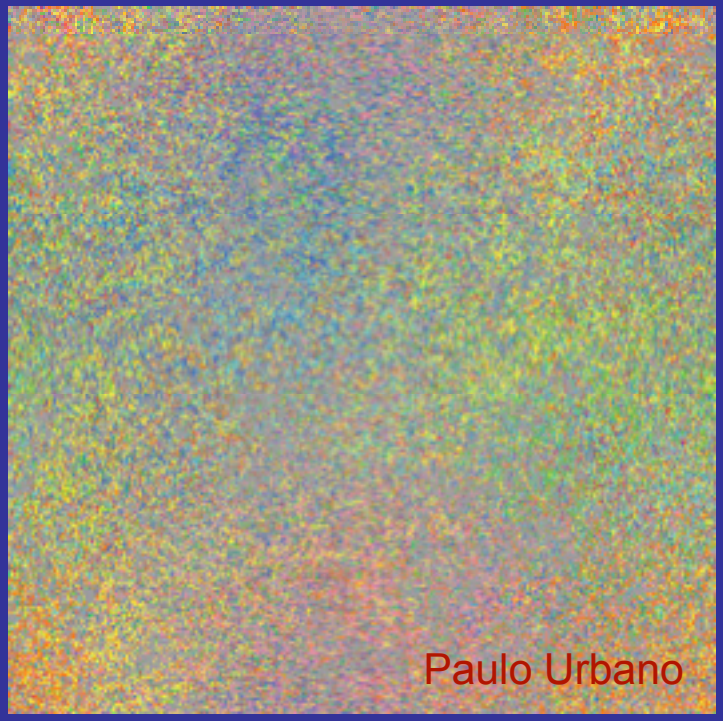
Multi-Agent Coordination and Collective Artificial Paintings



LabMag
Universidade de Lisboa
pub@di.fc.ul.pt

My Goal:

Apply techniques for coordinating a group of agents

to Swarm Art

I’m Going to Talk About:

Generative Art

Human Collective Art

Collective Artificial Art

Mechanisms of Coordination in Multi-Agent Systems

Pattern Explorations in Decentralized Systems

Generative Art

Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art.

Philip Galanter

Generative Art: focus on Process

Generative art refers to a way to create art rather than an art style.

Autonomy and Generative Art

The key element in generative art is then the system to which the artist cedes partial or total subsequent control.

Whether considered from the top down or the bottom up, the defining aspect of generative art seems to be the use of an **autonomous system** for art making

Philip Galanter

Randomization in Generative Art

In the era of computer-generated art the use of pseudo-random number generators becomes perhaps the most popular digital generative technique.

Wholly different reasons:

Zen inspired acceptance of all sounds as being equally worthy (John Cage).

Assault art-world expectations regarding art, provoque

Or simply an attempt to add an element of surprise to make things more interesting.

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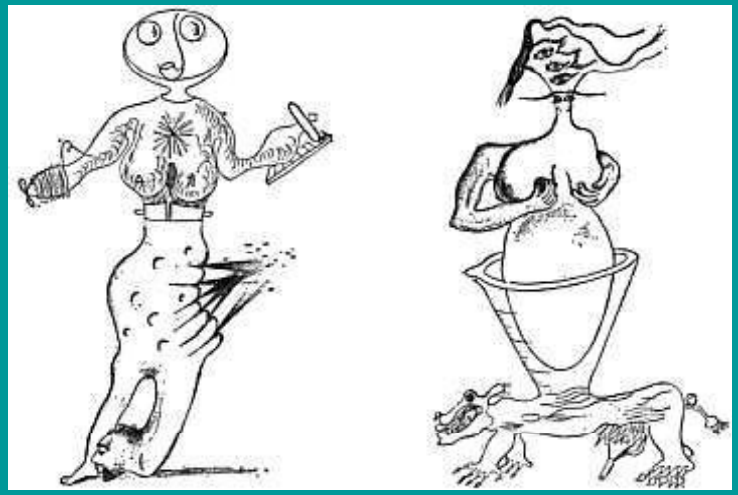
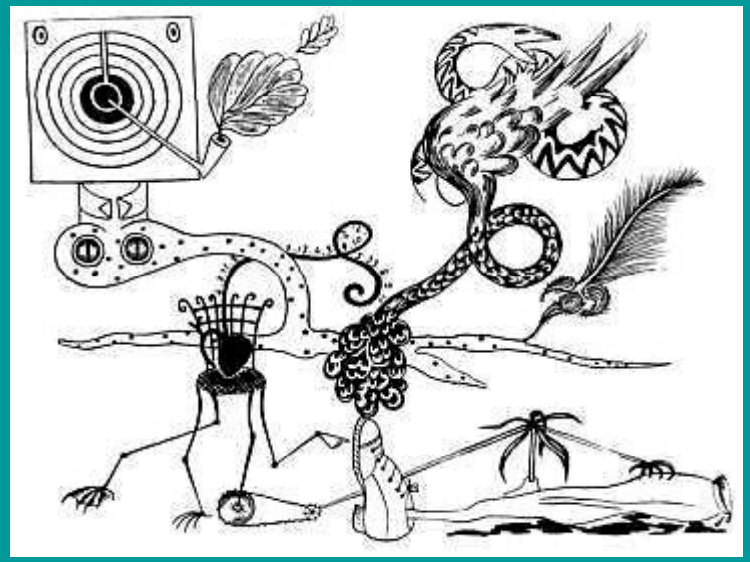
Cadavre Exquis
Exquisite Corpse



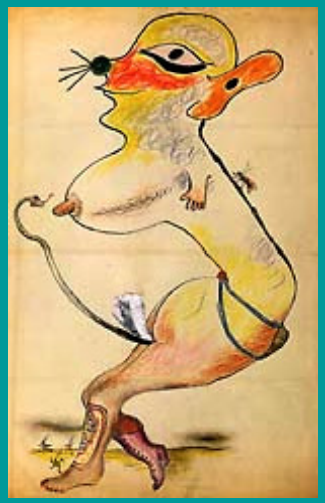
What is an Exquisite Corpse?

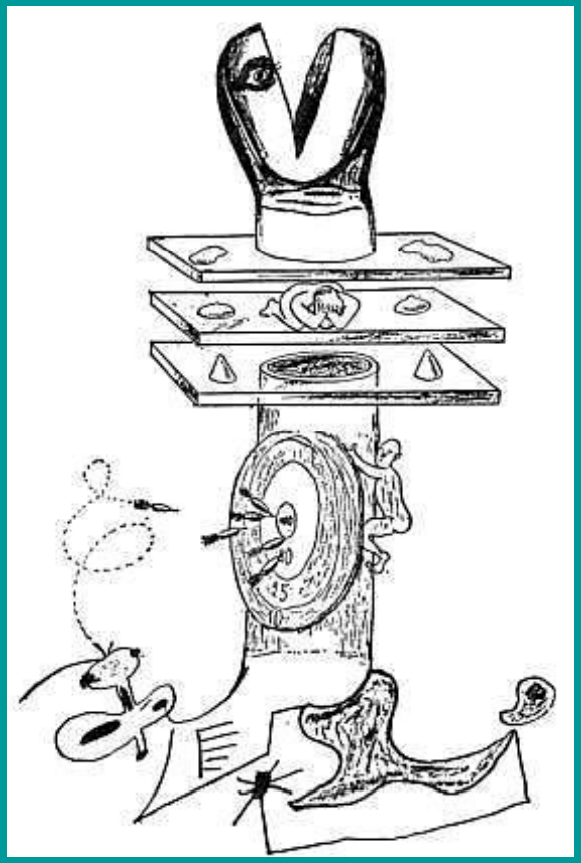
A **cadavre exquis** (exquisite corpse) is a game-based art form invented by the Surrealists that depends on a formulaic method adjective, noun, verb, noun, to create poems; head, torso (often in upper and lower parts), and legs for images. Each is based on an accidental or unconscious collaboration of at least two artists, that is, each provides his or her part without knowing what the other has selected.

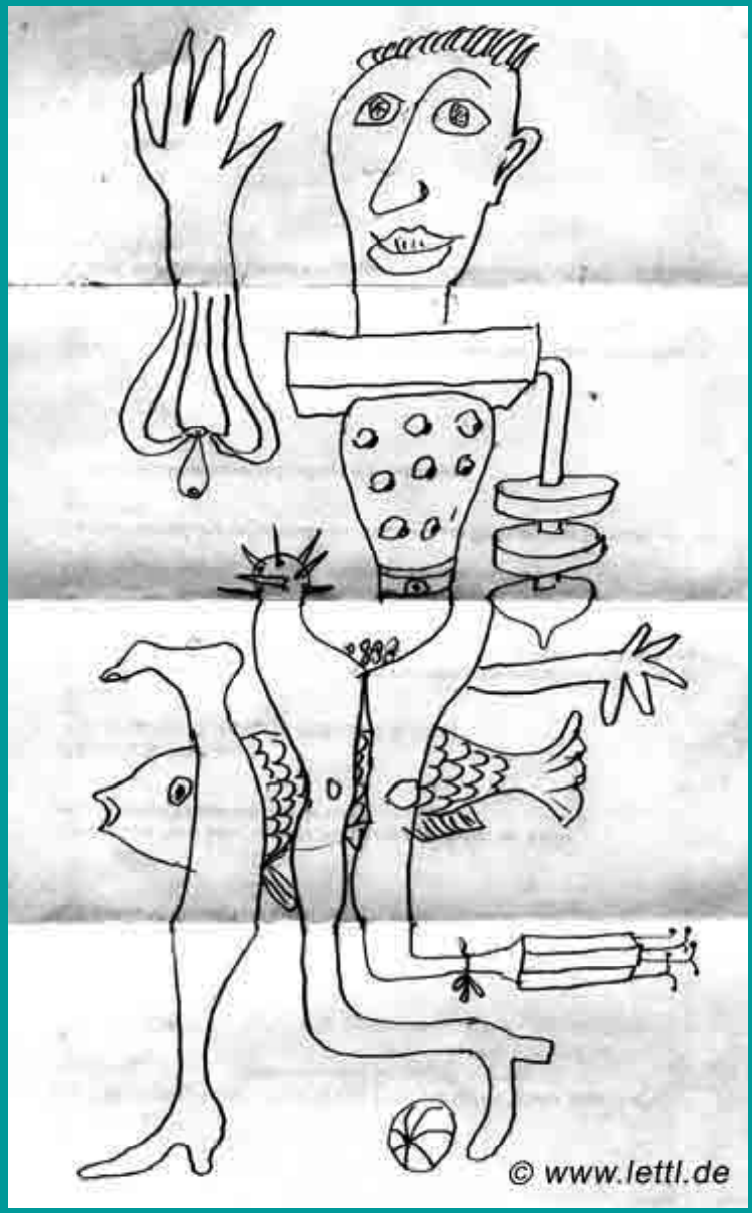


Le Cadavre Exquis, disegno di Cècile Eluard, Man Ray, Picasso

Cadavres Exquis?







Important Aspects in the Creative Process of the "Cadavre Exquis"

- ***Collective Creation***
- ***Fragmentation and Loss of Unity***
- ***Surprise, Impredictibility***
- ***Collective Pattern: the mistic of coincidences***
- ***Communication through the work***
- ***Interaction***
- ***Locality***

Designing a Collective of Painters

What we have to take into account when we design the painters behavior?

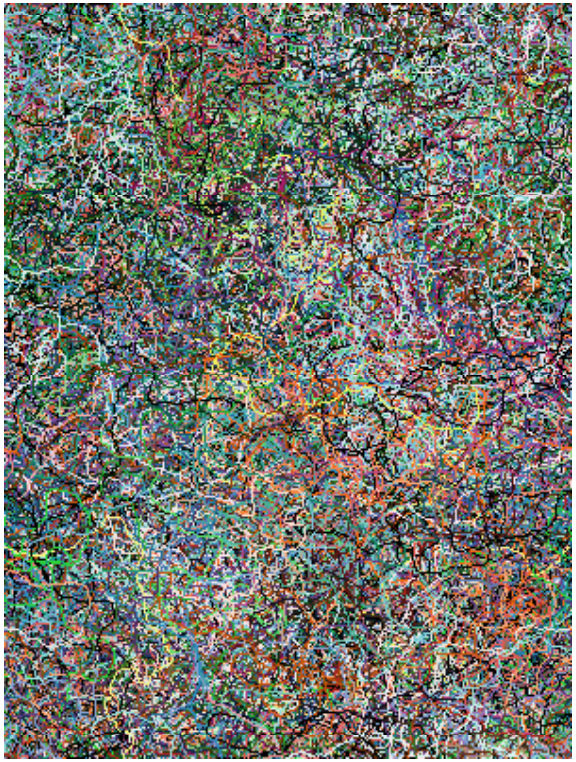
- The way they move
- The color of their traces

Restrictions

Paint is never repainted

The painting is finished if a certain canvas percentage is filled with paint

Non-Coordinated Painters



Wiggle

We distribute the painters randomly on the “tableaux” each one with Its own color that never changes, and they paint their patch and wiggle over and over.

```
;; One step
Ifelse finished?
        [stop]
        [ask turtles [paint
                rt random 40 - random 40
                fd 1]]
```

code in Netlogo

Uncoordination is boring

85 agents

329 agents

1659 agents

Colombines

the

Stigmergic Painters

Inspiration:

The chemical stigmergic communication of social insects

Stigmergy

In the late 50s Grassé introduced the concept of **stigmergy** which refers to a class of mechanisms that mediate animal-animal interactions.

The result of an individual's work can act as a direct source of stimuli for other individuals

More Stigmergy

Stigmergy can be seen as indirect interaction where each individual effects the behavior of others through the use of artefacts, such as building material or chemical traces. This artefacts made or left in their environment may feed back on them and organize collective behavior.

Colombines

The Colombines are a group of homogeneous artificial micropainters, individually very simple, purelly reactive that are going to paint a virtual canvas, using a “pallete” of colours.

We distribute the painters in an empty canvas and they are going to move, dropping a trace of paint until they fill the canvas completelly.

But the “Tableaux” is not a passive media, it has a capacity to attract the small painters.

The Canvas

The canvas is a bidimensional dynamic space, toroidal, formed by squared cells, a computational paper, (a donut or not), inhabited by the micropainters, in which two artificial materials coexist:

- Paint
- Chemical-α

Chemical-α is a chemical signal specific to the Colombines.

There is a background colour.

Chemical-α

Chemical-α has the capacity to attract painters, controlling the Colombines paths and traces, they have a fundamental role in the collective pattern emergence.

The main ideia

1. non-painted areas have more power to attract (they produce chemical)
2. odour-α diffuses along all neighbor patches (8 surrounding cells) (painted or non-painted patches).
3. Chemical evaporation at a constant tax

Cells Behaviour

1) If it is non-painted it increments the chemical in x units, otherwise conserve its quantity.

1) Diffuses a percentage of its chemical to its 8 neighbouring cells.

2) Deletes a percentage of its chemical (evaporation).

Colombine Charateristics

They have:
- orientation (0-360)
- position
- color
- speed

They can only occupy one cell

We can have more than one painter in a cell.

Limited perception: its own cell and the three cells in front.

Colombines Individual Behaviour

1) Senses the three cells in front and choose the one which has more chemical (climbing the chemical gradient), and turns in the direction of that cell (-45, 0 ou 45 degrees for the left, in-front, or right cell respectively);

2) Moves one step (step-length)

3) If its cell is not already painted it stamps it with its color, otherwise it does nothing.

Dynamic of Interaction between the Painters and the Chemical Landscape

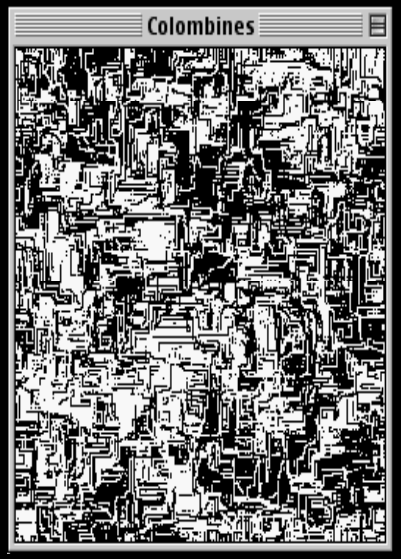
The “Tableaux” can be seen as a dynamic landscape in permanent mutation, that coevolves along with the micropainters—there is a dynamic interaction between the chemical distribution and the painters’ behavior.

The chemical world is information under the painted spots and under the background. There is a circularity: information guides the artists and those transfom that information.

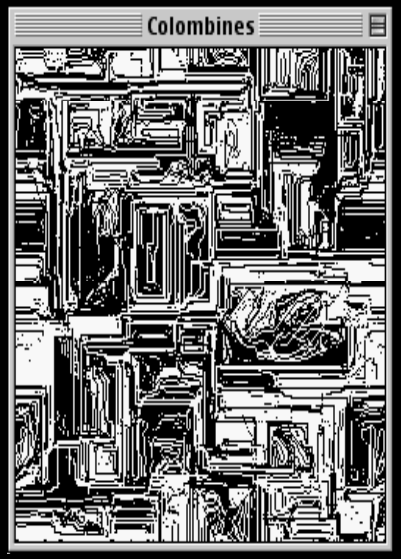
Thre is no direct communication between the painters but they interact stigmergically through the chemical signals.

Pattern, the colored forms, are the byproduct of this invisible colaboration between the small Colombines and their chemical environment.

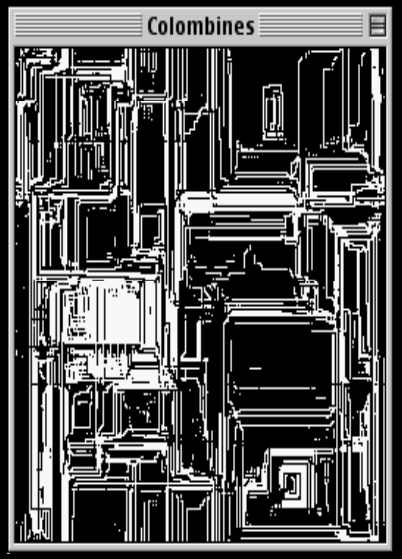
Historic Colombinic Paintings



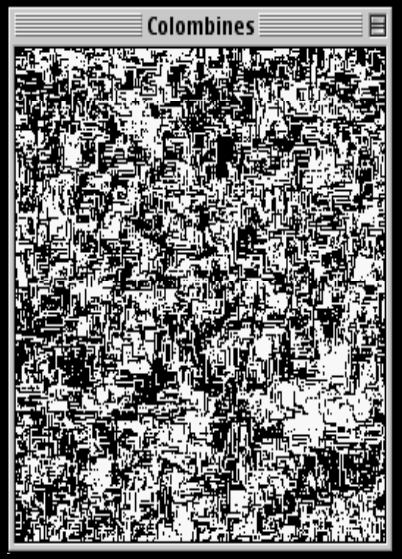
Alfama of Glass



A slice of the head
of Pacheco Pereira

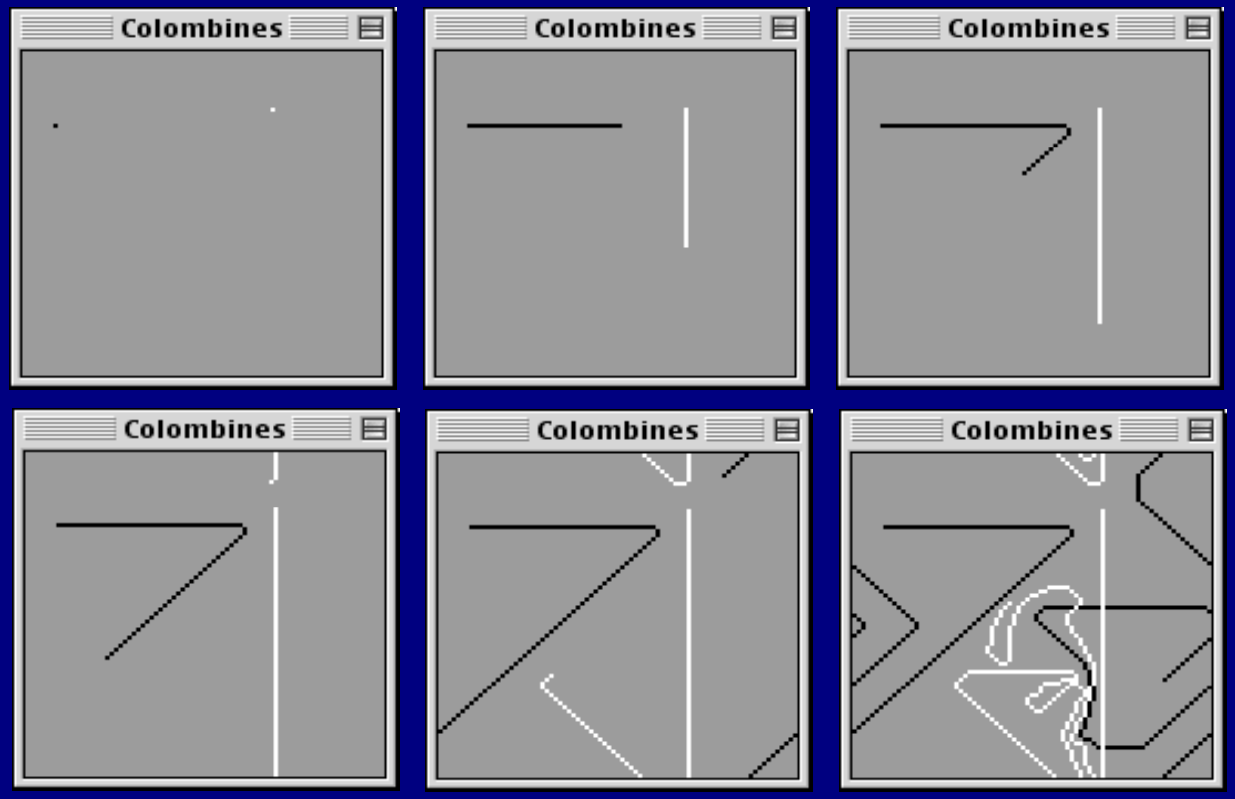


Coimbra of Xanana

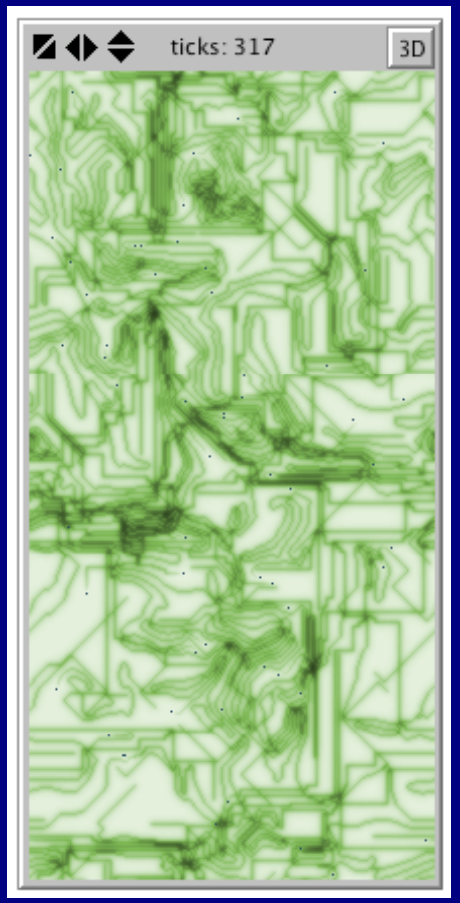


In the roof of
Hugo Pratt

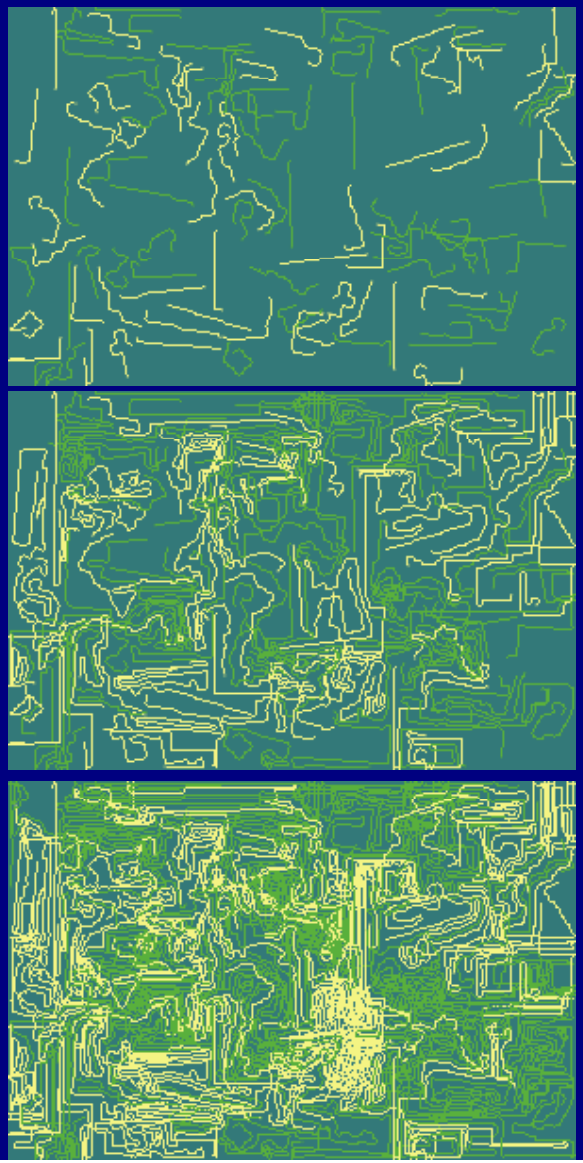
Pattern Formation



Chemical Cloud

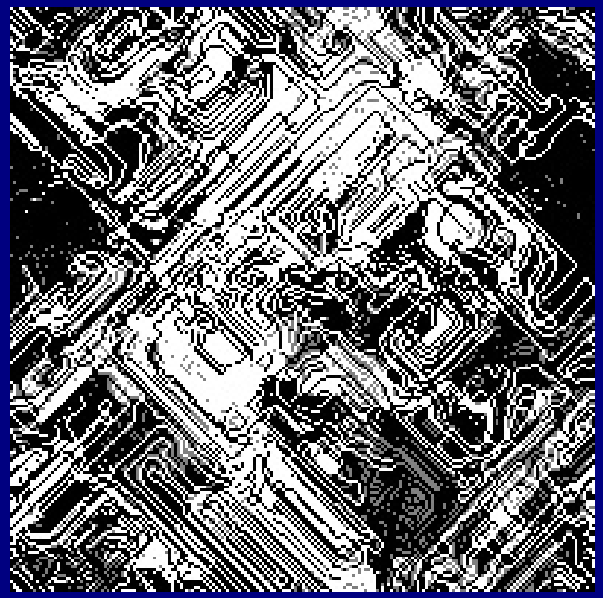
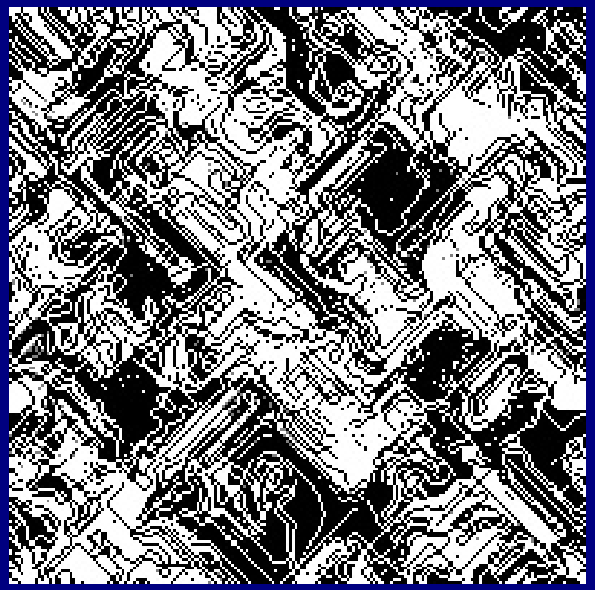
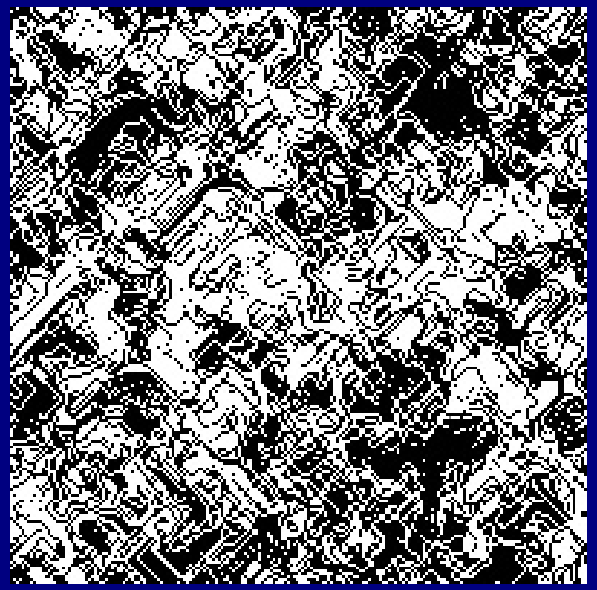


Evolution of a Painting



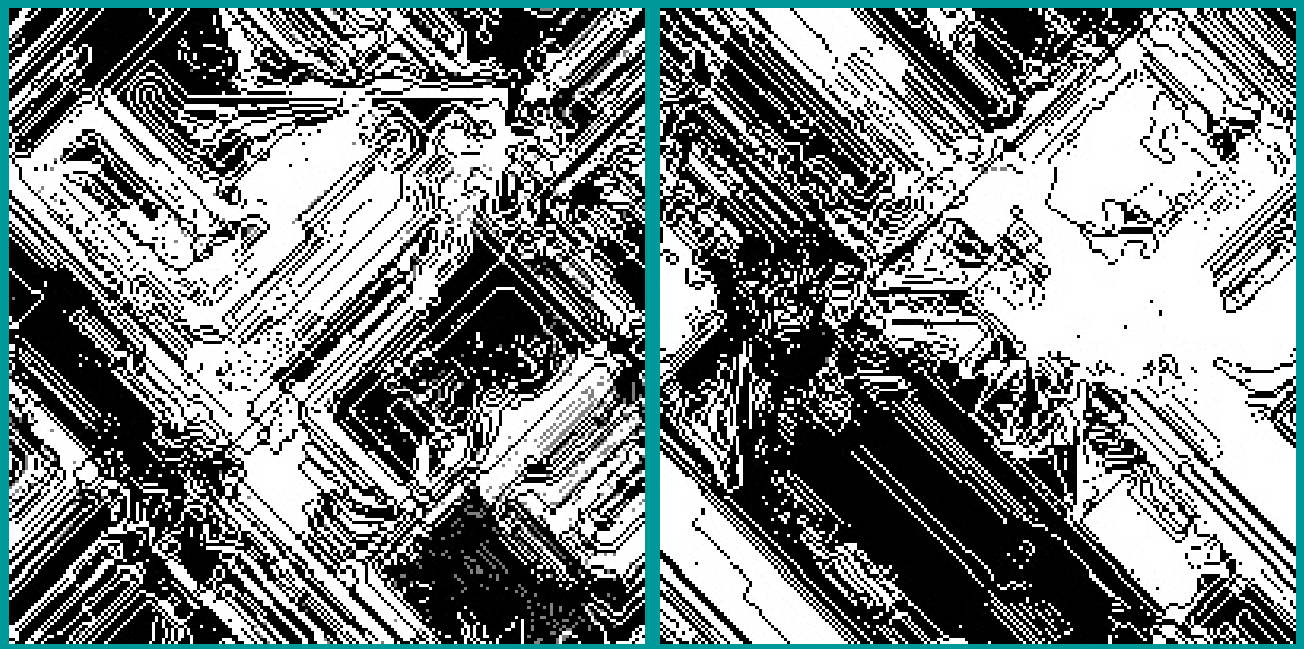
Variation with the number of agents

Some Paintings

Initial Groups

Initial Groups

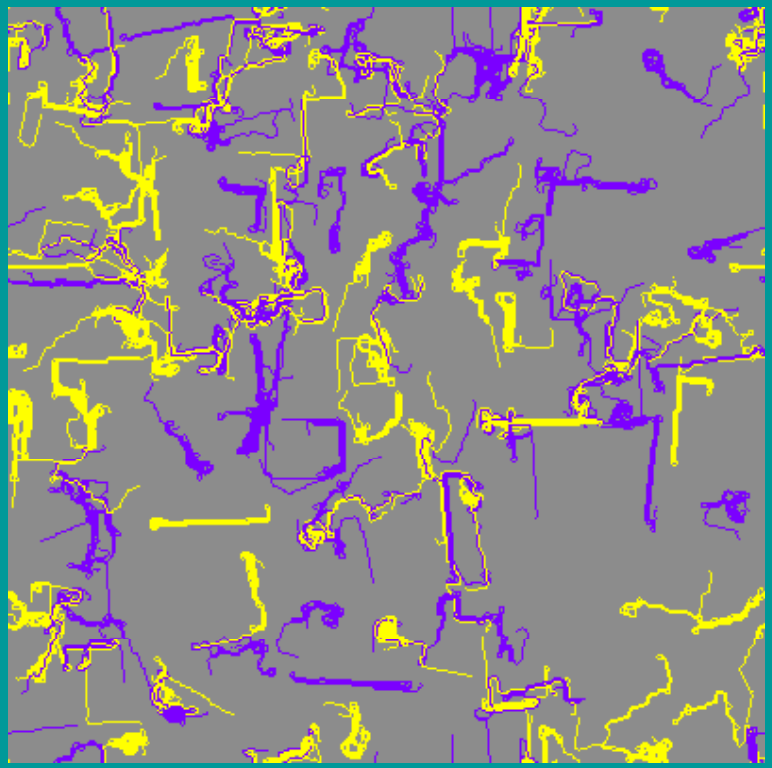


Anti-Colombines Variation

Now, the painted patches produce chemical instead of the non-painted ones.

Painters are attracted towards painted spots.

Anti-Colombines



Convention and Coordination

- Conventions, promoting uniform behavior, can be useful for decreasing conflicts between agents.
- Sometimes it can be very hard to antecipate and define “offline” what are the conventions
- How do agents achieve a uniform or consensual choice in a decentralized way, without a central control?

Uniform behavior is the goal

- We are only considering cases where the nature of conventions are not an issue… every possibility running to be chosen to win the convention has the same value a priori.
- What really matters is the fact that there is a uniform choice.

- **Priority rule:** give priority to the cars on the right or on the left?
- **Driving Lane:** driving on the right or on the left?

Pair-wise Encounters

- During an encounter, an agent chooses randomly one of its neighbors to interact and applies its strategy update rule

Variations on…

- Strategy update rules
- Different strategy update rules means different convergence dynamics.

Strategy Update Rules for the pair wise encounters

- External Majority
- The special case of Simple Imitation
- Recruitment based on force with Reinforcement

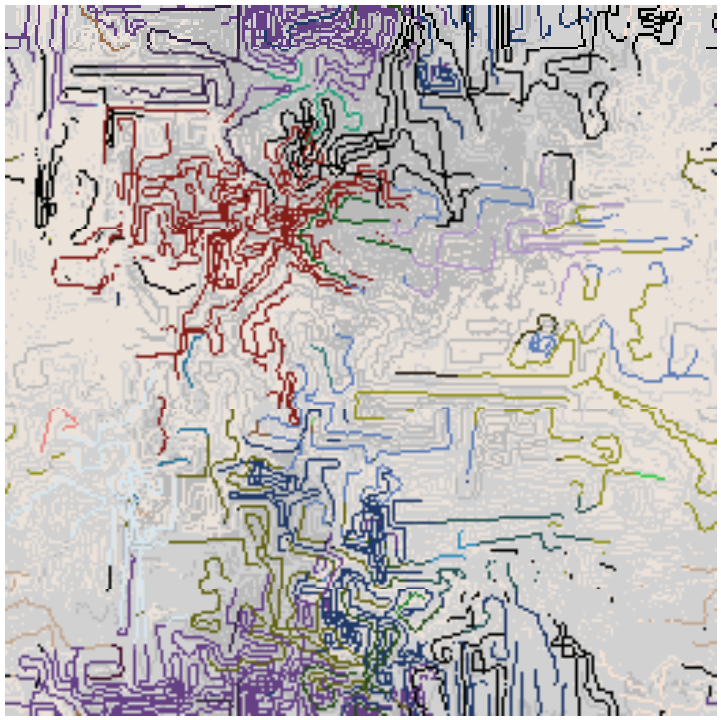
Simple IMITATION

- Just imitate the choice of its partner
- Quadratic on the number of agents (fully connected case)

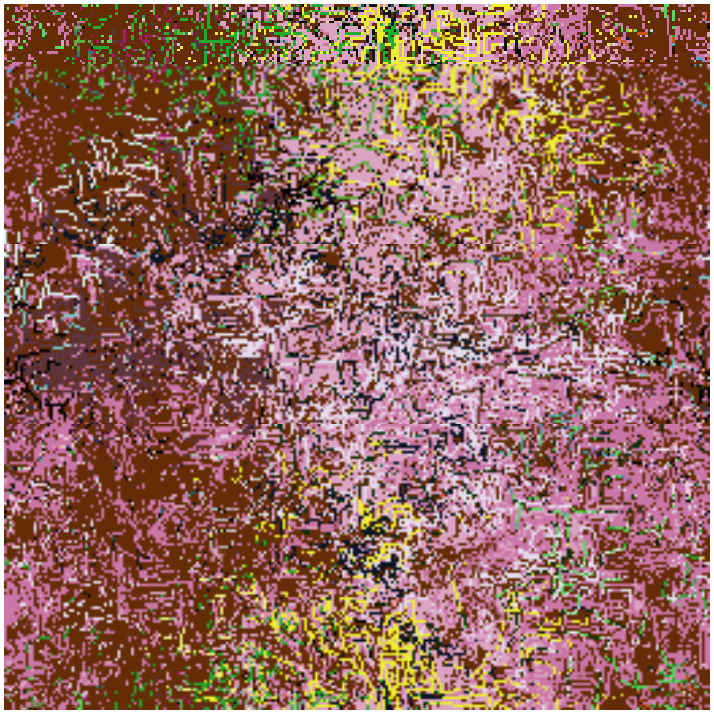
Simple IMITATION

- Perception radius for interaction with others
- Choose a random neighbor inside neighborhood
- Just imitate the choice of its partner

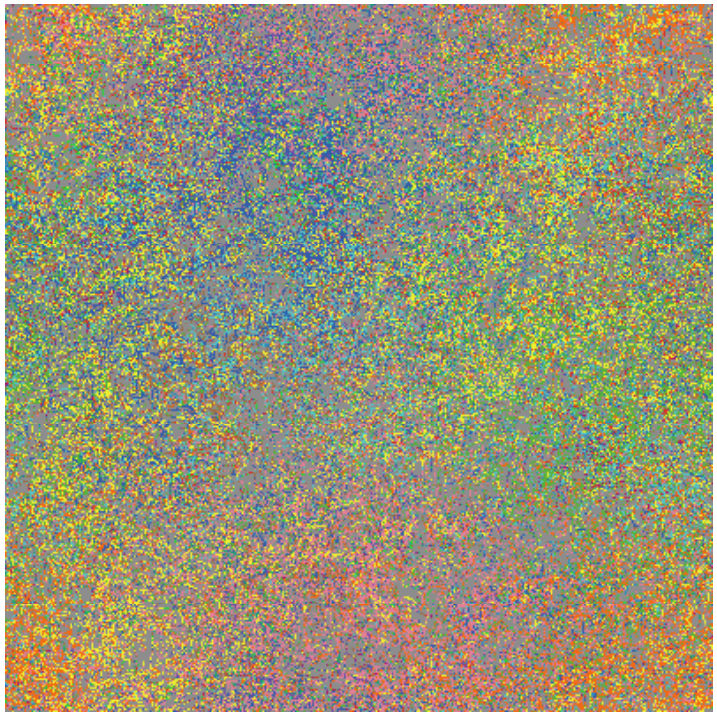
Simple IMITATION



Simple IMITATION



Simple IMITATION



Introducing Force

- Now agents will have a new attribute called **force**.

Recruitment based on Force with Reinforcement (RFR)

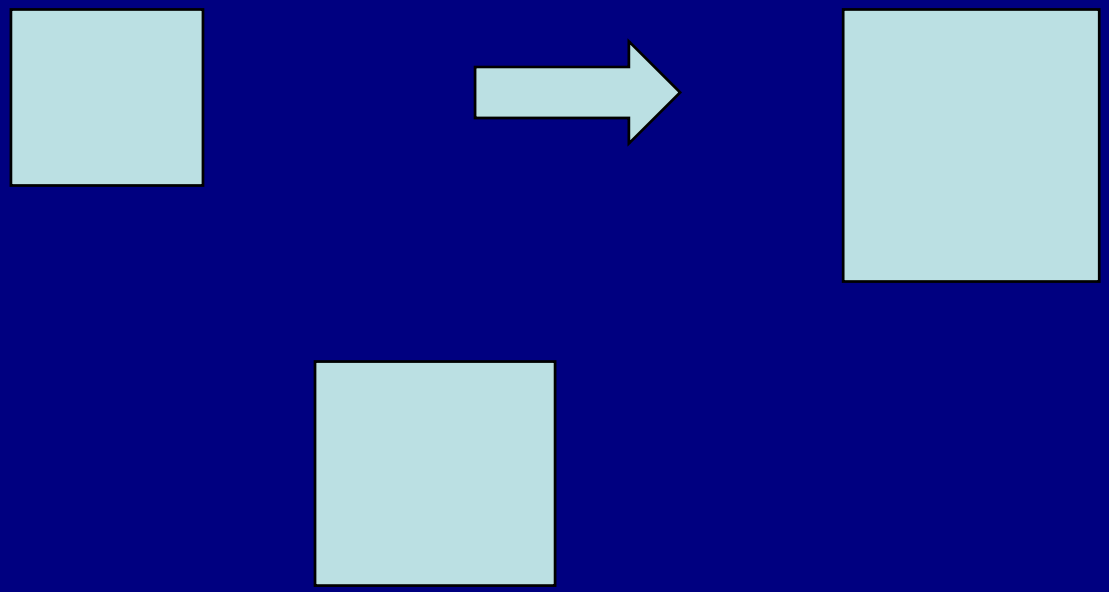
- The agent compare its own force with the one from its partner

1. If it is weaker or has the same force, it will imitate the winner's force and strategy

2. Reinforcement: if both were adoping the same strategy when they met then reinforce by increasing force in 1 unit.

All agents start with the same force value: 0

Illustration



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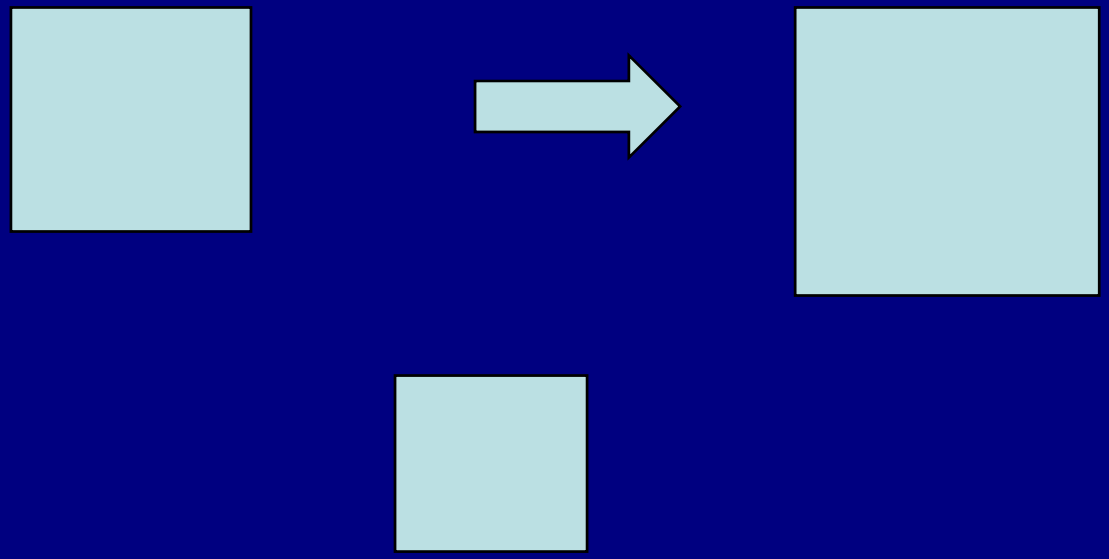

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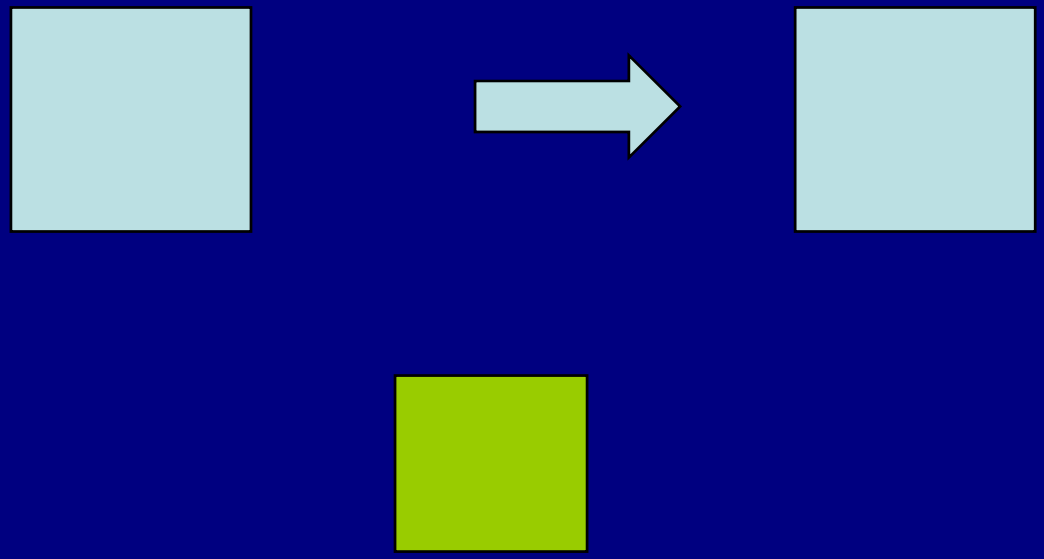

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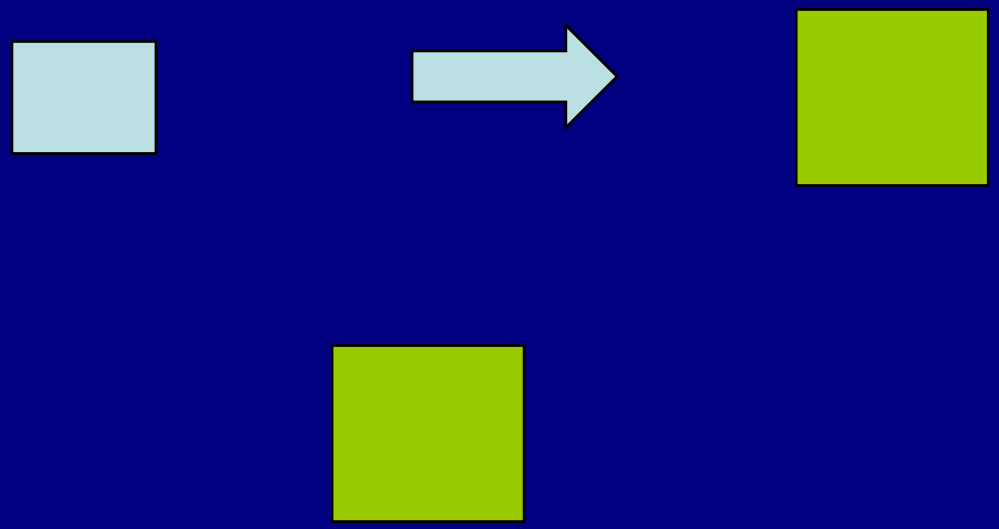


Dissidence

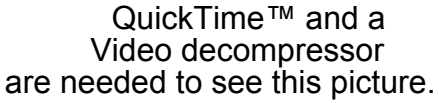
Counting the number of consecutive equals seen

After a certain threshold with some probability become a dissident

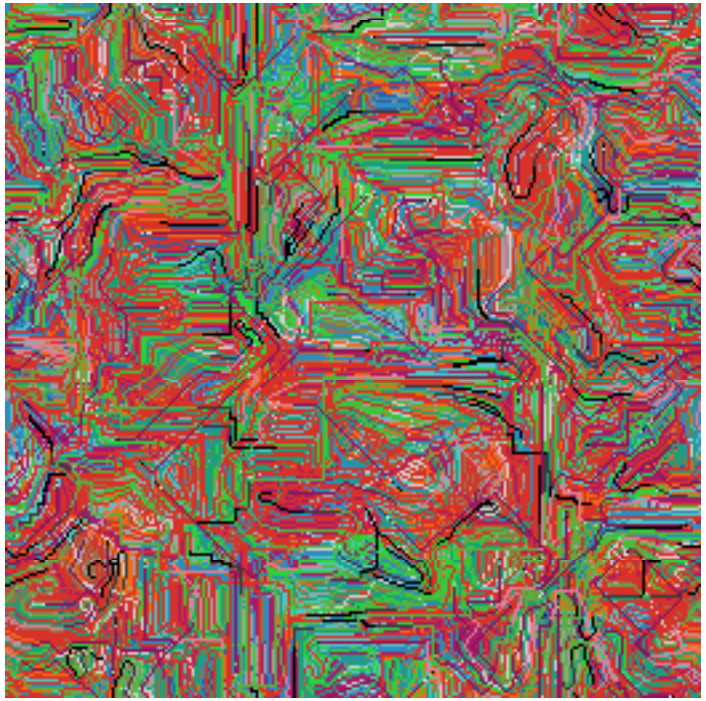
Becoming a dissident means changing the parameters of imitation in a random way, and increasing force (200 units).

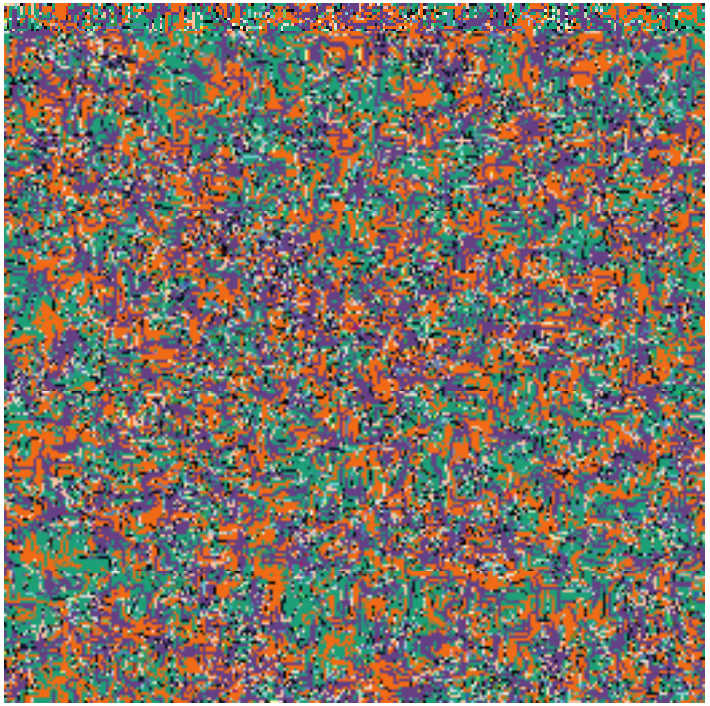
A lot of dissidents? No problem, convergence towards consensus is quick.

Cycles of consensus

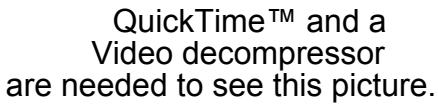


Cycles of consensus





Rotating and Imitating



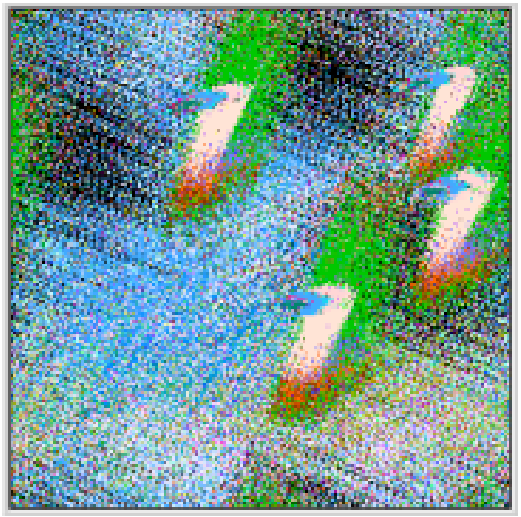
Rotating and Imitating again

QuickTime™ and a
Video decompressor
are needed to see this picture.

Mimetism of orientation

QuickTime™ and a
Video decompressor
are needed to see this picture.

Mimetism of orientation again



Mimetism of Position

QuickTime™ and a
Video decompressor
are needed to see this picture.

Mimetism of Position again