The Nagual Experiment

M. Annunziato
e-mail mauro.annunziato@casaccia.enea.it

Abstract

This paper refers to an experiment about the use of artificial life structures in order to simulate/evocate natural or artificial patterns. These patterns are the effect of the self-organisation of a population of individuals during their process of development and growth. Although the local dynamics and interactions have a chaotic (partially random) behaviour, the global dynamics of the population produces interesting and well structured patterns. The graphic images generated with these procedures show a wide variety of structures in terms of life (growth) simulations and graphic geometries.

1. Self-organisation

This paper describes an experiment at the border line between art and science. The cultural domain is the interference zone between the digital art and the theories of Chaos and Complexity.
The basic topic of my work is one of the fundamental concepts of the Theory of Complexity: the *Self-Organisation.* This concept, introduced by Ashby and Von Foerster in the 1960-1970, refers to the complex systems composed by a multitude of independent entities characterised by autonomous chaotic behaviour. The self-organisation is represented by the emerging of a global organised structure (order) in the system. This concept has been studied by several scientists (i.e. Prigogine [9] and Kaufmann [6]) and applied to analyzing living and not living systems. Finally, the self-organisation concept has been utilised in many contexts of human sciences (social systems, culture, psychology) and, naturally, art.

In the context of the computer simulations, several research branches have been started in order to study this specific aspect like the *cellular automata* approach based on a completely deterministic local rules [12]. Other research strategies have mixed the self-organisation with the natural selection including genetics, random generation (genetic evolution [4], *artificial life* [3,5], *fractal growth* [11]) and studies about the characteristics of living organisations (*autopoiesis* [8]).

The definition of these concepts are often qualitative. The scientist of chaos and complexity use the terms "*emerging pattern*" and "*emerging behaviour*" in order to refer to the self-organisation concept or to the behaviour of living entities. These ambiguous limits of the definitions (probably related to the fundation of a new language on this topics) leave a wide space to express it in terms of visual and generative arts . Several artists (mostly using computers) recall this concept in their works.

In a similar way, my goal is to investigate these topics (self-organisation in a context of artificial life) using the *left part* of our mind: intuition, emotions and aesthetic sensibility. In this sense, this experiment is free from any theoretical implication about the simulation of the *life-as-it-is* or the *life-as-could-be* on which biologists and physicists of the Artificial Life are engaged [5]. Simply, I want to take a walk in the *art-as-could-be* operating in the perceptive domain through the evolution of black-white digital images.

The name of the experiment described in this paper (*Nagual*) is inspired to the thirty years work of Carlos Castaneda and in particular to the mystic myth of Nagual [1,2]: a very ancient myth (diffused in the Latin-America) reviewed under different aspects by ancient and contemporary cultures. The unknown and uncontrollable part of us, with its powerful perceptive and creative capacities, is well represented by Nagual myth. In this way, the perception of the man is seen as the result of the organisation of *luminous filaments* converging together in an *assemblage point.* The position and configuration of the assemblage point and filaments determines the potential of perception.

I choice this reference because I found that the Nagual myth is an evocative vision of the self-organisation concept. Furthermore, the images I produce are constituted by evolving filaments which organise themselves in patterns. Finally, one of the main inspirations of my work is based on the metaphor between graphic emotive impact and mind dynamics.

2. The evolutionary process

The generation of the images is constituted by the evolution of a population of individuals represented as black points moving (or filaments growing) on the white space of the image (the *life space*). Each individual is described by a series of genetic characteristics which influence the movement modality (based on a model of *random-probabilistic walk*) and the probability of

reproduction and death. Furthermore, some environmental constraints influence the dynamics of the whole community.

The parameters of the evolution of each individual are codified through some individual features: character, energy, irrationality, fecundity and mortality. All these features are recorded in a genetic map. The collective development constitutes a new entity with its own autonomous and coherent pattern and with characteristics descending from the interaction and features of the population of individuals. During the evolution, the life space decreases and after a development time, the evolution is concluded.

The *character* codify the typical movement of the individual. The character *unforeseeable* is related to a movement with a completely random curvature. For the character *tending,* a higher probability is associated to pre-fixed curvature. The *constant* character is related to a movement with low fluctuations around a fixed curvature. The *evolutive* character is related to a movement with a curvature evolving along the time.

For each one of the defined characters a random component is associated. The importance of this component is defined by the *irrationality* feature. Increasing the irrationality, increases the random component. Finally the real movement of the individual is the result of the composition between the individual choice and an environment parameter which is named *freedom*. At high freedom the individual is free to follow his character. At low freedom the environment tends to impose to the individual the straight movement.

An individual dies when it meets the trail of another individual. Otherwise it can dies for natural death (depending by a mortality factor). One single individual can generate a son with similar genetic map but with a lower energy. This position is established to evoke the plant growth: the *branch-sons* are thinner of the parent. The reproduction rate is regulated by a reproduction probability (fecundity). A minimal threshold on the energy is required for the reproduction.

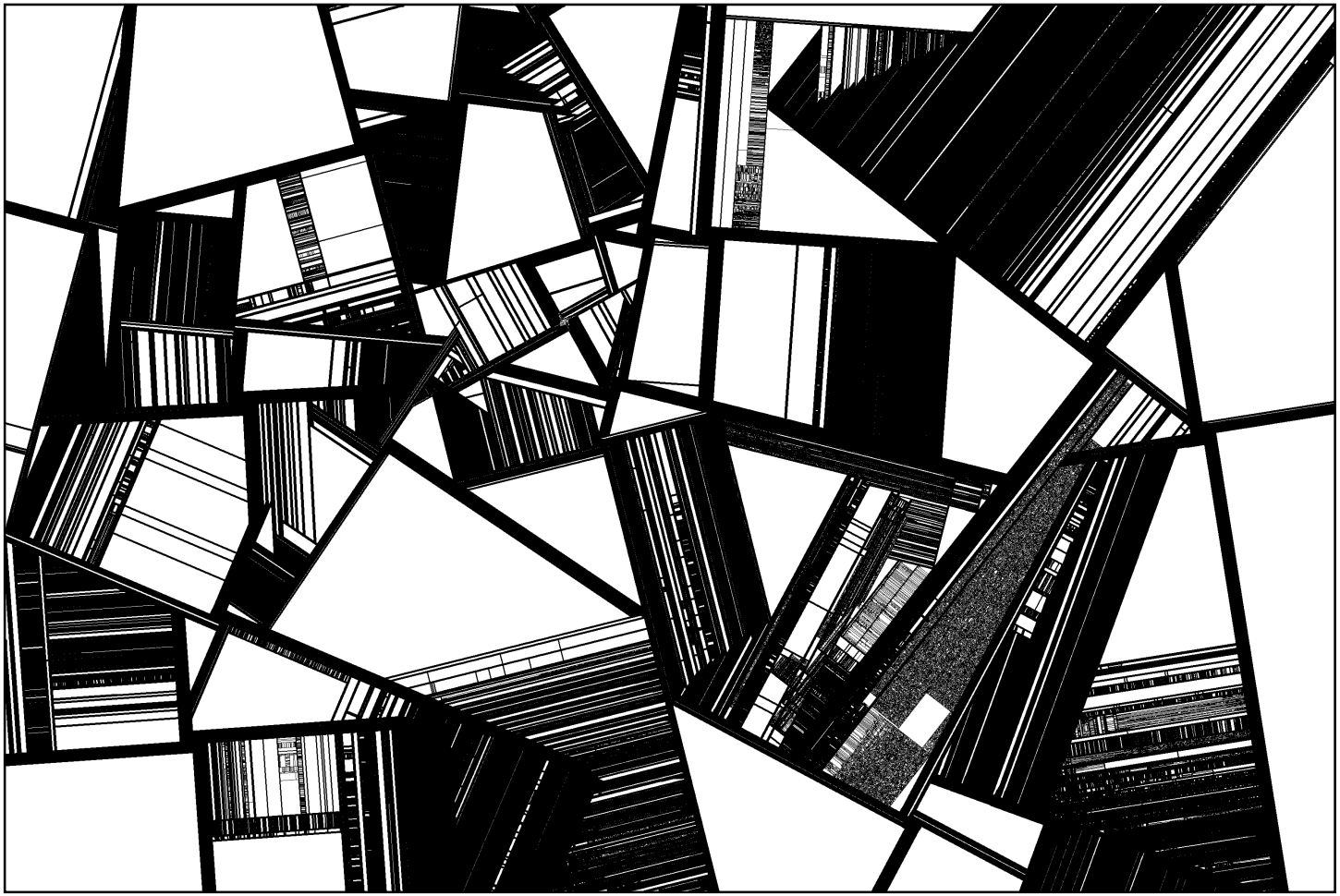

Fig. 1: “Linear Logos”

3. The Archetypal Patterns

Depending by the movement rules I established an emotive relation between the genetic characteristics and the graphic patterns. The straight lines represent the rational - analytic character or an unexpressed creativity. Lines with a constant bending represent a constant foreseeable behaviour, while the variability of the paths is referred to the unforeseeable or to the irrationality. The evolutive character is represented by a line changing in progress its curvature. The environmental coercion forces the individuals to reduce the changes of the direction. The case influence paths and birth of a new life. Through different characteristics of the individuals, chaos determine very complex shapes.

Changing the parameters of the process (it was impossible to explore all the configurations), this experiment generates very different patterns remembering the growth of populations (plants, animals, neural networks), landscapes (rivers, fractures, mountains, cultivated fields), human artefacts (chips, glass fragments, architecture) , visions (anthropomorphous shapes, animals).
All these shapes are characterised by a completely different distribution in the space and by different line and junction features (different *fractal dimensions* [7]) . The final global shape is strongly connected to the growth dynamics.

In this paragraph I will give some examples of resulting patterns. It can be considered as a research of primitive (archetypal) patterns which represents similar growth dynamics for completely different natural phenomena.

Using a low environmental freedom or individuals characterised by a low irrationality, a typical crystal like pattern is obtained as the example reported in fig. 1. Granular materials, glass fragments, or human artefacts (microchips, cultivated fields, urban architectures) are the principal evocations for these images.

Increasing the environmental freedom, specific shapes occur depending on the individual character. The fig. 2 show a examples of the *tending* character at low random component (low irrationality). It produces ordered spirals in space recalling the elegant design on the sea shells or the well structured plants.

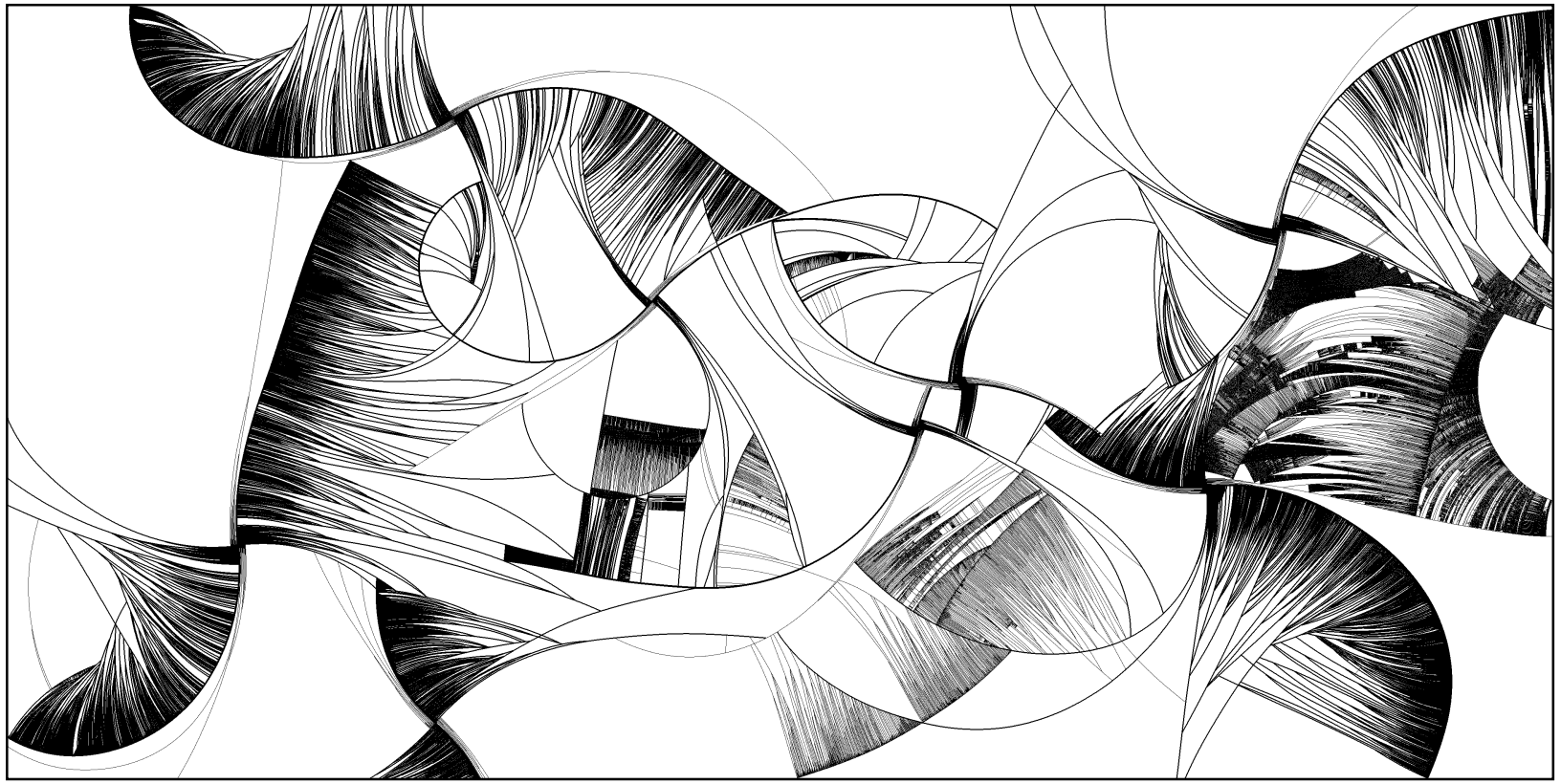

Fig. 2: “Tendency”

Fig. 3: “Neuron Landscapes”

Increasing the fecundity and mortality, the pattern of individuals with *unforeseeable* character produces long branches with short filaments. The collective pattern assumes the aspect of synaptic connections (fig. 3) or chromosome filaments.

The evolutive character gives very interesting results showing the self-organisation of spirals in large and small waves or in a very creative pattern when the random component is high (fig. 4). Other two interesting experiments show the evolution of a plant or micro-organism colony (high fecundity, fig. 5) or a very complex pattern with a large variety of shapes and articulations (fig. 6).

4. Bifurcations, Self-Organisation and Scale Effects

In the evolution process occur strong changes in the modality of the colonisation of the life space. They represent *bifurcations* in the individuals behaviour and interaction. Very dense zones are often alternate (adjacent) to low density zones. This mechanism, in most of the cases is due to the dynamic action of dominant individuals which act like *pioneers* creating strong divisions in the space. The subsequent colonisation of the space is driven by these *main streets* which define the borders of self-organisation of a local community of individuals.

The fig. 6 clearly shown an example of the importance of this effect. In this case it is possible to observe a different individual co-operation between different zones of the image. This image is one of the most interesting by the point of view of the self-organisation. It seems that an internal complexity is developed in order to organise individuals with characteristics which evolve during the development. The name I have given to this image is *Neuro-Society*: it recall me the dynamics of society as the global effect of the synergy of mind dynamics of a community of people.

An important condition, necessary to obtain self-organising behaviours, is the use of a high resolution for the image-lattice (wide life space at the initial conditions). The interesting characteristic of the resulting images is the very high density of graphic details. This feature gives to the observer the possibility of interact with the image at different scales outlining effects of *self-similarity* [7]. In this way it is possible to perceive as the pattern emerging in the total image is the result of interaction of many local self-similar patterns frozen in the final image. This effect recall the one utilised by the impressionists, which well realised the existence of a complex scale system under the perceptive level. By this point of view the characteristics vibration of their works can be related with the chaotic and fractal nature of the perceptive process and painted objects.

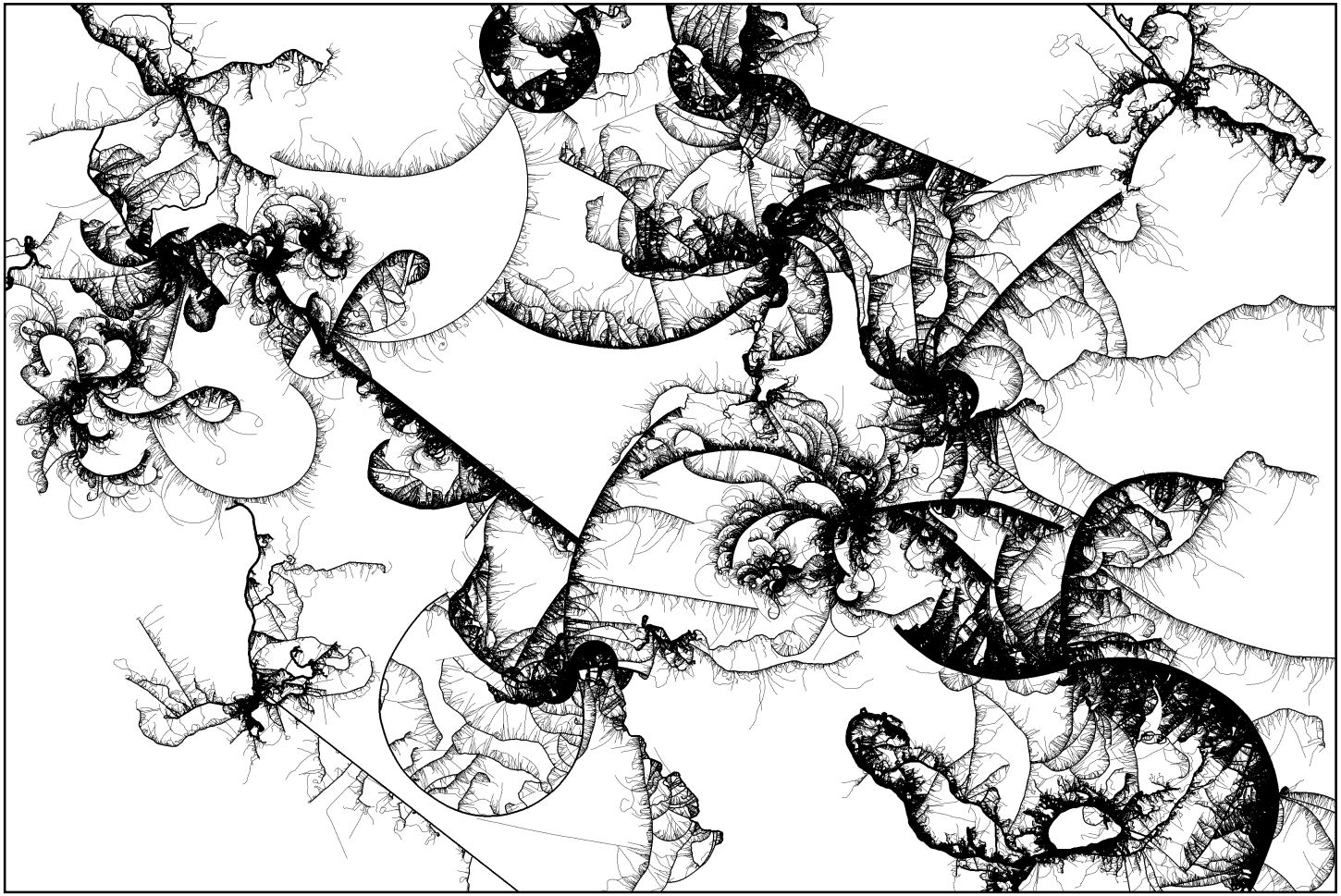

Fig. 4: “Creativity”

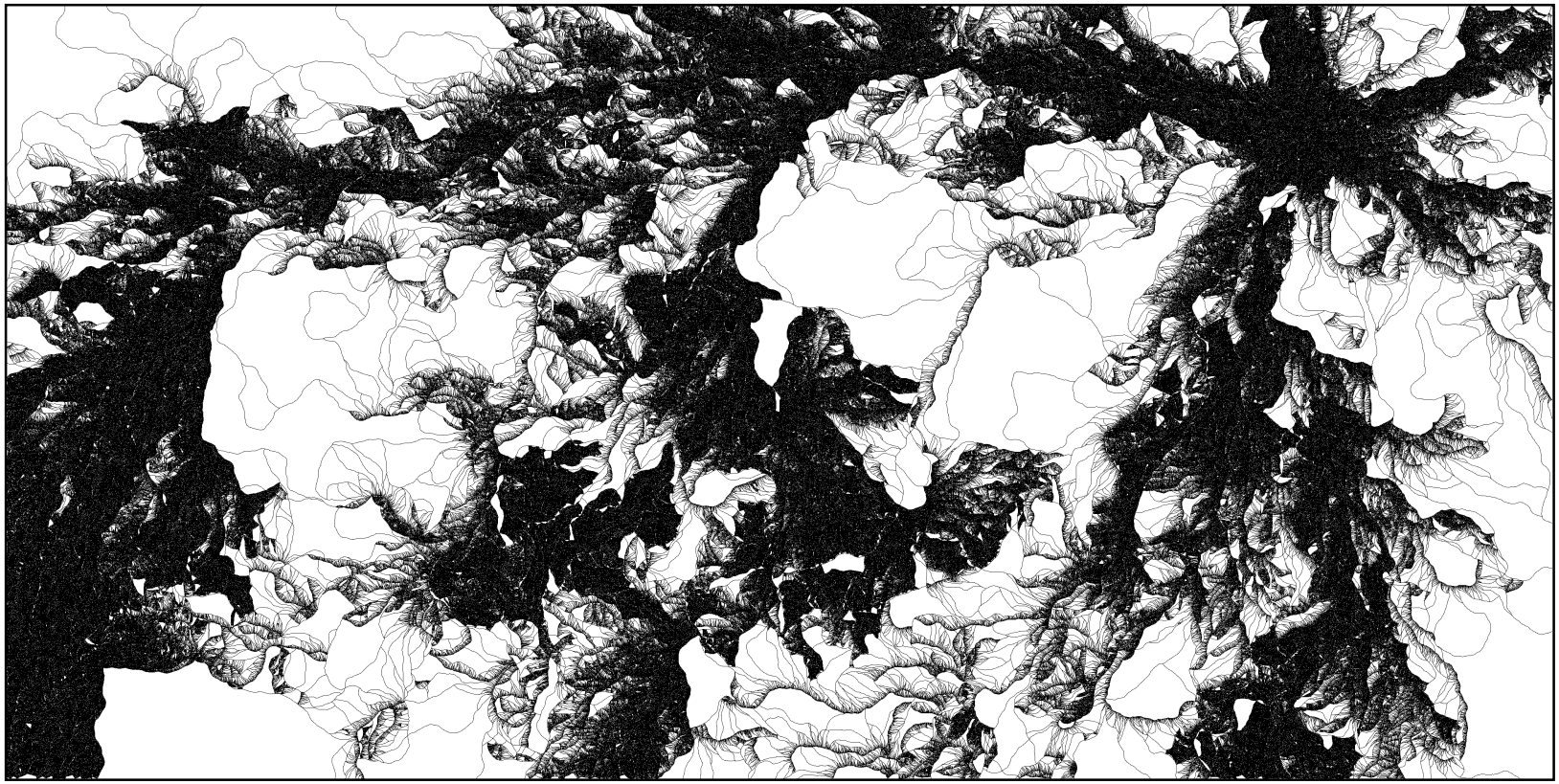

Fig. 5: “Micro-organisms of Memory”

Fig. 6: “Neuro-Society”

References

1. C. Castaneda. Tales of Power. Simon and Schuster, New York, 1972.
2. C. Castaneda. The Fire from Within. Simon and Schuster, New York, 1985.
3. Emmeche. The Garden in the Machine : The Emerging Science of Artificial Life. Princeton Univ. Press, 1991.
4. J.H. Holland. Adaption in Natural and Artificial Systems. University of Michigan Press. 1975.
5. C. Langton. Artificial Life. C. Langton Ed. Addison-Wesley. pp. 1-47, 1989.
6. S.A. Kaufmann. The Origins of Order: Self-Organisation and Selection in Evolution. Oxford Univ. Press, 1993.
7. B. Mandelbrot. The Fractal Geometry of Nature. Freeman, New York, 1983.
8. H. Maturana, F. Varela. Autopoiesis: The Organisation of the Living. 1973.
9. I. Prigogine, I. Stengers. Order out of Chaos. Bantam, New York 1984.
10. R. Thom, Structural Stability and Morphogenesis, Benjamin, Reading, 1975.
11. T. Vicsek. Fractal Growth Phenomena. World Scientific. Press. 1991.
12. S. Wolfram. Theory and Applications of Cellular Automata, World Scientific Press. 1986.