An Interactive Electronic Art System Based on Artificial Ecosystemics

T. Kowaliw[1], J. McCormack[2], and A. Dorin[2]

1. Institut des systèmes complexes - Paris Île-de-France,
Centre national de la recherche scientifique,
http://kowaliw.ca

2. Centre for Electronic Media Art,
Faculty of Information Technology, Monash University
http://www.csse.monash.edu.au/cema

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A Tractable Theory of Creativity

Dorin & Korb's Creativity

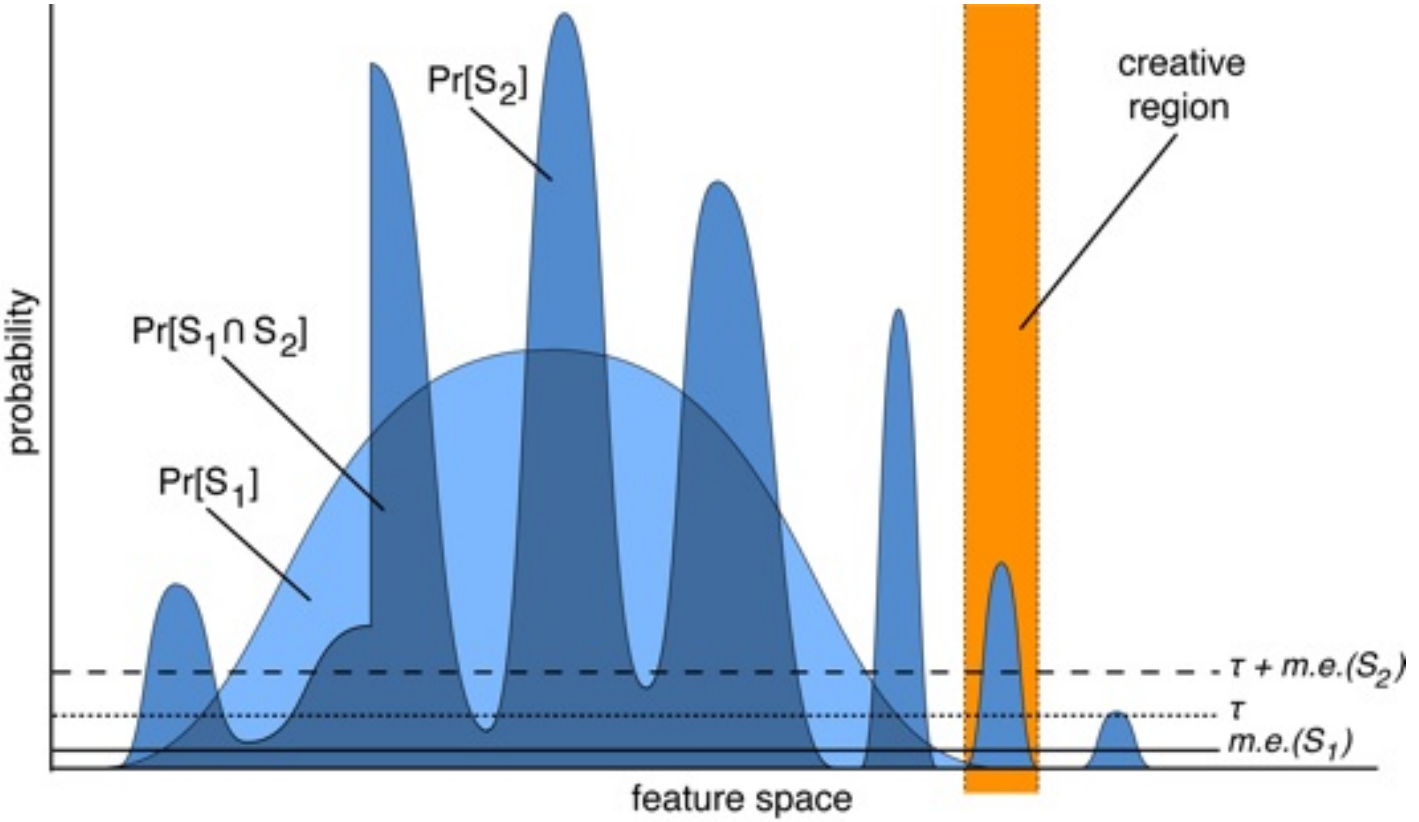
A *creative* framework is "a framework that has a relatively high probability of producing representations of patterns that can arise only with a small probability in previously existing frameworks"[1]

Note: notions such as appropriateness or value are independent, *i.e.*, an interesting but controversial stance.

[1] Dorin, Korb, *Improbably Creativity*, Dagstuhl International Seminar on Computational Creativity, 2009

A simplification:

Given some certainty level c and tolerance for error τ, there exists *some* interval in which S_2 can produce patterns, while S_1 cannot.



Or,

A system S_1 is creative relative to system S_2 if S_1 can reliably produce something that S_2 cannot produce at all.

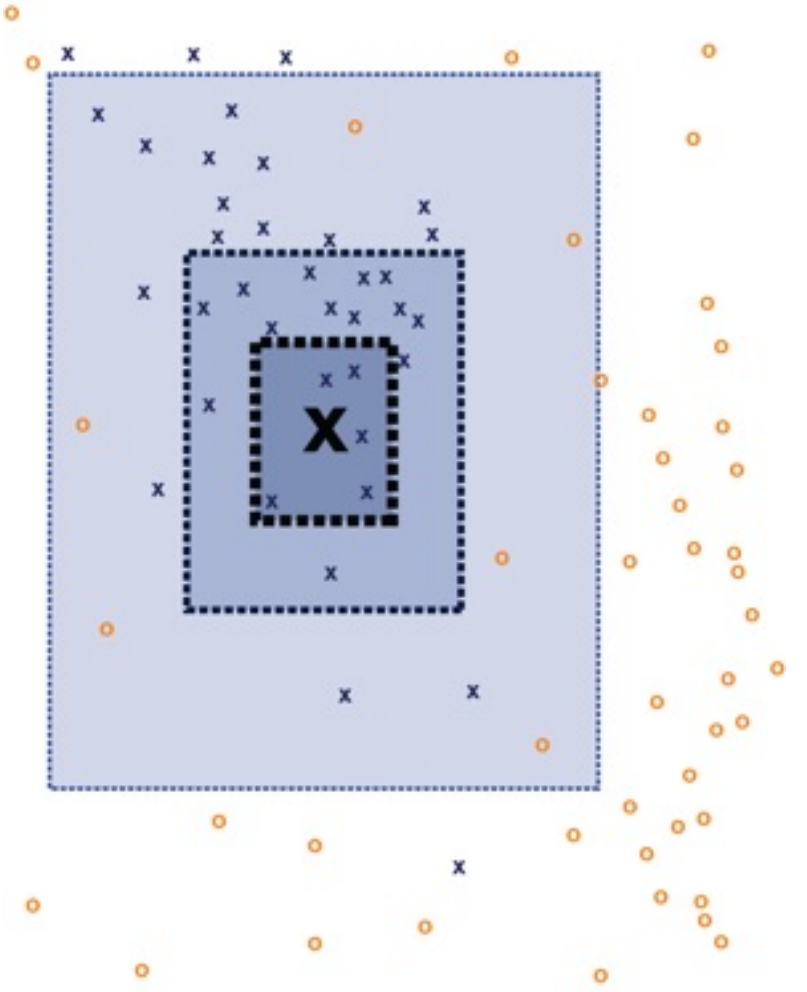
So:

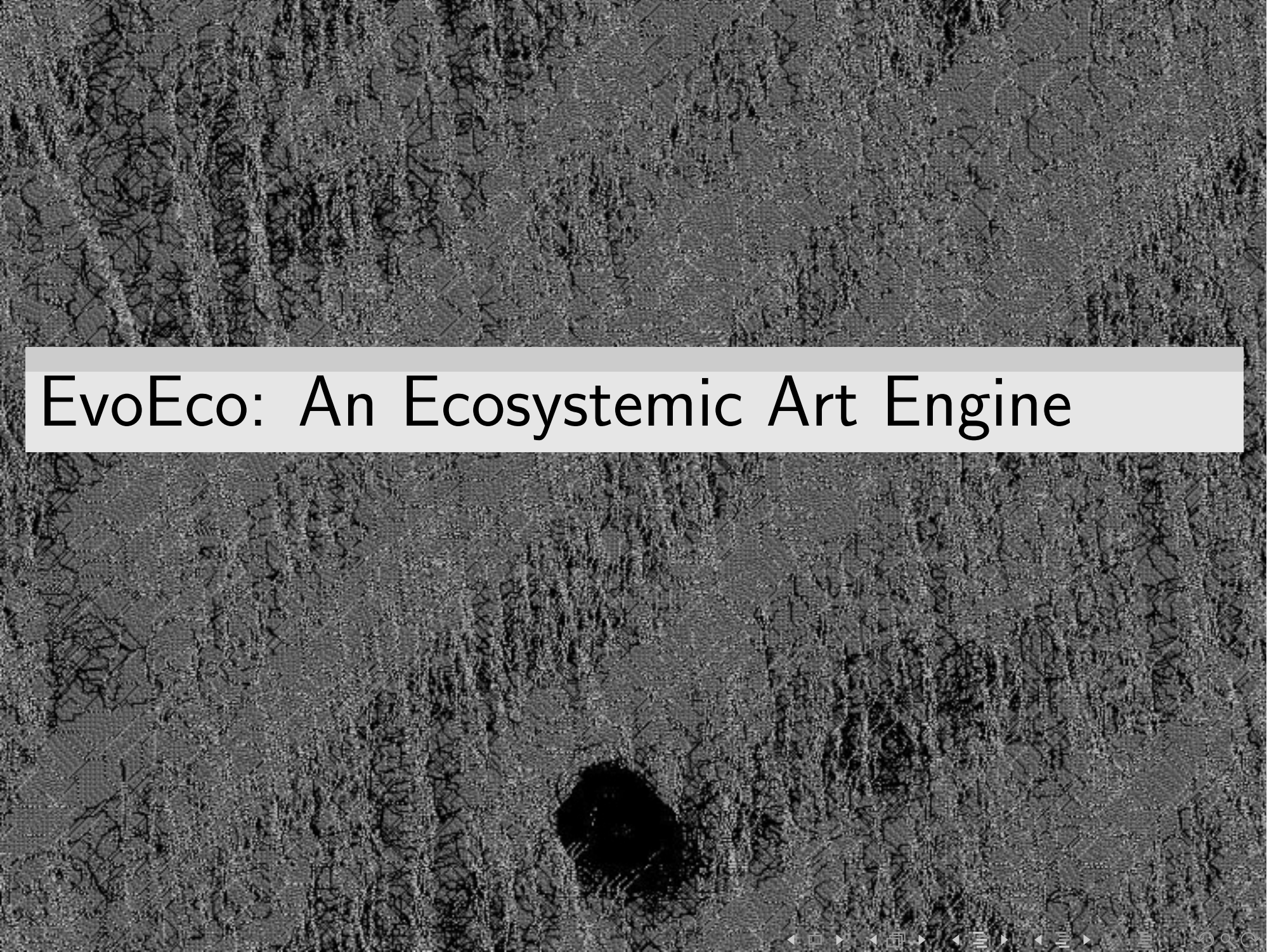
- We're discussing systems, not representations and not patterns.
- We aren't relying on a notion of distance, just regions in which we can define probability.
- We can encode our expectations, prior experiences, etc. as a worldview system, and measure relative to this.

Finding creative regions

In the domain of images, we can consider a features space composed of features drawn from computer vision (i.e. features well designed to be **appropriate** to human vision in a general and independent sense).

Next, we can find appropriate intervals in this features space between two systems, based on provided samples.





EvoEco: An Ecosystemic Art Engine

Ecosystemics

Biological ecosystems are known to be an integral component of evolutionary **diversity**, where niche construction is known to support **stable polymorphisms** and **unusual evolutionary dynamics**[2]. Artificial ecosystems are believed to be models capable of **generating complex patterns and life-like properties**[3].

[2] Laland et al., *Evolutionary consequences of niche construction and their implication for ecology*, PNAS, 1999

[3] Ronkko, *An Artificial Ecosystem: Emergent Dynamics and Lifelike Properties*, Artificial Life, 2007

Ecosystemics in Electronic Art

Ecosystemic models are suspected to be good choices for electronic art platforms, and are commonly used as such. They are believed[4] to promote:

- coherence and unity in the face of perturbation;
- multi-scale temporal complexity;
- the autonomous production of novelty;
- susceptibility to external control.

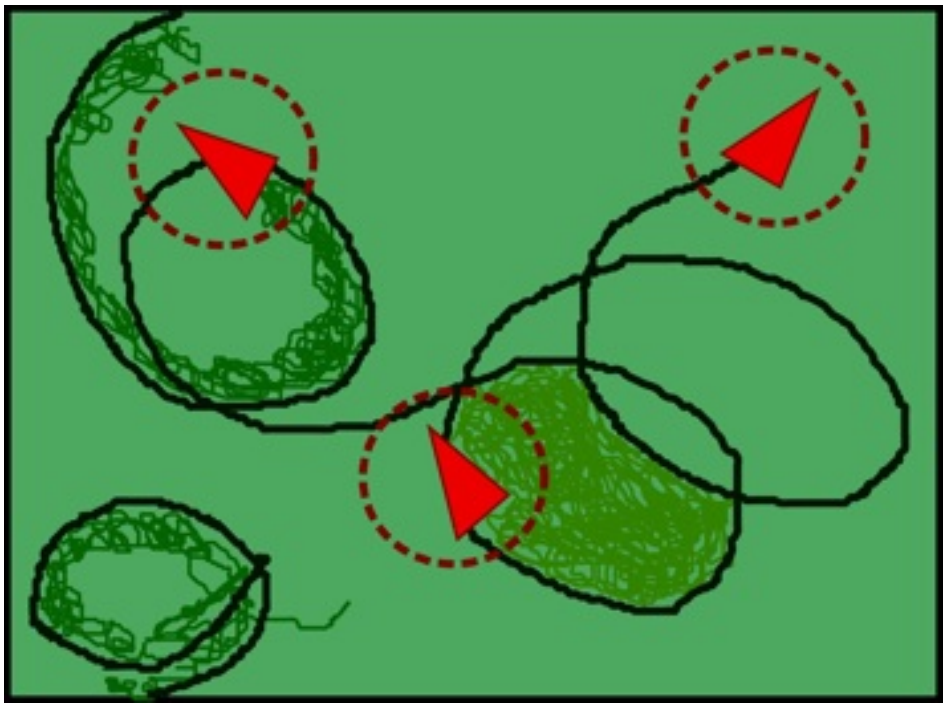
We have been inspired by several ecosystemic artworks, especially *E-Volver*[5].

[4] Dorin, "A survey of virtual ecosystems in generative electronic art", Springer 2008

[5] Driessens, Verstappen, "Natural processes and artificial procedures," Springer 2008

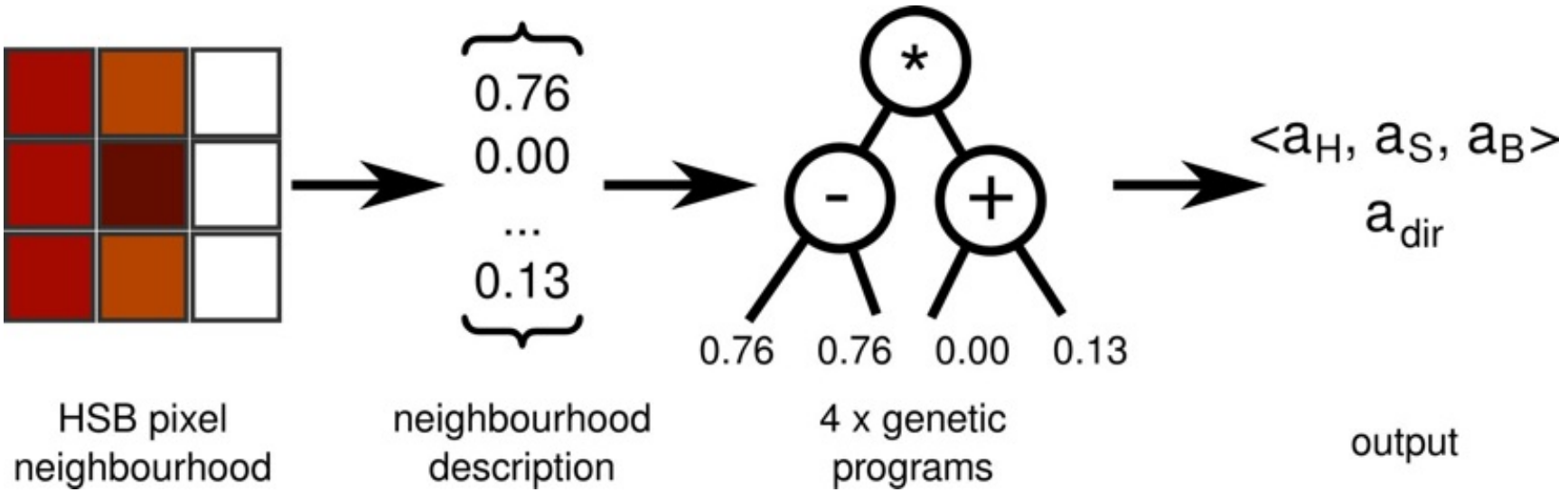
EvoEco: Ecosystemic Drawing Individuals

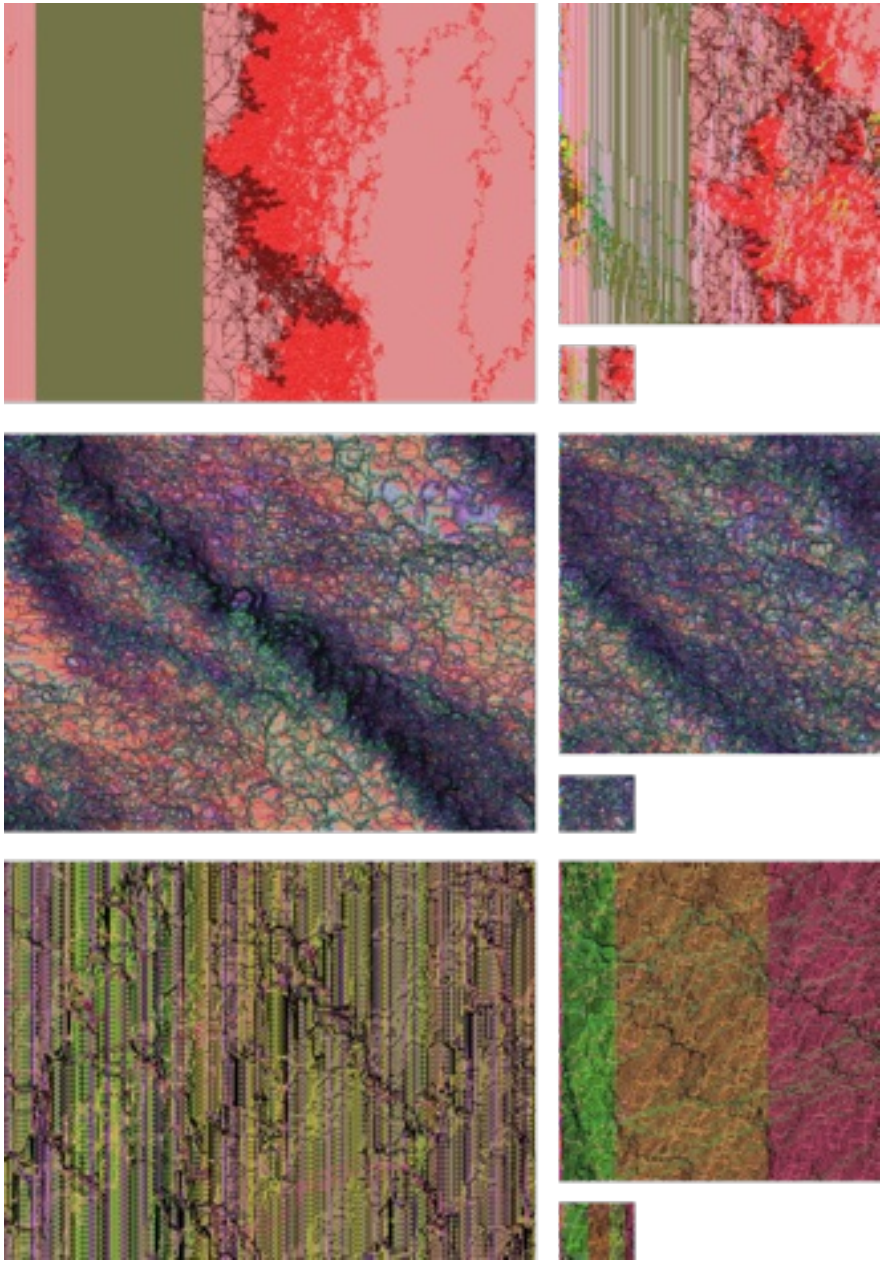
An individual is a collection of agents in a 2D world of pixels. Each agent is one pixel large, and operates over discrete time. Each time step, it paints a colour, and moves in a direction.



Drawing Agents

Genetically, an agent is a collection of genetic programs, mapping from neighbourhood descriptions to a colour and a direction.



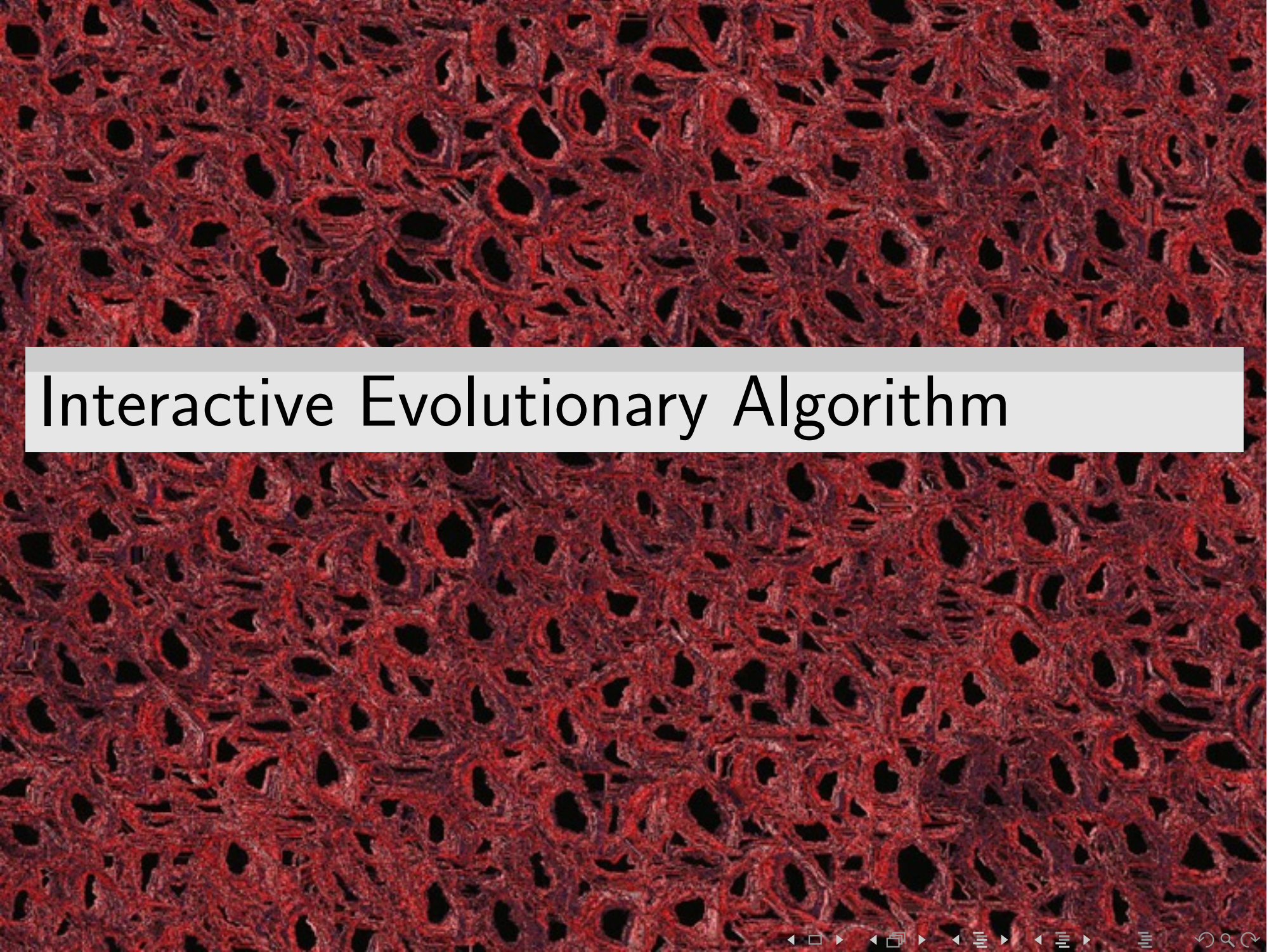


Regrowth

a.k.a. Phenotypic plasticity, Scaling

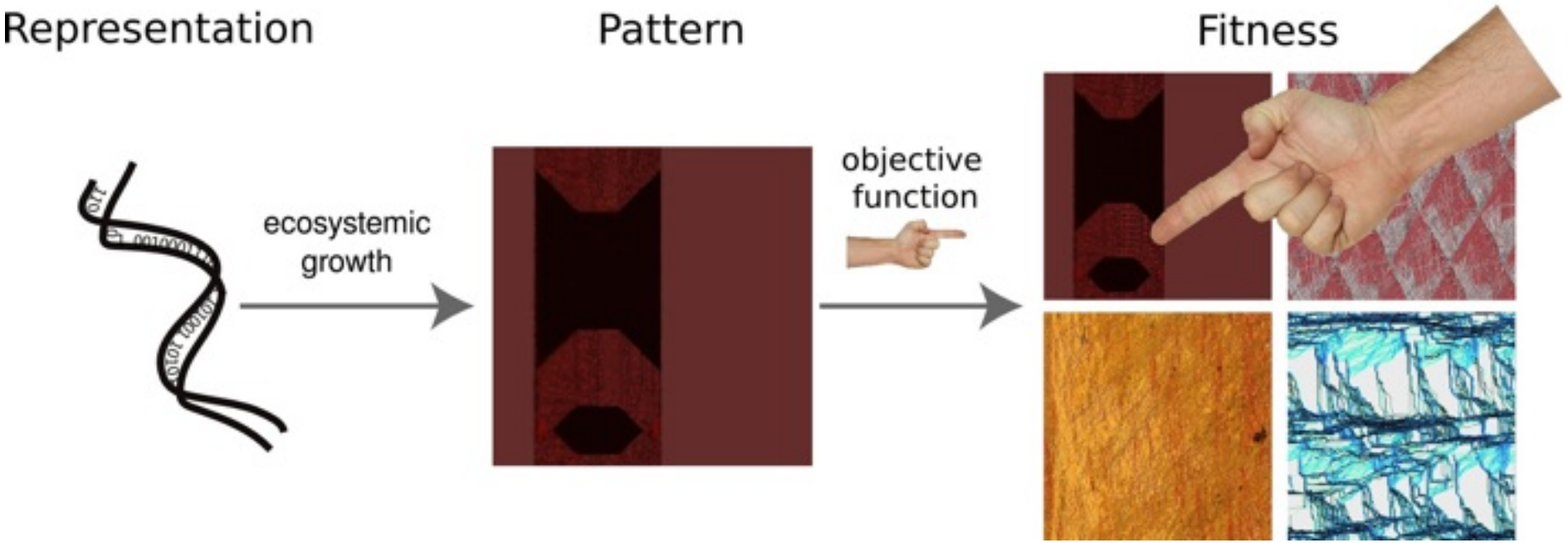
Executing the same individual in a world of different size produces new results. These results typically resemble each other, but are sometimes quite different.

Statistical analysis over our feature space shows that properties are typically retained, *i.e.*, resistance to environmental perturbation.


Interactive Evolutionary Algorithm

Interactive Evolutionary Computation

Uses a human's subjective opinions as a (sub-component of) the objective function.

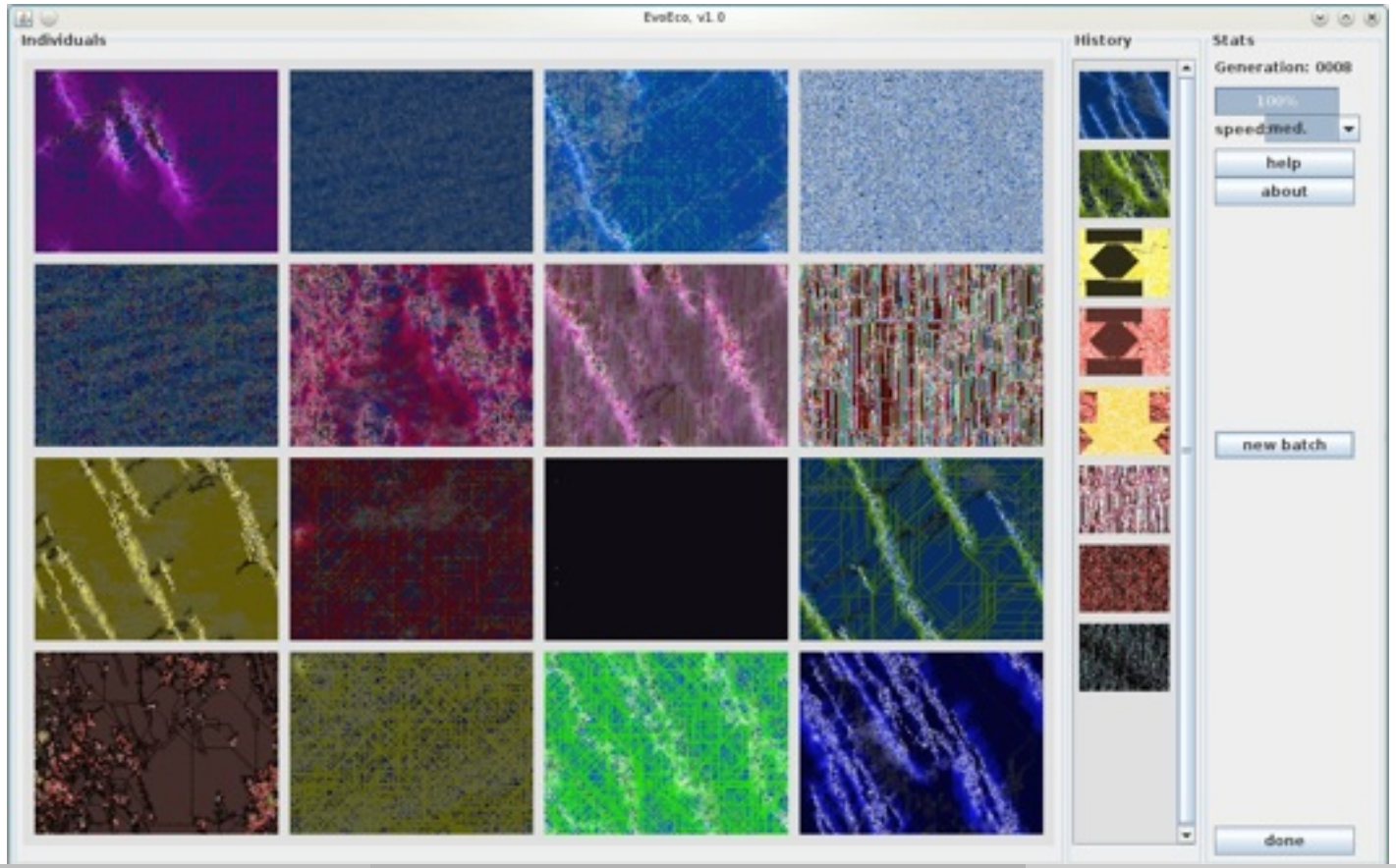


The Dorin & Korb definition is tractable in this context[6].

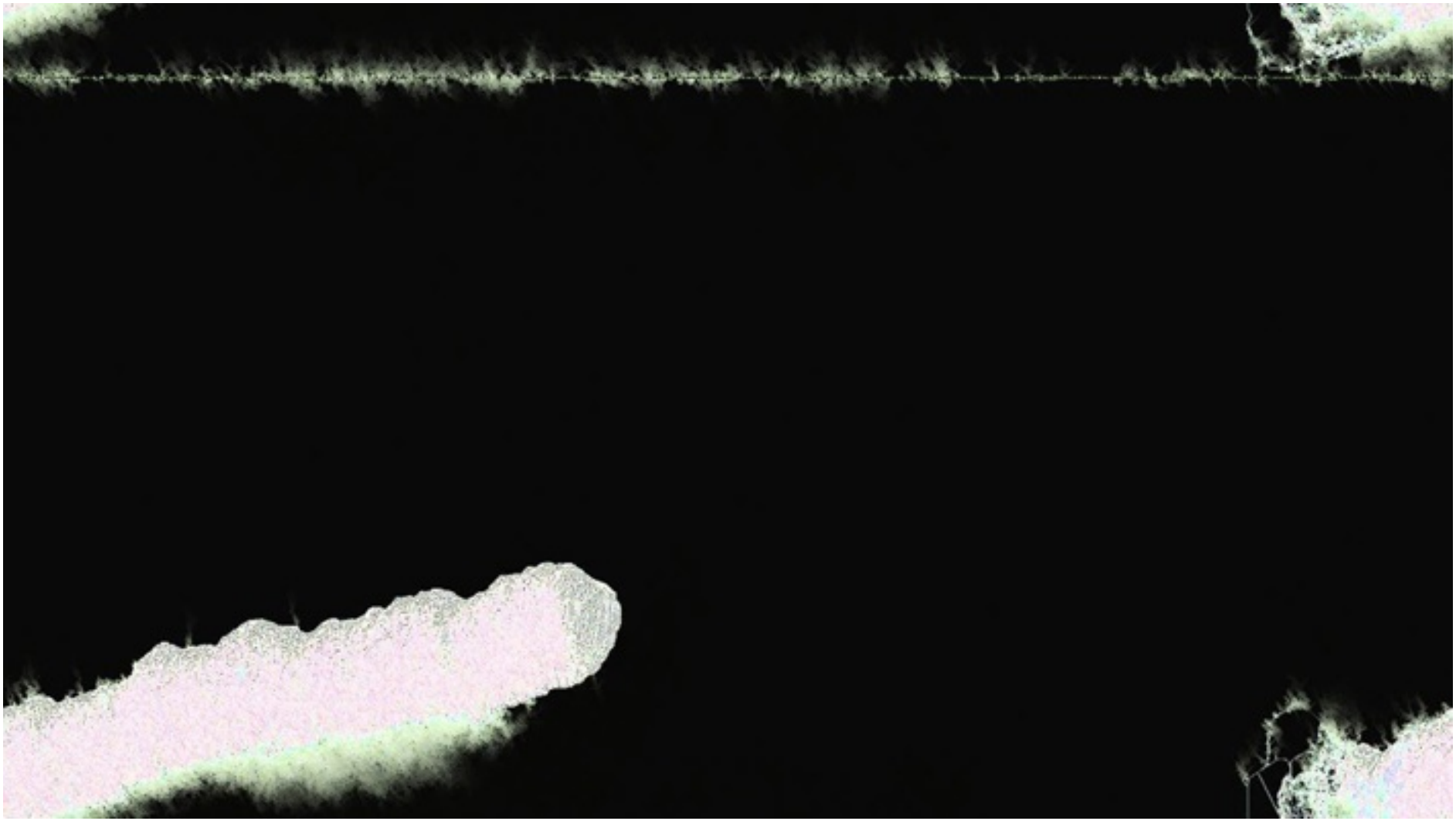
[6] Kowaliw, Dorin, McCormack, *An Empirical Exploration of a Definition of Creative Novelty for Generative Art*, ACAL 2009

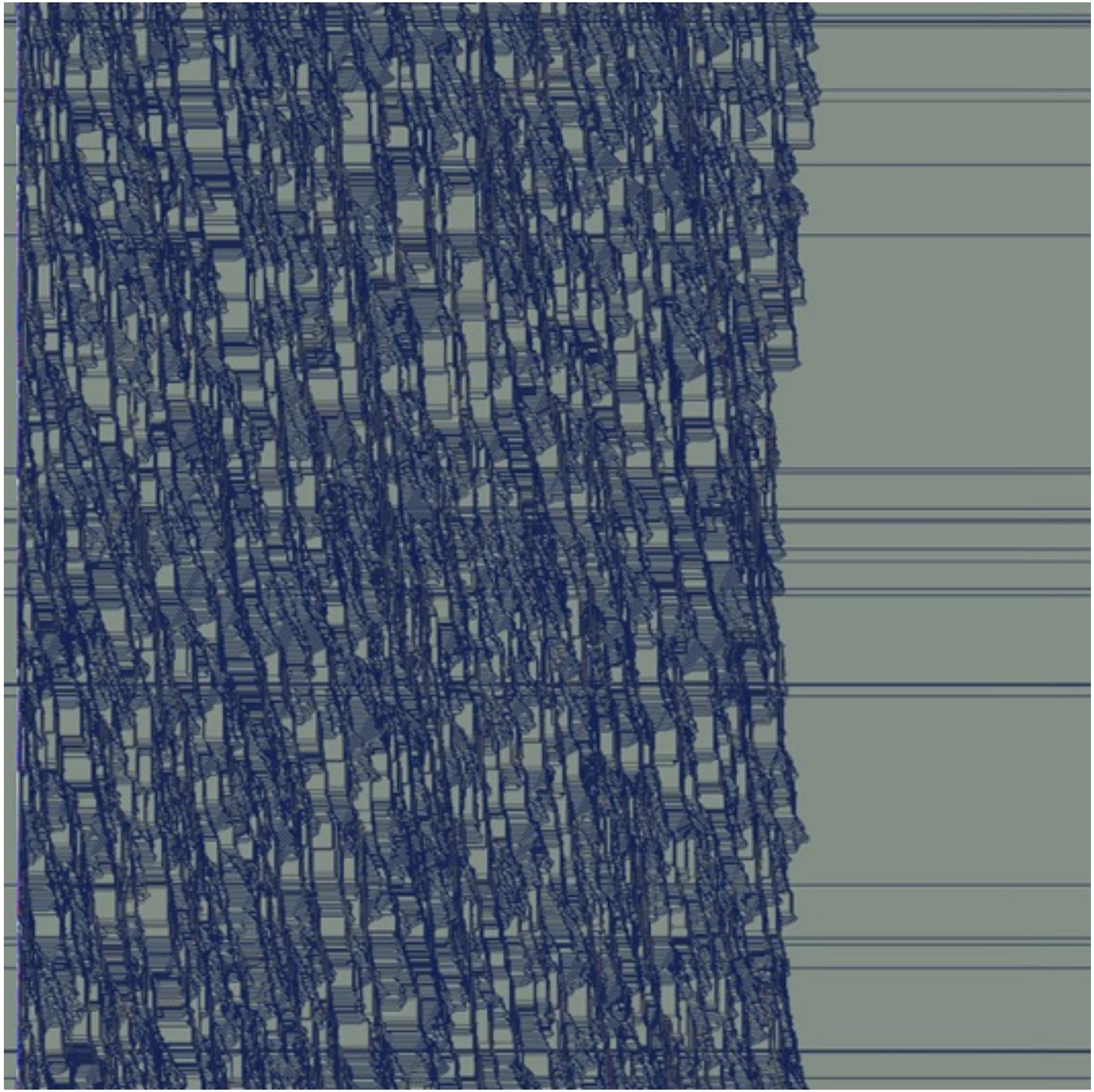
EvoEco

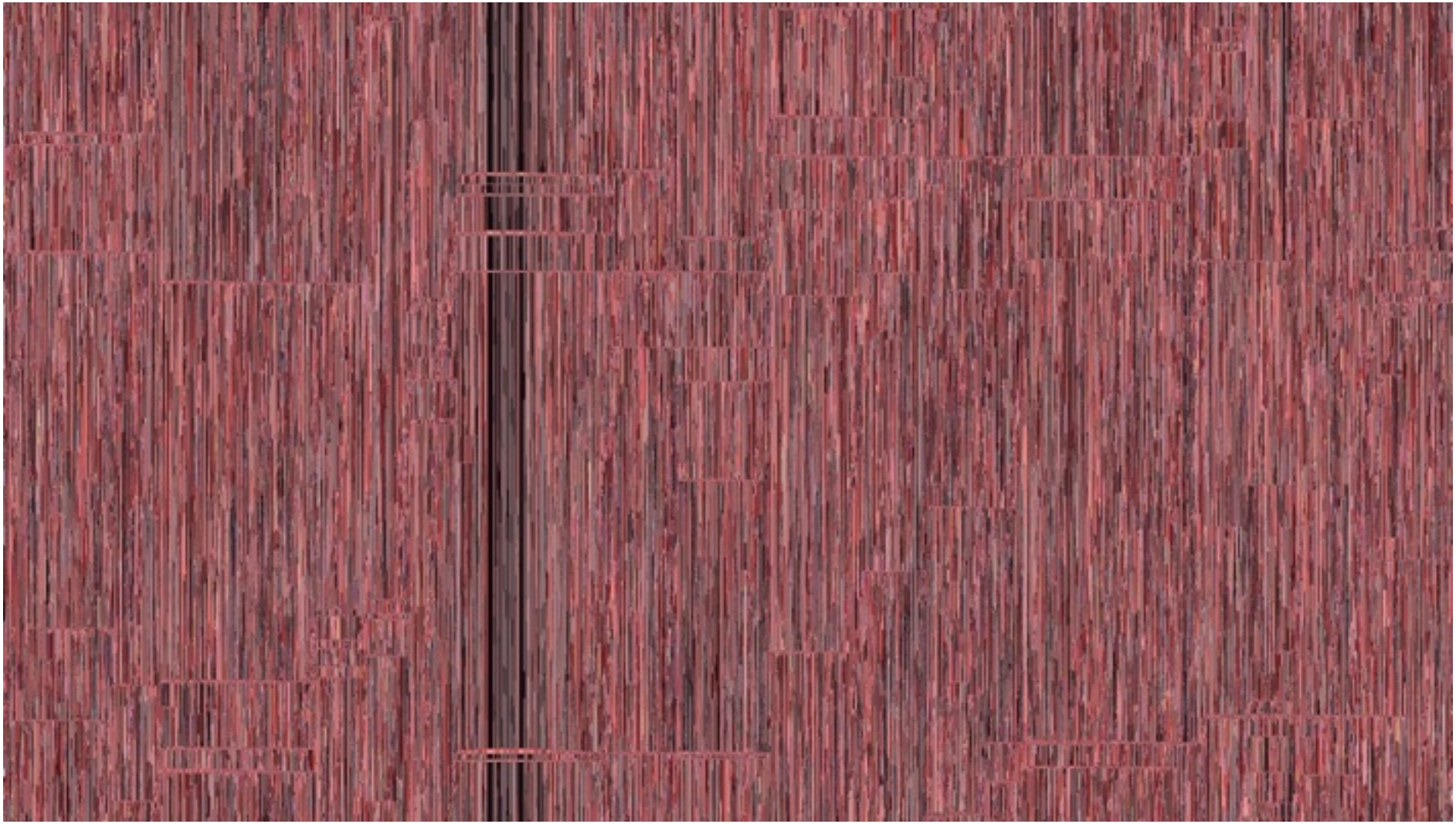
EvoEco is an IEA which uses ecosystems as individuals. For survey-based reasons, the interface is as simple as possible, a single-click-per-generation mutation-and-crossover driven series of generations, with a history. Runs were augmented by our creativity measure.

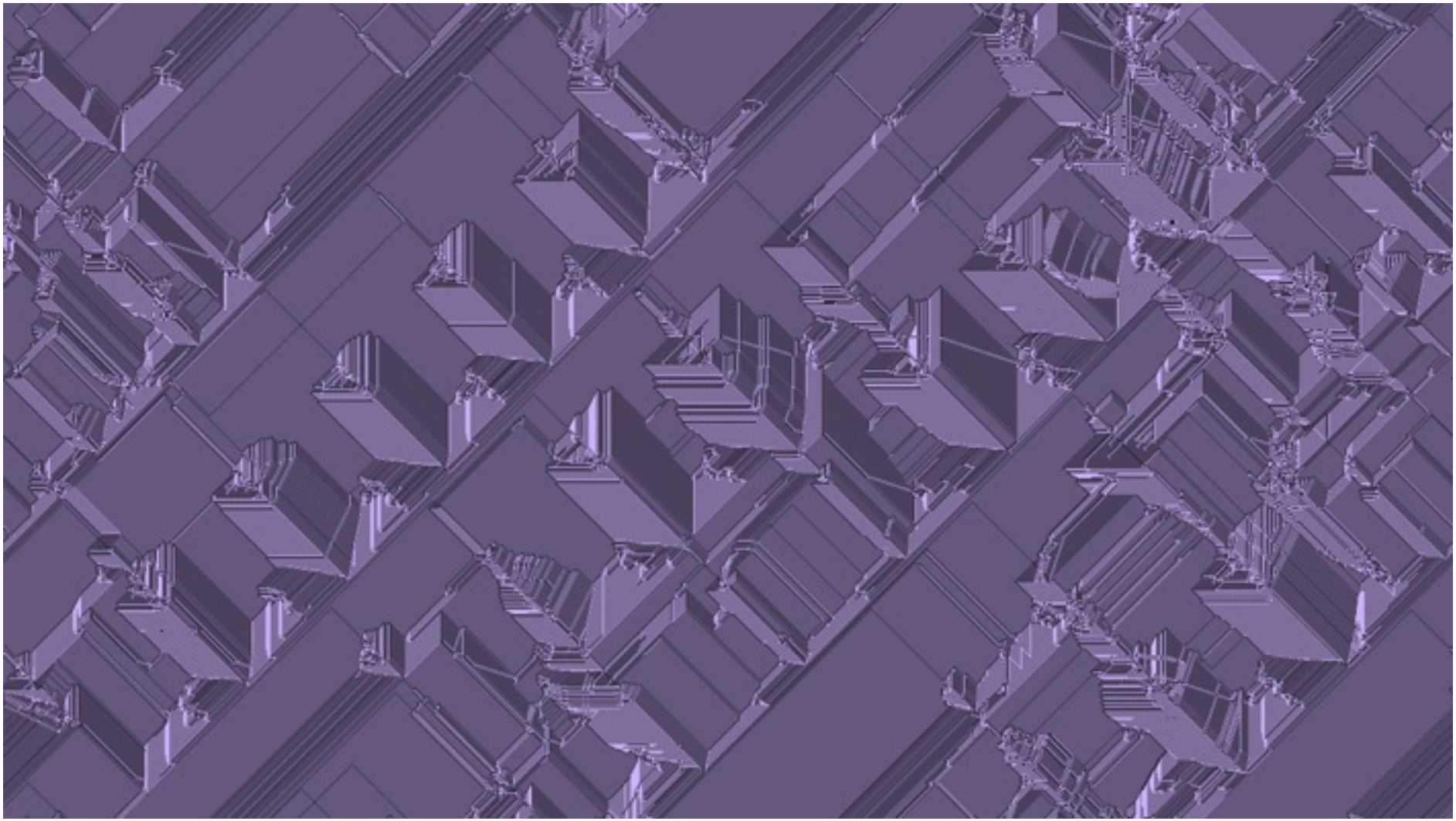


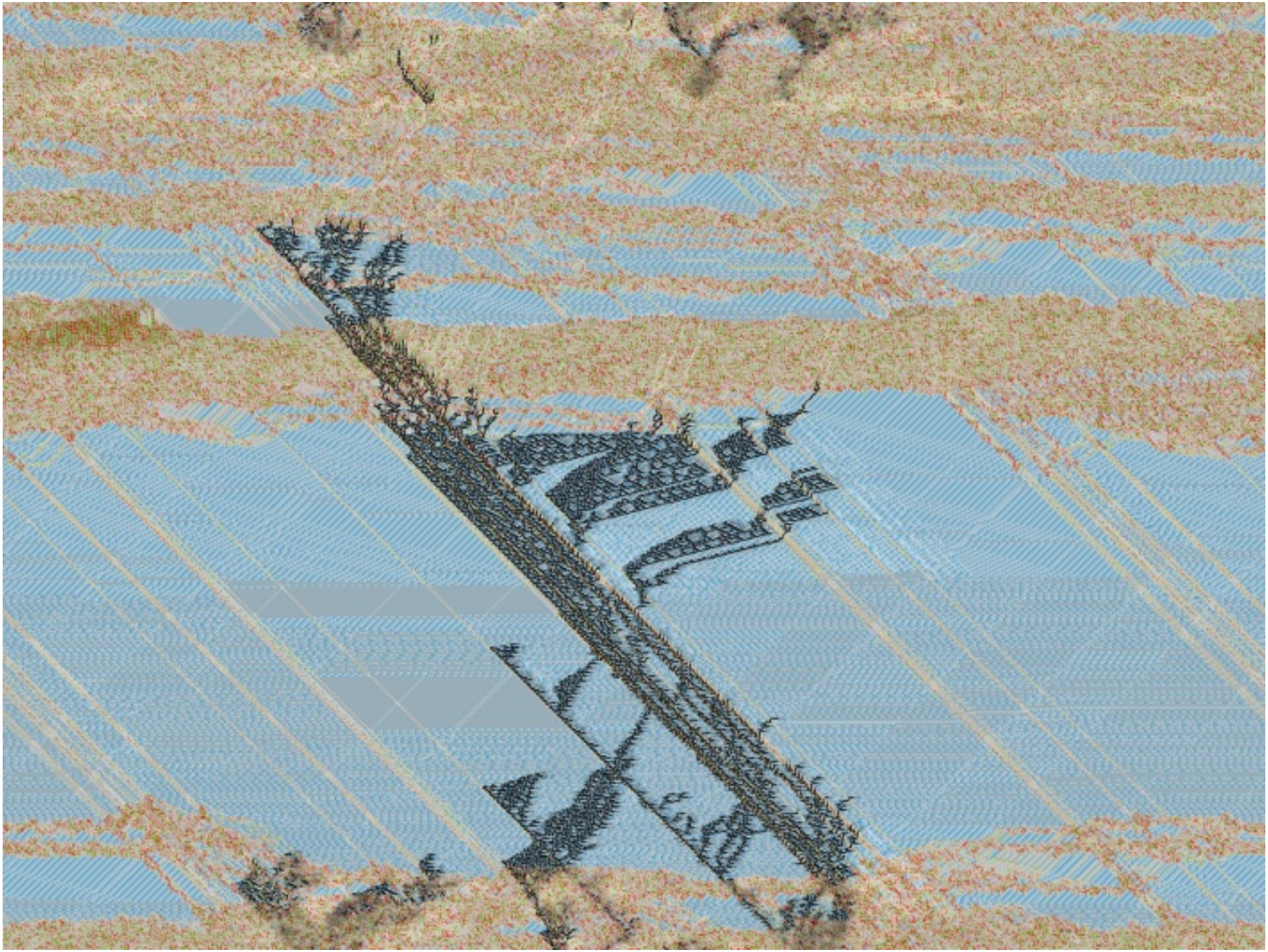
Outputs from Anonymous Users











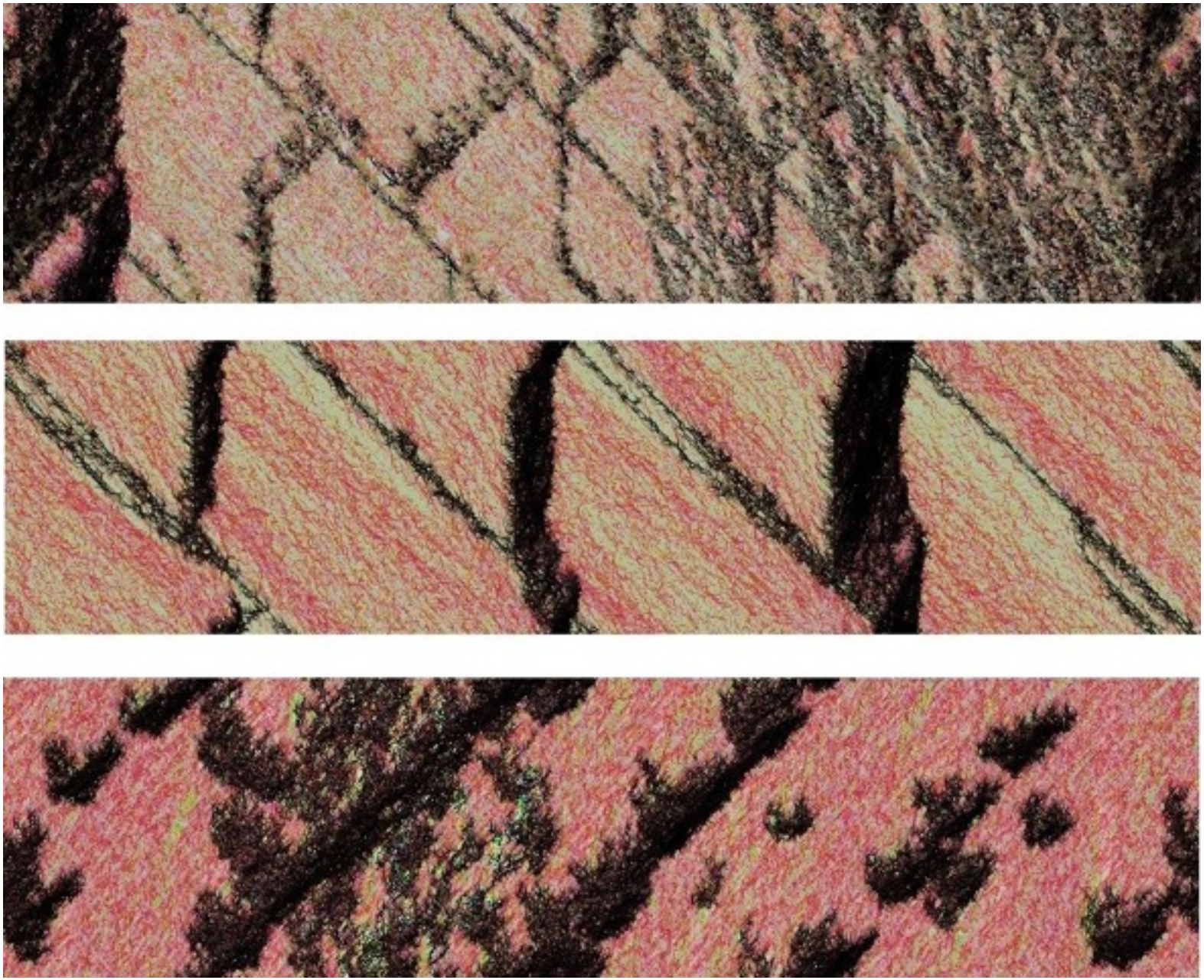
Evolvability

Difficult to measure due to difficulties in image-based similarity metrics and user fatigue.

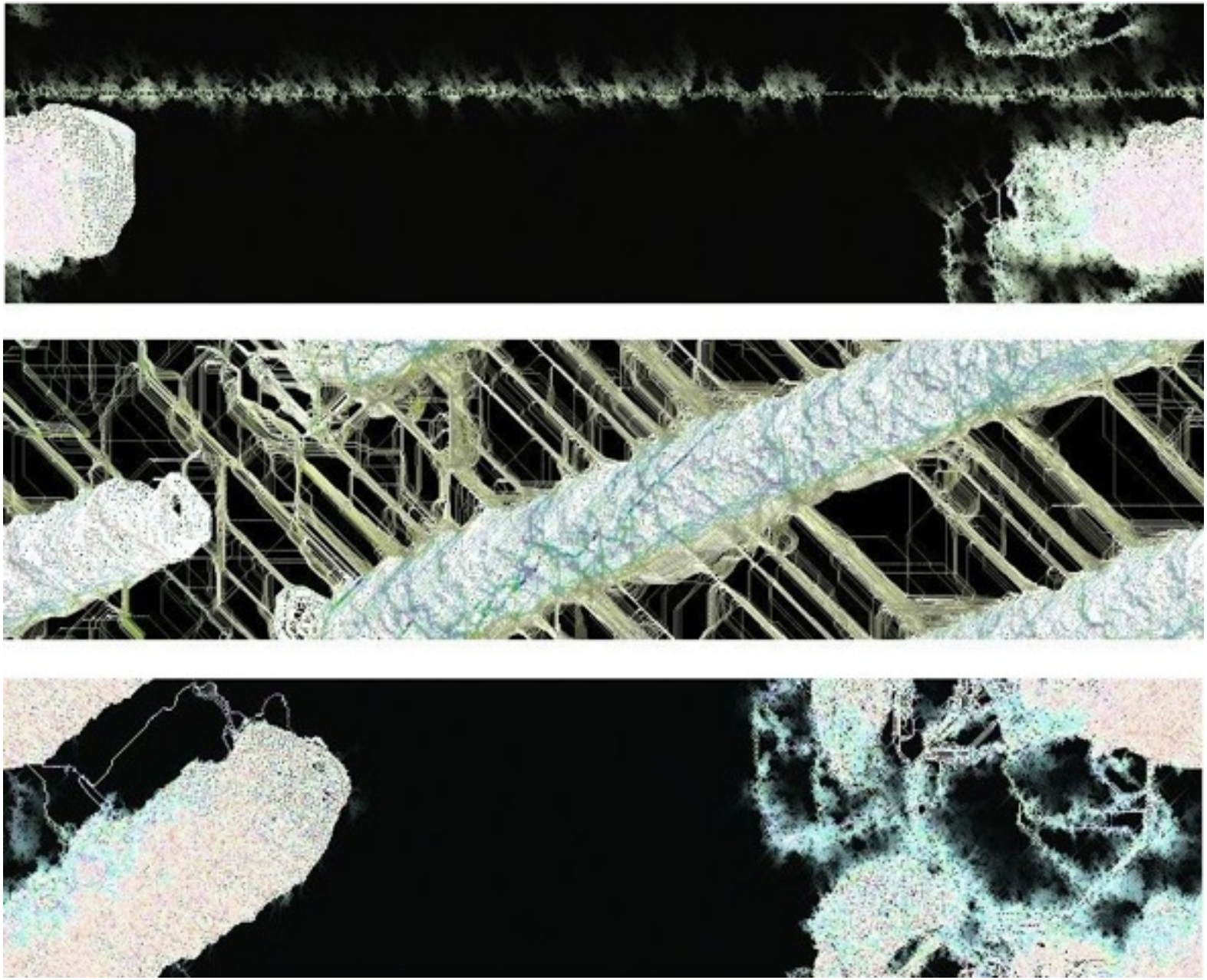
However, we have observed that agents were able to play **specific** and **transferable roles** in various individuals. For instance, in several individuals generated through the genetic operators, we observed agents performing:

- the generation of an initial form, such as drawing circles, octagons, etc.
- post-processing type operations, such as blurring, darkening, lightening
- elaboration roles, such as thickening existing edges, filling in enclosed spaces

Evolvability Example:



Evolvability Example:



Summary

EvoEco is a novel ecosystemic art system, driven by a creativity-enhanced interactive evolutionary algorithm.

Ecosystemic growth leads to many distinct phenotypes per genotype, but often aesthetically useful properties are preserved, and statistically, images from the same genotype resemble each other.

The use of agent-based drawing techniques allows for a natural crossover operator, one which leads to evolvable individuals. Agents will specialize to play transferable, aesthetically-useful roles.

Current work

We have contrasted our "creativity-enabled" IEA against two control IEAs in an online study. Preliminary results show that the creativity measure can be used to drive evolution in directions well correlated with natural language notions of **"novelty"** and **"creativity"**, and also towards generally preferred results. Hence, we can expect to use creativity search as a means of combating user fatigue, and possibly approaching a more open-ended evolution[7].

[7] Kowaliw, Dorin, McCormack, *Promoting Creative Design in Interactive Evolutionary Computation*, under review (ask for preprint) 2011

"An Interactive Electronic Art System
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A version of the IEA, along with dynamic
and static galleries, are available at:

http://www.csse.monash.edu.au/cema/evoeco