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?
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?

Self-organized criticality in the 'Game of Life'

Per Bak, Kan Chen & Michael Creutz
Nature 342, 780–782 (1989) | Download Citation

1f fluctuation in the “Game of Life”

Shigeru Ninagawa, Masaaki Yoneda, T., Sasaki Hirose

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

Authors
L. S. Schulman, P. E. Seiden

Journal of Statistical Physics

September 1978, Volume 19, Issue 3, pp 293–314 | Cite as
Implementation

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

Absorbing  Repeating  Infinite
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?

Grid Size: 50x50

Generation 1500

![Graph showing the relationship between fill fraction and population.](image-url)
Equation For Terminal Population?

Population After 500 Generations Vs Fill Fraction Vs Area

Absorbing

Terminal Population vs Fill Fraction and Area

\[ z = 0.03298 \times \text{Area} - 7.856 \]
\[ r^2 = 98.04\% \]

Asteroids

Terminal Population vs Fill Fraction and Area

\[ z = 0.04379 \times \text{Area} - 6.694 \]
\[ r^2 = 99.11\% \]

Infinite

Terminal Population vs Fill Fraction and Area

\[ z = 0.04850 \times \text{Area} + 7.276 \]
\[ r^2 = 99.08\% \]
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

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