

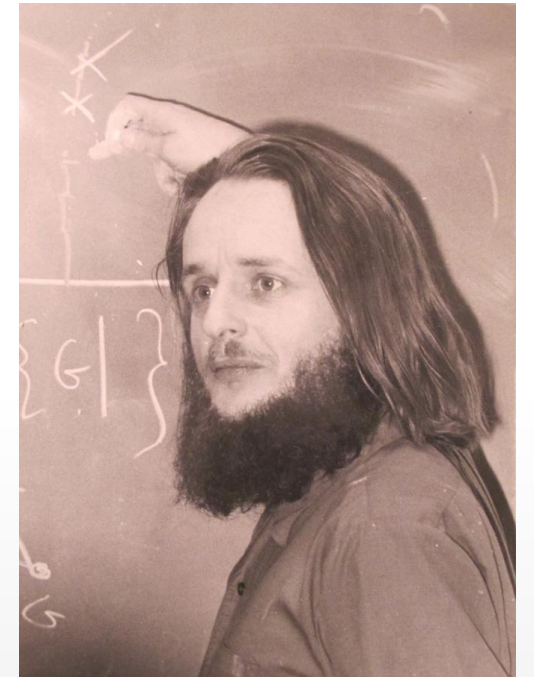
BOUNDARY CONDITIONS IN CONWAY'S GAME OF LIFE

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MENTOR: JAMES OVERDUIN

Conway's Game of Life (1970)

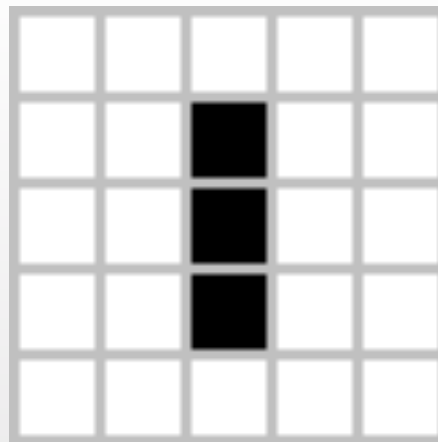
- A set of rules governing pixels on a grid
- These rules lead to patterns whose evolution is strikingly reminiscent of real life!
- Has led physicists to speculate that the “laws of nature” are not fundamental, but simply approximations to a deeper set of Conway-like rules on an underlying “spacetime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



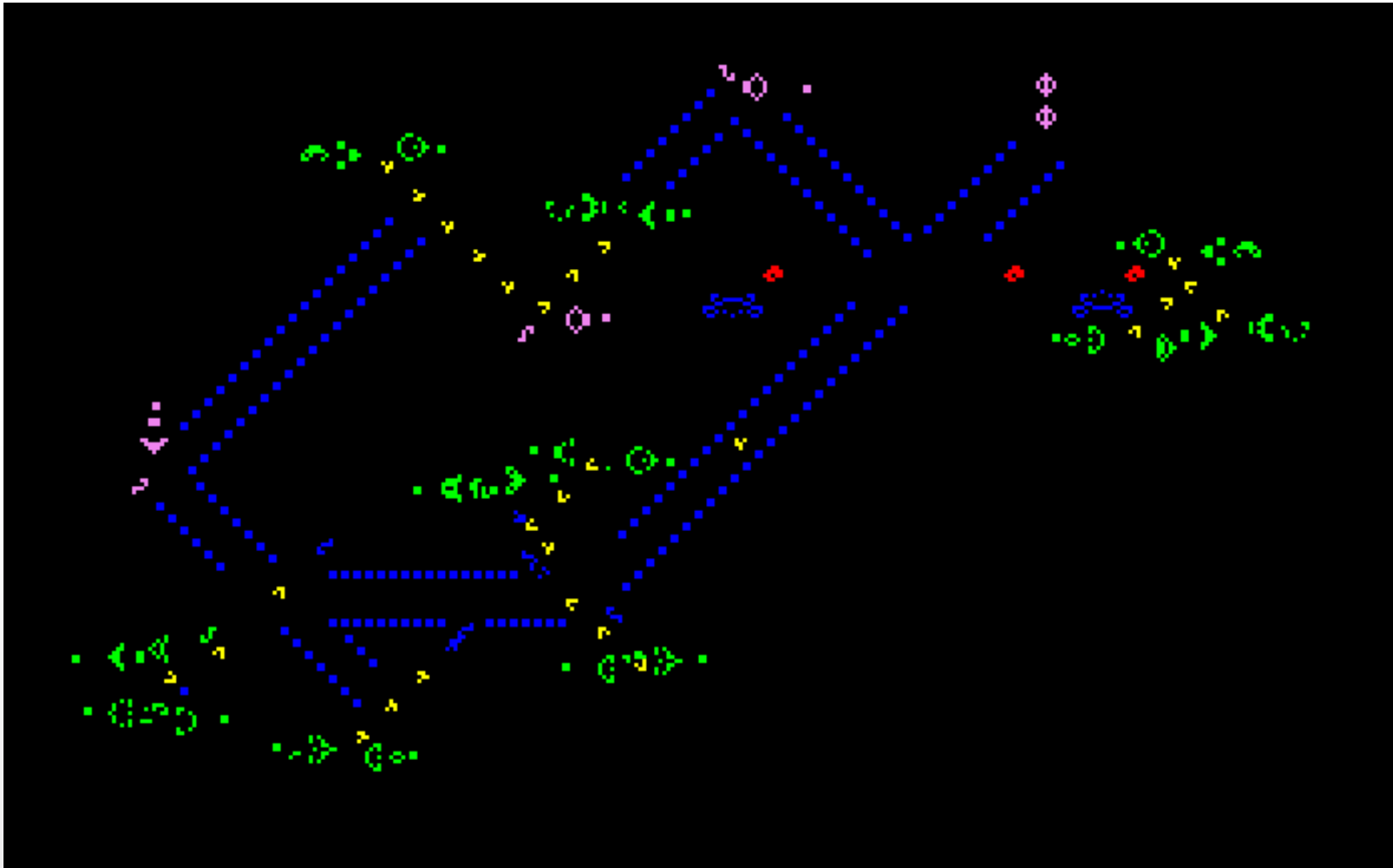
John Conway Circa 1969

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**)

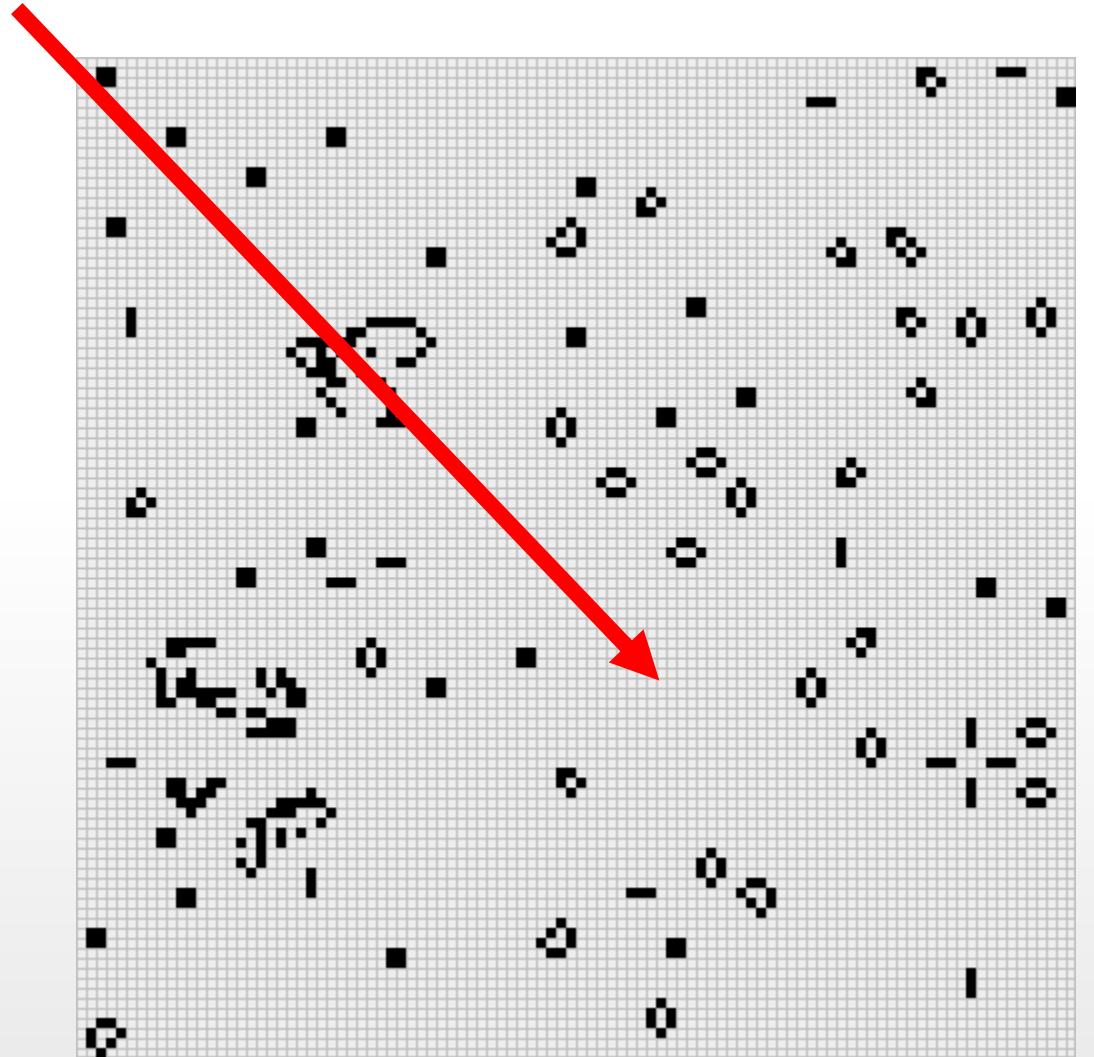
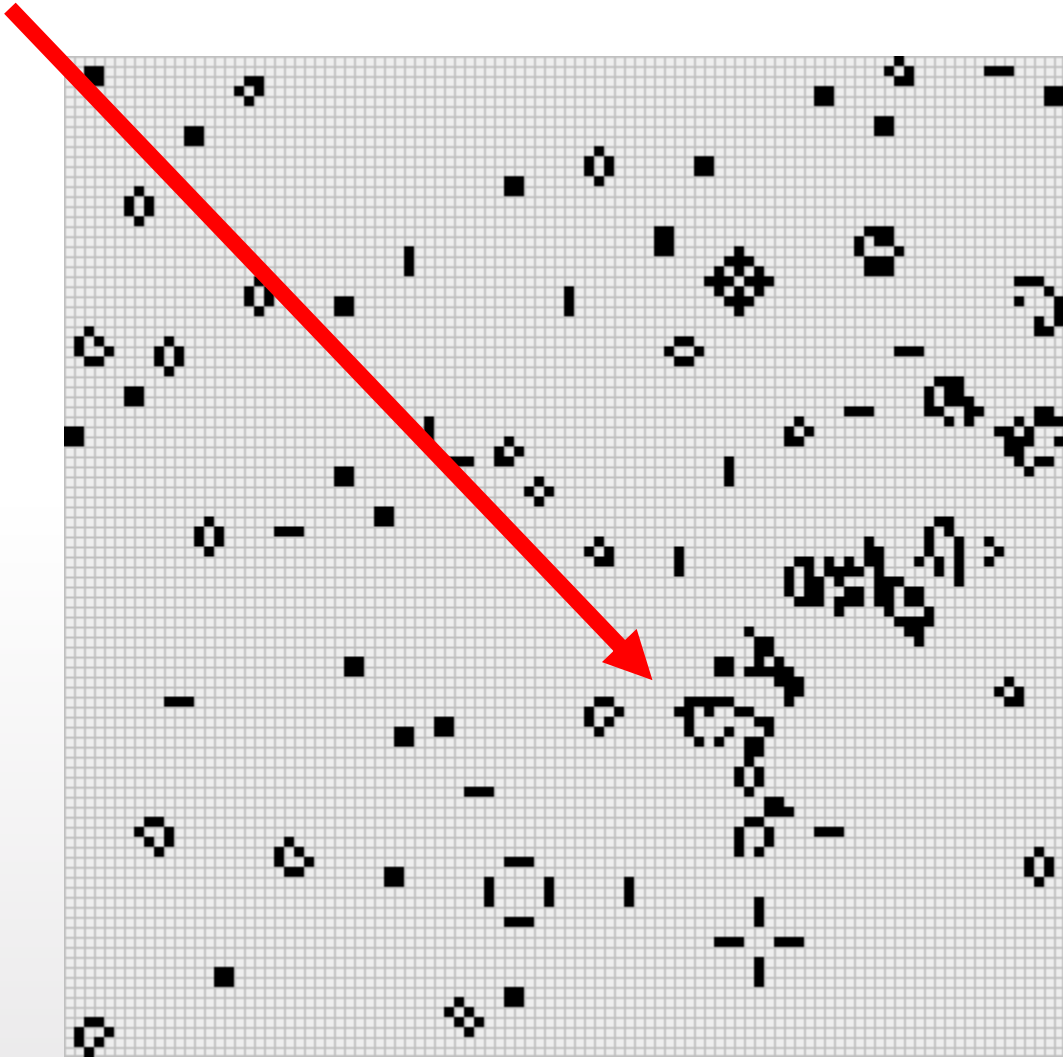


Slightly More Complicated Example



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

Small Variances Lead to Large Changes



People Actually Study This?

nature > letters > article

 **nature**
International journal of science

Letter | Published: 14 December 1989

Self-organized criticality in the 'Game of Life'

Per Bak, Kan Chen & Michael Creutz

Nature **342**, 780–782 (1989) | [Download Citation](#) ↓

[Journal of Statistical Physics](#)

September 1978, Volume 19, [Issue 3](#), pp 293–314 | [Cite as](#)

Statistical mechanics of a dynamical system based on Conway's game of Life

Authors

[Authors and affiliations](#)

L. S. Schulman, P. E. Seiden



Physica D: Nonlinear Phenomena

Volume 118, Issues 1–2, 1 July 1998, Pages 49-52

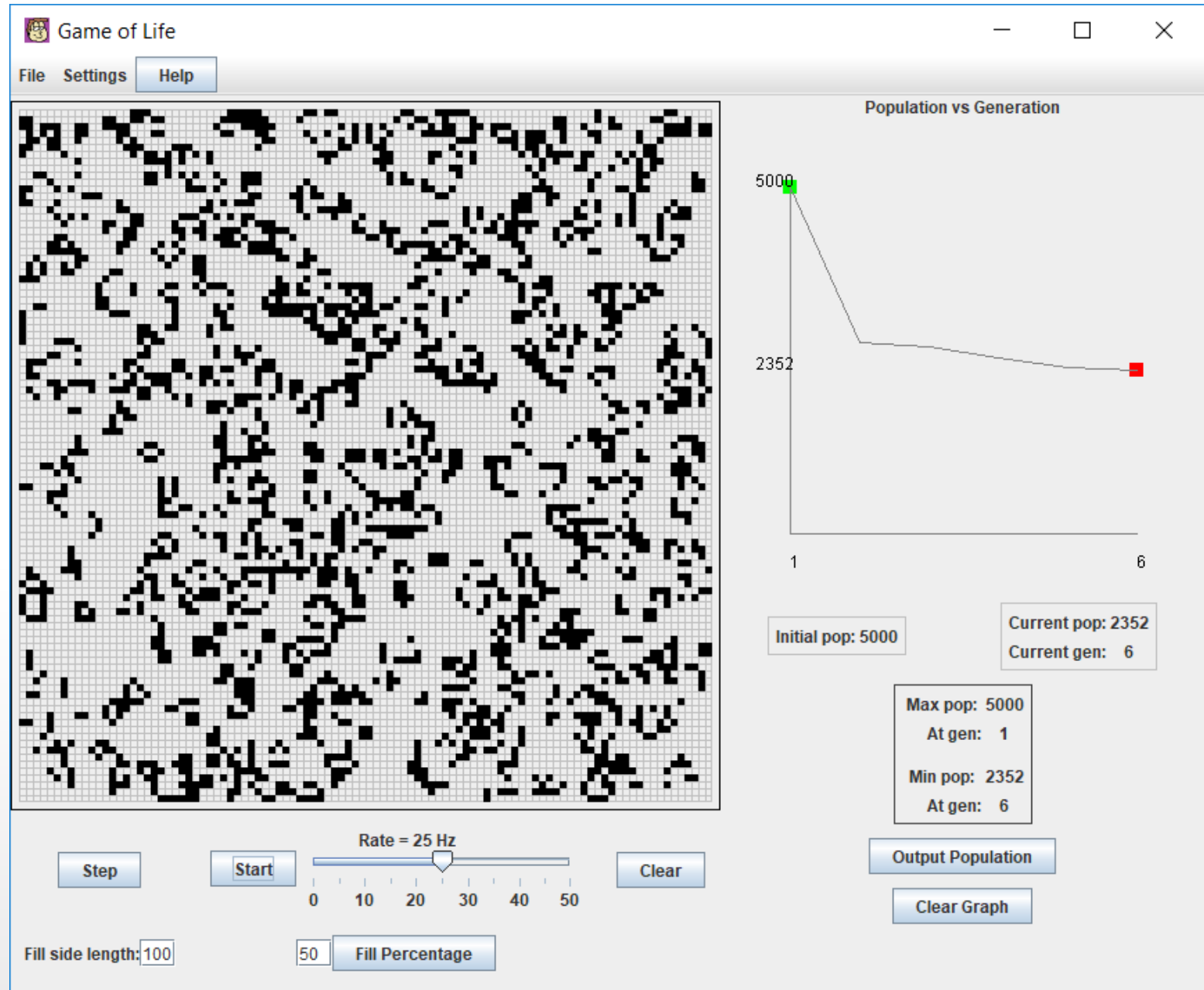


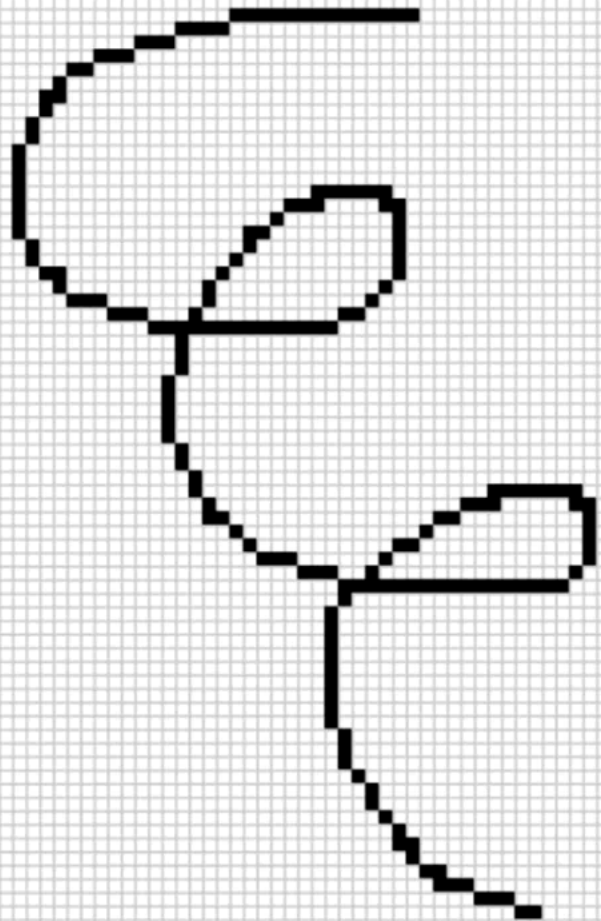
$1f$ fluctuation in the “Game of Life”

Shigeru Ninagawa, Masaaki Yoneda  , Sadaki Hirose

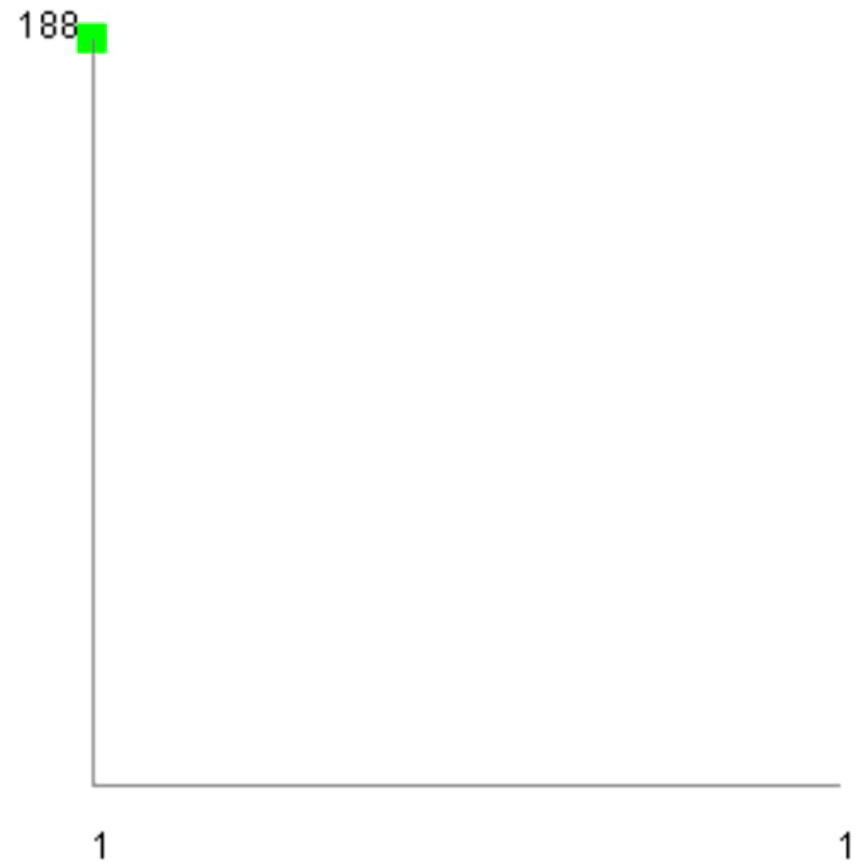
Implementation

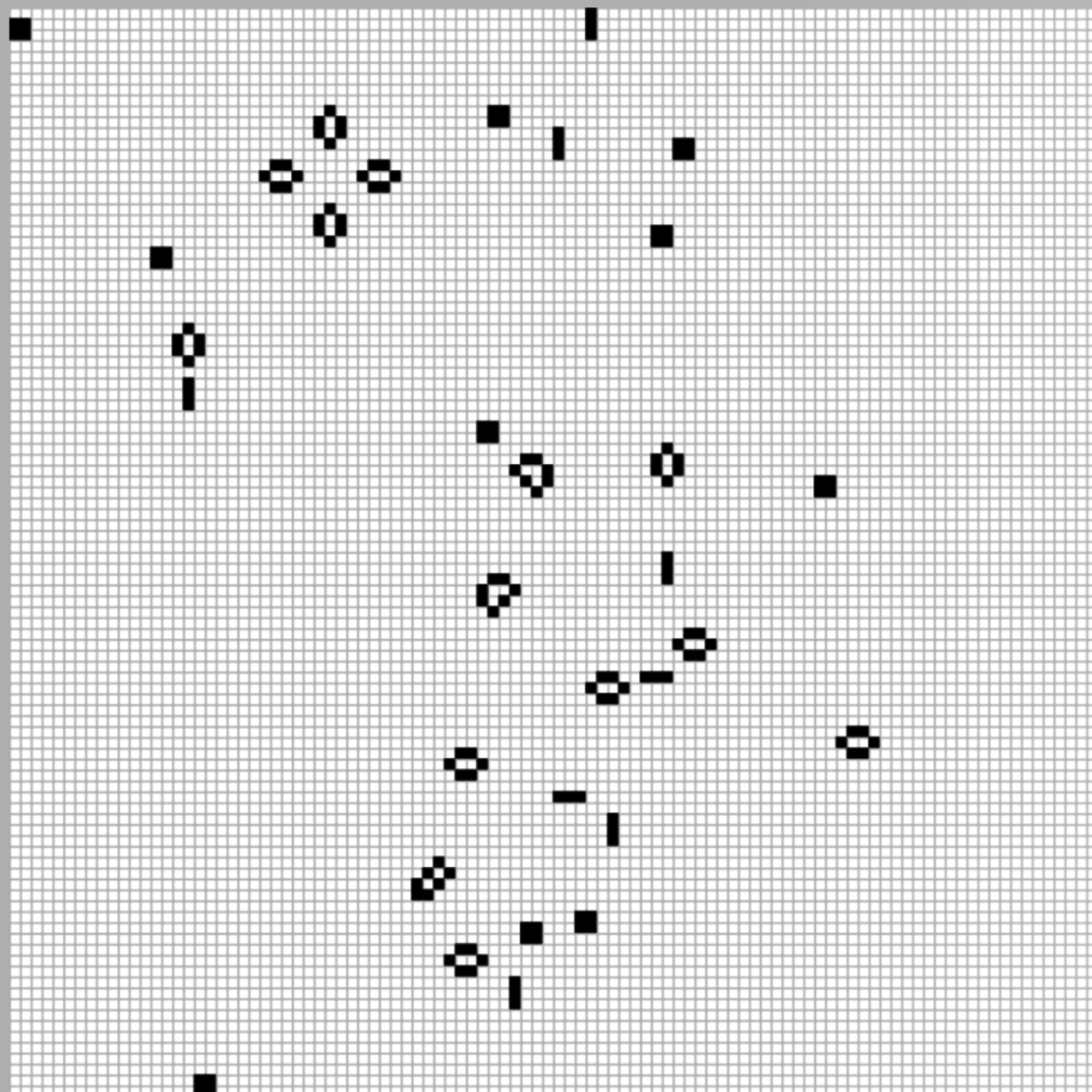
- Java-based program
- Features:
 - Graphical display
 - Population graph
 - Fill fraction
 - Resizable





Population vs Generation





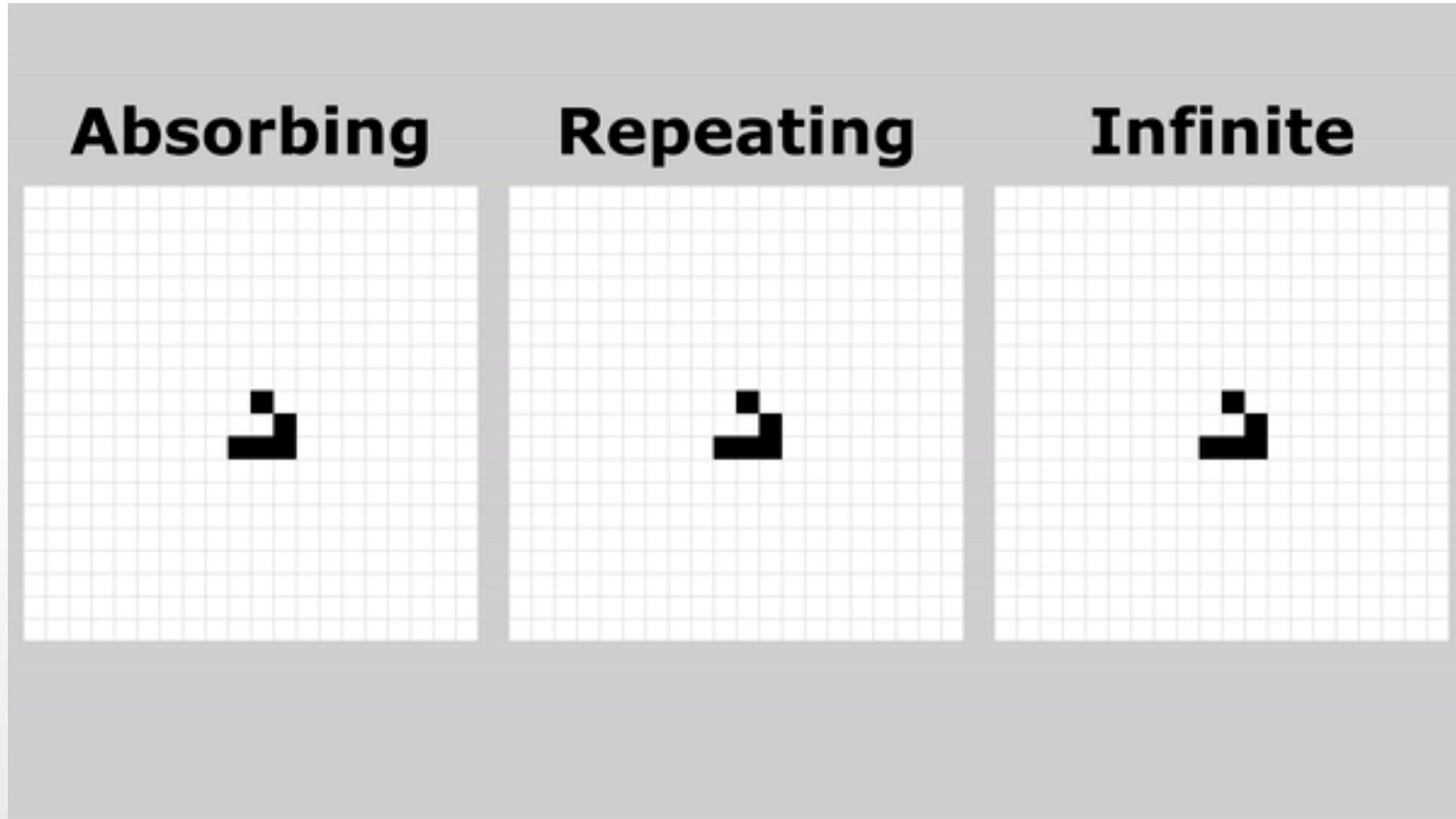
Population vs Generation



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?

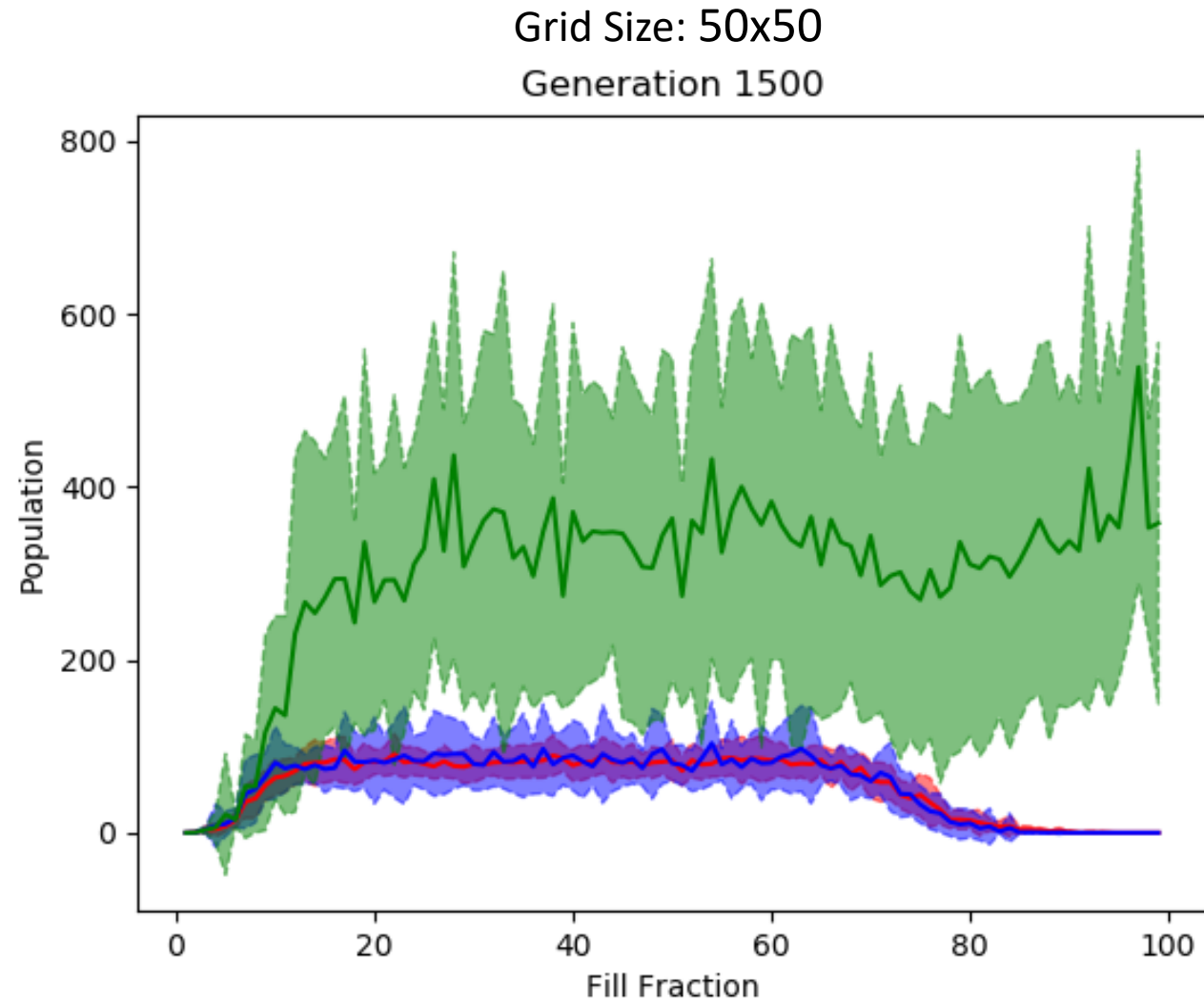
Boundary Conditions



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

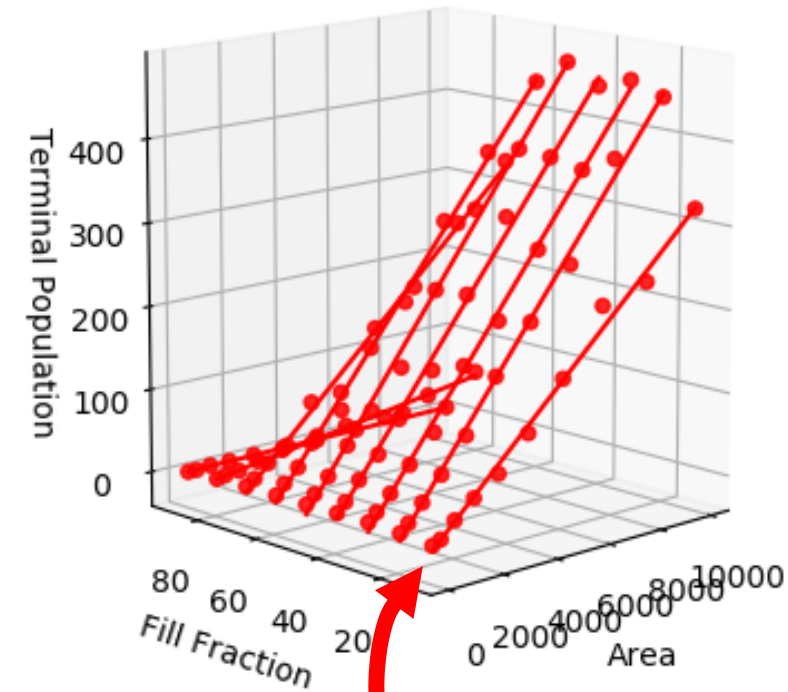
Link Between Fill Fraction and Population?



Equation For Terminal Population?

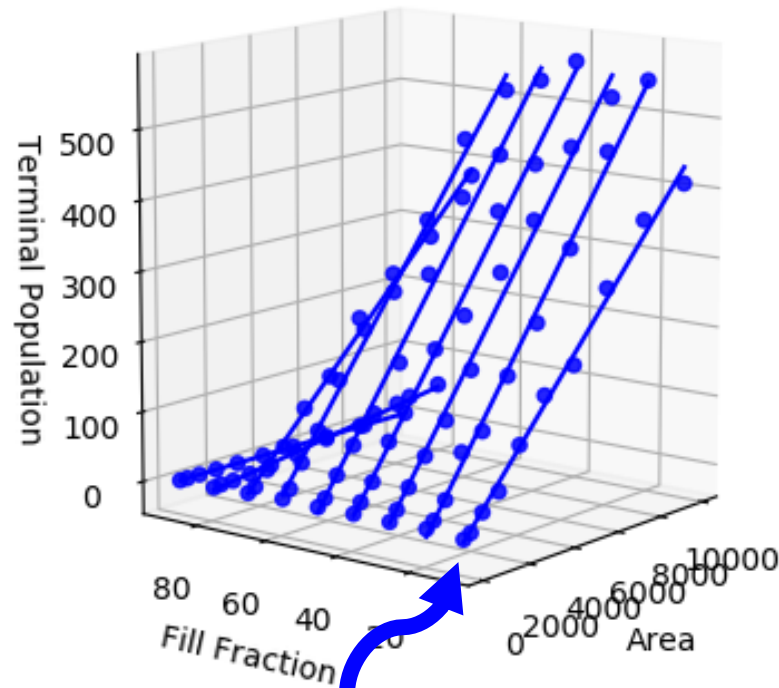
Population After 500 Generations Vs Fill Fraction Vs Area

Absorbing



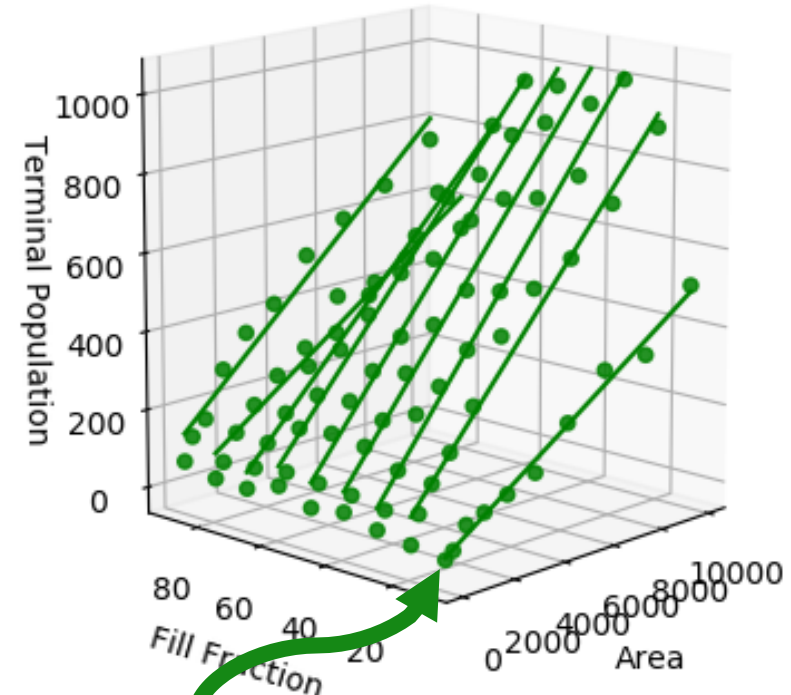
$$z = 0.03298 * \text{Area} - 7.856$$
$$r^2 = 98.04\%$$

Asteroids



$$z = 0.04379 * \text{Area} - 6.694$$
$$r^2 = 99.11\%$$

Infinite



$$z = 0.04850 * \text{Area} + 7.276$$
$$r^2 = 99.08\%$$

Open Questions

- Population reached a maximum at $\sim 40\%$ 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



9x250 km = 2250 km



18x125 km = 2250 km



49x62.5 km = 3062.5 km

Thanks to the Maryland Space Grant Consortium
for support!

