Self-Organisation and Generativity

Marie-Pascale Corcuff
GRIEF, ENSAB, Rennes, France
www.rennes.archi.fr/
e-mail: marie-pascale.corcuff@rennes.archi.fr

Abstract

Self-organisation is well illustrated in patterns, or more elaborate configurations, encountered in nature. But it is usual to oppose even those most refined constructions to human productions, in a dichotomy between nature and culture, that is well summarised by Karl Marx's quotation: "What distinguishes the worst architect from the best of bees is this, that the architect raises his structure in imagination before he erects it in reality." This paper questions this common opinion and discusses the place of self-organisation in art (including architecture), in artists' imagination, in their design process.
Some artists explicitly use self-organised processes in their work, a large part of so-called generative art consists in precisely that: "using an autonomous system", that is a non-human system, a system that generally has self-organised features, either borrowing from biology, chemistry, and so on, or simulating such self-organised processes with algorithms. But before that, artists could borrow from nature, and then from self-organised processes, their own procedures. In the domain of architecture and urban planning, someone like Frei Otto analysed and simulated self-organised patterns in order to invent human built configurations.
But, beyond those obvious references, it may be wondered if, and how, in more abstract works, self-organisation, that is spontaneous order emerging from local interactions without a global control, is actually carried out. Self-organisation of brain function is a strong hypothesis in neurology, and has been illustrated in visual perception in particular. Then it is legitimate to question the place of self-organisation in visual art production itself.
This leads to question (again) such commonplace topics as imagination, inspiration, beauty, order, randomness, and even desire and pleasure.

1. Foreword

Fig. 1: untitled,1992

The intent of this research is to make a link between two of my practices that may seem hard to reconcile, and actually are disconnected. On one hand I have practised drawing (one may say 'painting' except the tools I use are pencils, oil pastels, and so on) since a very long time, on the other hand, I like to write algorithms that generate images.
The series of drawings I refer to here

consist in, first, defining a square in the middle of a 50 cm x 65 cm sheet of drawing paper. I did 119 15 cm x 15 cm drawings (including 28 “hands”, see fig. 1) from 1985 till May 1992 (see fig. 2, 3) and 59 25 cm x 25 cm drawings from July 1992 till 2004 (see fig. 4).

Putting aside some of my drawings that are figurative, if I ask myself what happens while I am drawing, I suggest that it has something to do with self-organising processes. I wrote many years ago those two sentences: “*Par exemple, prendre deux crayons de couleur de teintes différentes et même agressivement incompatibles au départ, les emmêler, surveiller le conflit, avoir par moments très peur, et sentir tout de même que c'est de cette opposition que surgit la lumière. Ou bien, avec le crayon noir, les nuages; mais si cela ressemble à des nuages, c'est sans doute parce que les processus de formation sont similaires: les gouttelettes s'agglutinent autour de poussières microscopiques comme le graphite sur le papier refuse obstinément, malgré mes efforts, de former une couche uniformément grise.*” “For instance, take two crayons of different, and even aggressively incompatible hues, and intricate them, watch the conflict, be very afraid at time, and feel anyway that it is from this opposition that light arises. Or, with the black pencil, the clouds; but if it looks like clouds, it is probably because the formation processes are similar: water droplets agglutinate around microscopic dust just as graphite on paper obstinately refuses, despite my efforts, to form a uniformly grey layer.”

Fig. 2: “miz du 4” , 1985

Fig. 3: untitled, 1986

Fig. 4: untitled, 1996

Let me stress an important fact: I do not intend here to try to simulate my drawings with self-organisation processes. The reason why I bring this drawing practice up here is because I want to take the point of view of the artist, of the person who makes something, either with her hand or with her mind.
In the following experiments I explore self-organisation, which means that some form of overall order emerges through local interactions between elements of an initially disordered system. It also fits the definition of generative art by Philip Galanter: "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." [1] The 'art' part consists in reinterpreting those systems, particularly in interpreting some elements in terms of colours, and in extracting some frames from dynamic systems.

2. Generative experiments

2.1. Experiment #1

What triggered, amongst other references, the topics developed in this paper were pictures showed at GA2011 by authors which were not artists, but scientists, a chemist an a mathematician [2]. Though not intentionally artistic, their pictures were striking, beyond the scholarly and very instructive discourse on entropy they intended to illustrate. Without actually re-enacting their own process, fig. 5 illustrates a process leading to images similar to theirs.

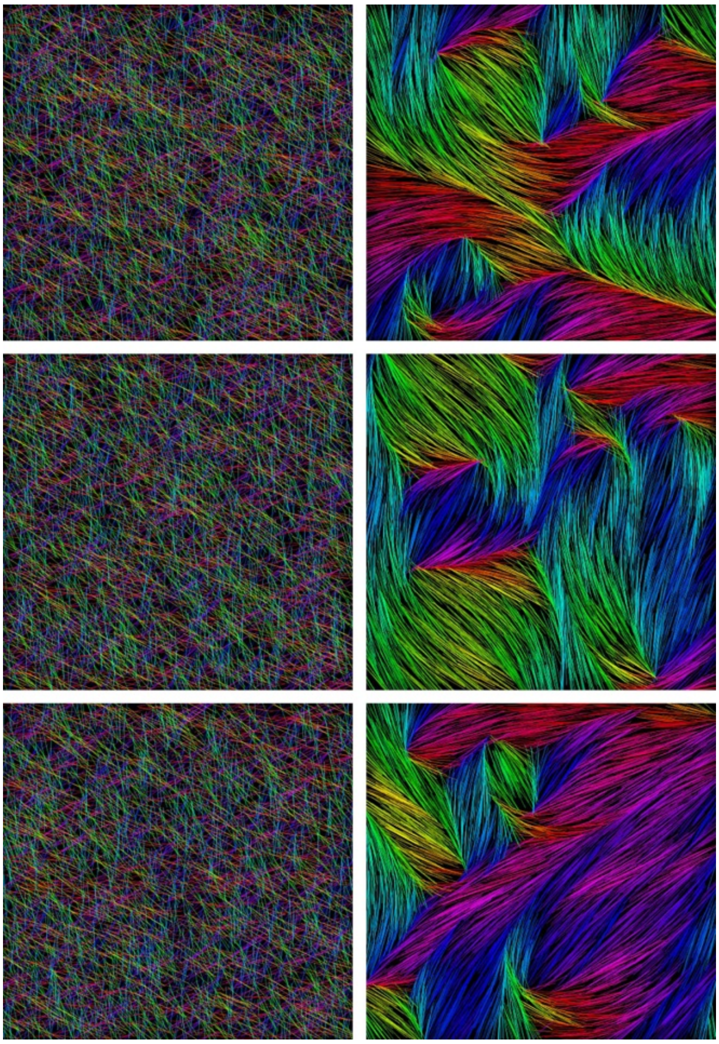

Fig. 5

One starts with a random distribution of rods with random orientations, and applies local changes of orientation in order to not having overlapping rods any more. Each rod is examined, and its orientation is slightly changed in order to be closer to that of any other intersecting rod. The process is iterated till some equilibrium is attained and it does not change any more, at least not too much. The result is not perfect, some overlapping may remain, but for our purpose it does not matter, it even contributes to some of the quality of the image. The process fits the definition of self-organisation: the three images on the left of fig. 5, which show initial distributions, are indistinct, when those on the right (showing the results of the process), though very similar to each other, have some kind of identity: one may prefer one of them, for whatever reason (the amount of such colour, the way it swirls more or less, and so on).

Trying to analyse what is pleasing in these pictures, which is certainly in good part subjective, two features retain the attention: one is the association of each orientation with one saturated colour in a graduated way, the other one is the seemingly 'natural' distribution of orientations. The first feature was introduced by Galanis and Ehler in order to let us better visualise the pattern of orientations. But it happens that it generates nice distributions of colours, beside letting us better evaluate order/disorder balance. One may compare those results with images where all rods are white against a black background (fig. 6), which may better please those who prefer understated art...

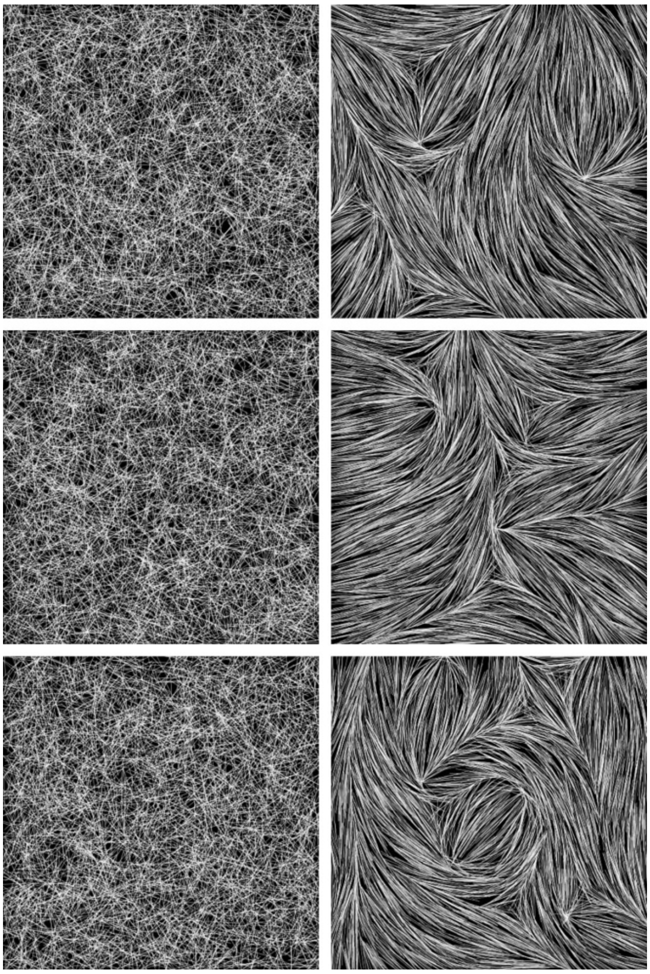

Fig. 6

Concerning the overall character of those images, we see some parts roughly aligned, and the transition between orientations is more or less graduated. The overall distribution could be describing as a field of directions, like for instance the field of wind directions in two dimensions, or iron fillings in a magnetic field.
Those images were produced with 5000 rods of length 100, in a 500x500 pixels square. Trying with shorter or longer rods in the same square leads to somewhat different results (fig. 7).

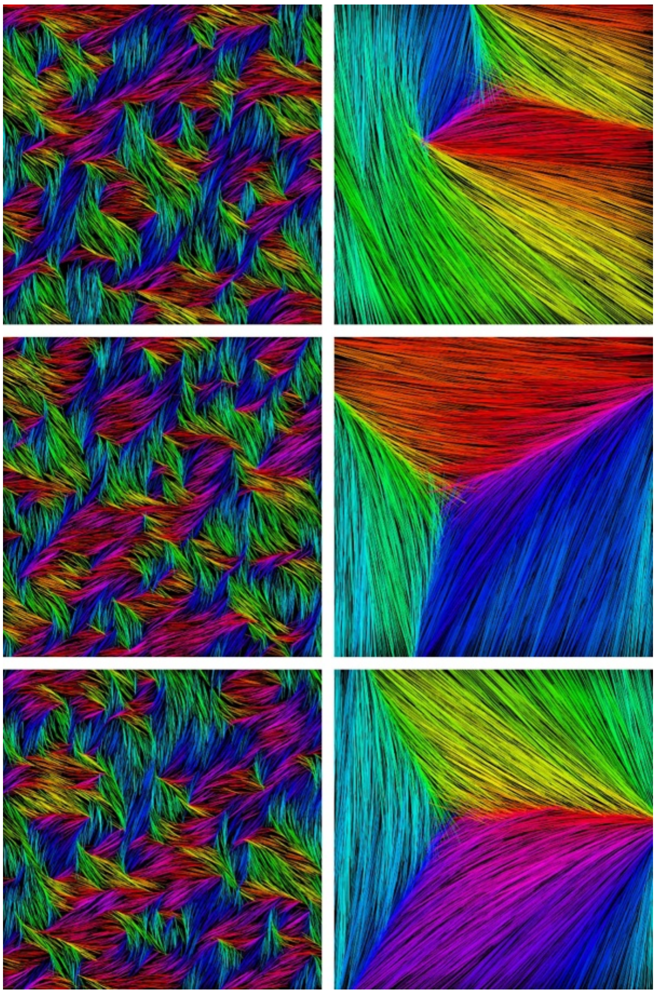

Fig. 7

Even if I was attracted at first by the saturated colours used by the authors of the reference images, I wanted to try another kind of representation of orientations by colours. What I chose was to map orientations, not on the hues of HSB colours, but rather on the saturation and brightness components of those colours, for a given hue (fig. 8, 9).

Fig. 8

Fig. 9

By slightly changing all orientations of the rods at one time, and then let the process of rearrangement occur, we do not obtain a simple rotation of the whole image, but a slightly different one. By repeating this action, we obtain a nice animation.
Another way of playing with this process is by introducing two different hues instead of one, for instance by attributing one to orientations between 0 and π/2, and another one to orientations between π/2 and π. This leads to images with interacting colours, as in fig. 10.

Fig. 10

2.2. Experiment #2

The rearrangement seen above is a kind of averaging, each rod getting an orientation respectful of its closest neighbours. Averaging is exactly what does the 'Isling' cellular automaton shown in GA2014 [3]. In its basic version, each cell may have one of two states, and at each step it adopts the average value of states of its neighbours. One must start with a random balanced repartition of the two states, and the application of the rule leads to an equilibrium where areas of state 0 and 1 are smoothly intricate, and altogether balanced (fig. 11).

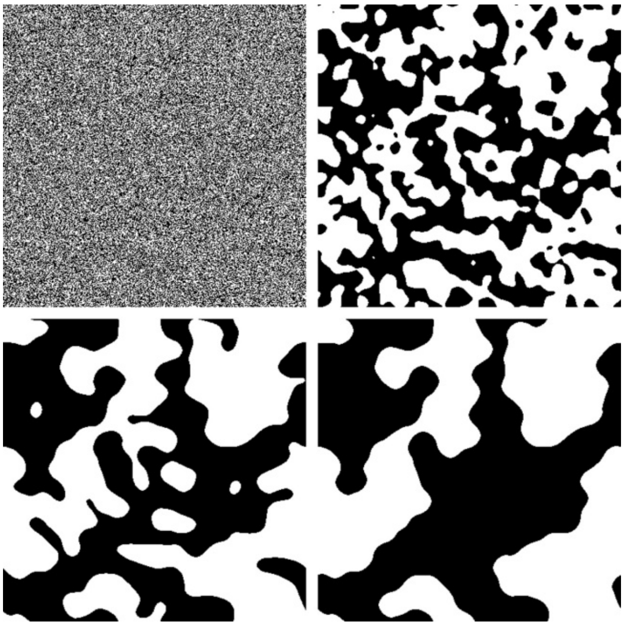

Fig. 11

Cells are identified to the pixels, and the two states to black and white, respectively. This CA allows to choose a depth for the neighbourhood, here a depth of three has been chosen. In that example as in all following ones, the bitmap has a periodic, or 'toric' topology.
Now we shall expand this CA into a 'continuous' version, by considering 256 states, ranging from 0 to 255. By applying the same rule, now potentially getting states of range 0 to 255 represented as levels of grey, we obtain a very disappointing foggy distribution as in fig. 12.

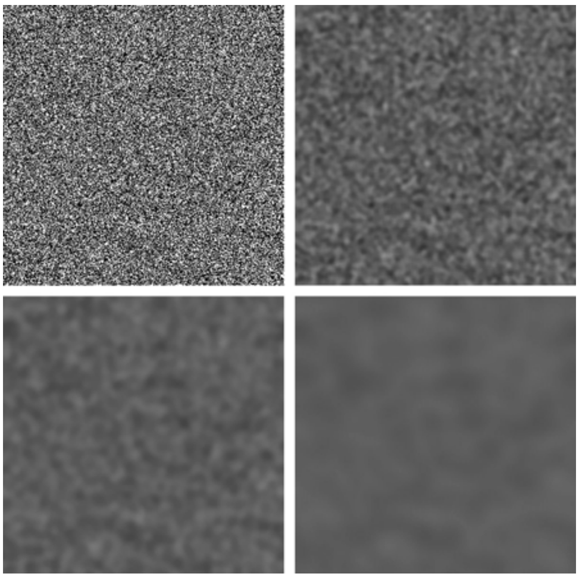

Fig. 12

States are all very close to the average, that is 127, so that we cannot very well distinguish them visually, though they are actually not all equal. They are distributed symmetrically around 127, so if we represent states smaller than 127 by black, and the other ones by white, we obtain something like fig. 11 (which has actually been produced in such a way).
We can also remark that states range from a minimum to a maximum, and we can map this distribution onto the interval [0,255]; which produces pictures like in fig. 13.

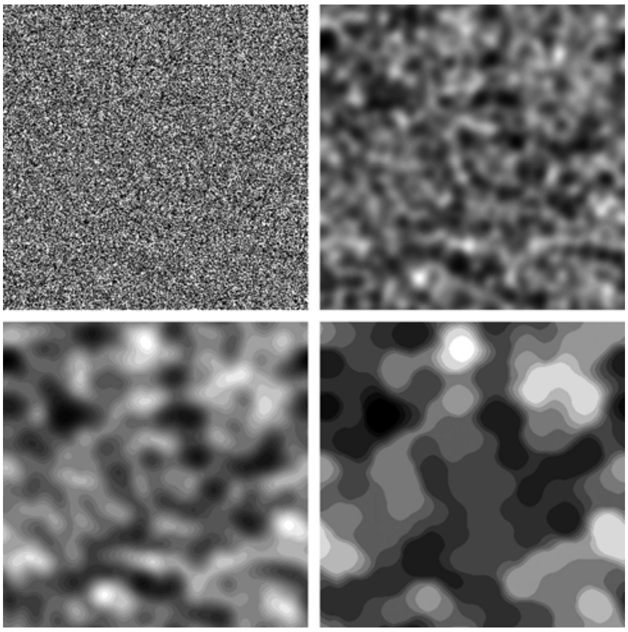

Fig. 13

We obtain an even more interesting representation by attributing a certain hue (red = 0 in HSB range) to states under 128, and another (cyan = 127) to states above, with saturation and brightness proportionate to the previously described mapping of the state (fig. 14).

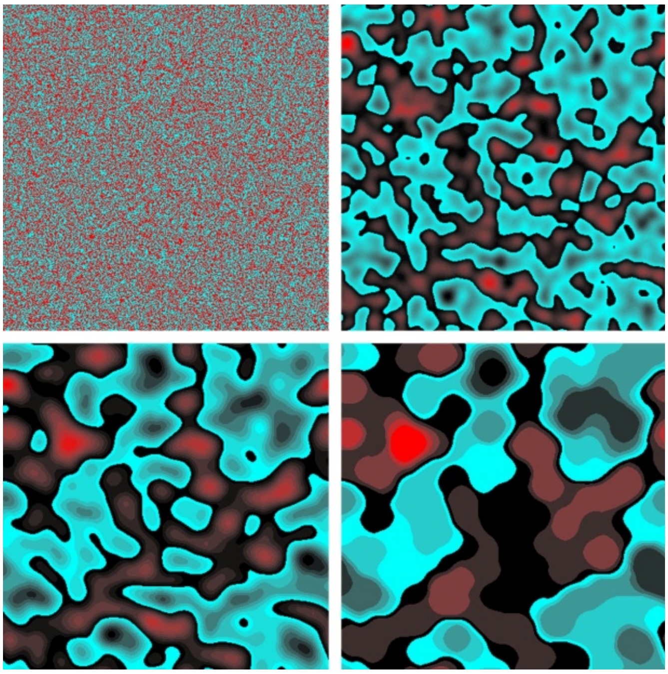

Fig. 14

Now we shall slightly change the rule in order to give some dynamics to this CA. We shall add a constant (127) to the average value used to get the new state of the cell; taking that value modulo 256 allows the process to go on. Because of the way states are represented, red and cyan alternate in the successive bitmaps, but, apart from that, we observe a new behaviour for this CA. A first phase looks a lot like with the previous system: smooth balanced intricate areas partition the image. But at one point, something strange occurs: some 'spots' appear, that grow and then vanish, while the "background" separates itself into two balanced parts (fig. 15).

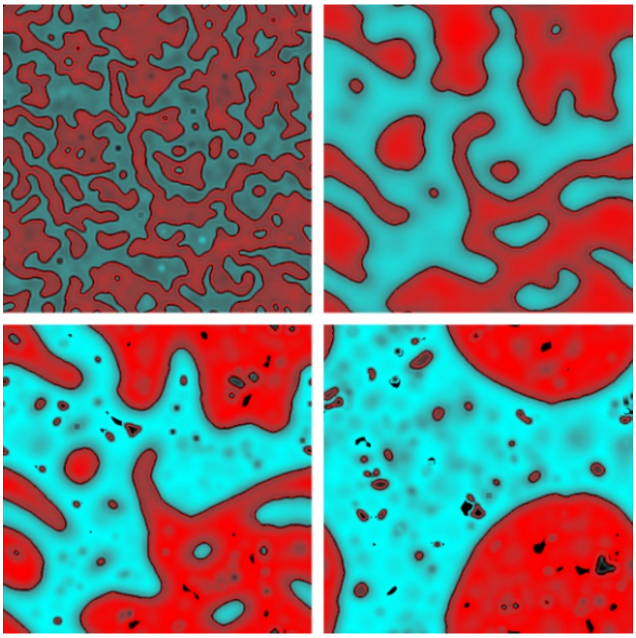

Fig. 15

Sometimes, one area overcomes the background. Some outcomes are shown in fig. 16.

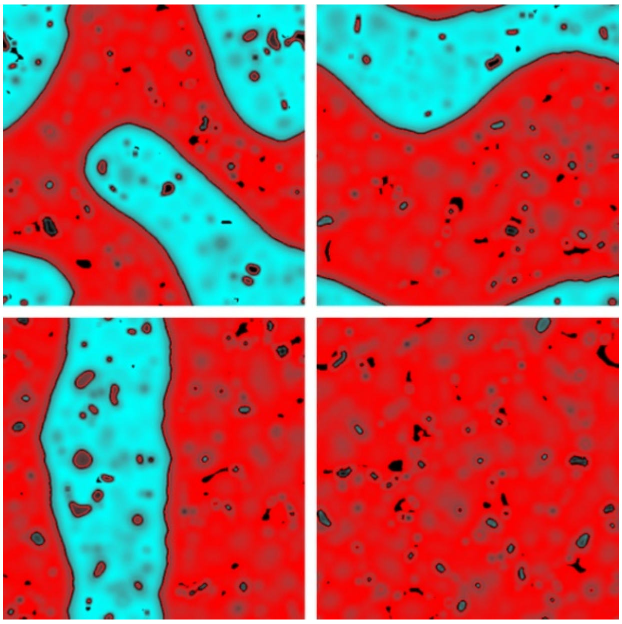

Fig. 16

For a last development of this CA, the specific rule is slightly changed again: instead of letting the next state be equal to the average of its neighbourhood, we add this value to the state of the cell itself. The 'modulo' operation allows again the CA to go on forever. This CA then becomes a well known one, showing after a while wave-like explosions, which is used to simulate special effects. For our purpose here we shall turn our attention to some of the frames, with the same representation of states by colours as above. From this succession of frames, we have extracted two pictures, shown in fig. 17, 18.

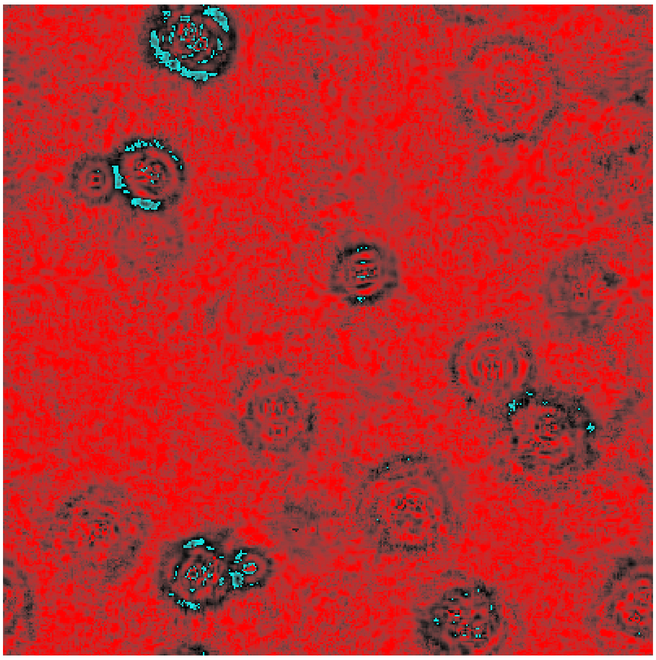

Fig. 17

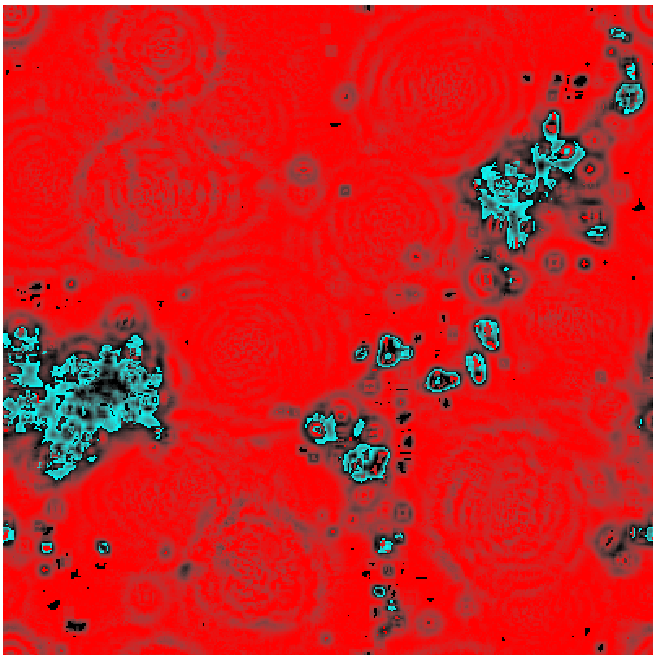

Fig. 18

2.3 Experiment #3

The last model we shall play with is the behaviour system known as a 'swarm', or at least a very simple personal version of it. This swarm consists in a set of particles (or agents, or 'boids') that move according to a simple set of rules involving only the neighbourhood of each particle. Those rules concern three behaviours: non-collision, cohesion, and alignment: in order to have a 'well behaved' swarm, particles are not supposed to collide, and they are meant to cohere and align with at least some of their partners. We then obtain a collective behaviour without any centralised control, and that looks like that of swarms of bees, flocks of birds such as starlings, fish schooling, and so on. By playing on the different basic local behaviours, that can be switched on or off, and on the amplitude of the neighbourhood required by the cohesion and alignment behaviours, we can get different kinds of global behaviour. We must add that the screen is considered as a periodic space, which means that it has the topology of a square flat torus: any particle leaving on the right border reappears on the left, and vice-versa, and the same applies to the top and bottom borders. Otherwise, particles could go out and never be seen again...

We shall here, again, take a step aside from the original purpose of this model, and play on different types of representation in order to obtain images, with aesthetic criteria, whatever that may mean. The main idea is to record traces of the particles, and to freeze such or such frame.

A first version uses small white particles on a black background, and, in that case, when a change in the parameters is provoked, the picture is erased. We get a lot of very different outcomes, a few of them are shown in fig. 19.

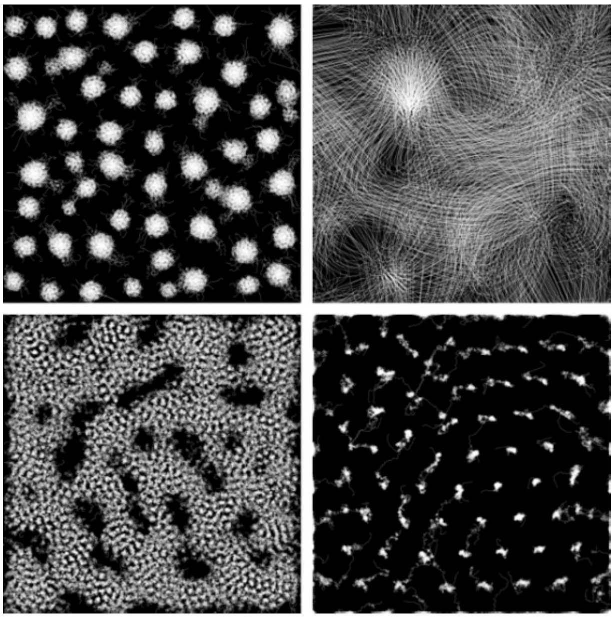

Fig. 19

A second interpretation consists in using the particles as pencils or brushes on a canvas. We never erase the screen, but the 'paint' is transparent, so it accumulates with time. A possible outcome is shown in fig. 20.

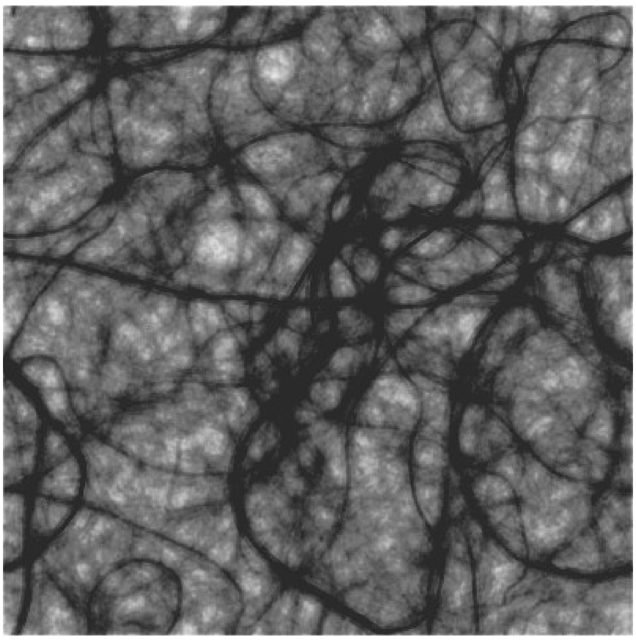

Fig. 20

For our last experiment, we borrowed the idea from our very first one: the particles are represented by rods, in the direction of their movement, and with colours depending upon their orientation. The screen is not completely erased between frames, but filled with a transparent colour.

A first version uses a 'blue' hue (H=15), with saturation and brightness corresponding to the orientation, and the screen is filled with transparent black (fig. 21).

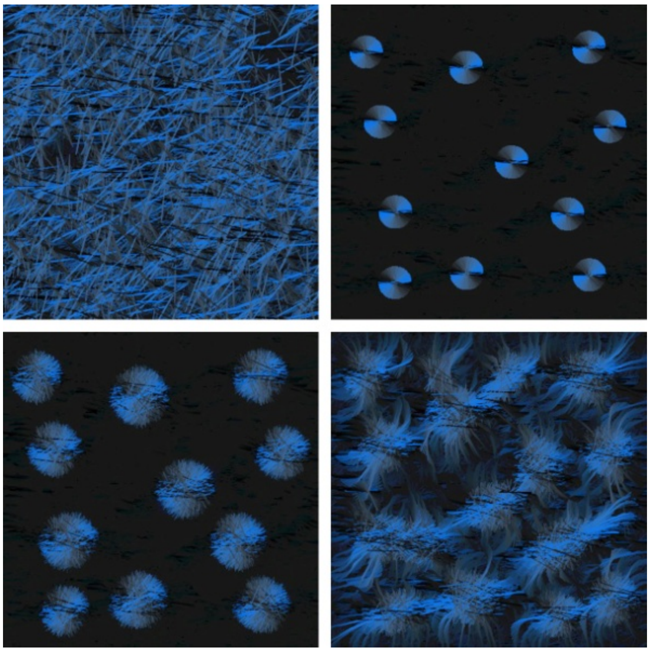

Fig. 21

A second version uses a 'ochre' hue (H=150), with the same specification for saturation and brightness, and the screen is filled with transparent white (fig. 22-26).

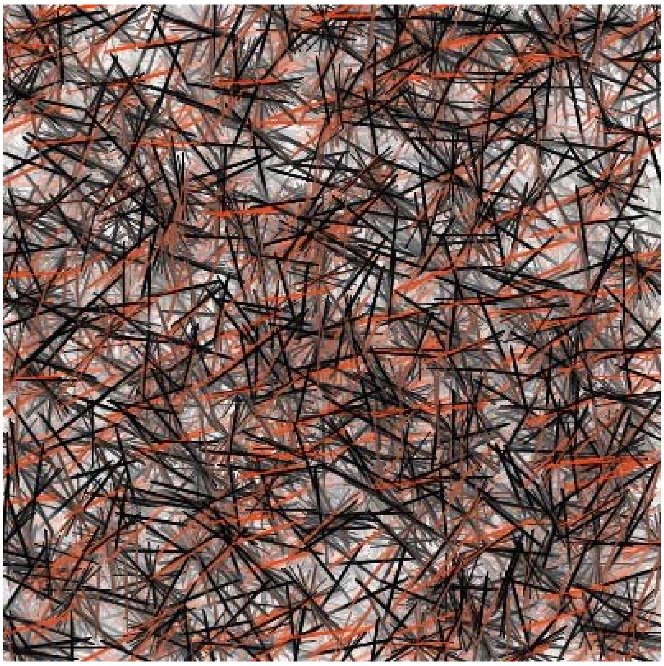
Fig. 22


Fig. 24


Fig. 23

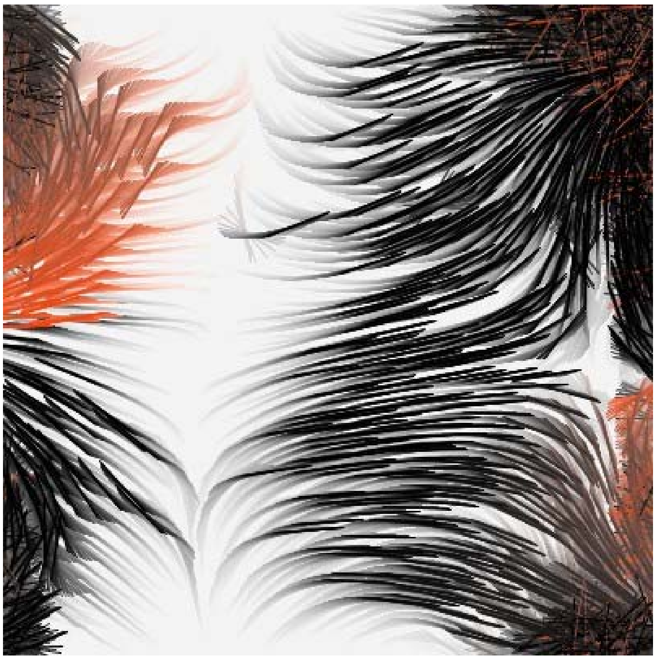
Fig. 25

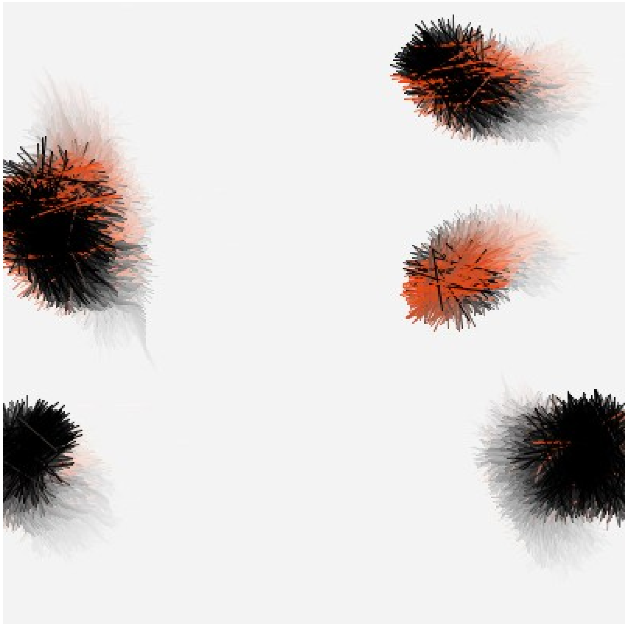

Fig. 26

All these images are frames extracted from the same process.

Afterword

A first remark I want to make about the outcomes of these experiments, and their ‘artistic’ quality, is their relationship to ‘conventional’ art. Fig. 10, for instance, may evoke some works by Hans Hartung, like “T1971-R30”, fig. 20 some of Pollock’s paintings, and so on. But that is neither the intent, nor the criterium, of these experiments. Once somebody told me, about my drawings, that they reminded him of some computer produced images, and that I should investigate that. But I did not agree. What I like, and need, when drawing, is the concrete interaction between the tools and the paper, the physical effort it implies: I prefer hard tools on strong paper, for instance, I never use soft tools like charcoal; it maybe is a remnant of the engraving practice I learned when I was a student, even if I did not pursue it. This work is more tactile, more haptic, that strictly visual, and even the odour of the pencils play a role, as I am sure that of paint is not negligible for painters.

On another hand, some of the images obtained above may remind us of natural patterns or configurations. That is not surprising, since self-organisation is a way nature uses in its own organisation, and for instance experiment #3 is directly inspired by the actual behaviour of birds or fish. But, more to the point of this paper, some images may evoke ‘natural’ human actions: boundaries in fig. 15 and 16, as well as traces in fig. 20, 23 and 25 look like ‘free hand’ drawing or painting. This is the result of the rules, and not of some contrived mathematical invention like splines or Bezier curves, which is an interesting point.

As a contribution to issues concerning generative art, I would like to analyse those experiments from the point of view of the person who did them. The role of the artist is one of the most discussed questions about generative art, as exposed by Galanter, but also for instance by Margaret Boden and Ernest Edmonds (himself a generative artist) in a paper [4] that thoroughly reviews the different forms of generative art and their issues, going back historically to such pioneers as Georg Nees, Frieder Nacke, Michael Noll, or Manfred Mohr. I would like to add to this list Vera Molnar, born in 1924, still very much alive and producing, who had an exhibition at the Galerie Oniris, in Rennes (France) this last summer [5]. Mohr and Molnar were pre-eminent in my first discovery of computer art. Boden and Edmonds’ characterisation of generative art (by comparison with computer or digital art, among other categories) is that “*the artwork is generated, at least in part, by some process that is not under the artist’s direct control*”, which is not very different from Galanter’s definition, but stresses more on the role of the artist, with all the nuances that may imply the locutions “at least in part”, and “direct control”.

Artists are the first spectators of their own work in progress, the first to judge what they are doing, what they are getting from their practice, either produced by their own hands, or by a computer. Even if the aim of the previous experiments *is not* to simulate 'manual' artists' works, my own or that of others, it is certain that some 'artistic' quality, whatever this means, is what makes me appreciate such or such result. In experiment #1, I appreciated that the mapping used in fig. 8 or 9 gave light and shadow illusion, and therefore depth to the images. In experiment #3, choices concerned the representation of the particles, either by rounds (of different sizes) or by rods, with different colours, and with different ways of going from frame to frame. As a result, fig. 23 and 25 look like watercolour, which is due to the representation by rods of a certain hue, with saturation and brightness proportionate to the orientation angle, and moreover to the transparent filling of the screen between frames. Whatever the rules, there are many different ways of transposing them visually, and this is one of the places where the artist has a role. Taking the example of a great generative artist's work, the "process compendium" series by Casey Reas [6], which set in motion relatively simple agent behaviours, are particularly remarkable ('beautiful') because of the way these moving agents are represented, either in movies, in prints, or even in sculptures.

With an on-going process, what is determinant too is deciding *when* to stop, *when* to freeze the process and catch a frame. That was particularly important for experiment #3, where the content of the screen is continually changing. This kind of decision is very close to what happens when drawing, especially when the drawing is abstract, and there is no model to attain. When to stop? is a very important question, one does not want to go too far, and maybe spoil the work... There is no definitive and objective answer to that question, it is a question of feeling, in which a certain fatigue may be taken into account.

Another role for the artist is, even if the rules are well established, to intervene on some of the parameters. In experiment #1 for instance, the relative size of rods and screen leads to more or less interesting results, here 'interesting' meaning a balance between order and disorder, an harmonious distribution of orientations highlighted by the colours that represent them. The comparison between figs. 5 and 6 lead me to stick to the initial choice of size for the rods. In experiment #3, parameters concern the quantity of particles, the size of their neighbourhood, and the setting of and on of their behaviours. In that case, those changes may even intervene during the process.

And, finally, or rather initially, because I presented the phases in a reverse order from their actual occurrence, one has to define rules. In my drawings, I define rules too. For instance, I choose only two crayons of different hues, or with a black pencil, I try to generate some light without using en eraser. The rules I used for the three experiments exposed here are very common rules. I did not really invent them, though I somewhat diverted them from their common use. It is in experiment #2 that I worked the most on the rules, evolving from a strict averaging CA to a dynamic system by slightly changing the specific rule (what is the next state of the cell?) from simple average, to (average + a constant), and then to (average + previous state). Certainly more expert generative artists may invent their own rule, but from my modest point of view, I must say that there is a certain pleasure in writing algorithms expressing rules, and see them work. There is even a pleasure sometimes in making errors, and seeing surprising results...

In conclusion, I would like to emphasize two apparently contradictory feelings one may have in doing such experiments. The first reflects one's free will, while the second stresses the relative autonomy of the system put in motion.

What is enjoying in dealing with algorithms may be abstracted with the question: "*what if?*". At any stage, I can write what I want, change any parameter I want. This potentiality gives a sentiment of freedom, of empowerment, even with limited skills.

On another hand, one wants also to be *surprised*. Either while drawing or writing algorithms, I do not know exactly what I shall obtain. I have some ideas, not anything may arrive, the settings are defined in a minimal way, but, given an initial context, a set of rules, I want the result to come as a surprise. I could never make the same drawing twice, the outcome depends upon a lot of unconscious or conscious elements, including my mood or state of mind at the time of the drawing, and probably also upon something one has to call randomness...

The models used in the experiments, belonging to the general field of self-organisation, have a 'natural' relationship to randomness. There would be no sense in experiment #1 to start from anything else than a 'random' distribution of orientations, since the purpose of the process is precisely to give 'some order' to a disordered configuration. In the same way, the first CA in experiment #2, not only goes from a random distribution of states to a rearranged one, but even *requires* to start from a balanced random distribution, as was shown in [3]. Concerning experiment #3, we see how the rules constrain particles to obey more 'ordered' behaviour whenever they happen to be randomly distributed, as in going from fig. 22 to fig. 23, or from fig. 24 to fig. 25 for instance. But in either experiment, the rules are deterministic, they are not stochastic at all, which does not mean that the results are totally predictable, which contributes to the 'surprising' effect I look for by doing these kinds of experiments.

References

[1] Philip Galanter, "What is Generative Art? Complexity Theory as a Context for Art Theory", GA2003

[2] Jennifer Galanis, Martin Ehler, "Disorder Disguised as Order: the Science of Randomness", 14th generative Art Conference GA2011, pp. 232-241

[3] Marie-Pascale Corcuff, Renaud Munch, Gwenn Rannou, "Randomness, (Dis)Order, and Generativity", XVII Generative Art Conference GA2014, pp. 230-248

[4] Margaret A. Boden, Ernest A. Edmonds, *What is generative Art?*, 2009

[5] https://oniris.art/expositions/vera-molnar-2019/

[6] http://reas.com/