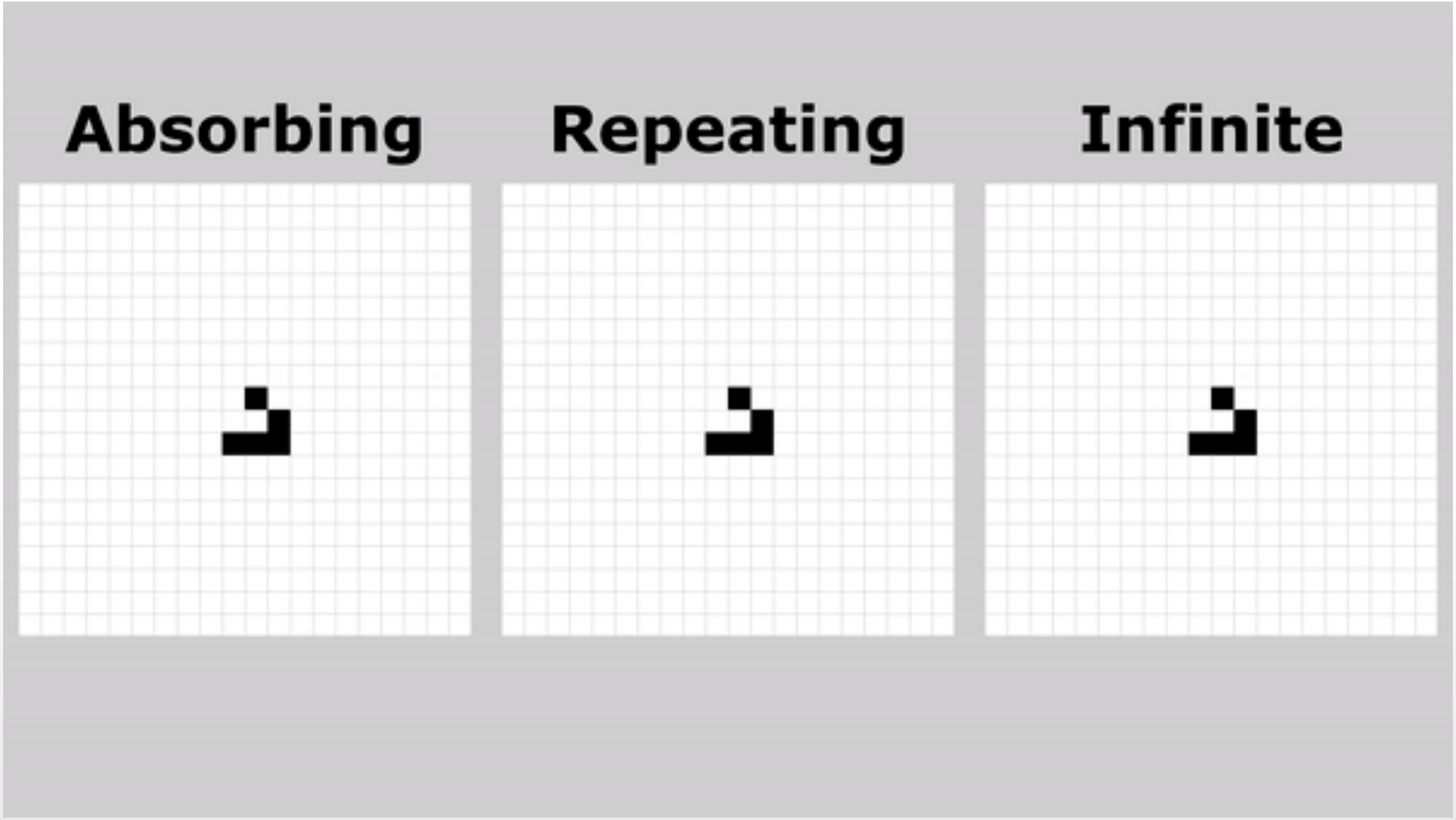



Population vs Generation
394
188
151
2
5112

Questions?

- After many generations, population tends to reach a terminal limit
- What factors affect this terminal limit?
  - Grid size
  - Fill fraction
  - Boundary conditions
  - Fractal dimension (measure of roughness)
- How to relate to entropy and the Second Law of Thermodynamics?

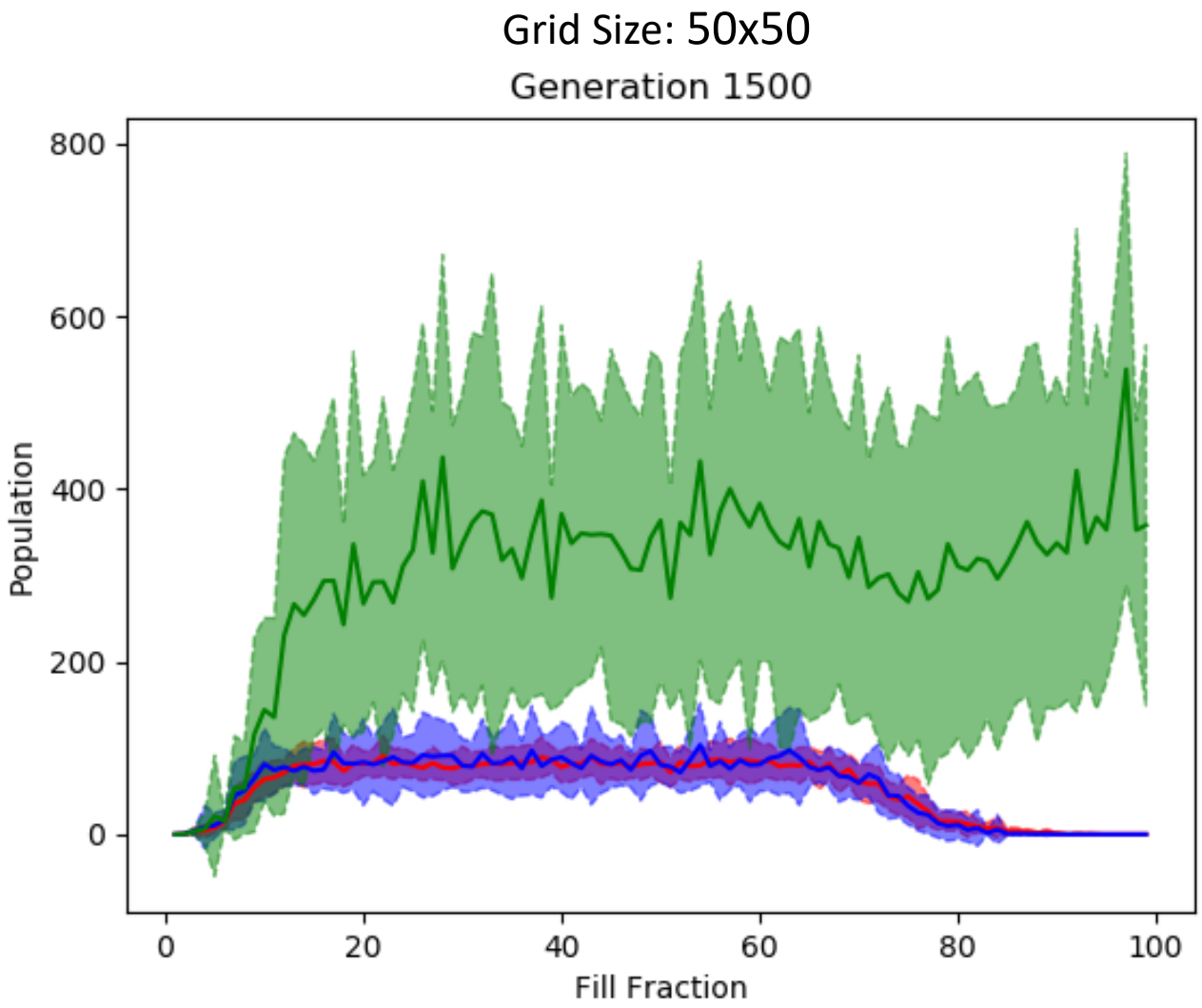
Boundary Conditions



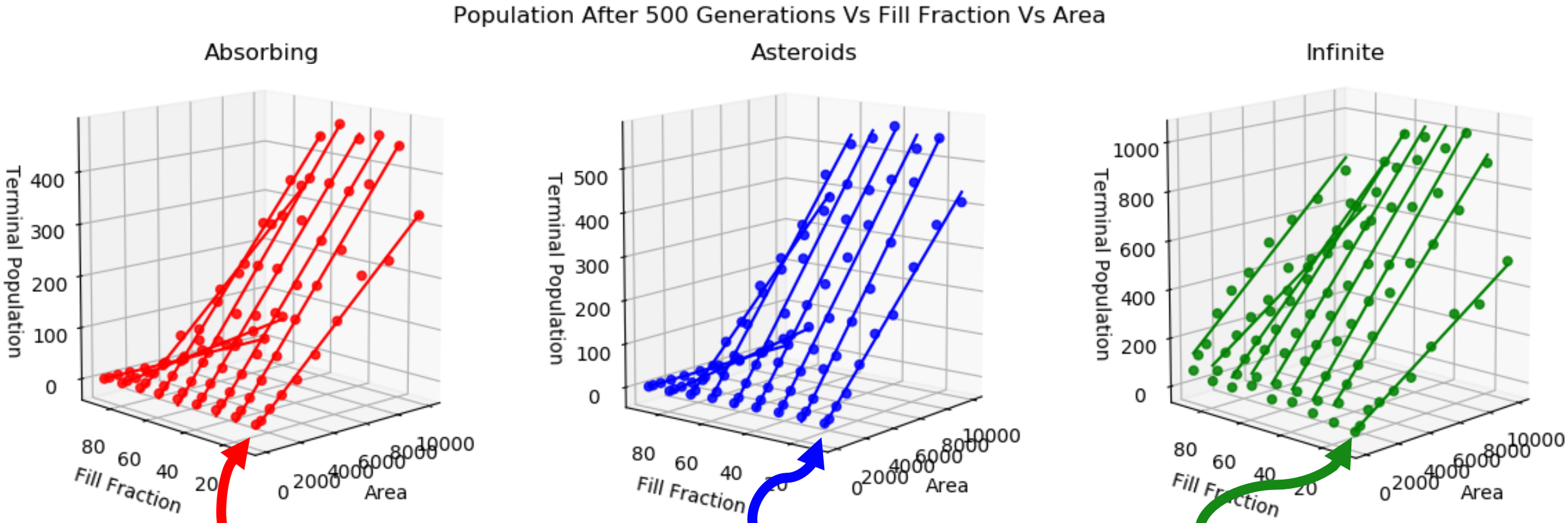
How Did We Collect Data?

- Automated data collection
- Collected population data after varying:
  - Grid size
  - Fill fraction
  - Boundary condition
- Averaged data of 30 trials of each configuration
  - Over 31 hours spent collecting data

Link Between Fill Fraction and Population?



Equation For Terminal Population?



z = 0.03298 * Area - 7.856
r^2 = 98.04%

z = 0.04379 * Area - 6.694
r^2 = 99.11%

z = 0.04850 * Area + 7.276
r^2 = 99.08%

Open Questions

- Population reached a maximum at ~40% fill fraction
- Population appeared symmetrical about maximum
- Why is there so little difference between absorbing and repeating boundary conditions?
- Thought differences between terminal populations of absorbing/repeating and infinite would decrease as grid size increased
  - Effect of BCs = C/A = 4/L

Future Work

- Additional ways to describe state
  - Fractal dimension
  - Number of connected life forms
- Game of Life in higher dimensions
- Definitions of entropy

Thanks to the Maryland Space Grant Consortium for support!