EVOLUTION AS ART FOR INTERSTELLAR SPACES

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Introduction

At the beginning I was surprised from the invitation of SETI to think about the realization of interstellar messages based on artistic content. "How can do, the extraterrestrial to interpret a human artwork ?". Going a little ahead on this topic I reflected about the apparent easy communication between human beings: this possibility is grounded over a very wide language of signs, symbols and common concepts. This symbology is not only of cultural origin but it is strongly related to the physiology of our body, from the sensors up to our cerebral structures. In example, two-dimensional symbols or acoustical icons or gestures are strictly built on the base of the body developed by the humans during their evolution.

Under this point of view, also the transmission of simple photo of the real world could induce many difficulties of interpretation for beings not equipped with plain view sensors (eyes). Moreover, the content of the picture is interpreted in relation to our experience in collecting solid models, colors and dynamic models from our reality. Without these experiences, we would not be able to interpret flat real images [1]. On the base of these difficulties it is clear that the building of interstellar messages it is a very hard task that requires the construction of a general code and eventually a general language. As a *main* street the basic idea involved in the proposal exposed in this paper is reduce as much is possible the dimensionality of message both in terms of content either in terms of format. The first consequence of the *dimensionality reduction* is related to the approach to illustrate the image content. Using flat images as a media, a first rule could be to avoid to describe a three-dimensional content or include symbols in the image. These features requires pre-learned solid modeling or an a-priori symbol meaning.

Considering this fundamental need, the use of artistic language it is very meaningful for various reasons: to manifest an *opening to the communication* and to build the first piece of an *interstellar code*. Such code will grow through many modifications and revolutions, but the objective of the first series of messages should be the transmission of the starting seed. This is exactly the objective of the project introduced in this paper: transmit a *conceptual center* around to which a general code could be constructed in the future. As explained in the following, the view angle is the building of an artistic shape embodying an evolutionary symbology.

1. Searching for cultural invariants of terrestrial and extraterrestrial civilizations

A conceptual center for an interstellar code would represent a cluster of concepts how much recognizable is possible, independently from the evolutionary path. This invariance should be intended not only in the cultural domain, but also in terms of whichever physical structure of the beings we are trying to communicate.

One of the concepts that better are focalized in this *common area,* it is the concept itself of *evolution*. Any civilization that have the technology to receive our messages, reasonably it has reached such level through an evolutionary path and it has consciousness of such a path. Furthermore, to place the evolution context at the starting center of an interstellar code introduces remarkable advantages for the subsequent construction of the communication language.

In particular, one of the most important reason is that the concept of evolution introduces the *arrow of the time*. This can be considered the unique universally recognizable context for the concept of time: an *evolutionary time*, not necessarily linear, is surely present in the culture of any civilization. Over this base it will be possible introduce concepts like *past* and *present* and symbols that we use to represent the various levels of the organization of the matter and organisms. Grounding over a timeline could be simple locate inorganic forms at the begin and humans at the end.

2. The artistic language

Using a scientific approach it would be very difficult to describe evolution without a base of common symbolic language. In the scientific language, the symbols are built to be unique, unequivocal, modular and analytical. In order to avoid communication errors, the scientific symbol must represent an unique meaning, avoid ambiguity, represent a concept with maximum clarity. Such language is not the best to build a first description of the evolution because it requires many human symbols in order to explain the evolutionary mechanisms. It should be more useful for the code construction when some basic symbols are established.

The artistic approach is different. The scope is not an unique identification of the meaning, but in general, a richness of meanings and multiple readings of the art piece. In place of the concepts there are *evocations* and *metaphors*. The margin of ambiguity plays a fundamental role in order to introduce a dialectics in the message and in the observer who receives the message. An artistic work generally represents a body of meanings and emotions that are related to the *interference* between author and observer. Probably, many primitive cultures have grounded the origins of the own symbolic constructions over artistic expressions. Finally, the artistic description of the evolution could be entrusted to a single image that embodies multiple evolution paradigms. Such approach is an important chance in order to open the exchange and to constitute the seed of the code.

The representation of the evolution in a single image is quite hard task. To focalize the problem I selected some specific features of the image listed in the following.

- To render the a*rrow of time* through transitions from *simple* to *complex*, from inorganic to organic, form chaos to structure.
- To clearly embody the temporal variations in the image and let emerge the own history.
- To enhance the relation between space and time, and between the structures created from past and recent evolutionary lines (self-costraining).
- To require any other explanation that are not already deductible studying the image itself : avoid symbols, three-dimensional modeling, any form of a-priori knowledge like typical terrestrial shapes we are use to manage.

3. The format of interstellar signal

The format of the signal used to send such image through radio wavers or laser pulse in interstellar space, is once again a difficult topic to face. An effort to simplify the image is necessary in order to generalize the message. The codification of the color introduces many difficulties. Typically our formats reflect our physiological structure (color receptors) or the devices where the image is targeted like printing or display. A *gray levels image* could be a good solution to avoid these problems, but the use of a specific number of gray levels (resolution in bits) it could complicate the message. The concept of *numerical base*, like in example the *byte* composed by 8 binary *bits*, is once again a not general concept. The best way is the representation of the image in the binary format 0-1. This codification does not imply a specific choice for the numerical format.

The second step to complete the format, is to define the criterion to organize the image bits in a mono-dimensional signal for the transmission devices. Conventionally we are used to codify the images in horizontal lines from left towards right. Some format starts from the bottom left corner, other ones from the upper left corner. These formats reflects a cultural attitude tied to the writing style. Moreover this style is not homogeneous everywhere, like in the Oriental writing. Therefore we need another effort to generalize the format.

Another limit is that two-dimensional images are optimal for beings having a set of plain sensors like our eyes. Representation depends by sensor typology. A being with spherical sensors, like acoustic or proximity sensors, could find more convenient to use temporal-spectral representation like musical notes or echoes diagram. To overpass these difficulties, once again, the way is to *reduce the dimensionality* of the message.

The proposal explained in the following, tries to build the image in such a way that every *line* of the image is a metaphorical representation of the same temporal period. In evolutionary terms this means the same historical époque. All the *pixels* of a line refer to the same block of data and represent an homogeneous content in the time. In some sense, the reading of this image is a sort of *unrolling the carpet of the evolution*. See in fig. 1 a scheme to illustrate the format.

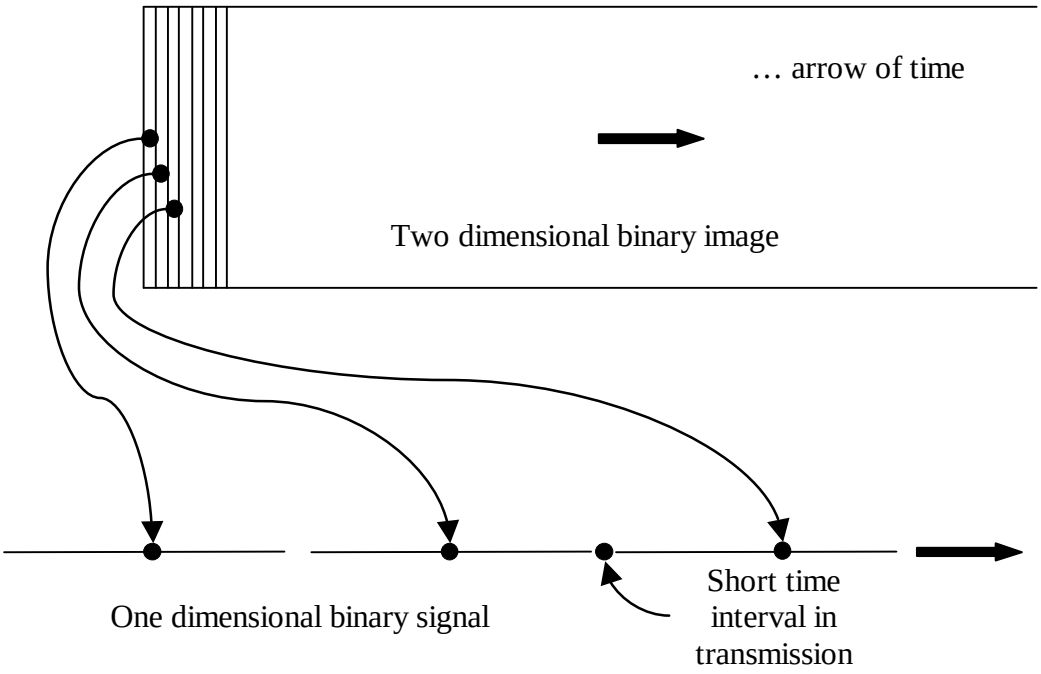

Fig. 1: codification of the image and of the signal

The only difficulty to interpret this image is to understand the module of the line, that is how many *cells of information* (pixels) are used to compose a line. In order to simplify the understanding of this data it is possible to insert a constant line at the beginning of the image and use a temporal interval in the transmission between two consecutive lines (see fig. 1).

In order to have a good rendering of the *evolution carpet* we need a large resolution both in the line side (about 500-1000 pixels per line) either in the time resolution (about 50000-100000 pixels). This numbers are based on a personal experience in the realization of very long image using a procedure explained in the next paragraph. In fig. 2 an example of this kind of images is presented (*Infolife IV*, 6000x30000 pixels). The image of fig. 2 is not built for the scope of this paper but it gives an idea of the format where the evolution time run from the left to the right side.

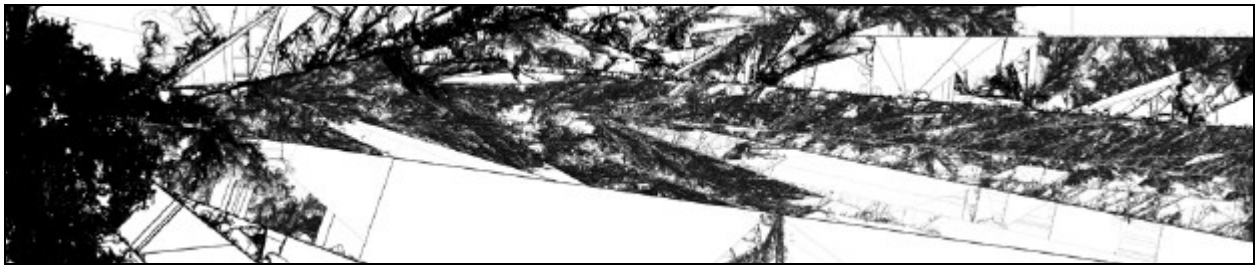

Fig. 2: *Infolife* (2001): the evolution time runs from left to the right side

One problem to check is to verify the possibility to send this kind of binary images embodied in interstellar messages: considering 1 bit per pixel, the size of the binary image can range from 3 to 12 Mb.

3. A project for interstellar images

A series of *graphical studies* of these images have been carried out on the base of the approach illustrated in the previous paragraphs. The studies are inspired to a procedure of generation of graphical images utilized to realize a collection of images named *Artificial Societies* [2][3][4] and adapted to the scope of the present project.

These experiments refer to the attempt to reproduce in graphical images, the aesthetic fascination of two concepts of base: *evolution* and *self-organization* [5][6], on the base of a simple mechanism of generation that use techniques of *simulated evolution* in the context of *artificial life* [7] environments.

3.1 The *Artificial Societies* approach in the image construction

The artificial life (*alife*) environment is a two-dimensional space initially empty. At the beginning, few individuals are let in the space and they begin to reproduce and develop a population. An individual is a filament which at the beginning is composed by a single cell. At each evolution cycle, the filament grows according to several possible models. All the parameters for the dynamics and reproduction are recorded in a genetic map which is defined at the individual birth and it remains constant during the individual life. The growing model is the composition of a deterministic component and a random component. The reciprocal importance of the two components is regulated by a parameter in the genetic map.

The model of the deterministic component has a large importance to determine the *emotion* given from the image and it is one of the main point to identify the *organic feeling*. The model *unforeseeabl*e is related to a growing with an homogeneous probability in direction changes. For the character *constant*, a higher probability is associated to a pre-fixed curvature in direction changes. The *evolutionary* character is related to a growing with a curvature evolving along the time. The *character* establishes an emotive relation between the genetic characteristics and the graphic patterns. The straight lines lets imagine a inorganic matter or a human artifacts. Lines with a constant bending evoke a natural form, while the chaotic variability of the paths is a symptom of organic forms. Another symptom of organic life appear for lines changing progressively its features or curvature inducing the idea of a slow evolution.

One single individual can generate a child -a branch- with similar genetic map but with a smaller line thickness. This position is established to evoke the plant growth: the *branch-child* are thinner of the parent. The child starts to grow from the head of the parent. The reproduction rate is regulated by a reproduction probability.

The collective development during the image construction, constitutes a coherent pattern with characteristics descending from the local chaotic interaction and features of the population of elements. Changing the parameters of the process, the set up generates very different patterns, remembering the growth of populations (plants, animals, neural networks), landscapes (rivers, fractures, mountains, cultivated fields), human artifacts (chips, glass fragments, architectures) visions (anthropomorphous shapes, animals) or simply emotional attitudes. All these shapes are characterized by a completely different distribution in the space and by different fractal dimensions.

3.2 Studies for an interstellar message

In this paragraph I tried to present some examples to illustrate how is possible an implicit rendering of concepts related to the evolution. These concepts could be selected and utilized to produce some *interstellar images*. The concepts I has selected are:

- The inorganic-organic transition
- The development of different evolution lines and biodiversity
- The self constraining organization
- The development of complexity and edge of chaos
- Emergent selection, cooperation and altruism

The inorganic-organic transition

This transition is the most difficult to render but it is one of the most important. In fig. 3 a study for an inorganic-organic transition is presented. In the right part, the lines appear as a coherent crystal-like tissue. The central line progressively evolves in a curvature creating *germs of life*. This evocation is probably induced by circles and spirals and especially by curves with a curvature variable in a narrow range in an unpredictable way. Still the little eye-lashed circles give an idea of reproduction. The figure in the left bottom part can recall a mother attitude defending his offspring.

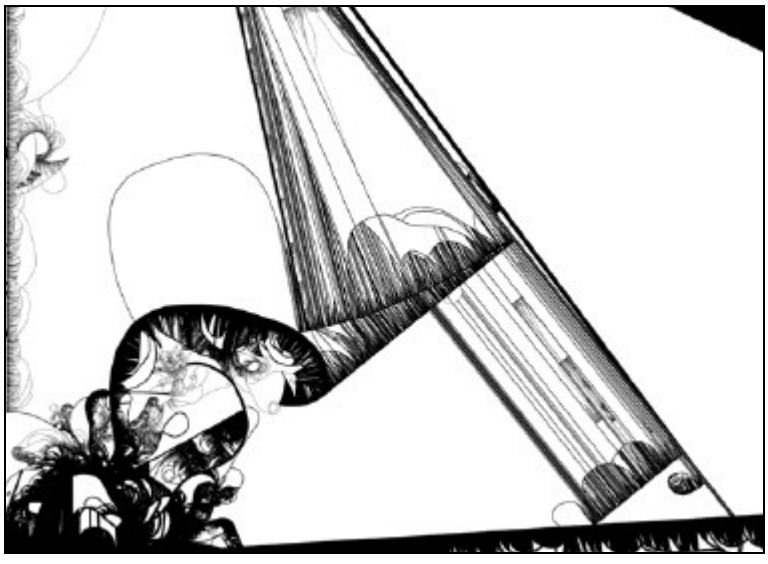

fig. 3: A Study for the inorganic-organic transition

In the final project the idea is to build a very long image where the *organic feeling* is progressively developed starting from the left side of the image. This means that is necessary to develop an environment able to induce this kind of *genetic evolution* trough the evolution of the growing modeling.

Development of different evolution lines and biodiversity

The evolution is not a continuous improvement of a single specie but the creation of many different species in reciprocal influence (ecosystems). Furthermore this process is not continuous but the transformation proceeds through bifurcations, biodiversity explosions and contractions, periods with no apparent modifications. Fig. 4 illustrates an attempt to illustrate this concept. The figure reports a detail of a larger image (*The Garden*) very interesting in this sense. Several groups of individuals with different features are emerged in the same image. These local group are characterized by similar behavior and unexpected bifurcations in different evolutionary lines. Graphically this appears as the development of different patterns in the image.

Fig. 4: Detail from *The Garden*. Different evolution lines are developed in the same evolution.

The self-costraining organization

The environment for a biological specie is continuously changing also for effect of the development of the specie itself and the other coevolving species. This aspect introduces a *self-constraining* organization which characterizes the interrelation between the several evolution lines emerged during the evolution. This interrelation is developed mixing influences based on temporal contiguity, like genetic inheritance, and spatial contiguity, like the competition between two species for the local resources. The self-constraining organization is very general and it can be applied also in the cultural domain: great geniuses open the way in the unexplored cultural space but they also act as containment for the next generations when that space is fully explored. New ideas are necessary and the old constructions can appear as barriers for the new developments.

In the *artificial societies* images, this aspect is reflected directly in the generation criteria. The position to obtain this effect is that a individual stops its growing (dies) when it clashes against the trail of another individual (*clashing rule*). The consequence of this rule is a particular modality of colonization of the life space. Some dominant filaments act like *pioneers* when explore a zone of space which is empty. During this colonization they create strong divisions in the space. Due to the fragmentation of the space (*islands*), the subsequent colonization develop local communities of

individuals (*micro-societies*) and evolution niches. The fig. 5 illustrates this process starting from the left to the right side where a typical cell-like structure is generated.

fig. 5: Self-constraining organization and development of structures

For a initial error in the software development, very few individuals escaped to the clashing rule. Analyzing this error I discovered this was due to an exception rising for a specific angle of clash. Due this error, sometime an individual is able to escape from the previous containment. When this error occurs, the escaped individual transports its genetic feature in another spatial niche founding another local colony with different features (see fig. 5). I prefer don't cut off this error because allow an interesting metaphor for the birth of a new genius (or a new genetic bifurcation) able to break the previous scheme.

The development of complexity and edge of chaos

The combination of these mechanism in the algorithm, produces a very interesting effect in the image during the evolution continuously creating complexity and structure. In this sense, these images are interesting because they illustrate a process of development of a complex organization. This organization is very different from order or chaos; it is something in the middle which clearly appears in the graphics.

fig. 6: *The edge of chaos:* creativity in the evolution

Furthermore another classical concept of the complexity paradigm is embodied in this transition: the *edge of chaos*. In these images, the edge of chaos is the point where the density of bifurcations is very high and the process is at maximum level of creativity. It is one of the most interesting zone where impressive shapes are created. Fig. 6 reproduces a detail of the central zone of image of fig. 5. This zone is surely the most rich in term of birth of *organic forms*.

Emergent selection, cooperation and altruism

One of the most interesting aspects of the evolution is the spontaneous development of cooperation and altruism as evolutionary consequences of the evolution mechanisms. It could be very important to transmit this content to an extraterrestrial civilization in order to create conditions for a reciprocal communication. Unfortunately this concept is really difficult to express in one image without use symbols of the human language or natural images of the earth.

An indirect way is expressed in the *Artificial Societies* images. They are based on *emergent selection*: there is any pre-programmed criteria to select the survival filaments and the only death rule is the *clashing rule*. This feature allows a strong dynamics in the development of variation in the phenotypes during the evolution. These variations are also pushed by a continuously variable evolutionary pressure due to the continuous decreasing of the free space.

At the beginning, smooth curvatures are self-selected due to the higher average life they are able to reach. This gives more chance to create a large offspring. During the evolution the micro-societies characterized by straight lines are filtered out because of they are not able to bypass obstacles. These societies have high coherence but low biodiversity and therefore low flexibility. Too much chaotic micro-societies, characterized by continuous changes in the curvature, are filtered out because of the individuals clash each other: too much internal fights and chaos. In the final part of the evolution, the available space is reduced, and the most suitable phenotypes are micro-societies with short paths, high reproduction rate and medium irrationality. This kind of societies are able to diffuse in every available space. In fig. 7 an example is reported where colors are used to better illustrate the evolution of four different lignage. In the right side it is possible to note the high density zone on the corners of the image corresponding to the last phase of the evolution.

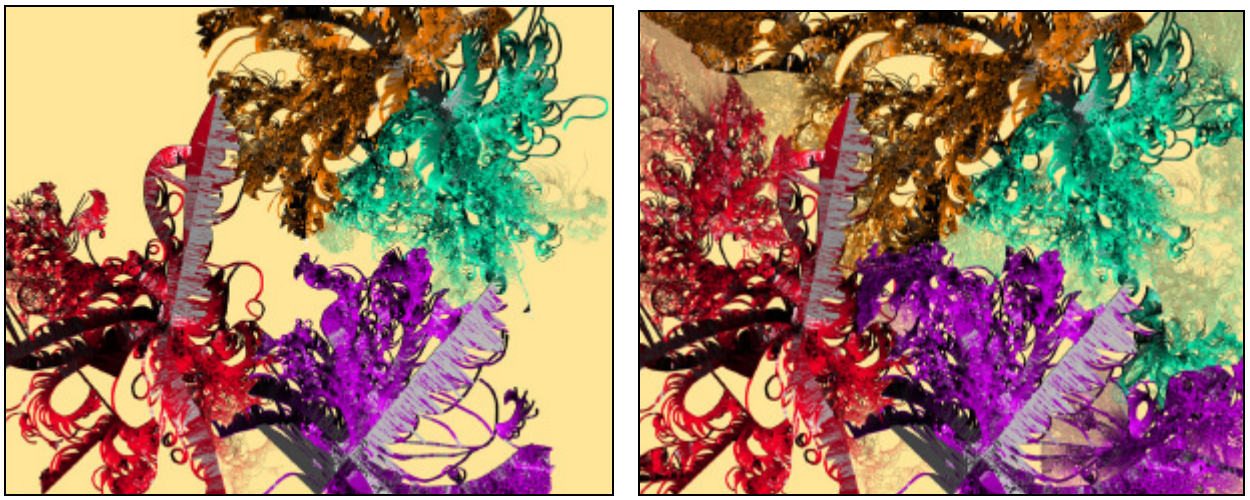

Fig. 7: The emergence of cooperation in the evolution

The interpretation of this graphical development could be very curios. The evolution promotes that groups which are more able to colonize the space. The winning groups are characterized by a cooperative behavior and the social power is obtained at expenses of the single individual which is characterized by a very short life. There are several ways to explain the emergence of this cooperation. One is based on a selection acting at group level (*group selection*), another could be based on the role played by the self-organization in evolution. The self-organization could promote an individual which is functional to the self-sustaining of the ecosystem. In this sense a short life individual could be not the best adapt to survive but it is the best choice to sustain that king of surviving society. The discussion about these two theses is out of the target of this paper, but what is important here is that these images can stimulate such kind of debate and dialectics in the observer. This is the real goal of multiple meanings interstellar images.

Conclusions

This paper reports one of thousands possible ways to elaborate an interstellar message based on a art-science approach. A question arises from this proposal. Let me suppose I receive a similar message from somewhere in the cosmos: " what I can think about the civilization sending these images ? ".

I tried to give myself an answer. "They use computers to simulate evolution mechanisms; it is not clear how much they know about life, cosmos and evolution; maybe they can say us few things, maybe a lot; but they have sensibility and interest for the life. It could be a good start for communicate". But this answer is only the though of a human.

References

1. Hoffman, D. D.," Visual intelligence: How we create what we see", New York: Norton. (1998).
2. M. Annunziato, "The Nagual Experiment," in *Proceedings of the First International Conference on Generative Art*,Milan, Italy, 1998, C. Soddu Ed., Editrice Librerire Dedalo, Milan 1998.
3. M. Annunziato, "Emerging Structures in Artificial Societies," in *Creative Application Lab CD-ROM* (Los Angeles: SIGGRAPH, 1999). On artificial societies, see also <http://www.plancton.com>.
4. Annunziato, M., Pierucci, P.: Relazioni Emergenti. Experimenting with Art of Emergence, Leonardo, Volume 35, Issue 2 (April 2002).
5. Prigogine, I. Stengers, " Order out of Chaos", Bantam, New York, 1984.
6. S.A. Kauffman, "The Origins of Order: Self-Organization and Selection in Evolution", Oxford, U.K. Oxford Univ. Press, 1993.
7. C. Langton, " Artificial Life, An Overview, C. Langton, ed. The MIT Press, Cambridge, Massachussets.