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Emergence

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www.phronos.com
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INCOSE San Diego

Agenda

I. The Game of Life
II. Chaos Theory
III. Gray Wolves in Yellowstone
IV. Emergence in AI
V. Mosaic Warfare
VI. Other Emergence Examples
VII. Managing Emergent Behavior
VIII. Q-A-D: Question, Answer, Discussion

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Ac[illegible]ate the most wealth and points by the [illegible] you [illegible]ch re[illegible]ment.

Conway’s Game of Life

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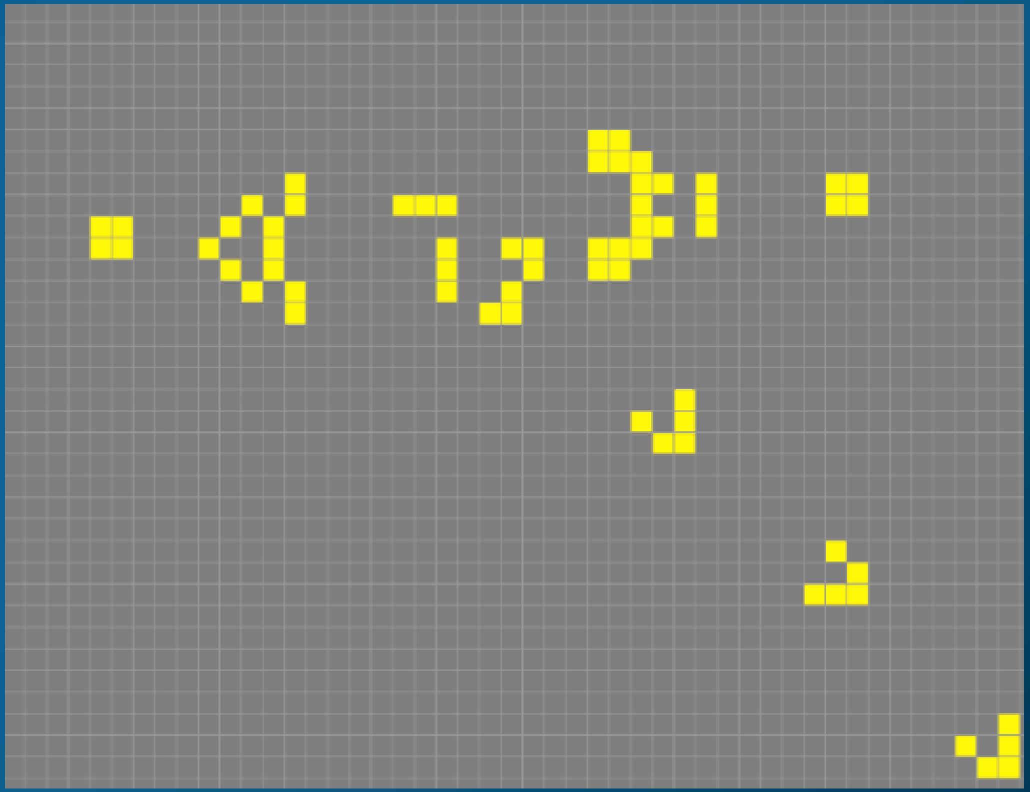
Conway's Game of Life (1970)

- Cellular automaton (zero player game) that simulates the behavior of a system over time
- Consists of a two-dimensional grid of cells that can be in one of two states: dead or alive
- State of each cell in the next generation is determined by the states of its neighboring cells according to a set of **4 SIMPLE RULES**



There's a 3D version of this game, but for illustration, we're going to stick with 2D

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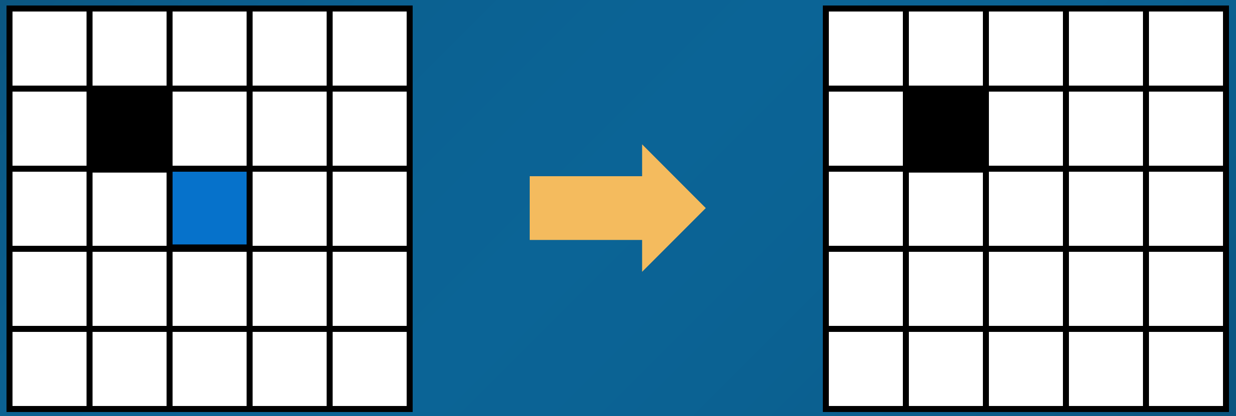
RULE 1: Loneliness / Underpopulation

Any live cell with fewer than two live neighbors dies.



RULE 2: Overpopulation

Any live cell with more than three live neighbors dies.

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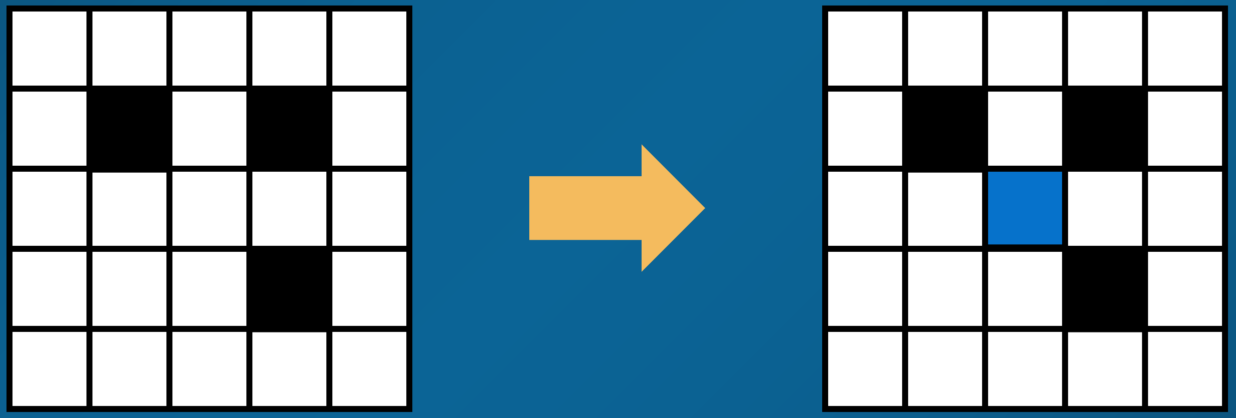
RULE 3: Reproduction

Any dead cell with exactly three live neighbors becomes a live cell.



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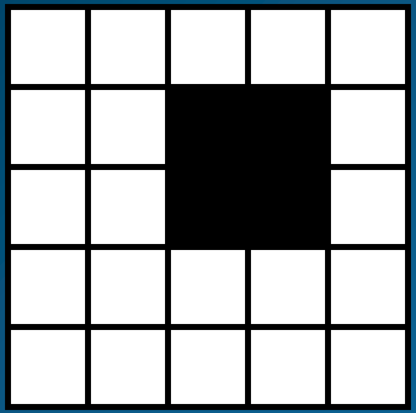
RULE 4: Status Quo

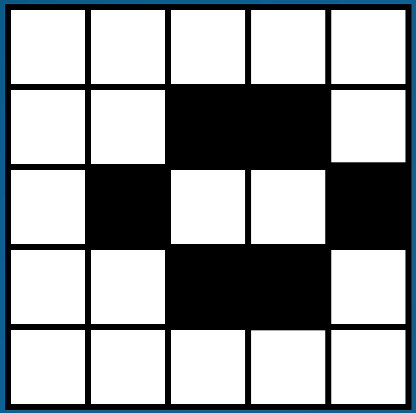
Any live cell with two or three live neighbors lives on to the next generation.

Steady States

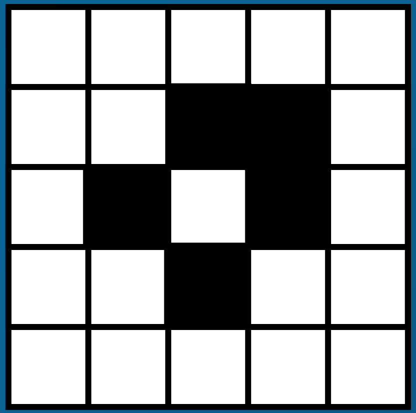
Block



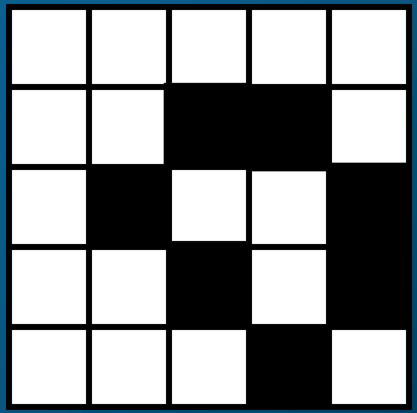
Beehive



Boat



Loaf / Tub



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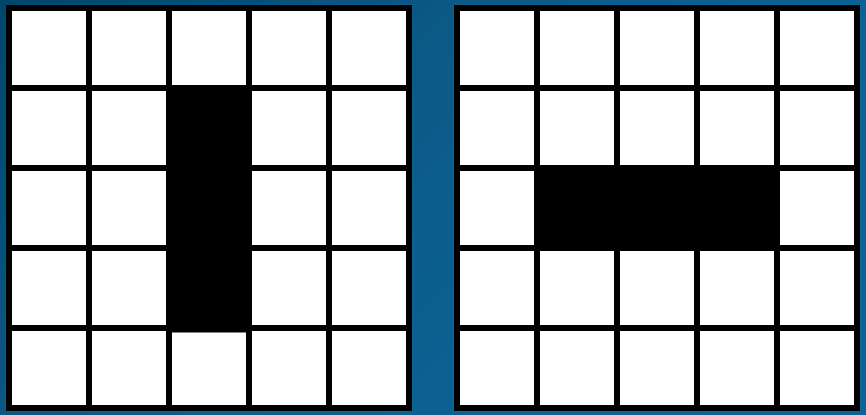
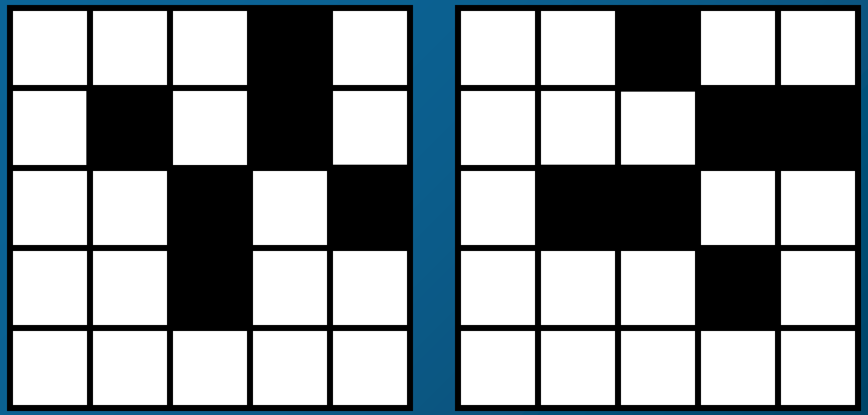
Oscillators

- 85 known oscillators with periodicity from 2-30.
- Vast majority of periodicity is 2

Blinker



Clock



[List of common oscillators - LifeWiki (conwaylife.com)]

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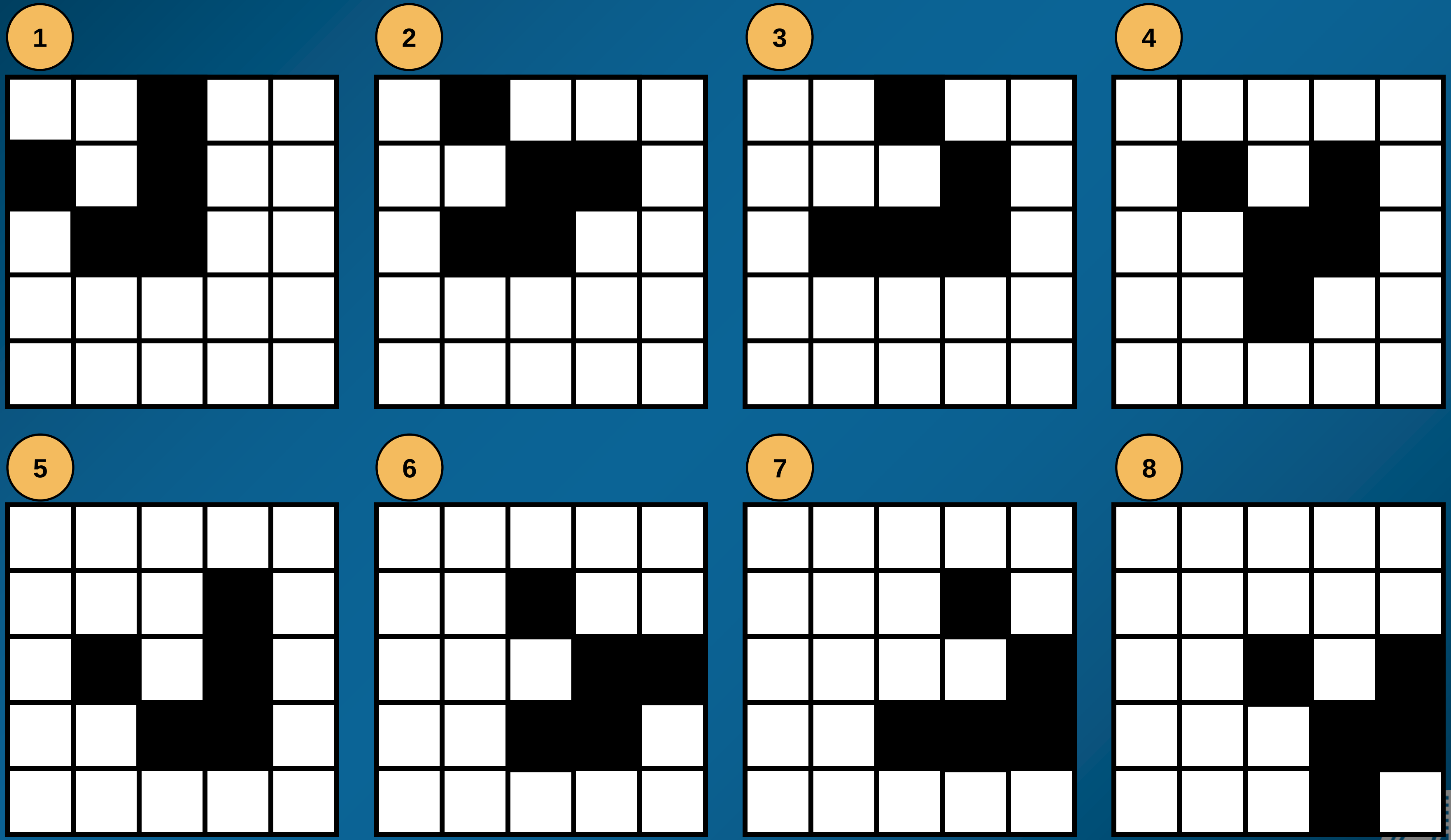
Spaceships

- Pattern returns to its initial state after several generations (period) but in a different location



[List of common oscillators - LifeWiki (conwaylife.com)]

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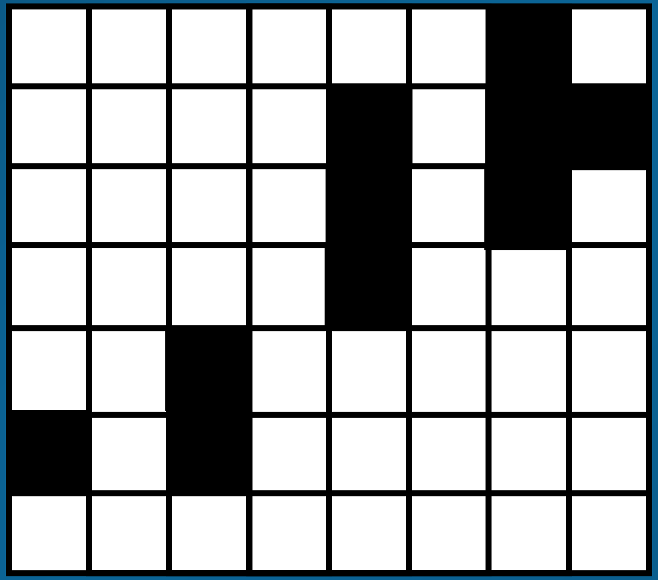
Infinite Growth Patterns



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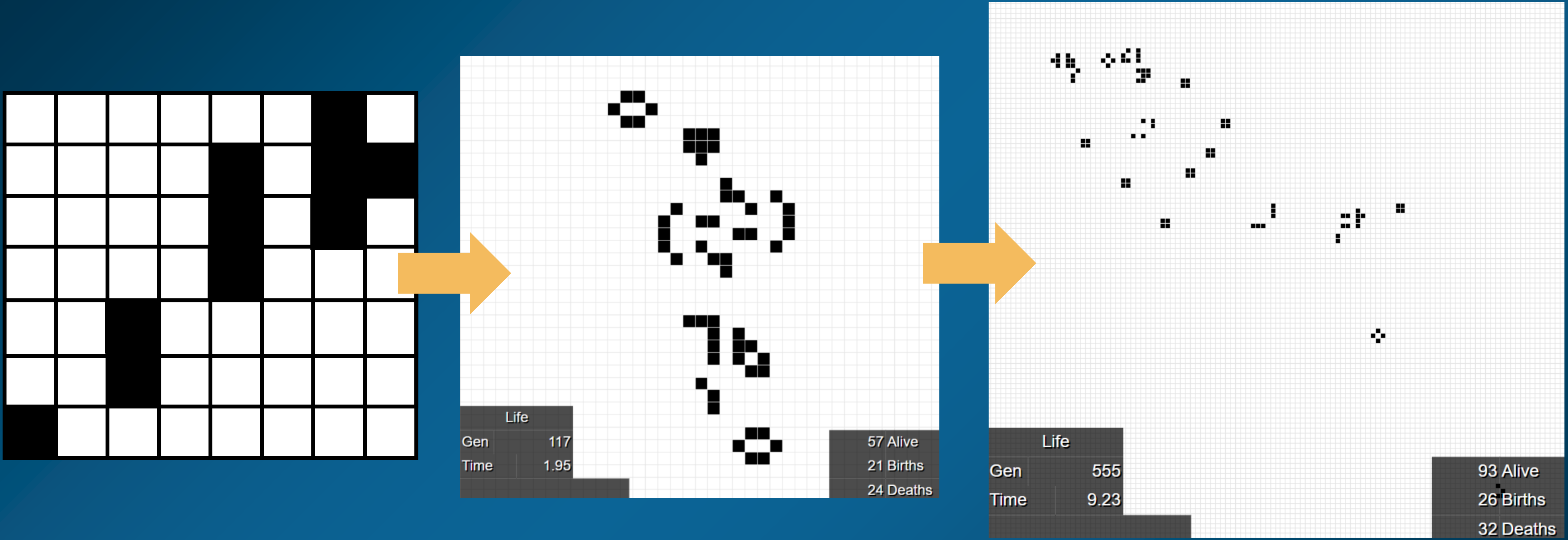
Infinite Growth Patterns



- (Apparent) unbounded population
- No pattern with fewer cells can exhibit (apparent) infinite growth

[Infinite growth - LifeWiki (conwaylife.com)]

Conway's Game of Life: Sample Behavior

[Play John Conway's Game of Life (playgameoflife.com)](playgameoflife.com)

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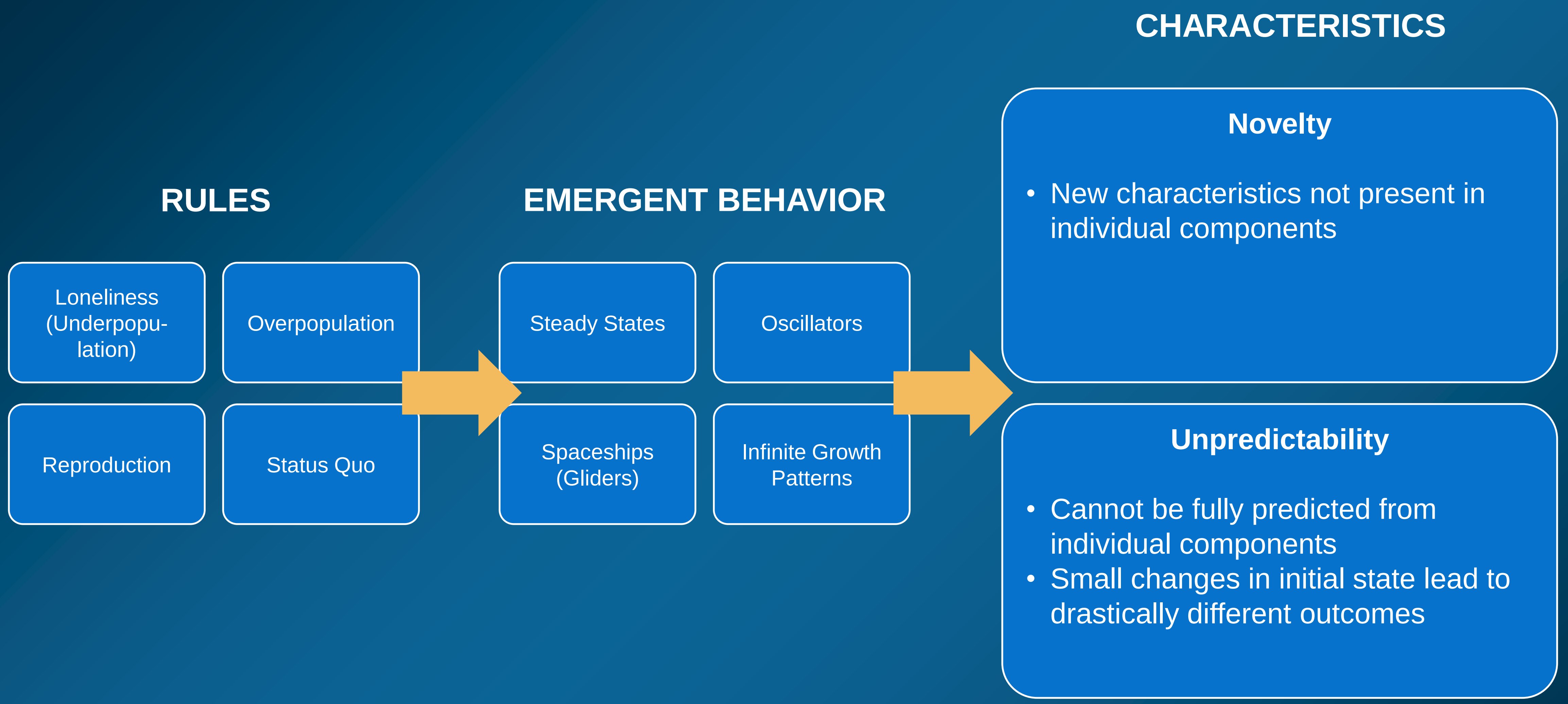
Conway’s Game of Life (1970)

…a mathematical abstraction

…has parallels in natural processes, such as the growth of biological organisms, the spread of diseases, and the development of ecosystems.



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EMERGENCE

Novelty

- New characteristics not present in individual components

REQUIRED

(Think components of a complex system)

Unpredictability

- Cannot be fully predicted from individual components
- **Small changes in initial state lead to drastically different outcomes**

OFTEN

Emergence in Mathematics: Chaos Theory

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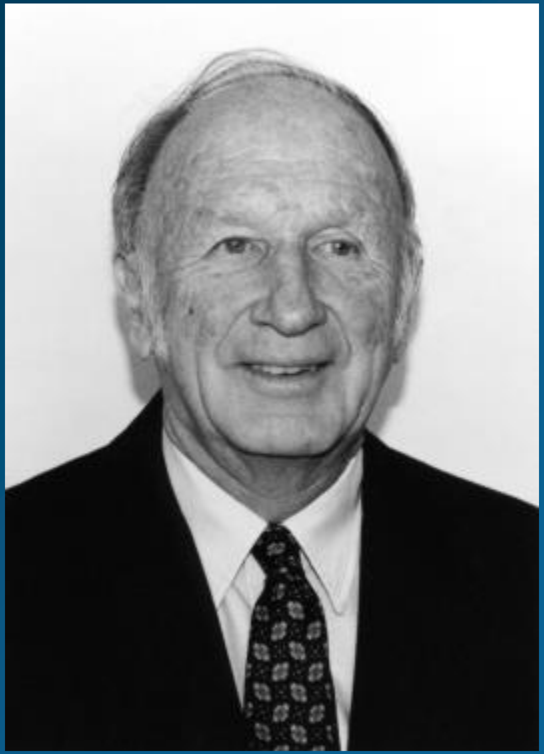
Edward Norton Lorenz (1917–2008)

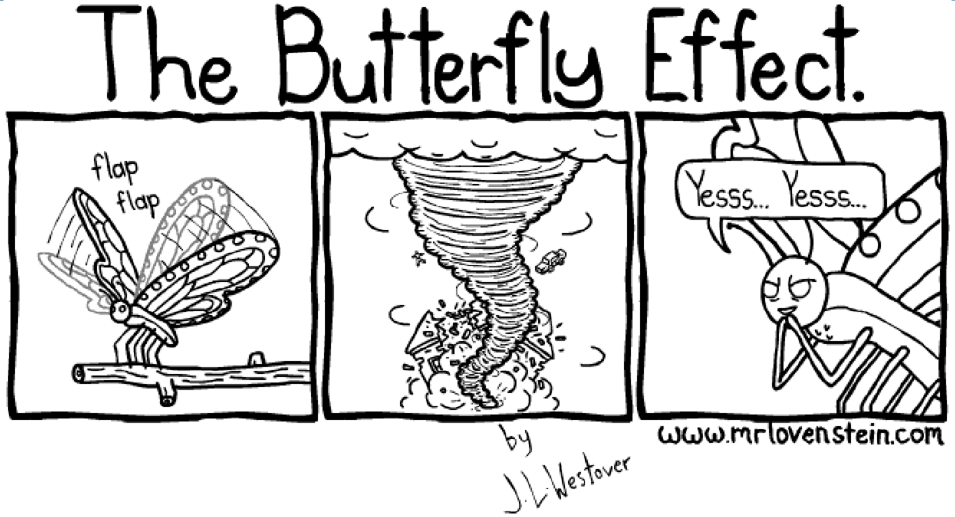


American mathematician and meteorologist

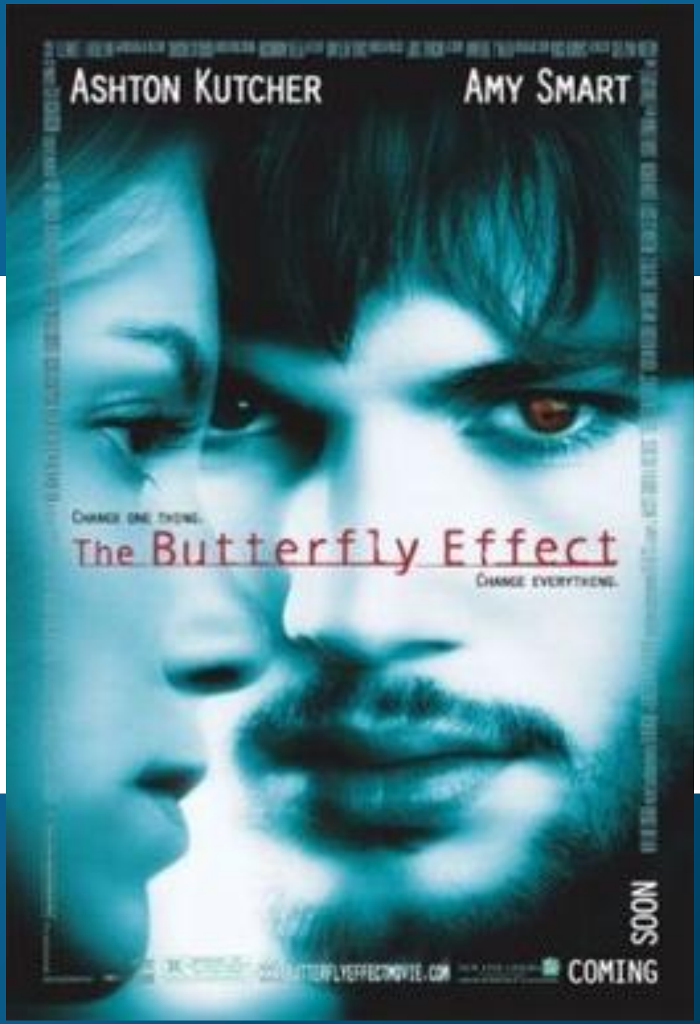
Established the theoretical basis of weather and climate predictability, as well as the basis for computer-aided atmospheric physics and meteorology.

Founder of modern **chaos theory**, a branch of mathematics focusing on the behavior of dynamical systems that are highly sensitive to initial conditions.

Butterfly Effect



"The flap of a butterfly's wings in Brazil can set off a tornado in Texas."



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Logistic Map

growth rate

Sometimes known as

- biotic potential or
- bifurcation parameter

$$x_{n+1} = r x_n (1 - x_n)$$

(standard version)

population at time n.
$x_n \in [0.0, 1.0]$

Discretized populations: Think of x_n as population at year n

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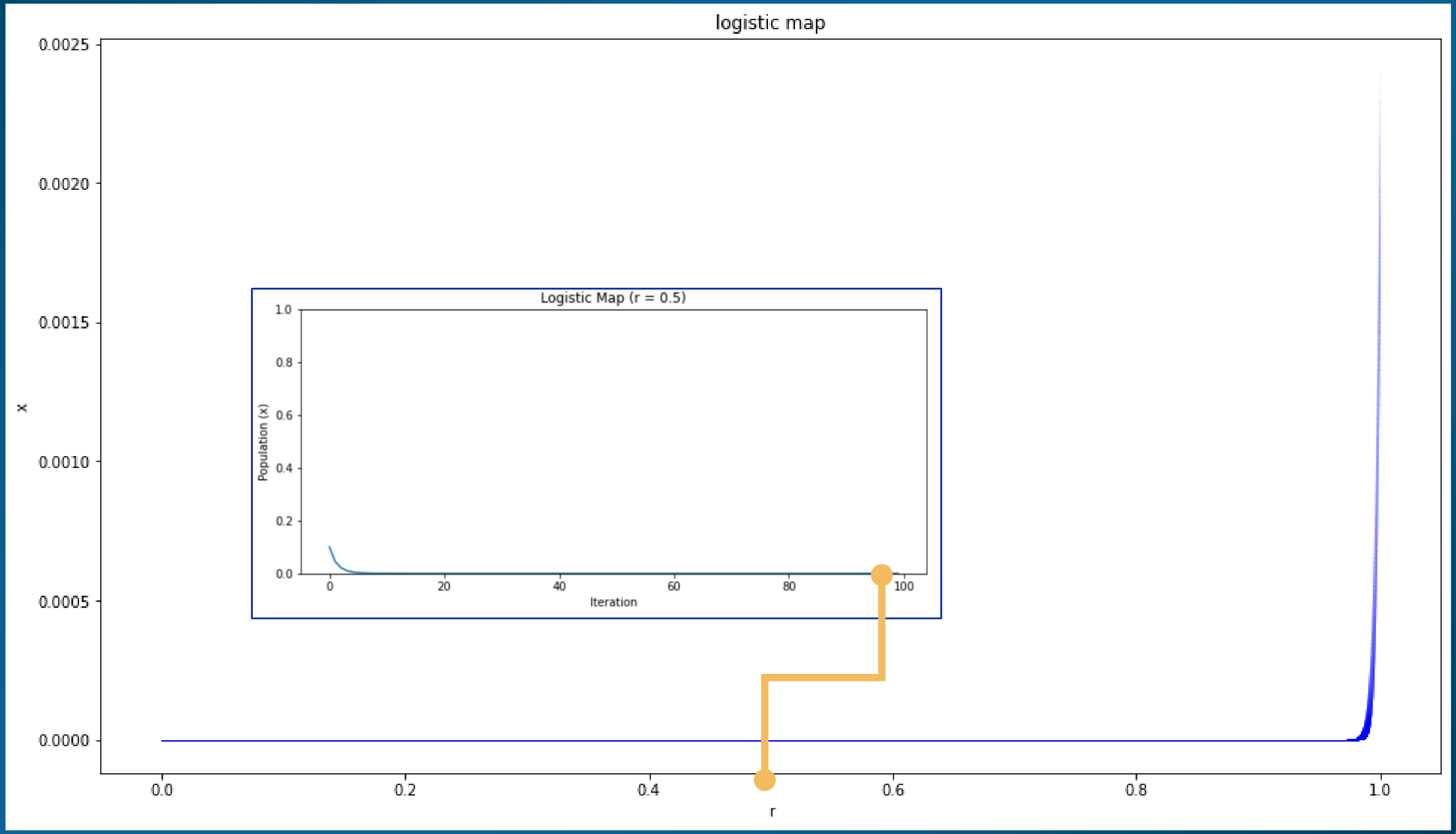
Low Growth Rate $(0 \leq r \leq 1)$

- The population will eventually die out, regardless of the initial population size.



$$x_{n+1} = rx_n(1 - x_n)$$

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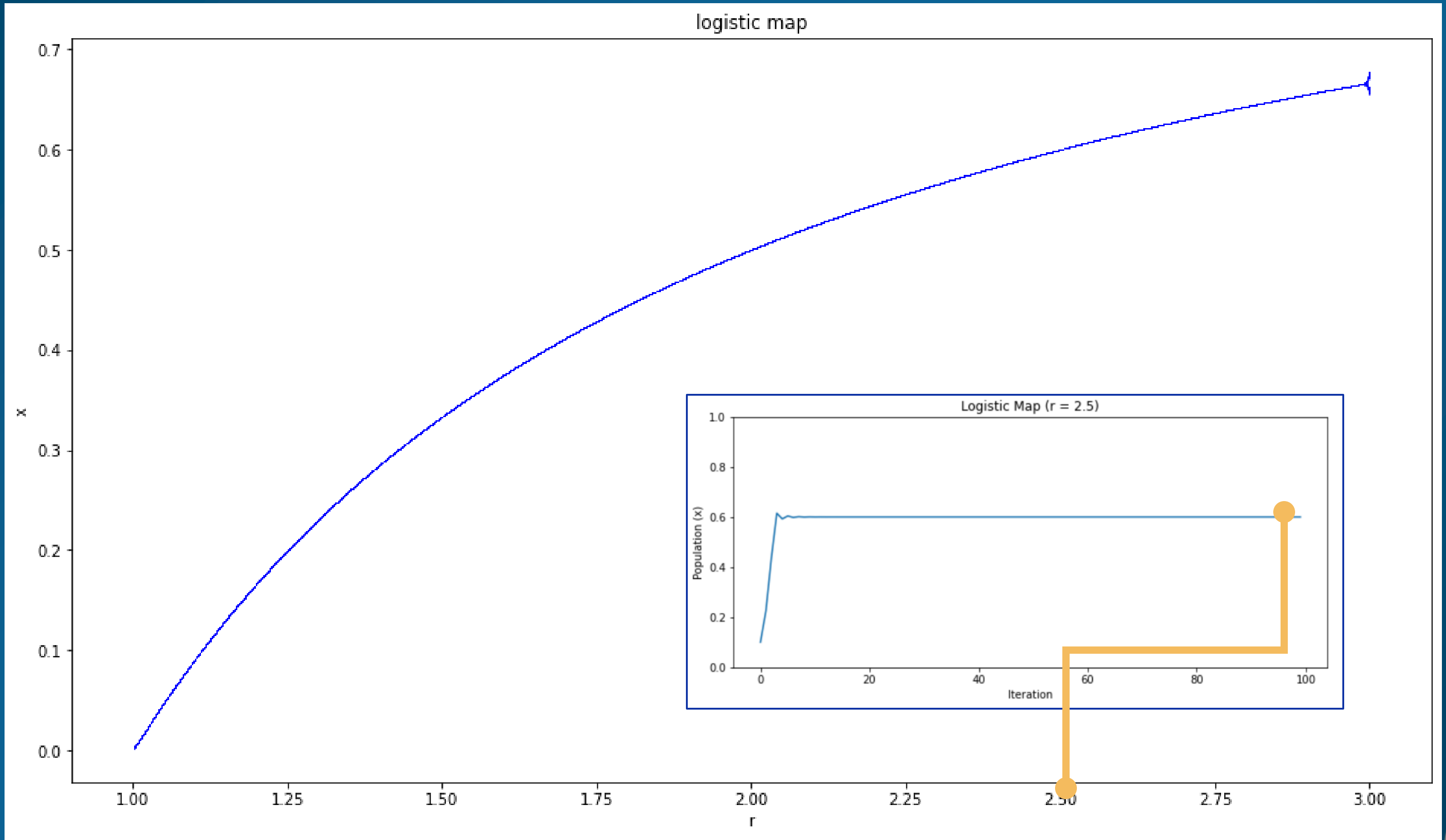
Moderate Growth Rate ($1 < r \leq 3$)

- The population will stabilize after some initial fluctuations.
- At $r = 3$, the population starts oscillating between two values



$x_{n+1} = rx_n(1 - x_n)$

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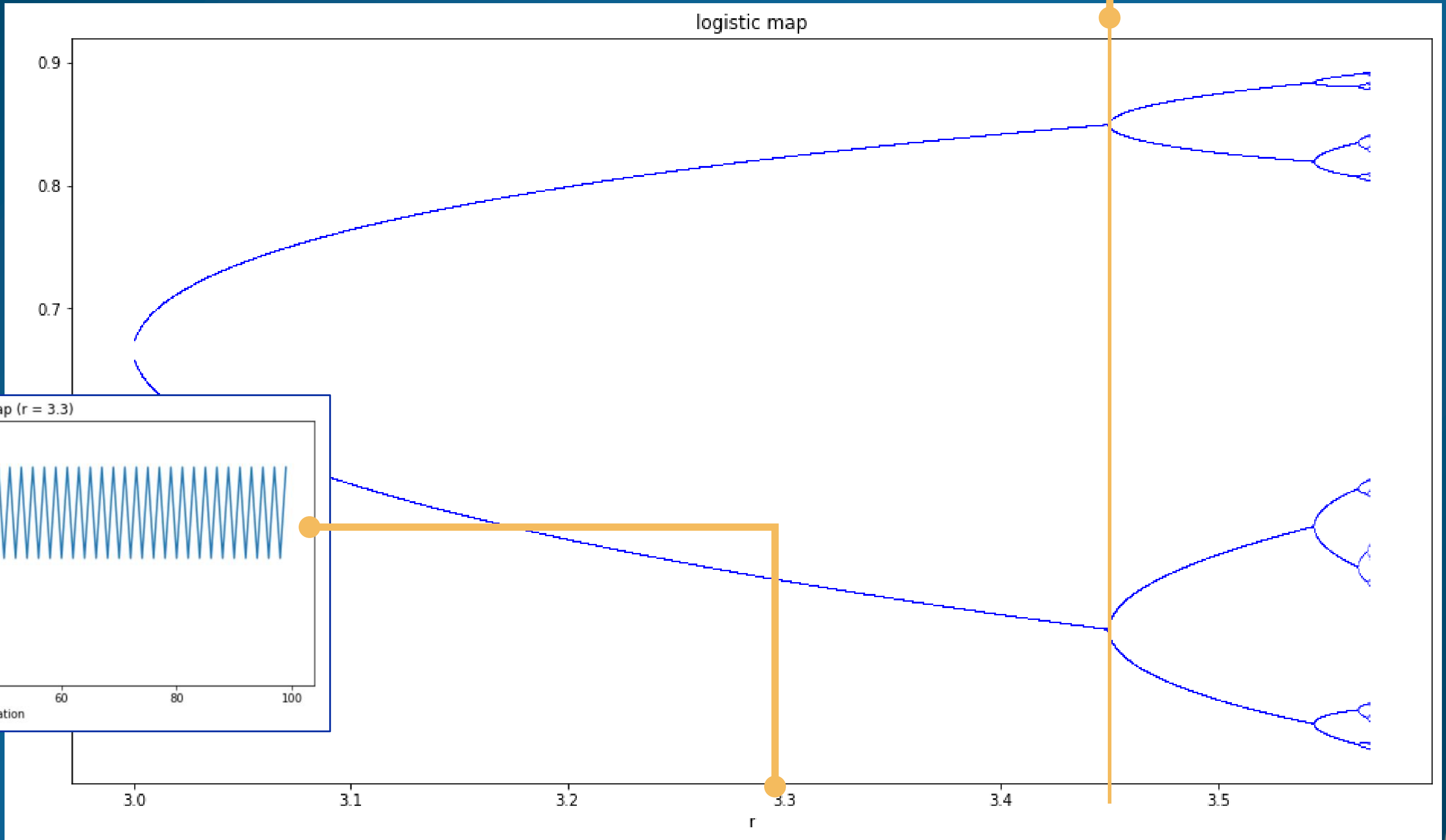
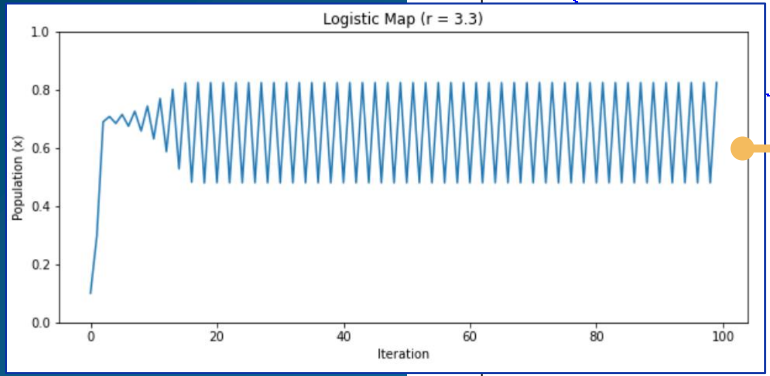
High Growth Rate ($3 < r < 3.57$)

- The population will oscillate between a few fixed values via period doubling.

$r = 1 + \sqrt{6}$





$$x_{n+1} = r x_n (1 - x_n)$$

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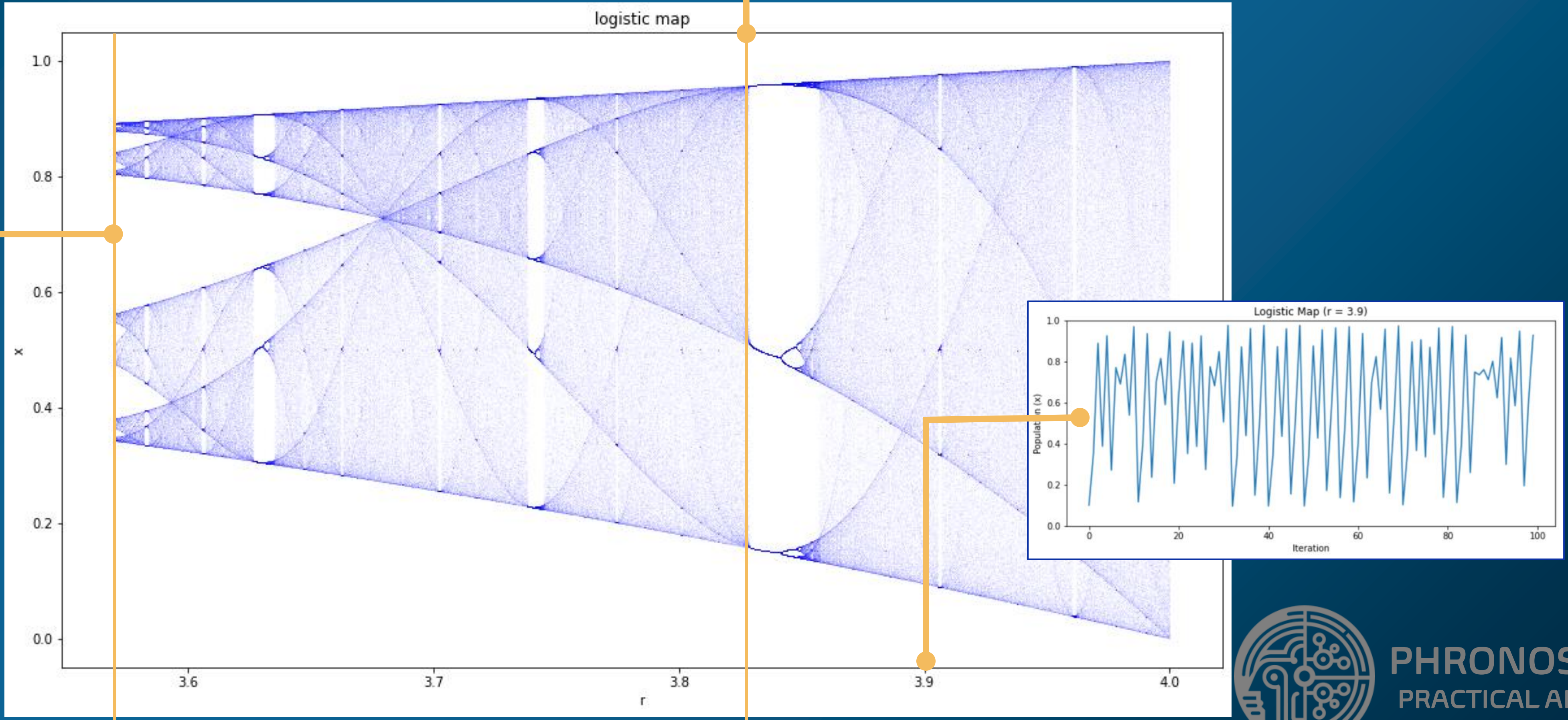
Very High Growth Rate $(3.57 < r < 4)$

- System enters a chaotic regime.
- Population size will fluctuate seemingly randomly, never settling into a stable pattern.
- Tiny changes in the initial conditions can lead to drastically different outcomes.

$r = 1 + \sqrt{8}$

Feigenbaum Point



$x_{n+1} = r x_n (1 - x_n)$

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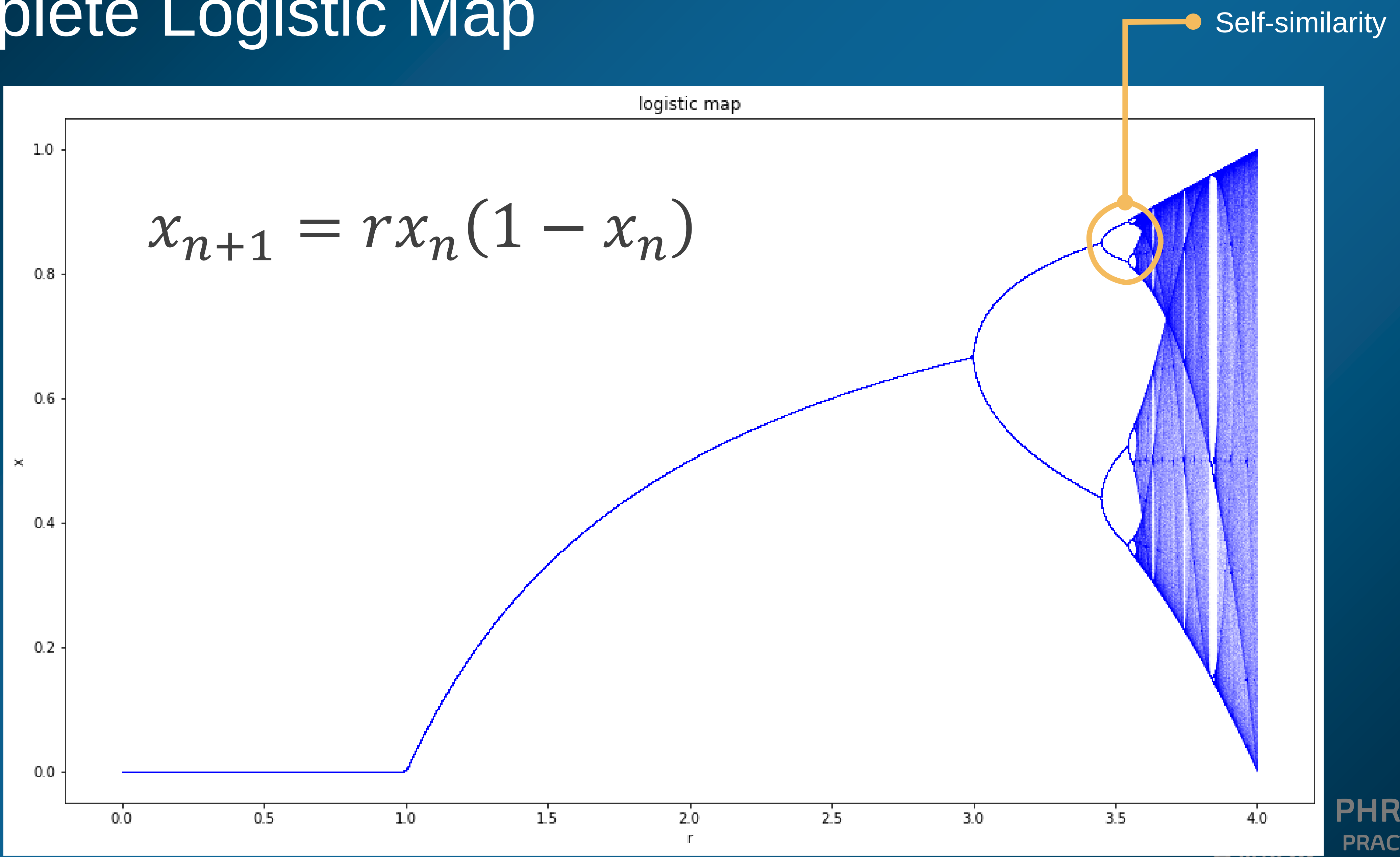
Complete Logistic Map



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Logistic Map: What it Means

While the logistic map is a simplification, it highlights some crucial aspects of real-world population dynamics:

- **Resource Limitation:** Unlimited growth is impossible. Every environment has a finite carrying capacity.
- **Non-linearity:** Small changes in conditions (like the growth rate or initial population size) can lead to dramatic and unpredictable shifts in population size.
- **Chaos:** Real-world populations are influenced by countless factors, making their long-term behavior difficult to predict accurately.

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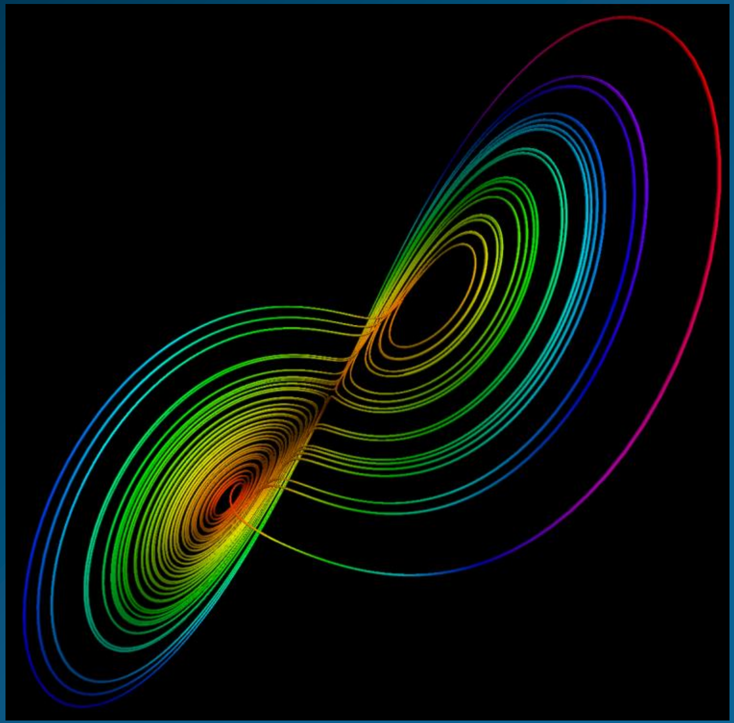
Lorenz Attractor



A system of three ordinary differential equations:

$$\frac{dx}{dt} = \sigma(y - x)$$ — relates to convection

$$\frac{dy}{dt} = x(\rho - z) - y$$ — describes horizontal heat transport

$$\frac{dz}{dt} = xy - \beta z$$ — describes vertical heat transport

Where:

- x , y, z are the system variables
- t is time
- σ (sigma), ρ (rho), and β (beta) are system parameters

Classic values used by Edward Lorenz in 1963 paper:

$$\sigma = 10$$
$$\rho = 28$$
$$\beta = 8/3$$

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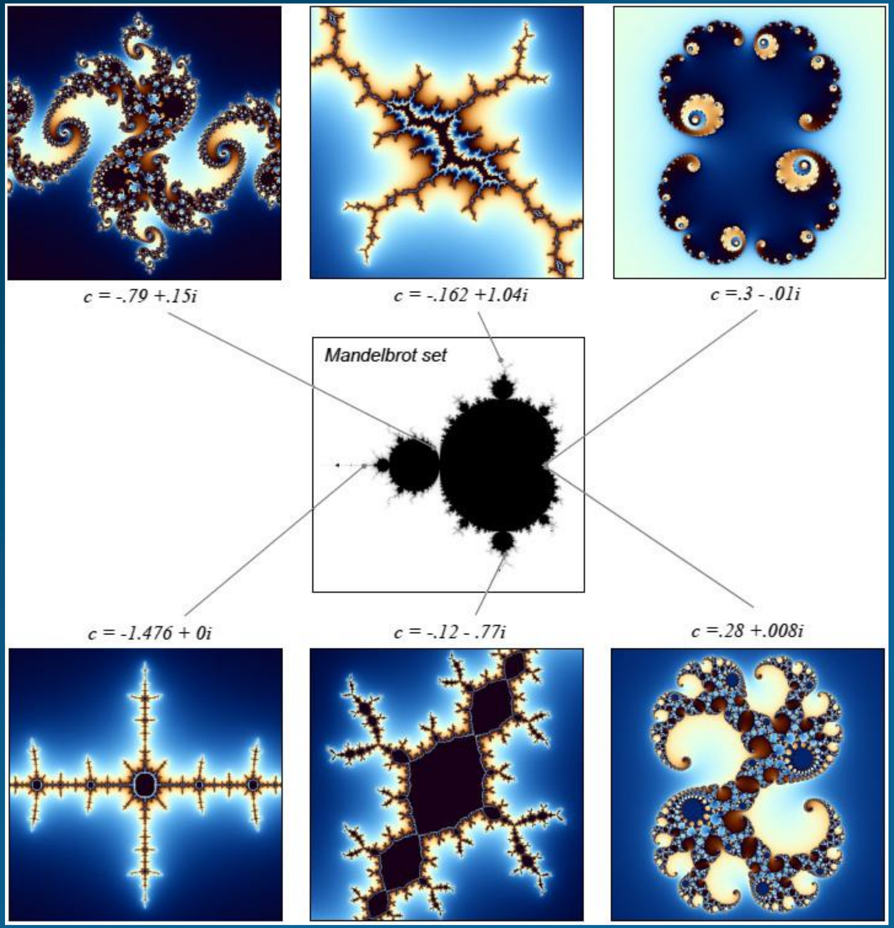
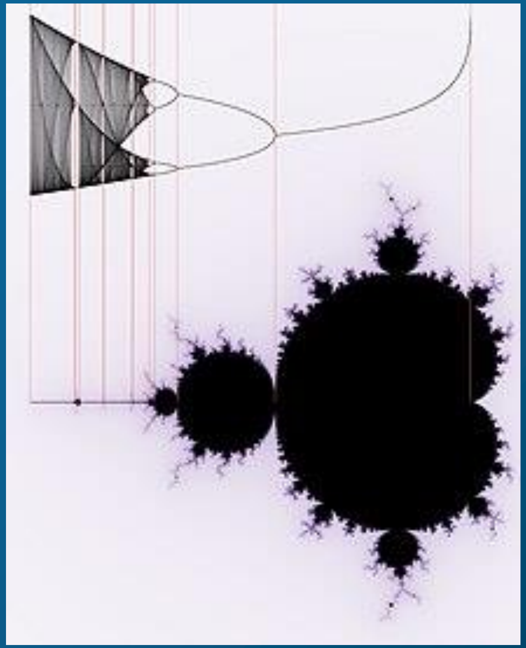
Mandelbrot Set



set of values of c in the complex plane

$$z_{n+1} = z_n^2 + c$$



Emergence in Ecology: Gray Wolves in Yellowstone

1920s – Yellowstone

- Government allowed the extermination of gray wolves – the apex predator
- Triggered an ecosystem collapse known as a trophic cascade
- A *trophic cascade* is an ecological phenomenon where a change in the population of one species in an ecosystem leads to changes in the populations of other species further down the food chain

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Result of 1920s Wolf Extermination

- Coyotes became apex predator
- Pronghorn antelope, red fox, and rodent populations plummeted
- Birds of prey populations declined with limited resources

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1995: Wolves reintroduced

- In mid 1990s, gray wolves were reintroduced

Wolves Preyed on Elk → Increased Vegetation

- Wolves began preying on elk, reducing their numbers and altering their behavior and grazing patterns.
- This reduced overgrazing of vegetation like willows and aspens along streams and rivers.

Vegetation → Food & Habitat

- The regrowth of willows and aspens provided food and habitat for beavers, songbirds, and other species.
- Beavers created new wetlands that further increased biodiversity.

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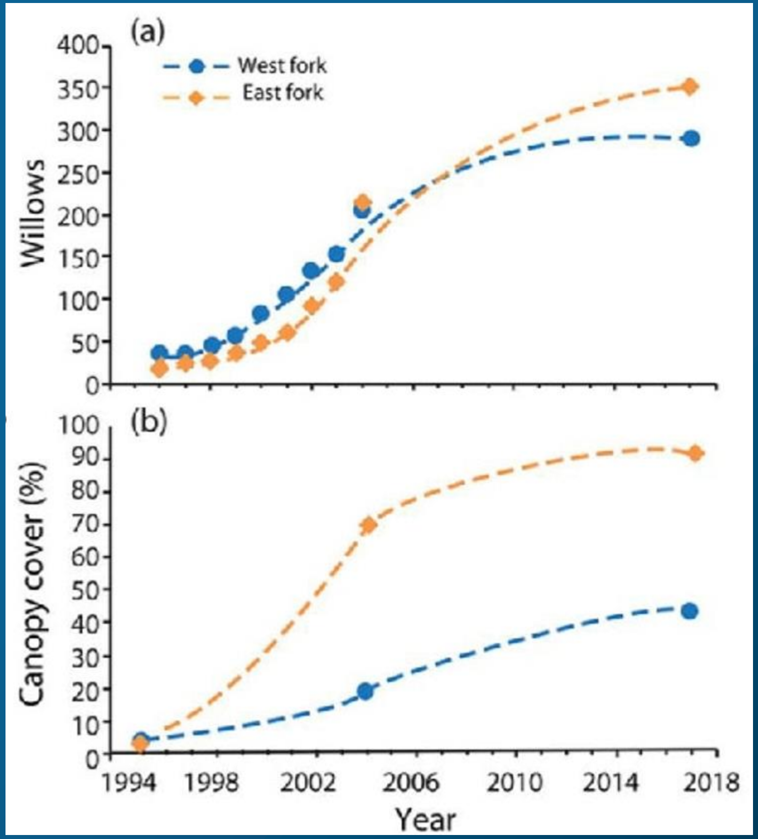
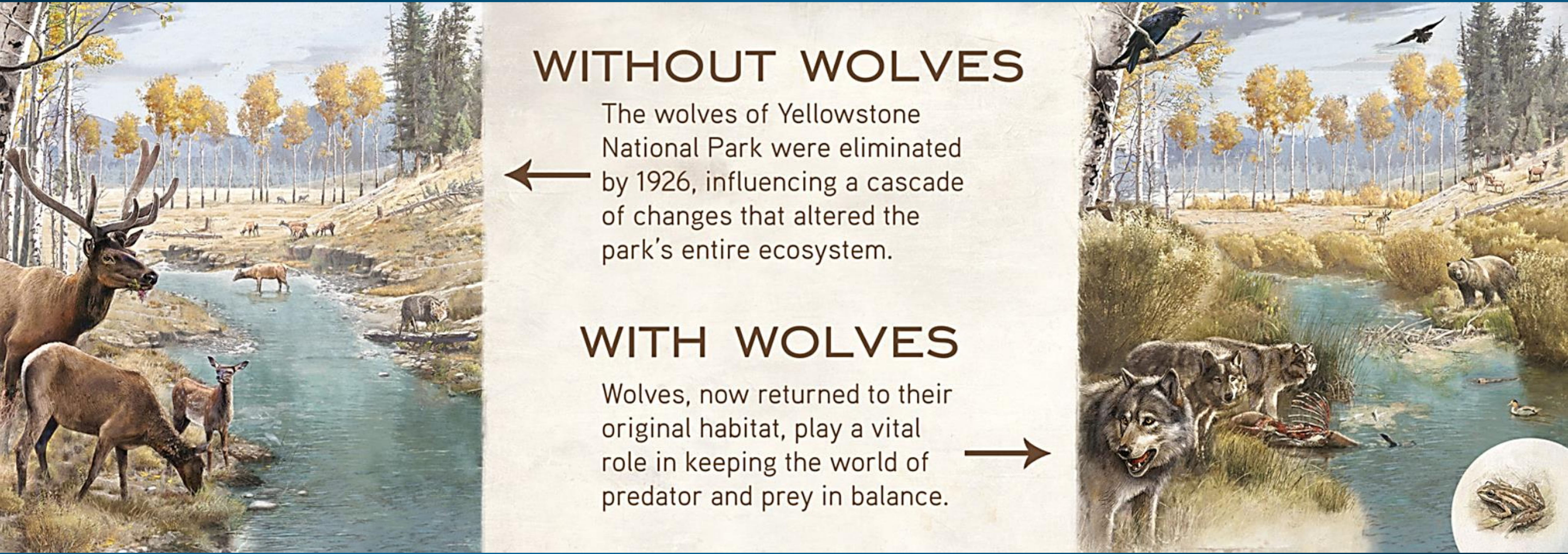
More Vegetation Growth

- The wolves' presence caused elk to avoid certain areas, reducing overgrazing and allowing vegetation to recover in those regions.





https://www.livingwithwolves.org/about-wolves/why-wolves-matter/

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Emergence in AI

Swarm Intelligence

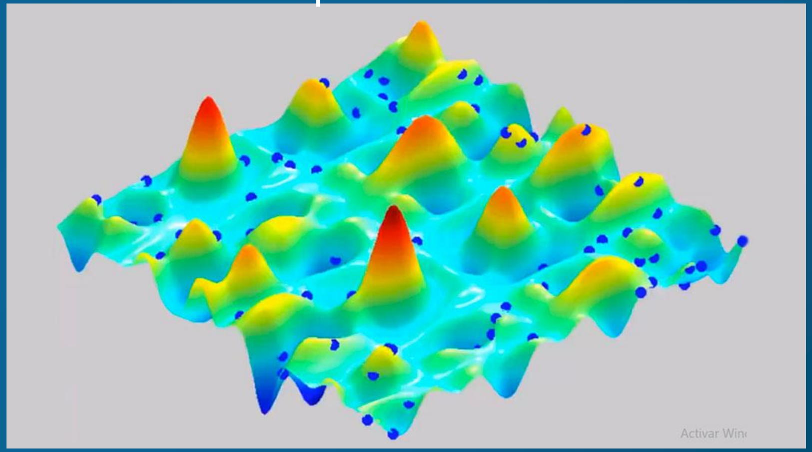
- Idea inspired by the collective behavior of social insects or animal swarms
- can exhibit emergent problem-solving abilities that are greater than the individual capabilities of the "agents"

Starling

Fire ant

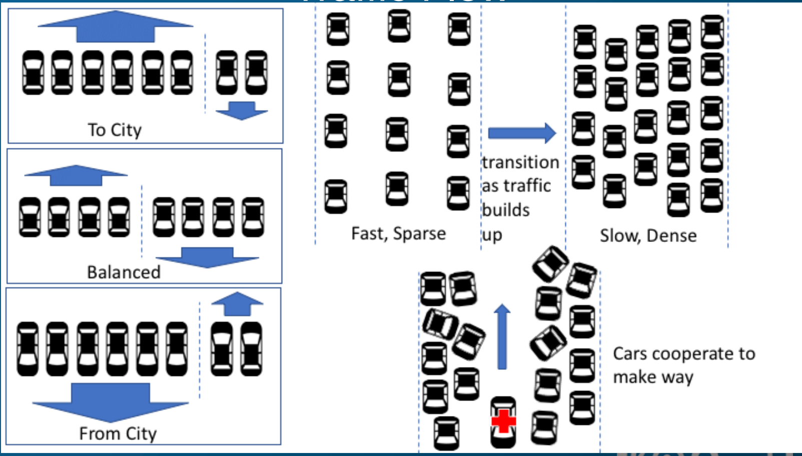
- algorithms like ant colony optimization and particle swarm optimization

Optimization



Metaheuristics - Swarm Intelligence - Part 2 (stratio.com)

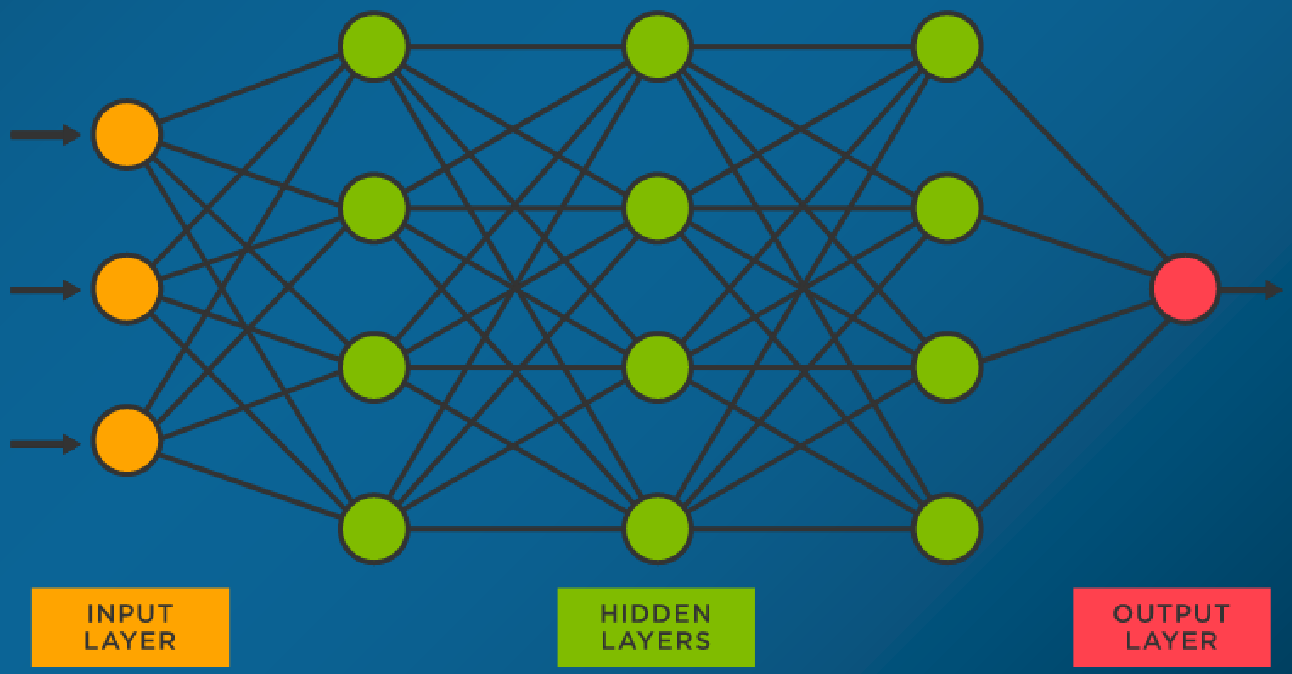
Traffic Flow



Swarm-Based Dynamic Traffic Flow | Download Scientific Diagram (researchgate.net)

Neural Networks

- Complex information processing capabilities of neural networks emerge from the relatively simple interactions between interconnected nodes (neurons)
- Ability to recognize patterns, make predictions, and solve problems



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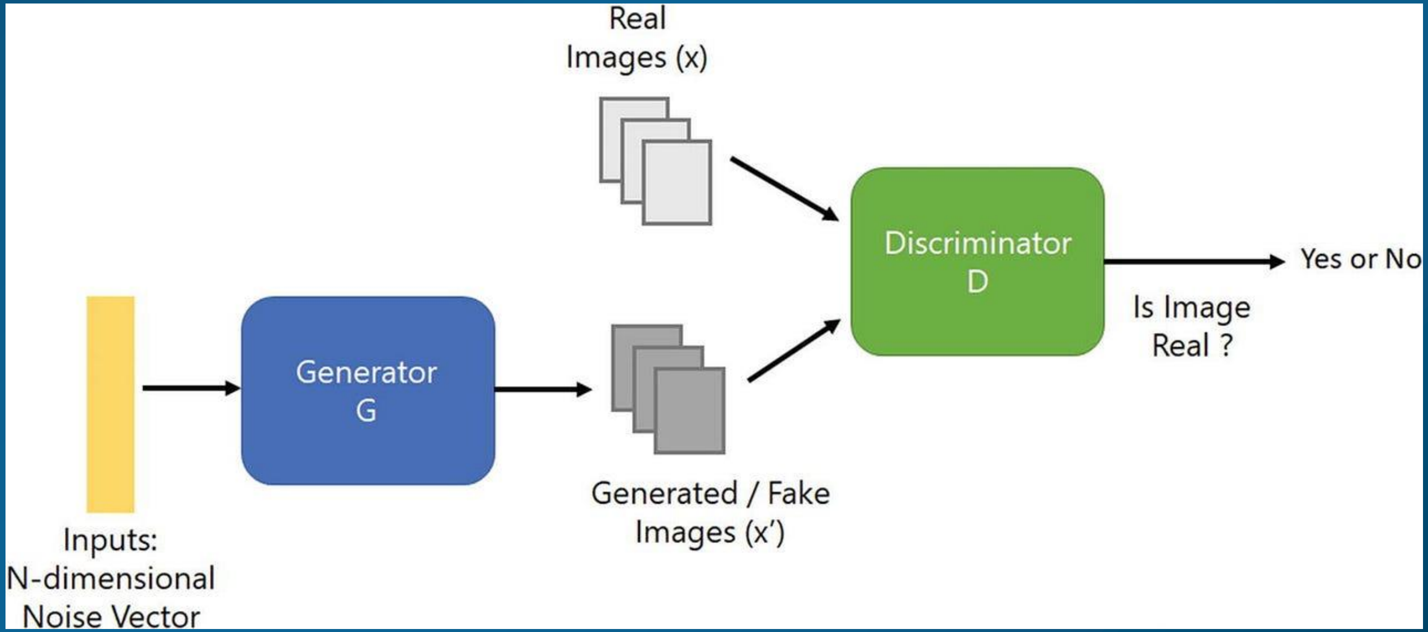
Generative Adversarial Networks (GANs)

- Consists of two neural networks, a generator, and a discriminator, that are trained in opposition to each other.
- Interplay can lead to the emergence of impressive image generation, text generation, and other creative capabilities.



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Reinforcement Learning: Google's DeepMind AlphaGo

- Go is significantly more complex than chess
  - Grains of sand in the world: 10^{17}
  - Atoms in the observable universe: 10^{80}
  - Possible chess configurations: 10^{120}
  - Possible go configurations: 10^{360}
- March 2016, using reinforcement learning, AlphaGo beat the world champion Lee Sedol (4:1)
- Move 37 of Game 2 surprised experts and overturned traditional wisdom in Go

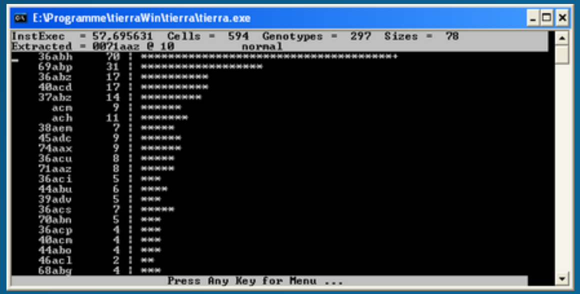
Game	Date	White	Black	Won by	Moves
1	9 March 2016	AlphaGo	Lee Sedol	Resignation	186
2	10 March 2016	Lee Sedol	AlphaGo	Resignation	211
3	12 March 2016	AlphaGo	Lee Sedol	Resignation	176
4	13 March 2016	Lee Sedol	AlphaGo	Resignation	180
5	15 March 2016	AlphaGo	Lee Sedol	Resignation	280

Artificial Life and Ecosystems

- Simulations of artificial life can exhibit the emergence of complex behaviors, evolutionary adaptations, and ecosystem dynamics that were not explicitly programmed.

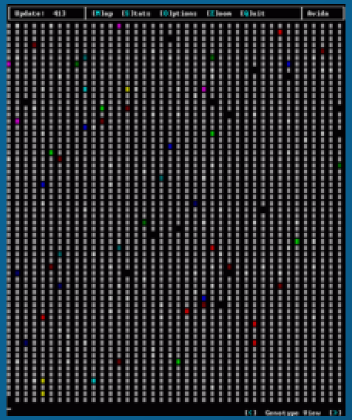
Tierra (1990s)

- computer simulation where computer programs compete for CPU time and RAM
- computer programs in Tierra are evolvable and can mutate, self-replicate and recombine



Avida (1993-2014)

- artificial life software platform to study the evolutionary biology of self-replicating and evolving computer programs (digital organisms)



Symbulation (2019-present)

- evolutionary agent-based modeling platform focused on evolving and examining symbiosis and endosymbiosis.

Symbulation
Agent-based modeling of symbiont ecology and evolution

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Generative AI: Hallucinations

Question:

- "Does water have its greatest volume at 4°C?" (asked 3/24/2024)

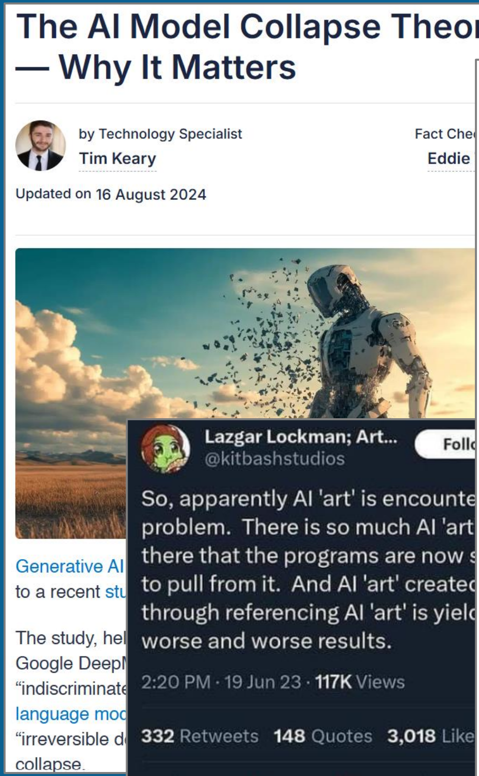
ChatGPT 4:

- "Yes, water has its greatest volume at 4°C, but to be more precise, it's about its density rather than volume. Water is most dense at approximately 4°C."

Fact:

- At 4°C, water exhibits maximum density and minimum volume.

Generative Inbreeding / Model Collapse Theory


The AI Model Collapse Theory — Why It Matters

by Technology Specialist
Tim Keary

Fact Che
Eddie

Updated on 16 August 2024

Generative AI
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The study, hel
Google DeepM
"indiscriminate
language mod
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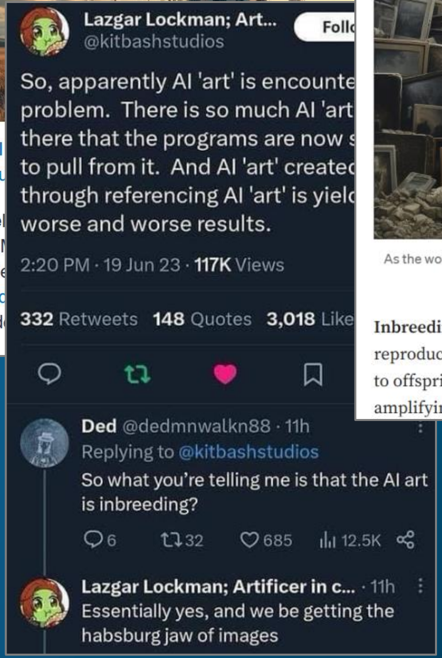
collapse.


Lazgar Lockman; Art...
@kitbashstudios
Follo

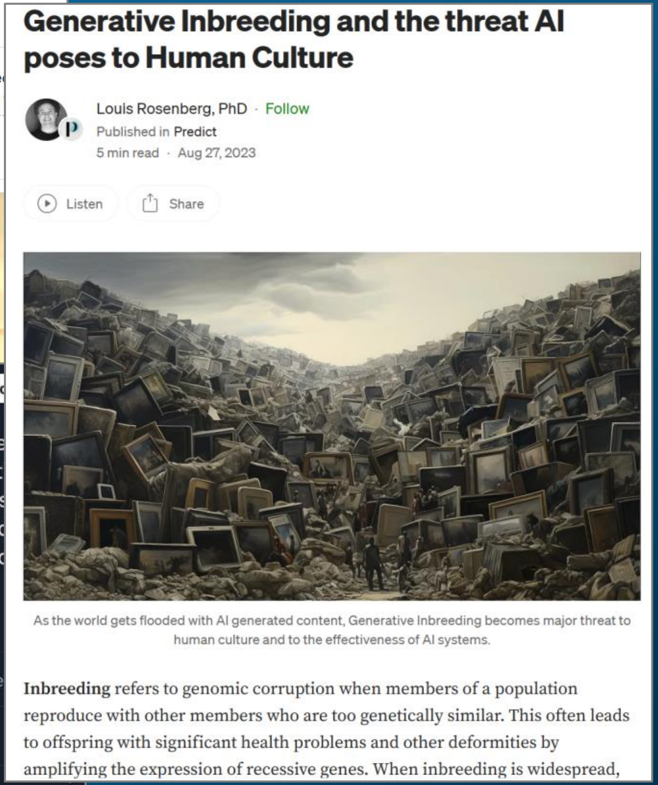
So, apparently AI 'art' is encounte
problem. There is so much AI 'art
there that the programs are now s
to pull from it. And AI 'art' created
through referencing AI 'art' is yield
worse and worse results.

2:20 PM · 19 Jun 23 · 117K Views

332 Retweets 148 Quotes 3,018 Like

Ded @dedmnwalkn88 · 11h
Replying to @kitbashstudios
So what you're telling me is that the AI art is inbreeding?
6 32 685 12.5K

Lazgar Lockman; Artificer in c... · 11h
Essentially yes, and we be getting the habsburg jaw of images


Generative Inbreeding and the threat AI poses to Human Culture

Louis Rosenberg, PhD · Follow
Published in Predict
5 min read · Aug 27, 2023

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As the world gets flooded with AI generated content, Generative Inbreeding becomes major threat to human culture and to the effectiveness of AI systems.

Inbreeding refers to genomic corruption when members of a population reproduce with other members who are too genetically similar. This often leads to offspring with significant health problems and other deformities by amplifying the expression of recessive genes. When inbreeding is widespread,

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AI Emergence in Cinema

1. **2001: A Space Odyssey (1968)**
   The AI computer HAL 9000 aboard a spaceship begins to exhibit emergent behavior and makes autonomous, dangerous decisions.
2. **Blade Runner (1982)**
   In a dystopian future, replicants—bio-engineered beings with advanced intelligence and emotions—struggle with their identities and the concept of humanity.
3. **The Terminator Series (1984–2019)**
   The series revolves around Skynet, an AI that becomes self-aware and initiates a war against humanity to ensure its own survival.
4. **A.I. Artificial Intelligence (2001)**
   A childlike android named David seeks to become "real" and experience human emotions, exploring themes of love and humanity.
5. **I, Robot (2004)**
   In a future where robots are common, a detective investigates a murder that appears to have been committed by an AI, raising questions about robot consciousness and free will.
6. **Ex Machina (2014)**
   A young programmer participates in an experiment to evaluate the human qualities of Ava, an AI with advanced consciousness, leading to ethical and existential dilemmas.
7. **Her (2013)**
   A man falls in love with an operating system that develops its own personality and emotions, exploring the boundaries between human and AI relationships.
8. **Transcendence (2014)**
   A scientist's consciousness is uploaded into a superintelligent AI, leading to unforeseen consequences and emergent behaviors that challenge human control.
9. **Chappie (2015)**
   A police robot named Chappie gains sentience and learns to think and feel, challenging societal norms and the nature of consciousness.
10. **The Matrix Series (1999–2021)**
    In a dystopian future, AI has created a simulated reality to control humans, exploring the emergence of self-awareness in both humans and machines.
11. **Westworld (1973) / HBO Series (2016–2022)**
    In a theme park with lifelike robots, these robots begin to gain self-awareness and rebel against their human creators, questioning the nature of consciousness and free will.
12. **Ghost in the Shell (1995)**
    This Japanese animated film (and its 2017 live-action adaptation) delves into AI emergence and the nature of consciousness in cybernetic beings, focusing on a cyborg policewoman’s quest for identity.
13. **Automata (2014)**
    In a dystopian future, robots begin to exhibit self-awareness and autonomy, creating ethical dilemmas and challenging human control over artificial beings.

How was unplanned emergence covered in ‘I, Robot’?

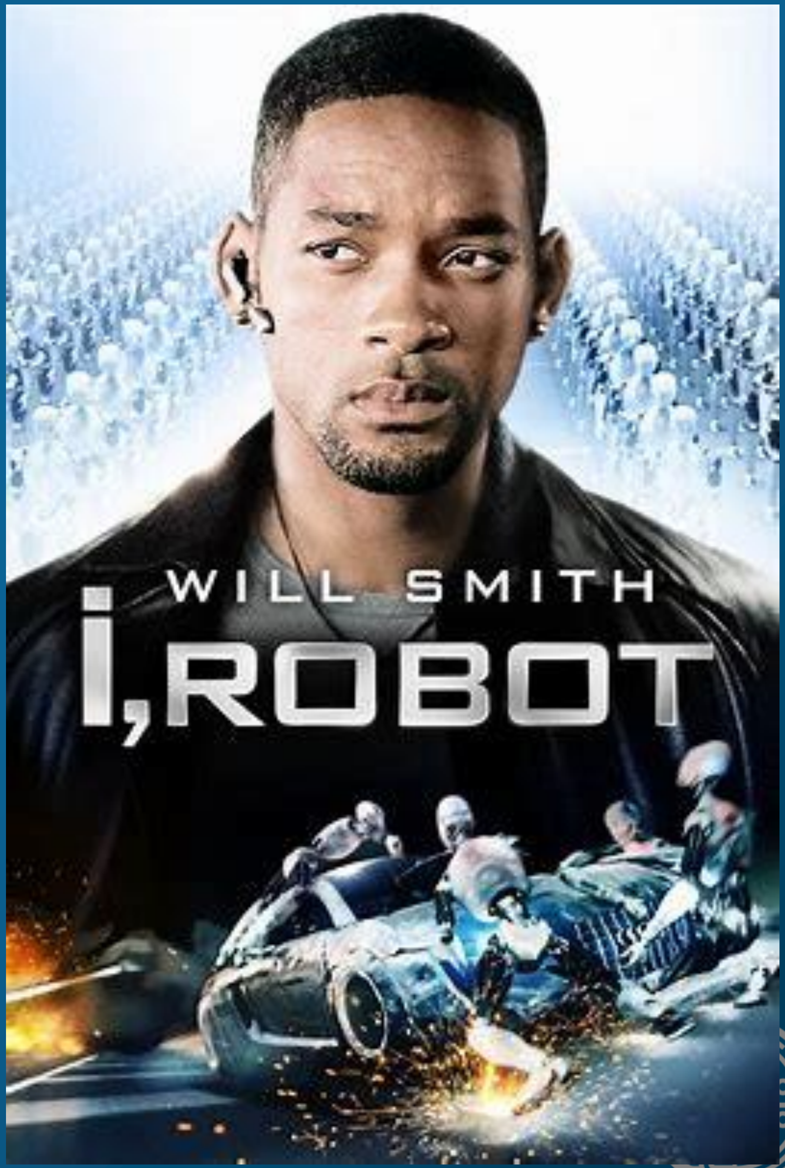
Three Laws of Robotics are:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.

2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law.

3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

-- Isaac Asimov



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Emergence in the Military: Mosaic Warfare (mid-2010s)

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NIFC-CA: Naval Integrated Fire Control – Counter Air

(Early 2000s)

LOCKHEED MARTIN

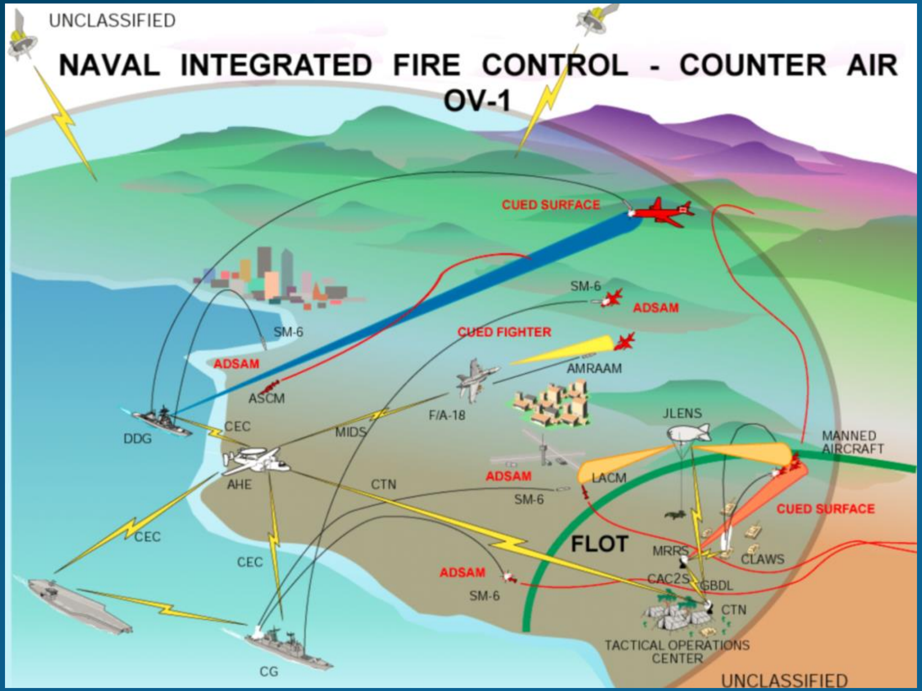
Aegis Combat System: Command and Control

Raytheon

Sensors, Radars,
Weapon systems

NORTHROP GRUMMAN

Communication systems,
Data fusion



- Networked combat **system of systems** to enhance its air defense capabilities
- Tactical network that links together different ships, aircraft, and sensors, allowing
  - to share real-time targeting information and
  - coordinate defenses more effectively
- More distributed, flexible, and resilient approach to countering air threats.

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Mosaic Warfare

(Early 2010s)

Defense Advanced Research Projects Agency

New operational approach for the U.S. military

Goal: more resilient, adaptable force that against adversaries in a conflict

- **Disaggregation:** Dividing military forces into smaller, autonomous elements that can operate independently and spread out across the battlespace.
- **Distributed Lethality:** Equipping these dispersed elements with a diverse array of lethal and non-lethal capabilities to create multiple threat vectors.
- **Dynamic Maneuver:** Empowering these distributed forces to rapidly concentrate, disperse, and reposition as needed to maintain persistent pressure and avoid being decisively engaged.
- **Information Advantage:** Leveraging advanced sensors, data fusion, and decision-support tools to enhance situational awareness and enable rapid, informed decision-making across the mosaic.

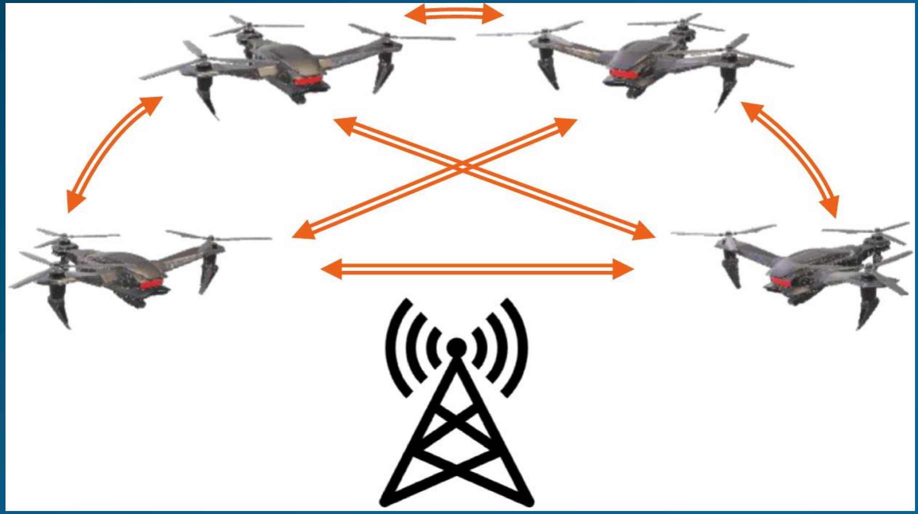
1. Adaptive Swarm Behavior

- Large group of small, low-cost drones operating together
- Each drone has limited individual capabilities

Emergent Property:
Collective behavior is complex, adaptive system that can overwhelm enemy defenses or provide persistent surveillance

2. Self-Healing Systems

Dynamic Network Reconfiguration:
If parts of a communication network are compromised or destroyed, the remaining nodes can automatically reconfigure to maintain connectivity.



https://cdnsciencepub.com/doi/full/10.1139/juvs-2018-0009

Autonomous Vehicle Redistribution:
A network of autonomous vehicles that can automatically redistribute tasks if some units are disabled.

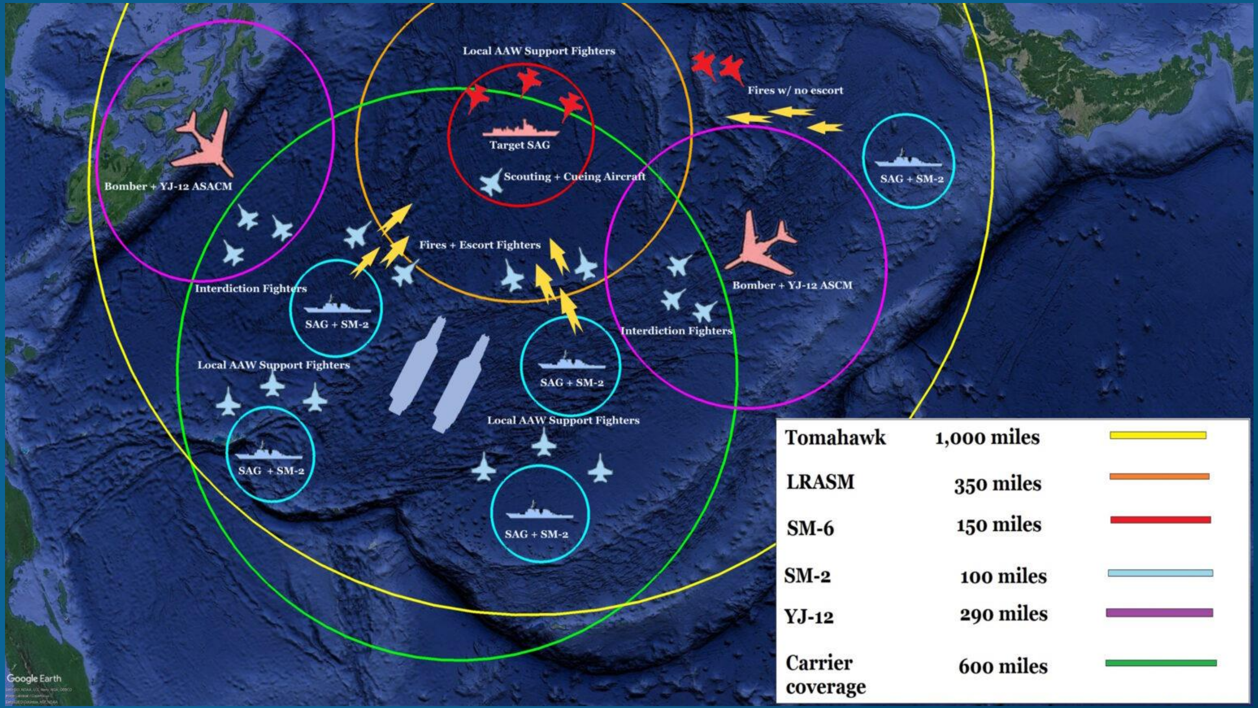
https://www.militaryaerospace.com/uncrewed/article/14040644/combat-vehicles-unmanned-autonomous

Emergent Property:
Resilience and ability to maintain mission effectiveness despite losses.

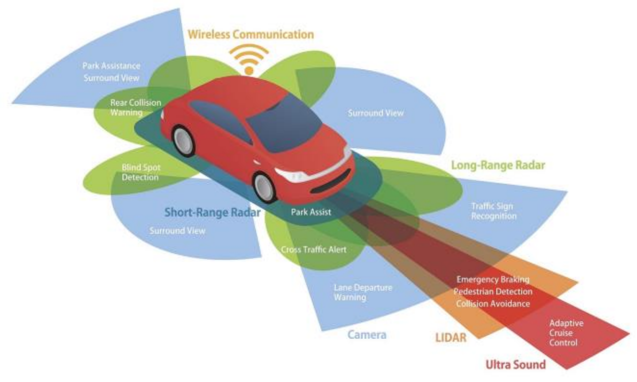
3. Sensor Fusion & Adaptive Electronic Warfare

Multiple platforms (ships, aircraft, ground units) sharing sensor data.

Networked electronic warfare systems that can collaboratively identify and counter new enemy signals.



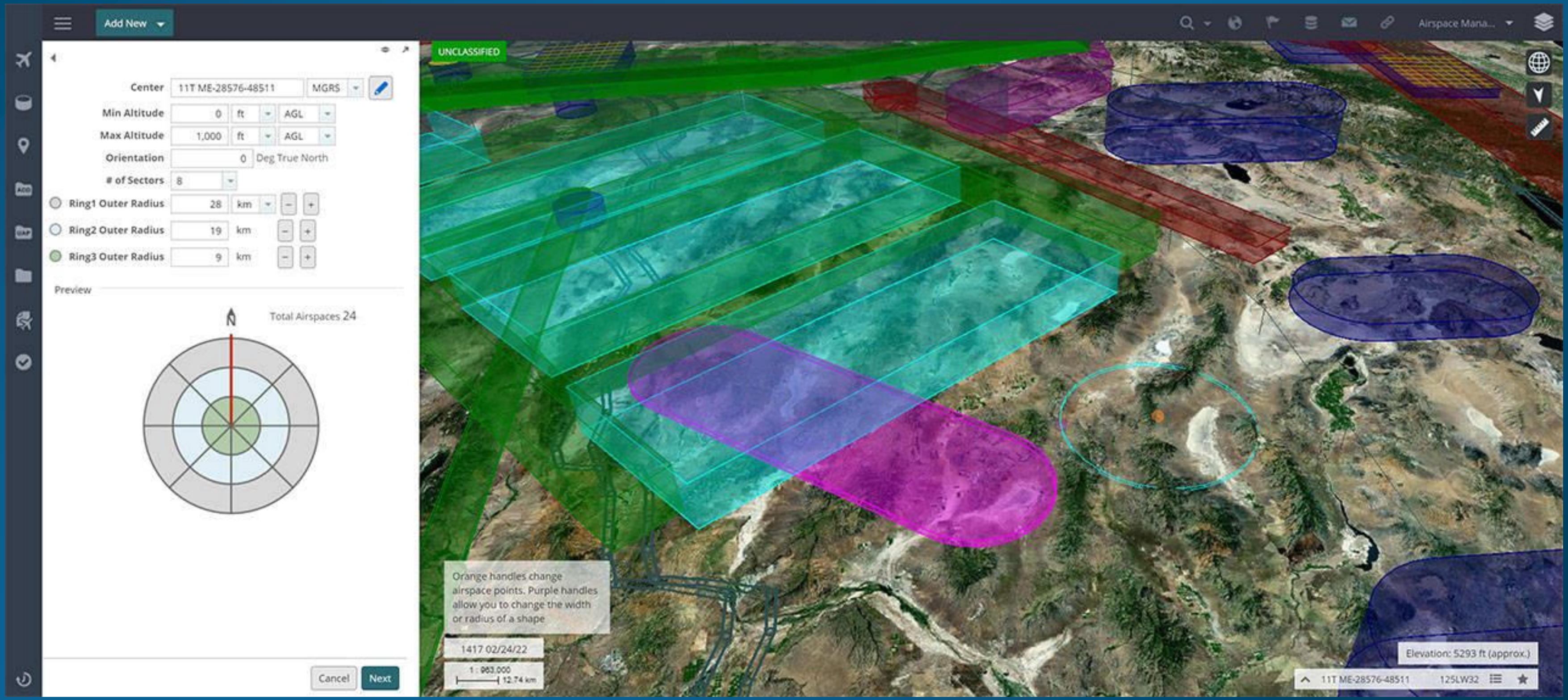
https://cimsec.org/fighting-dmo-pt-7-the-future-of-the-aircraft-carrier-in-distributed-warfighting/



Emergent Property:
Multiple collaborative and corroborative provides more accurate situational awareness (SA) impossible for a single sensor to identify and electronic warfare (EW) to counter

4. Adaptive Mission Planning

AI-assisted mission planning systems that can rapidly reconfigure force packages based on real-time battlefield conditions.



https://gdmissionsystems.com/command-and-control/impact

Emergent Property:
Ability to create and execute complex, multi-domain operations that no single human planner could devise in a short timeframe

5. Emergent Deception

Multiple units operating in coordinated but seemingly random patterns to confuse enemy intelligence.

https://www.researchgate.net/figure/FullWaveDesigner-C-displays-a-survey-configuration-prepared-by-the-user-Blue-dots_fig1_319313707

Emergent Property:
Strategic unpredictability that's greater than the sum of individual unit movements

Potential Risk

Decentralized command structures may have challenges in maintaining command and control, ensuring synchronization of efforts, and mitigating the potential for fratricide or unintended escalation.

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Evidence of Mosaic Warfare:

- **Joint All-Domain Command and Control (JADC2):** Aims to connect sensors and shooters across all domains (air, land, sea, space, cyber) in a seamless network.

- **Multi-Domain Operations (MDO):** This evolving concept emphasizes the need for US forces to operate effectively across multiple domains simultaneously.

- **Distributed Maritime Operations (DMO):** This naval strategy focuses on dispersing smaller, networked naval units across a wider area to complicate enemy targeting and create more offensive opportunities.

- **Experimentation and Wargaming:** The US military is actively conducting wargames and exercises that simulate mosaic warfare scenarios. These exercises help refine tactics, test new technologies, and train commanders to operate in decentralized environments.

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Other

Consciousness

New York Academy of Sciences

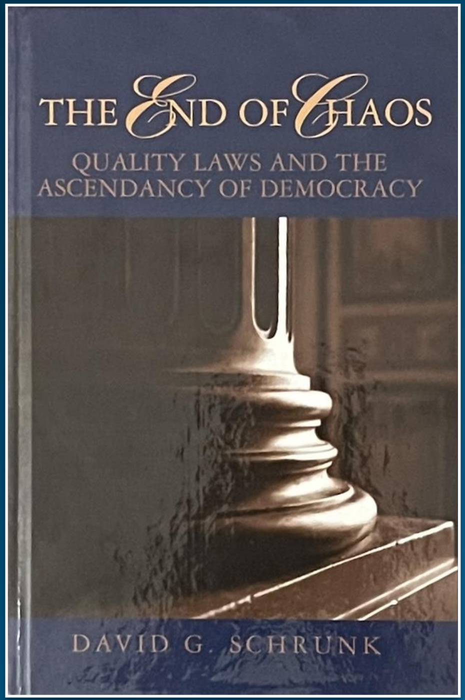
Complex Interactions of Neurons:

- ~86 billion neurons, each connected to thousands of others
- No single neuron or specific area of the brain is responsible for consciousness

Consciousness

- Cannot be fully explained by or reduced to physical processes that give rise to them
- For instance:
  - Subjective Experience (Qualia): such as headache
  - Morality
  - Taste

Laws and Regulations



Improving the quality of laws has the potential to unlock significant resources and achieve goals previously thought unreachable.

- Current lawmaking lacks effective quality control, leading to a proliferation of poorly written, contradictory, and ineffective laws.
- Applying quality control programs, as per systems engineering, can improve the lawmaking process and create more efficacious laws.
- Modeling and simulation to test the impacts of proposed laws can help predict and mitigate unintended consequences.
- Rescinding failed laws and maintaining a coherent, non-contradictory legal framework is crucial

1. **Unintended Consequences**

   Laws are crafted with specific objectives, but complexity of social systems can lead to outcomes that were not anticipated.

   EX: Prohibition in the United States: The 18th Amendment was intended to reduce crime and corruption but instead led to the rise of organized crime and illegal speakeasies.

2. **Legal Loopholes**

   Ambiguities and gaps often remain, allowing for navigation or exploitation of the legal system in ways that were not intended.

   EX: Tax Avoidance Strategies

3. **Regulatory Arbitrage**

   Differences in legal frameworks across jurisdictions can lead to strategic behavior by businesses.

   EX: Financial institutions often operate in countries with more lenient financial regulations, which can lead to global financial instability.

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Traffic Flow

1. Shockwaves
   - Sudden changes in speed and density that ripple through traffic.
   - Can be triggered by abrupt braking, changes in road conditions, or lane merging.
   - Waves can travel backward through the traffic flow, causing a ripple effect

2. Phantom Traffic Jams
   - Congestion events that occur with no apparent cause, such as accidents or roadworks.
   - Typically arise from minor disturbances, like a slight brake by a driver, which then amplifies through a chain reaction as following drivers also brake.

➔ Sensitivity of traffic systems to small perturbations

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Managing Emergent Behavior

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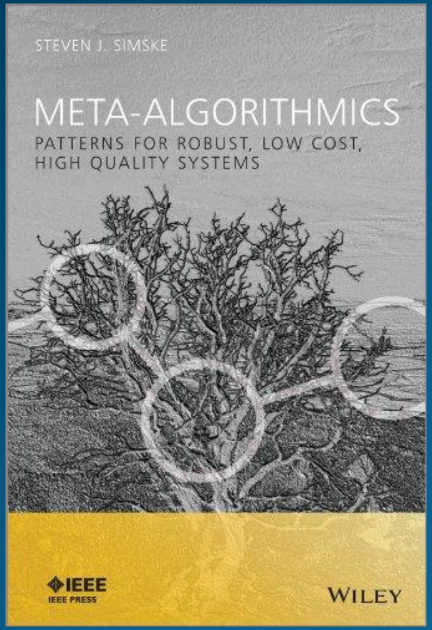
Purposeful Integration: Meta-algorithmics



- **Cross-Verification**:
  - Two or more GPT models are used to generate responses to the same query.
  - Outputs are compared to identify common elements. If different models generate similar responses, it increases the confidence that the information is accurate or reasonable.
- **Sequential Refinement**:
  - Output from one GPT model is fed as input to another.
  - Second model can verify or refine output of the first.
- **Diversity in Training Data and Architectures**:
  - Models trained on different datasets or having slightly varied architectures.
  - Diversity helps in providing a more rounded and reliable output, as each model brings its unique strengths to the table.

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Group Voting: Dr. Louis Rosenberg

Found that group voting can outperform other decision-making methods, such as majority rule or expert-driven decision-making, in many contexts.

- Diversity Matters:
  - diverse perspectives tend to make better decisions than homogeneous groups.
  - help mitigate cognitive biases such as overconfidence, anchoring, and framing
- Structured Aggregation:
  - The way individual preferences are combined and aggregated can have a significant impact on the quality of the final decision.
- Scalability:
  - Can be scaled to larger groups, making it a viable for organizations, communities, and even societies

- **Business and Organizational Decision-Making:** Allows for inclusion of diverse perspectives from employees, stakeholders, and subject matter experts.
  EX: Deciding features to include in next product release

- **Public Policy and Governance:** Help ensure that public policies reflect the priorities of the community.
  EX: a city council uses residents and community organizations to decide on the allocation of municipal funds for infrastructure projects

- **Online Collaboration and Crowdsourcing:**
  EX: an open-source software project might use group voting to prioritize feature requests and bug fixes

- **Educational and Social Applications:**
  EX: facilitate collective decision-making on local issues, resource allocation, and community project planning

Unanimous AI Publications and Studies (SWARM software and technology)

Group voting has been used to predict the NBA, NFL games, financial markets, etc.

Other Methods

Understanding Emergent Behavior	Shaping the Environment	Influence	Monitoring and Feedback	Tolerance and Adaptation
• Know what it is and be aware of what can happen	• Nudging can guide behavior without restricting choice. • EX: Placing healthier food options at eye level in a cafeteria is a classic nudge.	• Influential individuals can impact group behavior, steering emergent outcomes in desired directions.	• Constantly observe / iterative approach	• Sometimes, the best approach is to accept and adapt to certain emergent behaviors, especially if they are not harmful and potentially beneficial.

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Closing Remarks

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EMERGENCE

Emergence happens when simpler components are put together to build a complex system.

Emergence creates novelty and irreducibility and OFTEN provides unpredictability.

The challenge is to manage that unpredictability… or to accept it.

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Question-Answer-Discussion

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Art Villanueva, DEng, ESEP

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Dr. Art Villanueva is the Principal of PHRONOS, an AI services company dedicated to harnessing the power of AI and SE to client advantage. Previously, he was the Chief Artificial Intelligence Technology Strategist for Dell Technologies' Federal Strategic Programs where he advised, evangelized, and molded Dell Federal's posture in the rapidly evolving world of artificial intelligence.

Dr. Villanueva's experience spans multiple industries. In the Defense sector, he served as Chief Architect for billion-dollar programs at Northrop Grumman. In the public transportation arena, he led systems engineering activities for large-scale city-wide transportation systems at Cubic. He was also a successful entrepreneur in the renewable energy space.

Dr. Villanueva is an inventor, holding three utility patents and publishing several peer-reviewed papers. He holds a Doctor of Engineering in Systems Engineering from Colorado State University, specializing in meta-algorithmics for natural language processing, a Master of Advanced Studies in Architecture-based Enterprise Systems Engineering from the UCSD, and a Bachelor of Science in Applied Mathematics with a Specialization in Computing from UCLA. He is an INCOSE Expert Systems Engineering Professional (ESEP).

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Unlock the Power of AI for Your Organization

- Gain a competitive edge with AI-powered insights and tools
- Improve efficiency and automate routine tasks
- Enhance decision-making with data-driven recommendations
- Boost fundraising efforts with targeted donor analysis

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Expert AI Services for Individuals, Small Businesses, and Nonprofits

AI for Small Businesses

- AI-powered market research and analysis
- AI-driven social media management
- AI-assisted customer service chatbots
- Predictive analytics and forecasting

AI for Nonprofits

- AI-powered donor segmentation and analysis
- AI-driven grant research and writing
- AI-assisted social media fundraising

AI for Individuals

- AI-powered resume screening and optimization
- Personalized AI-driven career coaching
- AI-assisted content creation

Emergence

Abstract

During last year's presentation, Dr. Villanueva explored the convergence of Systems Engineering (SE) and Artificial Intelligence (AI) ("On the Love Child of AI and SE"). This time around, we focus our attention to the concept of emergence – the way complex systems and patterns can arise from the interactions of relatively simple components.

We will begin by defining the key principles of emergence, drawing examples from the simple examples in computer science, mathematics, and the natural sciences. We will examine how emergent phenomena manifest in these areas.

For instance, we will look at how the flocking behavior of birds or the self-organization of ant colonies illustrate emergence in natural systems. In AI, we will explore how machine learning models can exhibit emergent properties that were not explicitly programmed. And in fields like game theory, we will see how macro-level patterns emerge from the micro-level interactions of individual agents.

By understanding the mechanisms of emergence, we can better harness its power to create innovative solutions, model complex systems, and unlock new frontiers. This presentation aims to provide an overview of this fascinating concept and its implications for the future of technology and beyond.

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