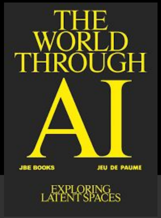
The Art of Self-Organization: Morphogenesis and Generative Systems

M200A Art & Technology

Presented by

Italo Rojas

Books

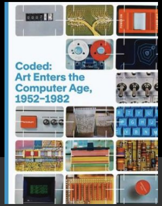


The World Through AI

Latent space. Multi-dimensional, abstract mathematical framework where neural networks organize and encode data.

Art & Science at CALTECH

Expose different works about science and its relation with art in CALTECH. The visuals as a key component.



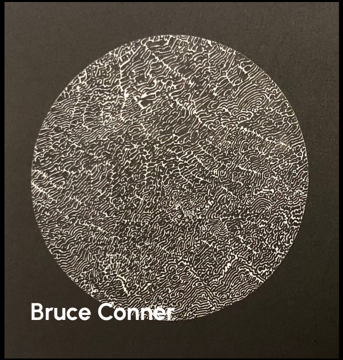
Coded: Art Enters the Computer Age,

It highlight a interest in algorithms and rule-based approaches to creation. Art + computers.

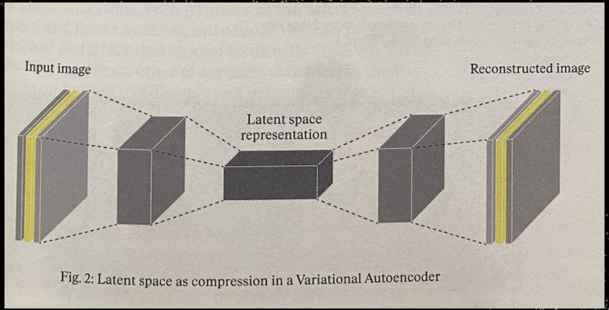
Books


Agnieszka Kurant


Joan Fontcuberta


Bruce Conner


Lilian Schwartz


Input image
Reconstructed image
Latent space
representation
Fig. 2: Latent space as compression in a Variational Autoencoder


Joseph Nechvatal

What is behind this patterns?

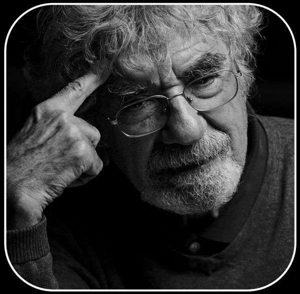
@meotive

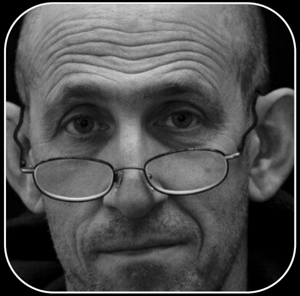
@gosoundmitch

@mannyb

Content

1 Introduction: The Framework





Humberto Maturana (1928-2021)

Biologist and Philosopher

Scott Camazine (1952-)

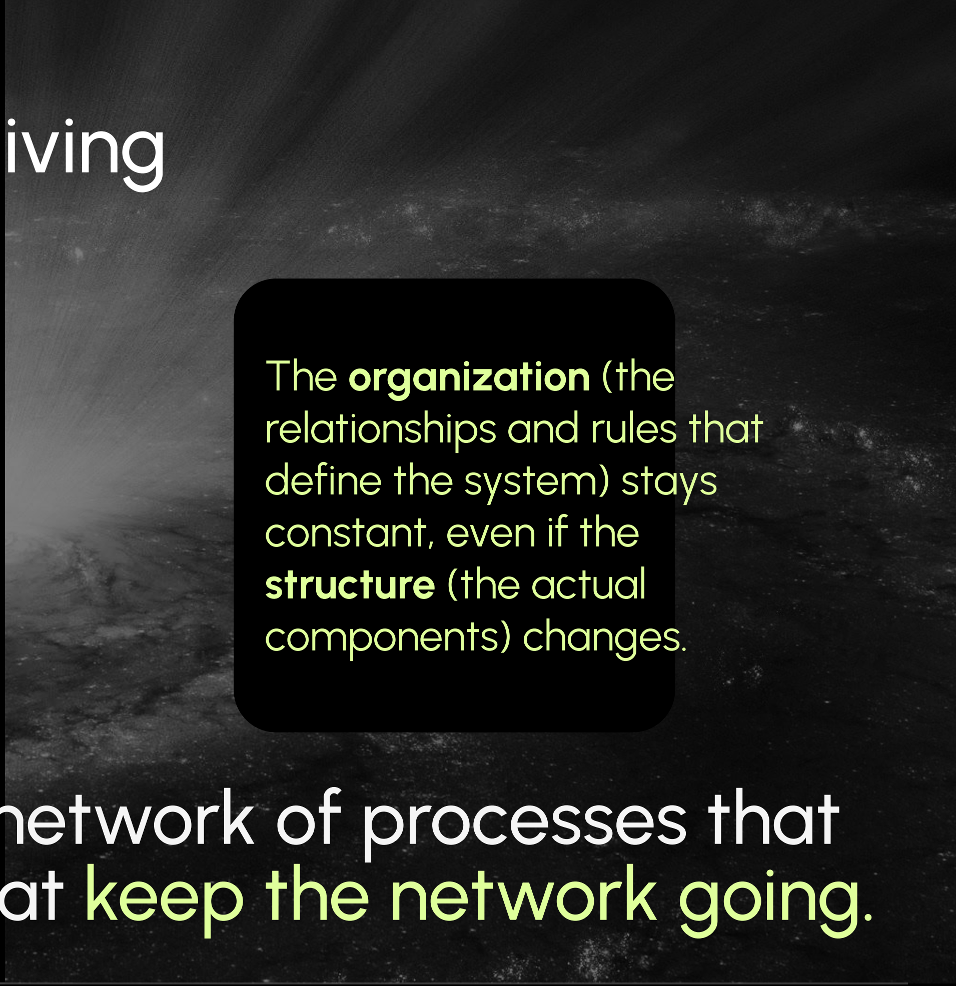
Biologist, Artist

Fritjof Capra (1939-)

Physicist, Deep Ecologist

The Organization of the Living

(Humberto Maturana, 1975)



The **organization** (the relationships and rules that define the system) stays constant, even if the **structure** (the actual components) changes.

Autopoiesis: Life is a closed network of processes that produce the components that keep the network going.

Self-Organization in Biological Systems

(Camazine & Scott, 2001)

Global patterns arise from local interactions among individuals following simple behavioral rules (Pattern formation and environment role)

Patterns in nature can arise without central control. Instead, they emerge from simple rules followed by many interacting agents.

III approach

The Web of Life

(Fritjof Capra, 1997)

Biological and ecological systems behave in nonlinear ways, leading to emergent properties. Relationships and patterns matter more than isolated components.

Living systems must be seen as networks of relationships, continually organizing themselves through dynamic processes.

The Framework

Maturana

Organization
Structure
Self-production

Camazine

Global patterns
Local rules
Environment

Capra

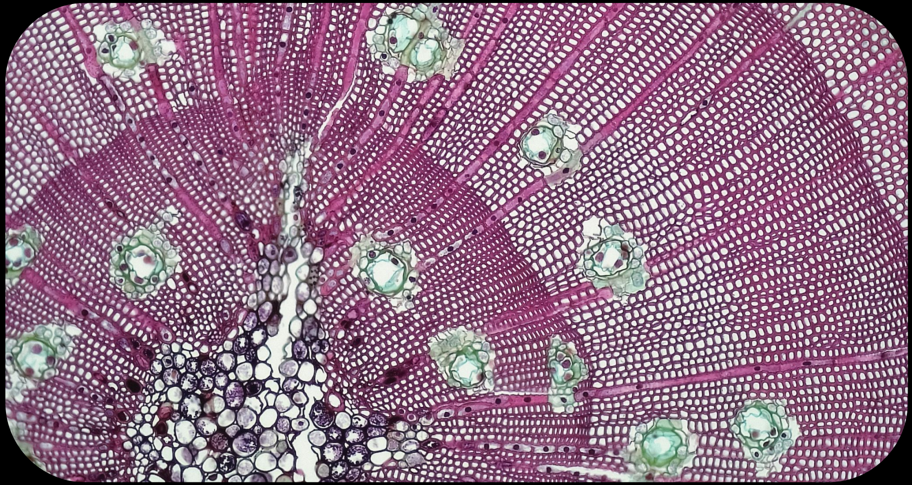
Emergence
Relationship
Patterns

2

The rules: biology, signals & decisions

References:

1. Fricker, M. D., Heaton, L. L., Jones, N. S., & Boddy, L. (2017). "The Mycelium as a Network." Microbiology Spectrum, 5(3).
2. Smith, R. S., et al. (2006). "A plausible model of phyllotaxis." Proceedings of the National Academy of Sciences (PNAS), 103(5), 1301-1306.
3. Levin, M. (2014). "Molecular bioelectricity: how endogenous voltage potentials control cell behavior and instruct pattern regulation in vivo." Molecular Biology of the Cell, 25(24), 3835-3850.



@andremouton, @rexroshan, @berkshirecommunitycollege

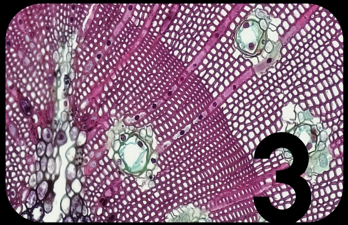
Write a statement about the core principles that guide your company's actions.

Mycelial Branching

Autonomous agent making local decisions based on resource cost vs. potential gain.
Ex: Explorers

Phyllotaxis

The "winner-takes-all" effect. When a cell's auxin level crosses a threshold, that location is chosen to start a new organ (a leaf primordium). This is the morphogenesis event.
Ex: Actors



Bioelectricity

The voltage map. The system is not "grow as much as possible," but "reach and maintain a particular shape," growth slows or stops once that goal is satisfied.
Ex: Buildings

3

Patterns & algorithms

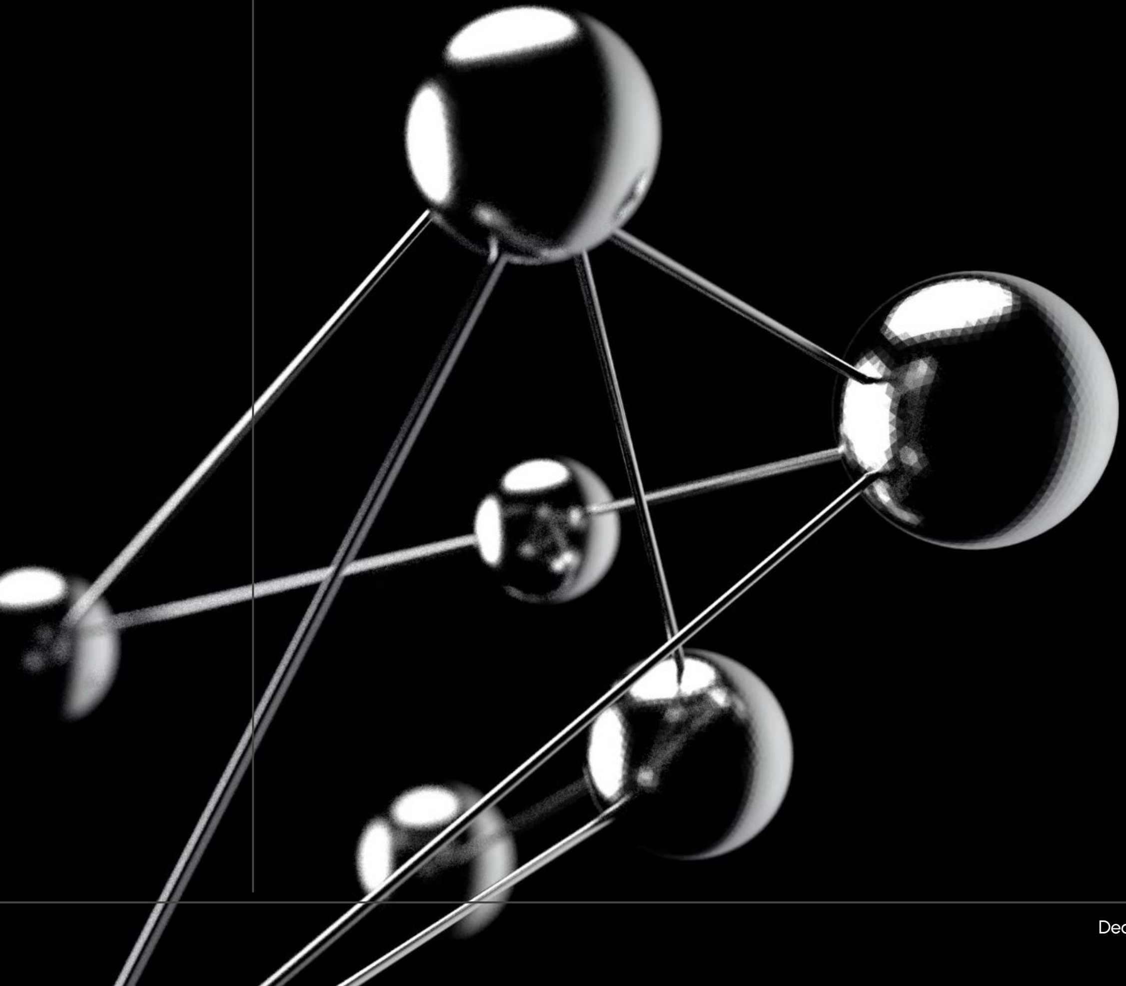
References:

1. Prusinkiewicz, P., & Lindenmayer, A. (1990). The Algorithmic Beauty of Plants. Springer-Verlag.

2. Turing, A. M. (1952). "The Chemical Basis of Morphogenesis." Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 237(641), 37–72.

3. Tero, A., Takagi, S., Saigusa, S., Wu, Q., Sugawara, K., Miyamoto, Y., ... & Nakagaki, T. (2010). "Rules for Biologically Inspired Adaptive Network Design." Science, 327(5964), 439–442.

4. Witten, T. A., & Sander, L. M. (1981). "Diffusion-Limited Aggregation, a Kinetic Critical Phenomenon." Physical Review Letters, 47(19), 1400–1403.

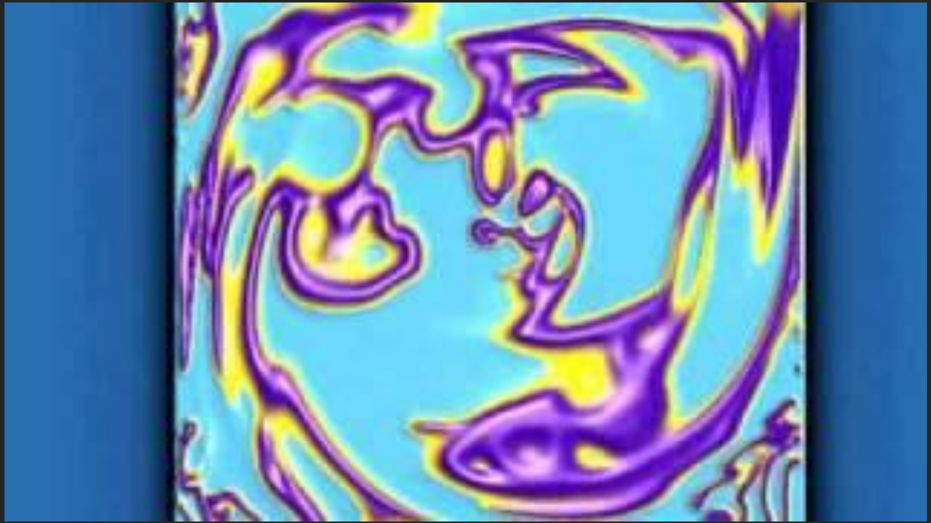


L-Systems (Lindenmayer Systems)

The pattern is driven by an axiom (starting string) and a set of production rules (If/Then statements) that are applied recursively to the string.

For simulating Phyllotaxis and fractal self-similarity.

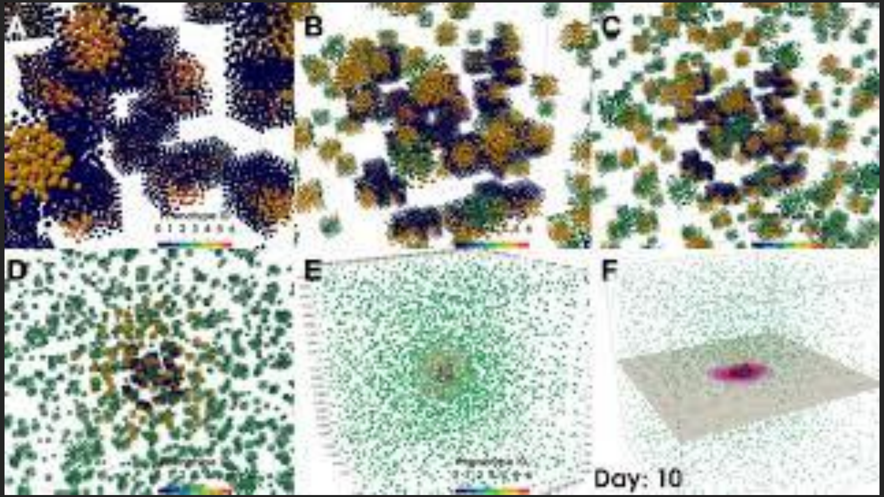
Reaction–Diffusion (R-D) Processes



Pattern formation is driven by the interaction of two competing chemical species: an Activator that promotes its own production and the production of an Inhibitor that spreads rapidly to suppress the Activator.

For simulating Turing Patterns

Agent-Based Growth Models



Autonomous agents (or particles/nodes) that follow simple, local rules (attraction, repulsion, path following) and leave behind pheromone or chemical trails that influence the decisions of other agents.

For simulating Optimized Networks, Flow Paths, and Maze Solving

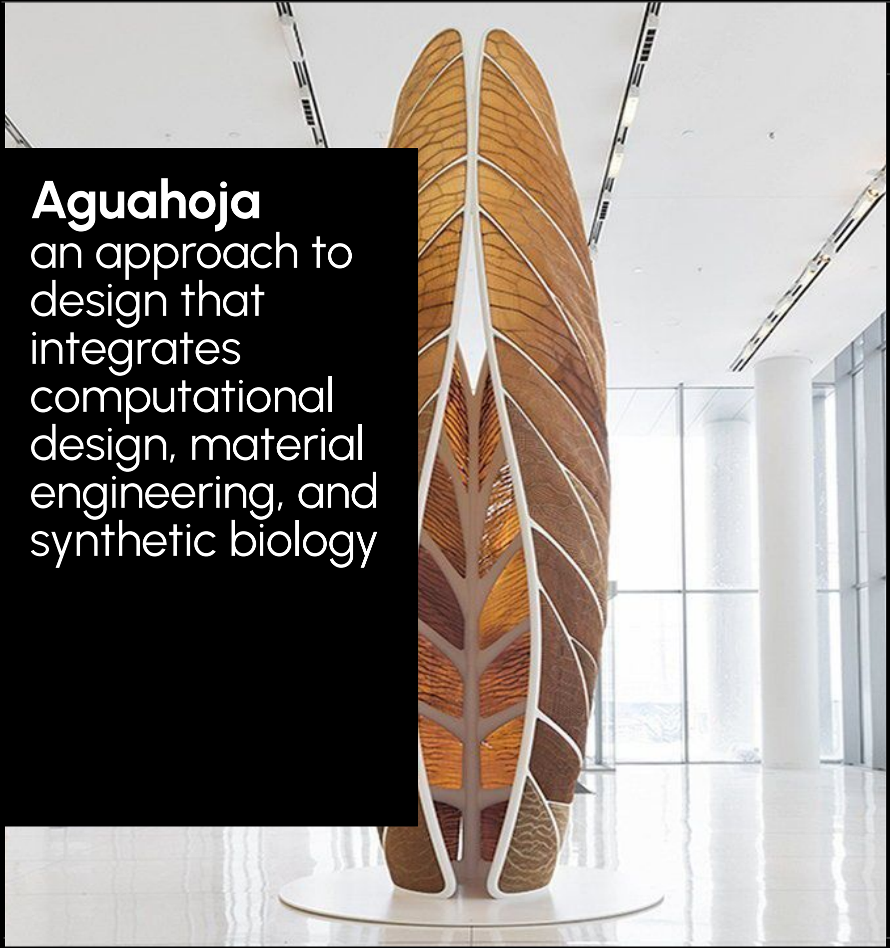
Diffusion-Limited Aggregation (DLA)

Stochastic growth model where particles undergoing a Random Walk (simulating diffusion or limited supply flow) attach irreversibly to a growing cluster, typically fixed at a central seed particle (the Attractor).

For simulating Fractals

4

Art

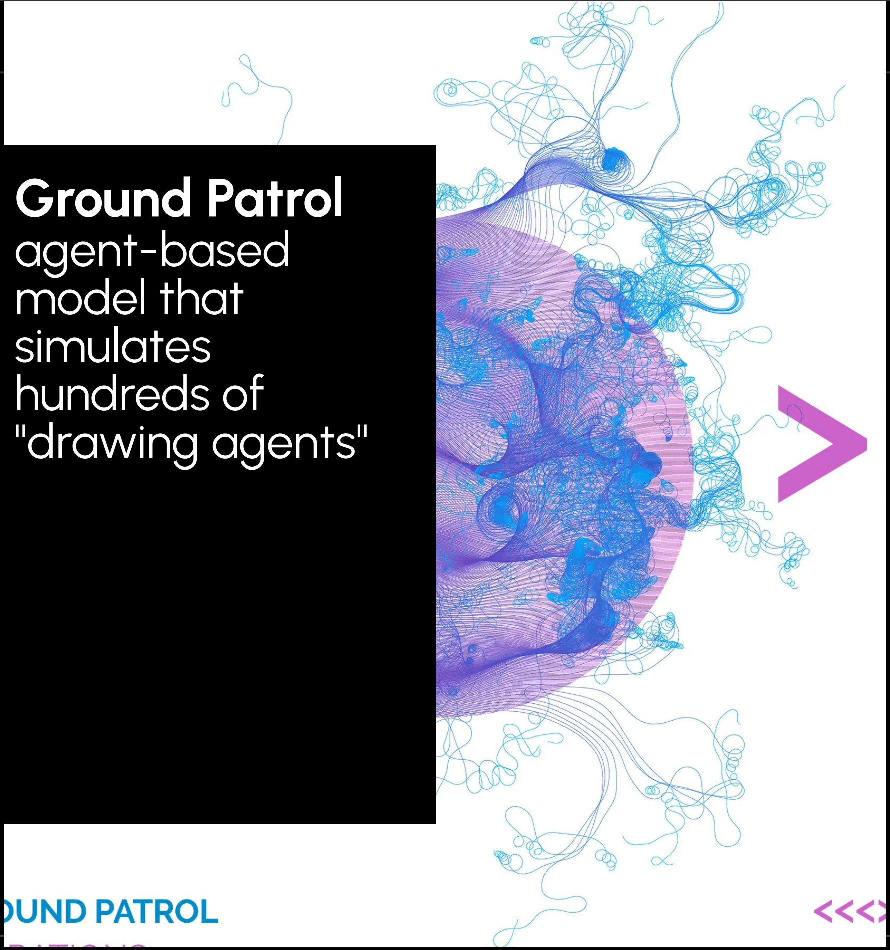


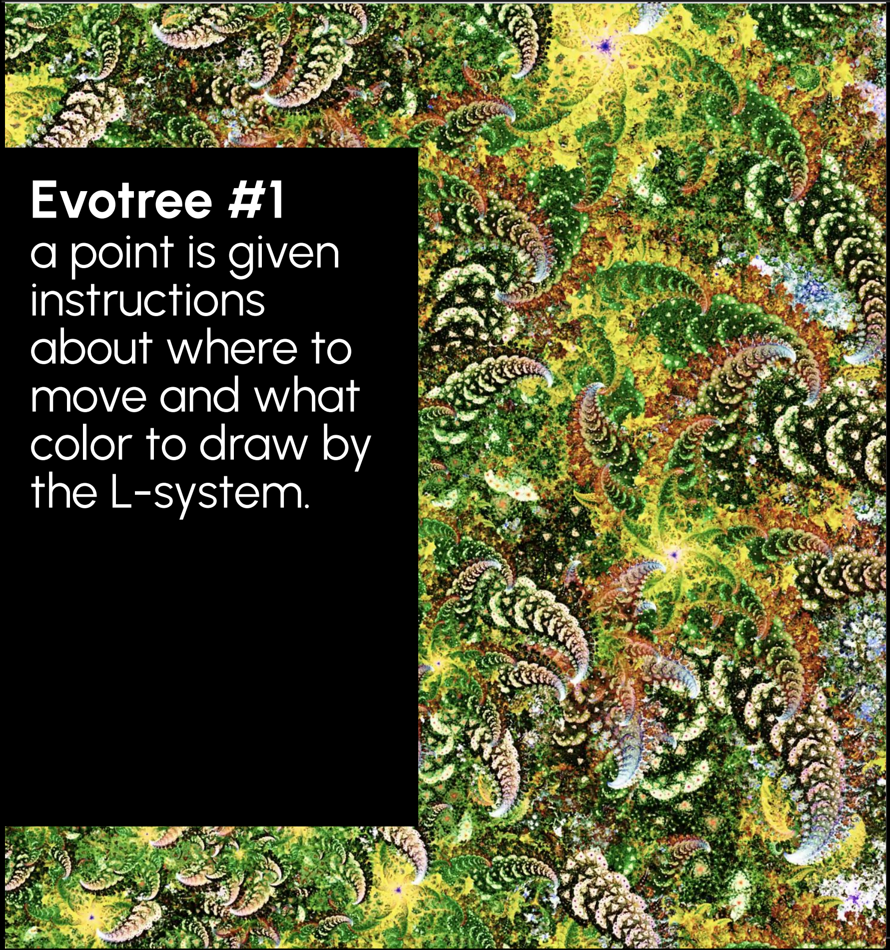
Aguahoja
an approach to design that integrates computational design, material design, material engineering, and synthetic biology

EDEN
a data-driven design approach to uniting human-centric cultural typologies with Nature-centric needs to maximize ecological thriving

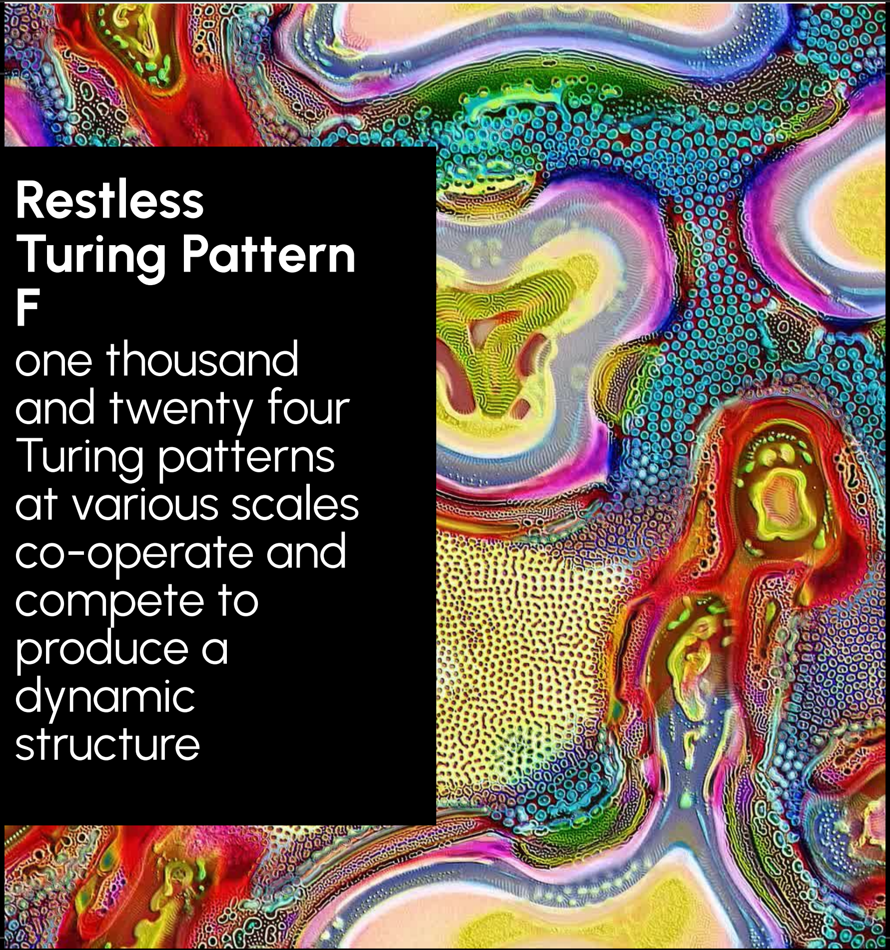
Morphogenesis Series
a series of digital still images created using custom software based on biological models of development

Ground Patrol
agent-based model that simulates hundreds of "drawing agents"

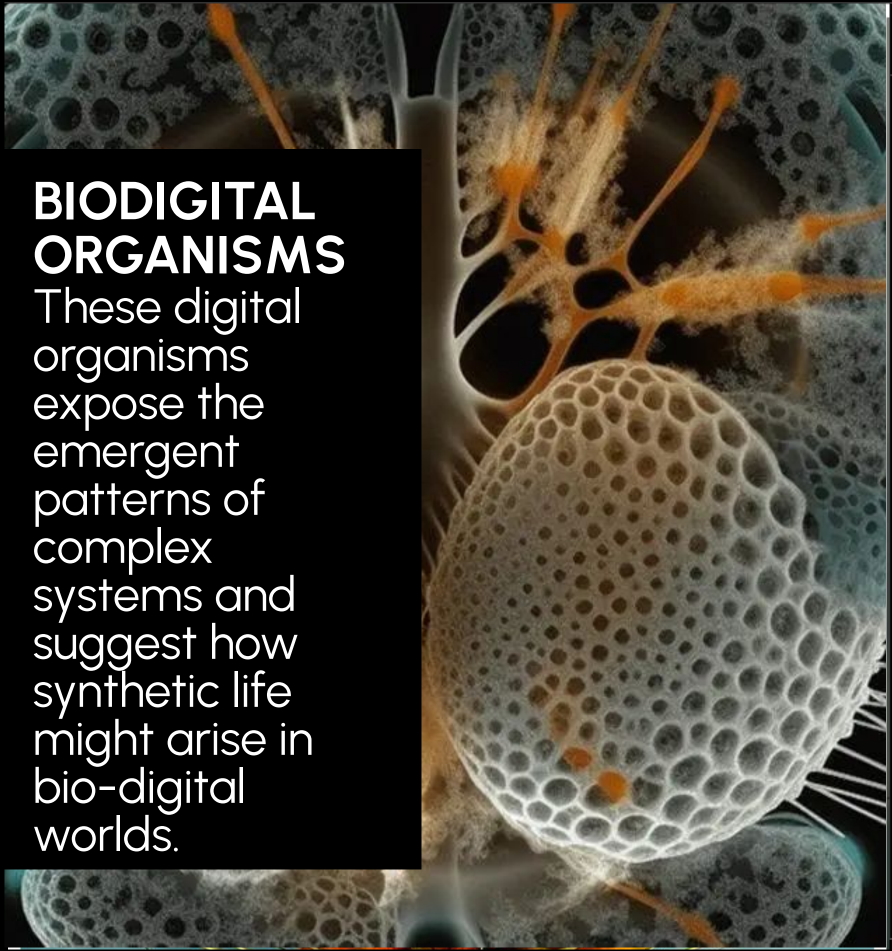




Evotree #1
a point is given instructions about where to move and what color to draw by the L-system.

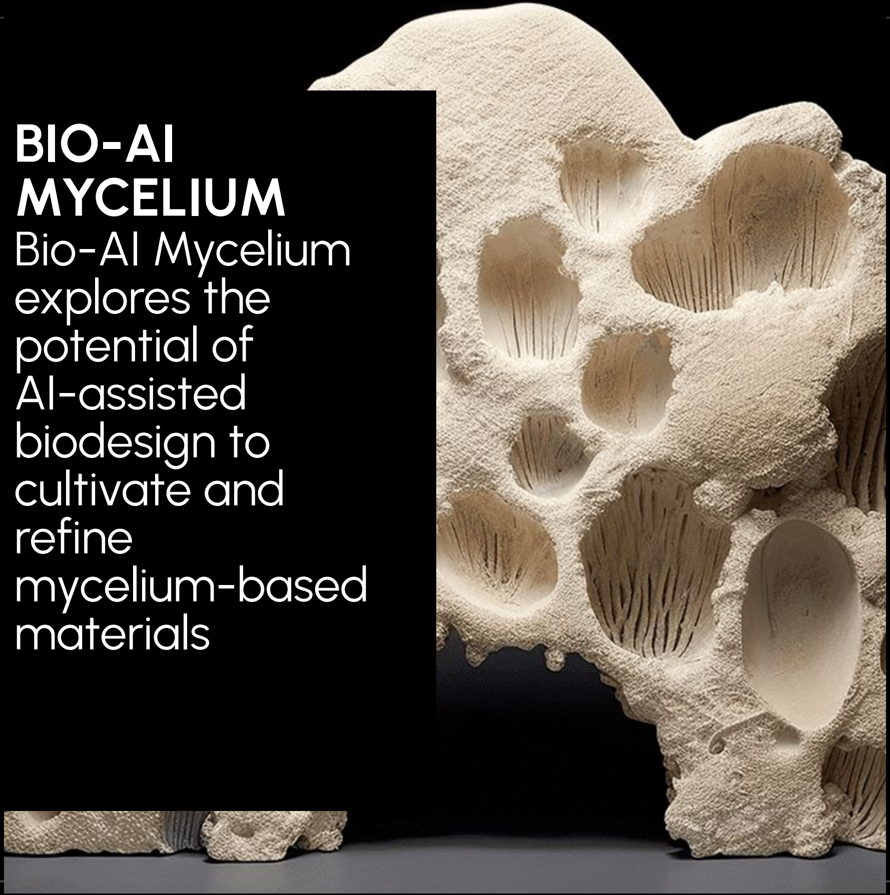


Restless Turing Pattern F
one thousand and twenty four Turing patterns at various scales co-operate and compete to produce a dynamic structure



BIODIGITAL ORGANISMS

These digital organisms expose the emergent patterns of complex systems and suggest how synthetic life might arise in bio-digital worlds.



BIO-AI MYCELIUM

Bio-AI Mycelium explores the potential of AI-assisted biodesign to cultivate and refine mycelium-based materials

Takeaways

1

Systems: Relations over components

Form arises from the flow, not the node

2

Nature as a teacher

The solution space is defined by the constraint

3

First algorithms, then play

Behavior precedes structure; define the rules, and the structure will self-assemble

4

Blending disciplines

Bioelectric map apply to the digital world. New conditions, new patterns.

Thank you