ArtiE-Fract: The Artist's Viewpoint

Evelyne Lutton, Emmanuel Cayla, and Jonathan Chapuis

INRIA - Rocquencourt, B.P. 105, 78153 LE CHESNAY Cedex, France,
Evelyne.Lutton@inria.fr,Emmanuel.Cayla@inria.fr,Jonathan.Chapuis@inria.fr,
http://www-rocq.inria.fr/fractales/ArtiE-Fract

Abstract. ArtiE-Fract is an interactive evolutionary system designed for artistic exploration of the space of fractal 2D shapes. We report in this paper an experiment performed with an artist, the painter Emmanuel Cayla. The benefit of such a collaboration was twofold: first of all, the system itself has evolved in order to better fit the needs of non-computer-scientist users, and second, it has initiated an artistic approach and open up the way to new possible design outputs.

1 Randomness in a creative process: freedom or uncontrollability ?

The programming of a software for artistic purposes is a challenging task: the computer software framework usually locks the user inside many interaction constraints that are sometimes considered as an obstacle to creativity.

Recent advances in interactive evolutionary algorithms (IEA) [2] have initiated many attractive works, mainly based on the idea of "maximising the satisfaction of the user" via a guided random search [1, 15, 19–21, 24–27]. The use of randomness in this particular way yields an additional "creativity component," that may or may not be considered as helpful by the artist, with respect to the way this random component is controllable. The success of such approaches is thus strongly dependent at least on the choice of a convenient representation and of an adequate set of genetic operators.

Additionally, a problem to be considered very carefully when using randomness in an artistic process is linked to the use of randomness itself, which can be considered by the user as an uncontrollable component of the system, triggering a reflex of reject. A disturbing question can indeed be raised: who is the "artist": the user or the machine ? Both positions can be defended, of course, and several fully machine-driven artistic attempts have been performed.

In the ArtiE-Fract experiments [8], we have tried to put the artist in the loop, and worked to limit this negative perception of the use of randomness. The system has been designed and programmed in order to let the user fully drive or partially interact with the evolutionary process at any moment (ArtiE-Fract is not an "artist"). The idea is to give the possibility to the human user to tame and to adapt the random behaviour of the system to his own artistic approach.

This paper is organised as follows: The ArtiE-Fract software is presented in section 2 (details can also be found in [8]) the artistic experiment is then detailed in section 3, and figures 4 to 9 present a sample of the work of Emmanuel Cayla. Main influences on the design of ArtiE-Fract and conclusions are presented in section 4.

2 ArtiE-Fract: Interactive Evolution of Fractals

Fractal pictures have always been considered as attractive artistic objects as they combine complexity and "hierarchical" structure [3, 13]. Going further into their mathematical structure (for example with iterated function systems attractors, [4]) one has a more or less direct access to their characteristics and therefore, shape manipulation and exploration is possible [11, 22].

In ArtiE-Fract, an Evolutionary Algorithm (EA) is used as a controlled random generator of fractal pictures. The appropriate tool is interactive EA, i.e. an EA where the function to be optimised is partly set by the user in order to optimise something related to "user satisfaction." This interactive approach is not new in computer graphics [27, 24], we extended it to the exploration of a fractal pictures space and carefully considered flexibility with the help of advanced interactive tools related to the specific fractal model that is used.

2.1 Man-machine Interaction

Interaction with humans usually raises several problems, mainly linked to the "user bottleneck" [20]: human fatigue and slowness[1]. Solutions need to be found in order to avoid systematic and boring interactions. Several solutions have thus been considered [20, 26, 2]:

- reduce the size of the population and the number of generations,
- choose specific models to constrain the research in *a priori* "interesting" areas of the search space,
- perform an automatic learning (based on a limited number of characteristic quantities) in order to aid the user and only present him the most interesting individuals of the population, with respect to previous votes of the user.

Allowing direct interactions on the phenotype's level represents a further step toward efficient use of IEA as a creative tool for artists. The idea is to make use of the guided random search capabilities of an EA to *aid* the creative process. This is why in ArtiE-Fract, the user has the opportunity to interfere in the evolution at each of the following levels:

- *initialisation*: various models and parameters ranges are available, with some "basic" internal fitness functions;
- *fitness function*: at each generation, a classical manual rating of individuals may be assisted by an automatic learning, based on a set of image characteristic measurements (may be turned on or off);

[1] The work of the artist Steven Rooke [21] shows the extraordinary amount of work that is necessary in order to evolve aesthetic images from a "primordial soup" of primitive components.

- *direct interaction with the genome*: images can be directly manipulated via a specialized window and modified individuals can be added or replaced in the current population (a sort of interactive "local" deterministic optimisation). A large set of geometric, colorimetric and structural modifications are available. Moreover, due to the specific image model, some control points can be defined on the images that help distort the shape in a convenient, but non trivial manner;
- *parameter setting and strategy choices* are tunable at any moment during the run.

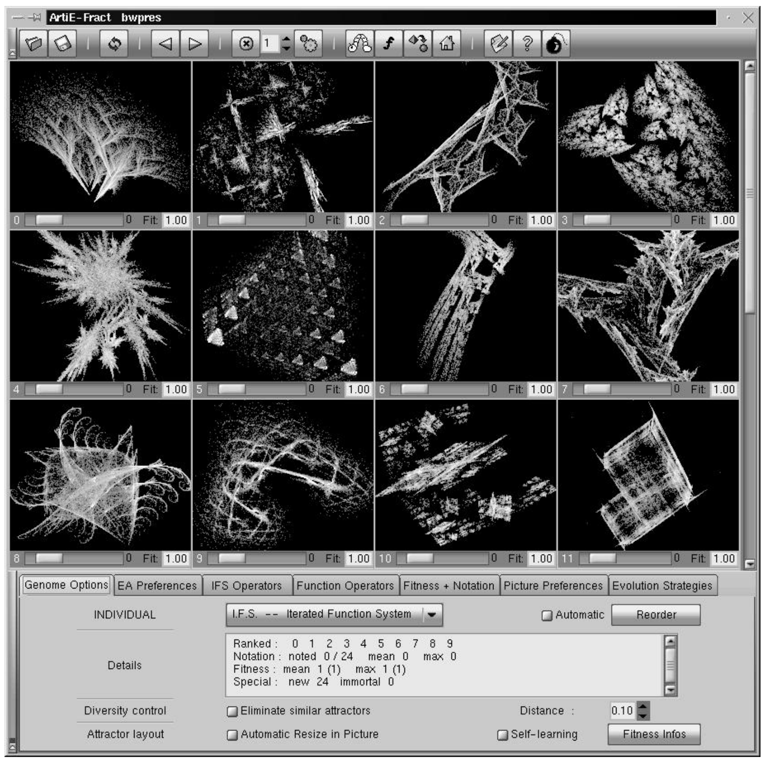

Fig. 1. Main Window of ArtiE-Fract

2.2 Advanced Evolutionary Strategies

Another specific component of ArtiE-Fract is the Parisian approach implementation, which also can be turned on or off at any moment of the evolution. This component has been designed to favour exploration and genetic diversity.

The Parisian approach has been designed relatively recently [10] and is actually a generalisation of the classifier systems approaches [12]. It is based on the capability of an EA not only to push its best individual toward the global optimum, but also to drive its whole population in attractive areas of the search space. The idea is then to design a fitness landscape where the solution to the problem is given by the whole population or at least by a set of individuals, and not anymore by a single individual. Individuals do not encode a complete solution but a part of a solution, the solution to the problem being then built from several individuals that "collaborate."

This approach is to be related to the spirit of co-evolution: a population is a "society" that builds in common the solution that is search for, but on the contrary to co-evolution, the species are not specifically identified and separated. Of course the design of such algorithms becomes more complex than for a direct –standard– EA approach, and the diversity of the population is a crucial factor in the success of a Parisian approach. Moreover, splitting the problem into interconnected sub-problems is not always possible. However, when it is possible to do so, the benefit is great: a Parisian approach limits the computational waste that occurs in classical EA implementations, when at the end of the evolution, the whole final population is dumped except the best individual only. Experiences and theoretical developments have proved that the EA gains more information about its environment than the only knowledge of the position of the global optimum. The Parisian approach tries to use this important feature of EAs.

A Parisian EA may have all the usual components of an EA, plus the following additional ones:

- *two* fitness functions : a "global" one that is calculated on the whole population or on a major portion of it (after a clustering process or elimination of the very bad individuals, for example), and a "local" one for each individual, that measures how much this individual contributes to the global solution.
- a distribution process at each generation that shares the global fitness on the individuals that contributed to the solution,
- a diversity mechanism, in order to avoid degenerated solutions where all individuals are concentrated on the same area of the search space.

Developing a Parisian EA for interactive creative design tools is based on observation of the creative process. Creation cannot be reduced to an optimisation process: artists or creative people usually do not have precisely in mind what they are looking for. Their aim may fluctuate and they sometimes gradually build their work from an exploration. "User satisfaction" is a very peculiar quantity, very difficult to measure, and to embed in a fitness function. This is the reason why ArtiE-Fract has been equipped with a Parisian approach mode that can be activated at any time during the run of the system using a translation module between classical and Parisian populations.

2.3 Evolution of attractors of Iterated Function Systems

Another important aspect of ArtiE-Fract is the choice of the search space. As we have told before, a way to limit "user fatigue" is to reduce the size of the search space in order to navigate in a space of *a priori* interesting shapes. The choice made in ArtiE-Fract is the space of 2D fractal shapes encoded as iterated function systems (IFS). This gives access to a wide variety of shapes, that may appear more or less as "fractals."

ArtiE-Fract thus evolves a population of IFS attractor pictures, and displays it via an interface, see figure 1. More precisely, these IFS attractor pictures are encoded as sets of contractive non-linear 2D functions (affine and non-affine), defined either in cartesian or polar coordinates. A set of contractive functions represents an IFS, i.e. a dynamical system whose attractor can be represented as a 2D picture. These mathematical objects were considered as interesting as they allow to encode rather complex 2D shapes with a reduced number of parameters.

IFS were extensively studied in the framework of image and signal compression [11, 14, 23, 4], however all IFS models explored in fractal compression were based on affine sets of contractive functions.

From an artistic standpoint, affine IFS give access to an interesting variety of shapes (the "self-affine" fractals). But the use of non-affine functions, beside the scientific interest of exploring this rather unknown space, yields a variety of shapes that may look "less directly" fractal. This is another of the specifics of ArtiE-Fract: three models of IFS are used (affine, mixed and polar), separately or in combination. Each of them induces a slightly different topology on the search space, which gives privileged access to various image types.

Figures 1 and 2 present a set of images created by several users (non-necessarily artists !), that suggest biological images or vegetation, as well as some very "geometric" ones.

This additional freedom, based on the use of non-linear functions seems to be experimentally attractive to artists, as it allows the expression of various inspirations.

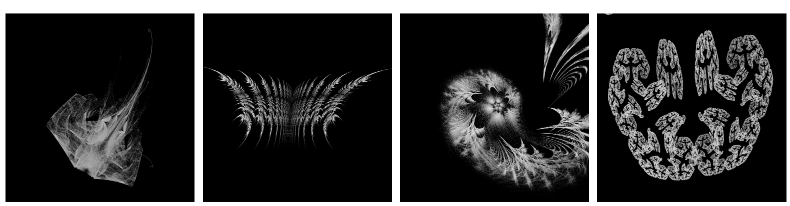

Fig. 2. Sample images obtained with ArtiE-Fract

3 Example of an artistic process: how Emmanuel Cayla uses ArtiE-Fract

Emmanuel Cayla's first approach to ArtiE-Fract is precisely this flexible access to fractals. Actually the artist advocates that a new intimacy is built between mathematics and painting as it happened during the "Renaissance" with geometry, proportion and perspective. This new relationship doesn't imply only fractals but those are certainly meant to play a key role in this reunion.

To start his exploration of the fractals' universe on the ArtiE-Fract software, the painter first decided to set the graphical parameters of a set functions and to stick with those. He had indeed the feeling that it is too difficult to properly browse such a search domain without defining a static reference framework. The first of these decisions was to put colours aside and to work only with black ink on a white background. The second parameter had to do with noise, also known as "grain" or "distorsion" whose level was uniquely set over the whole initial population.

Indeed, the "noisify" operator of ArtiE-Fract, is an important component of this artistic approach. This operator adds a random noise to the value returned by the function during the drawing of the attractor image, see figure 3. This is an important factor of visibility of scattered attractors, as it conditions the thickness of the simulated "paintbrush."

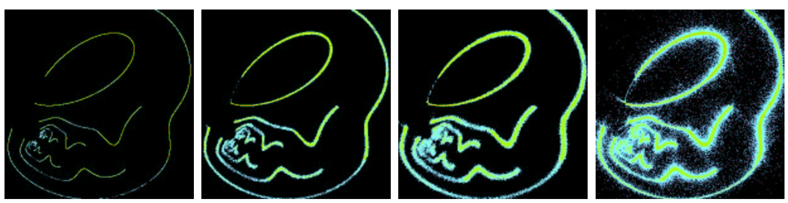

Fig. 3. Original IFS and 3 mutated IFS with various noise levels.

With these two settings, the painter produced the first generations of images having approximately (as it is however produced by a random process, even if it is strongly limited in this particular case) the desired characteristics.

The third of these *a priori* constraints parameters is the image format, in other words the graphical proportion and size of the generated images. For the moment, the default setting (square images) has been used. This point has however been considered as a limitation by the artist, and has to be considered in future evolutions of the software.

Experience shows that extraction of individuals that are interesting from the pictural standpoint is indeed a directed process. All the individuals that are acknowledged as "picturally effective" by the artist, i.e. all the individuals he identifies as matching his artistic visions, are the outcome of a process based on selection and gradual construction. Selection of individuals during the successive generations is a bit more sophisticated of a process than a simple "good"/"bad" categorisation. The painter is familiar with images and the criteria used for conservation and "reproduction" of individuals in the creation process of ArtiE-Fract are going to be based on observations such as : "This individual is interesting for the feeling of movement it produces, I will mate it with that one whose use of blacks and blurs is appealing; I will also add this other one, it is a bit less interesting but the other two could greatly benefit from the way it plays with lines..." As one can see, the artist indeed plays the role of constructor. ArtiE-Fract might bring a great deal of randomness in the process but painters have always worked with randomness and taken advantage of "artistically interesting incidents."

Another interesting aspect is the tuning of the various "usual" genetic parameters, for instance, population size. It appeared pointless for the painter to work with generations rich of hundreds or thousands of individuals for the five following reasons:

- Computation time increases with the number of individuals.
- In any case the population will need sorting.
- Whatever happens, one will remain within the same family of shapes.
- There are enough individuals exhibiting originality, even in smaller sized populations.
- One is dealing with infinite spaces and may we work with 20, 40, 100 or 3000 individuals that we would only encompass an infinitely small space of possibilities with respect to the potential creativity of the system.

What the artist is looking for, before anything else, is expression, more precisely poetic expression. And with ArtiE-Fract, it works. This means that with this software, one is able to browse and discover meaningful shapes like those our mind enjoys flying over: lakes, mountains piercing the clouds, forgotten cities, trees taking over old walls, people standing on icebergs near the North Pole... And it is essentially here, although not only, that this approach of numeric arts moves us.

4 Conclusions and Future developments

Of course this fruitful collaboration has deeply influenced the design of many components of ArtiE-Fract, as an artist has sometimes a completely different viewpoint on the software tools.

For example, besides the specific way he selects and notates the images, strong control tools were considered as crucial. Direct interactions were thus designed[2], such as simply "killing" an individual and controlling the "reproduction-elimination" step of the evolutionary process. The artist also stressed on the fact that the visual evaluation of a picture is strongly dependent on the surrounding images and background, point that was neglected by the ArtiE-Fract developers so far.

[2] A "strongly controlled evolution mode" is now available in ArtiE-Fract.

Fig. 4. Dancing woman *(Danseuse)* – Emmanuel Cayla

Another point has to do with the creation of repetitive sequences such as borders: The "modulo," "mirror" and "symmetries" effects have been for instance programmed to produce shapes that can be continuously juxtaposed.

Until now, Emmanuel Cayla based his work mainly on the "global evolution" tools of ArtiE-Fract, i.e. the Parisian evolution modes were used only as harsh exploration tools, to open new research directions at some stages, when the population becomes too uniform, for instance. He however produced unexpected shapes, in comparison to what was produced before by inexperienced designers. His use of black and white was also noticeable, see figures 4 to 9. It stressed on the importance of predefined simple evolution modes:

– that concentrate the search on some specific aspects of the design, such as "evolution of color only," "evolution of shape only,"
– that tune the degree of randomness in the evolution process, like "strong control" or "weak control."

Natural follow-ups to this project include working with colours, new operators, and getting together with the world of applied fine arts (e.g. decorated ceramics or fabric along with a lot of other potential opportunities for original applications of the system). This will demand new specifications for new functionalities in ArtiE-Fract. These improvements will focus on structure properties and design of the shapes where fractals grow as well as on composition of colour palettes and their expression in the system. And finally, as Emmanuel Cayla says, "ArtiE-Fract is a tool that should help us come up with new shapes in the world of artistic drawing."

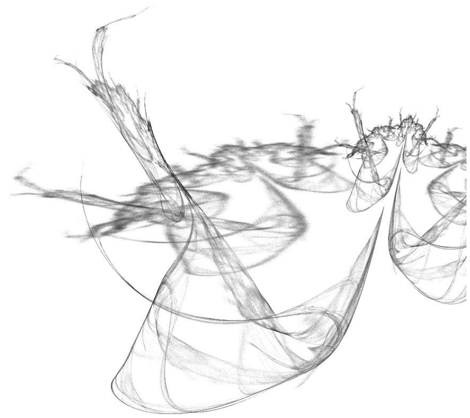

Fig. 5. SWIMMING FOSSILS *(Fossiles nageant)* – Emmanuel Cayla

Acknowledgments The authors would like to thank Yann Semet for his kind help during the writing of this paper.

References

1. P. J. Angeline, "Evolving Fractal Movies", *GP 1996: Proceedings of the First Annual Conference*, John R. Koza and David E. Goldberg and David B. Fogel and Rick L. Riolo (Eds), pp 503–511, 1996.
2. W. Banzhaf, "Interactive Evolution", *Handbook of Evolutionary Computation*, 1997, Oxford Univ. Press.
3. M. F. Barnsley, "Fractals Everywhere," *Academic Press*, New-York, 1988.
4. M. F. Barnsley and S. Demko, "Iterated Functions System and the Global Construction of Fractals," *Proceedings of the Royal Society*, A 399:243–245, 1985.
5. E. Cayla, "Tapis-bulles 1," prototype d'une approche multi-agents des formes et des couleurs, 3èmes journees francophones sur l'IA distribuees et les systemes multi-agents. Chambéry 1995
6. E. Cayla, "L'atelier des tapis-bulles', interprétation et "compression" des poèmes graphiques", Journees d'etudes et d'echanges "Nouvelles techniques pour la compression et la représentation des signaux audiovisuels", CNET-CCETT, Cesson-Sévigné, 1995
7. E. Cayla, "D'un logiciel de CAO aux variations Goldberg de Bach", Le micro bulletin, CNRS n53, pp. 162-182, 1994 (Communication produite aux entretiens du Centre Jacques Cartier, Montréal 1992)
8. J. Chapuis and E. Lutton, "ArtiE-Fract: Interactive Evolution of Fractals", 4th International Conference on Generative Art, Milano, Italy, December 12-14, 2001.

Fig. 6. HARSH HORIZON *(Horizon violent)* – Emmanuel Cayla

9. P. Collet, E. Lutton, F. Raynal, and M. Schoenauer, "Individual GP: an Alternative Viewpoint for the Resolution of Complex Problems," GECCO 99, *Genetic and Evolutionary Computation Conference*, Orlando, Florida, USA, July 13-17, 1999.
10. P. Collet, E. Lutton, F. Raynal, M. Schoenauer, "Polar IFS + Parisian Genetic Programming = Efficient IFS Inverse Problem Solving", *Genetic Programming and Evolvable Machines Journal*, Volume 1, Issue 4, pp. 339-361, October 2000.
11. B. Forte, F. Mendivil and E.R. Vrscay, 'Chaos Games' for Iterated Function Systems with Grey Level Maps, SIAM Journal of Mathematical Analysis, vol 29, No 4, pp 878-890, 1998. http://citeseer.nj.nec.com/146020.html
12. D. A. Goldberg, "Genetic Algorithms in Search, optimisation, and Machine Learning," *Addison-Wesley Publishing Company, inc.*, Reading, MA, January 1989.
13. J. Hutchinson, "Fractals and Self-Similarity," *Indiana University Journal of Mathematics*, 30:713–747, 1981.
14. A.E. Jacquin, "Fractal Image Coding: a Review," *Proc. of the IEEE*, 81(10), 1993.
15. S. Kamohara, H. Takagi and T. Takeda, "Control Rule Acquisition for an Arm Wrestling Robot", in IEEE Int. Conf. on System, Man and Cybernetics (SMC'97), vol 5, Orlando, FL, USA, 1997.
16. J. Lévy Véhel, F. Paycha and J.-M. Rocchisani Multifractal Measurements of Lung Diseases In First International Conference on Fractals in Biology and Medicine, 1993.
17. E. Lutton, J. Lévy Véhel, G. Cretin, P. Glevarec, and C. Roll, "Mixed IFS: resolution of the inverse problem using genetic programming," *Complex Systems*, 9:375–398, 1995.
18. P. Machado, A. Cardoso, All the truth about NEvAr. Applied Intelligence, Special issue on Creative Systems, Bentley, P. Corne, D. (eds), Vol. 16, Nr. 2, pp. 101-119, Kluwer Academic Publishers, 2002.
19. N. Monmarche, G. Nocent, G. Venturini, and P. Santini. "On Generating HTML Style Sheets with an Interactive Genetic Algorithm Based on Gene Frequencies",

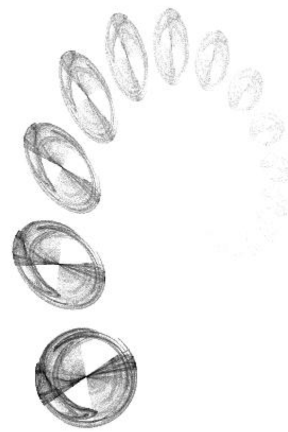

Fig. 7. FUNNY CIRCLES *(Drôles de cercles)* – Emmanuel Cayla

AE 99, Dunkerque, France, November 1999, Selected papers, Springer Verlag, LNCS 1829, 1999.

20. R. Poli and S. Cagnoni, "Genetic Programming with User-Driven Selection : Experiments on the Evolution of Algorithms for Image Enhancement", in 2nd Annual Conf. on GP, pp 269-277, 1997.
21. S. Rooke, "The Evolutionary Art of Steven Rooke" http://www.azstarnet.com/~srooke/
22. F. Raynal, E. Lutton, P. Collet, "Manipulation of Non-Linear IFS Attractors Using Genetic Programming" CEC99, *Congress on Evolutionary Computation*, Washington DC, USA, July 6-9, 1999.
23. D. Saupe and R. Hamzaoui, A bibliography for fractal image compression. Institut fr Informatik, Universitt Freiburg, Germany. 1996. Available as ftp://www.informatik.uni-freiburg.de/documents/papers/fractal/biblio.ps.gz.
24. K. Sims, "Artificial Evolution for Computer Graphics," *Computer Graphics*, 25(4):319–328, July 1991.
25. H. Takagi, M. Ohsaki, "IEC-based Hearing Aids Fitting", IEEE Int. Conf. on System, Man and Cybernetics (SMC'99), Tokyo, Japan, vol 3, pp 657-662, Oct. 12-15, 1999.
26. H. Takagi, " Interactive Evolutionary Computation : System Optimisation Based on Human Subjective Evaluation", IEEE Int. Conf. on Intelligent Engineering Systems (INES'98), Vienna, Austria, pp 1-6, Sept 17-19, 1998.
27. S.J.P. Todd and W. Latham, Evolutionary Art and Computers, Academic Press, 1992.
28. Some related web sites: http://www.genarts.com/karl
http://www.cosy.sbg.ac.at/rec/ifs/
http://www.accad.ohio-state.edu/~mlewis/AED/Faces/
http://draves.org/flame/

Fig. 8. Fox *(Renard)* – Emmanuel Cayla

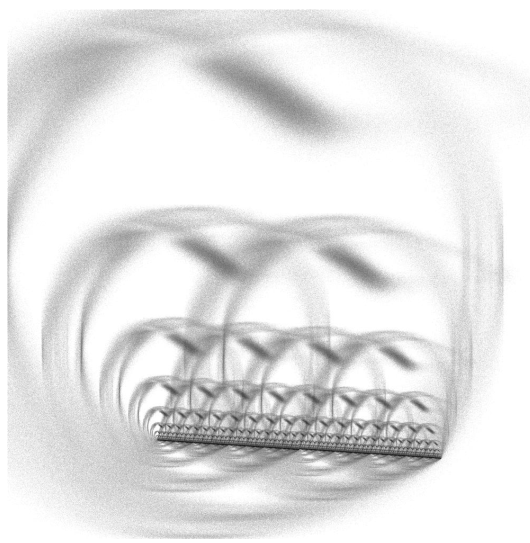

Fig. 9. Water wheel *(Roue d'eau)* – Emmanuel Cayla