Towards Artificial Societies

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Abstract

The progress in the scientific understanding/simulation of the natural evolution mechanisms and the first technological realizations, intelligent toys, self reproducing machines, smart information retrieval agents on the web, are creating the base of a "new step in evolution": the coming of the *artificial beings* and *artificial societies*. Although this could seem a visionary hypothesis drawn by technological advances, in our opinion it raises interesting questions: are those true life forms, is this true life evolution? As a matter of fact, a new cultural paradigm inherited from the theories of evolution and complexity is already growing: culture itself, aesthetics and intelligence are seen as emergent self-organizing qualities of a collectivity, evolved along time through both genetic and language evolution. For these reasons artificial life is going to be an anticipatory and incredibly creative area for the artistic expression and imagination. In this paper we try to correlate some elements of research in the fields of artificial life, art and technology, in order to sketch the development of hybrid digital worlds, where the artificial beings are able to evolve their own culture, language and aesthetics, and are able to interact with natural beings. Finally we report our experience on an interactive audio-visual art installation, based on two connected hybrid virtual worlds based on artificial life environments. In these worlds, the digital beings can interact, reproduce and evolve through the mechanisms of genetic mutations. People can interact with the artificial beings, creating an hybrid ecosystem and generating emergent shapes, colors, sound architectures and metaphors of imaginary societies.

1.Patterns of Convergence

Recent trends in information and communication technologies, reveal an impressive convergence among different research disciplines, AI (artificial intelligence), VR (virtual

reality) and AL (artificial life). More and more projects involving environments where real people can interact with artificial entities are realized. The concept of "*virtual reality*" is now merging in the wider concept of "*virtual world*", as conjunction of a virtual environment with artificial evolving creatures. In these projects, the efforts on the development of "*intelligent beings*" acting as "*autonomous agents*" in a "*virtual environment*", raise basic questions related to the current definition of terms as life, intelligence, evolution. This convergence is stimulating a completely new approach in the definition of current virtual worlds architectures. In the more advanced applications it can even produce a paradigm shift. The *man-machine interface* is shifting into *hybrid ecosystem.* The *environment* is no more a *static virtual set* of rules, and becomes a *dynamic environment,* co-evolving under the action of the living agents. Interaction and dynamics in such worlds cannot be based on an action-reaction list of correspondences, but should be based on an open evolution, where genetics and self-organization allows the survival of the overall system. Recently an impressive collection of progresses have been made in the field of reproduction of the autonomous behavior, particularly in the field of the artificial life. The historical dream of Von Neuman [VON66] of self-reproducing machines seems today more at hand: new advances showed simulated machines able to develop an increase in complexity at each self-reproduction stage (see the "Langton loop" [LAN84]). The first attempts on self-reproducing machines succeded recently [LIP00]. From the technology point of view, the well known tamagochi, a very low technology game, had an enormous success just for a smart emulation of some simple life functions. The Aibo toy-robot of Sony [KUS00] is probably the first (commercial) one of a long series of toys which learn playing and develop an autonomous behavior. Current experimentation on robots developing a communication language [KAP00], will probably give some more answers on the possibility that artificial beings could develop "*culture*". An interesting more dimension has been shown by the use of the evolution of *artificial societies* in order to develop the control strategy for complex industrial processes [ANB00]. The already mentioned basic questions raised by all these ideas, stimuli and advances, are answered today, in the world of artificial life thinkers, in two ways: the *weak alifers* (all is just a simulation of real life) and the *hard alifers (* these are realizations of a new and real life form). One the main support to these interpretation comes from the concept of *autopoiesis* of Maturana and Varela [MAT92] as a network of production processes where the function of each component is to participate to the production, or transformation, of other components on the network. In few words, living systems are characterized by the production/transformation

of "itself". In *alife* based systems, often it is really difficult to asses this property, and most of the time the concept of *evolvability* [LAN89] is used as a qualitative measure of a sort of *potential of life*.

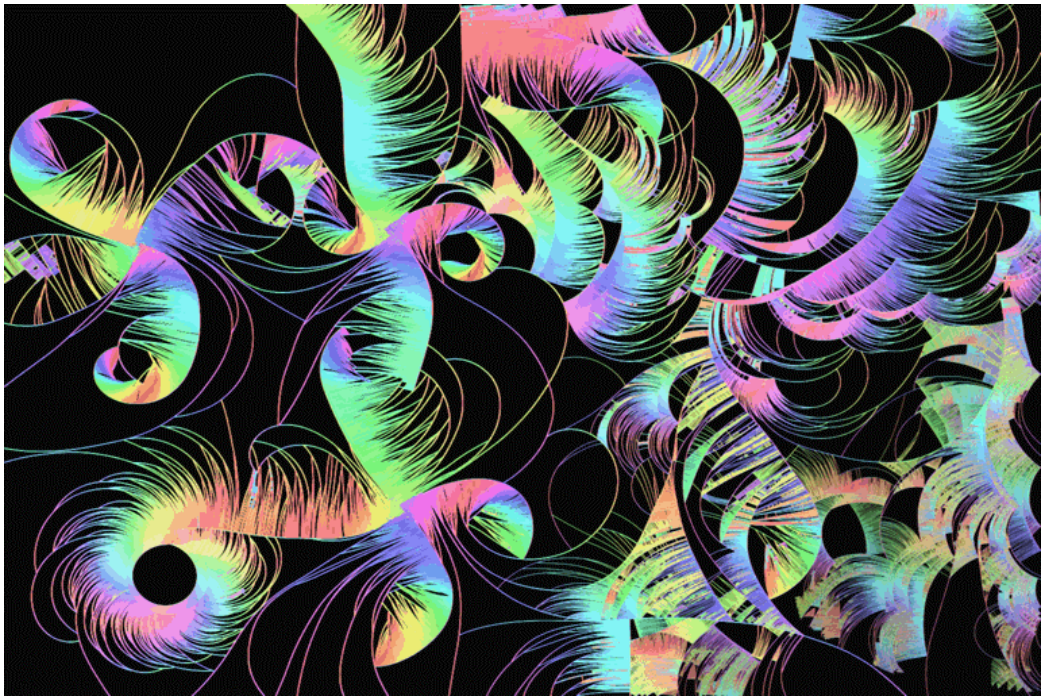

Fig 1: Volute. Generated from the alife interactive installation "Relazioni Emergenti".

2.Artificial Life and Art

This convergence of scientific and technological contexts, has been anticipated by the *complexity theories*, which gave the basic theoretical support for the re-unification of physical and social sciences. This is going to be a key interference area between science/technology and art. In the last few years, several artists started exploring the potential of artificial life concepts in artistic fields. The development of new languages and tools is transferring the visions of these artists (*artlifers)* into tangible objects (artworks, entertainment systems, games, technologies). One of the expressive dimensions is the idea of *evolution:* a progressively increase of aesthetics [SIM94], or a development of intelligence or emotionality [TOS96], or an adaptation to the environment [TER98]. Another theme is the development of complexity and the biodiversity [SOM97, ANN98]. In most of the cases, the suggestion is focalized on the evolution of one [TOS96] or few artificial individuals [RIN00], or on a restricted number of species [SOM98]. Other approaches are based on the dynamics of large

population (*artificial societies* [ANN99]). Also the *evolution time* is an important aspect in the alife art expression, i.e. the correspondence between the *evolution window* presented in the artwork with the "*true*" overall evolution time. A well developed individual [TER98] is often taken as an indicator of the evolution direction, and different artworks enhance the evolution dynamics perception, allowing to detect it in short times [ANN98]. One of the most interesting aspects is the relation between the artist, the observer and the artwork. The artwork is a generative context based on open simulators, and the interesting aspects appear as *emergent qualities* [KAW99, SOD00]. This has been referred as *art of emergence* in [AP99]. The relation between the creator and the artwork is going to be very *dynamic*, and the artwork seems to have his own personality. The creative process is a dialectical interference between the artist and the artwork in order to drive, improve, select or simply *open* the final result. Another element which can constitute a real challenge in the expressive play, is to open this relation to the people interaction. The interaction with single/few people [SOM98] or with the web community [RAY98,ANT99] can open the evolution to higher complexity. The interaction can transform the artist-artwork system in an *emergent relationship* among the artist, the *actors* and the artificial individuals. That means an *hybrid living ecosystem* where real people and artificial beings can start up new imaginary worlds.

Fig 2: Real-artificial interaction (from the alife interactive installation "Relazioni Emergenti").

3.Artificial Societies

By our point of view one of most important issues identified in these technological, scientific and artistic research is that intelligence of living beings is the a result of the collective accumulation of positive genetic and behavioral mutations and self-organization strategies, developed during a long evolution time. This concept, enounced by J. Monod [MON71], can be the base for an evolving artificial society. With a single powerful computer we can realize good alife simulations [EPS96, CAS97], but the boundary of this world is really too narrow to achieve a good degree of evolvability. The translation of these experiences on a network of computers can raise the possibility of development of an autonomous digital life. Some experiences in this sense are encouraging, as in the project Tierra [T. Ray, RAY98], where programs are able to reproduce itself and travel on a network searching for available computing power (cpu) and *life space.* Other interesting experiences are the development of *intelligent avatars*, digital creatures with little autonomy representing a real person, on the network. The practical application of these creatures in virtual shops, entertainment, publicity, is growing up very fast, and *party for avat*ars are already organized by the Biota group [BIO00]. The thesis is that we are at the birth of the first world wide artificial society. Maybe we have to wait several decades to achieve enough computational power, enough network space, enough degree of evolvability, but presently we are founding the bases of a new life dimension. Whether this is a new dimension for real beings, or the birth of a completely new specie (the digital one), is a matter of opinion. In the Monod anticipation [MON71], (see also the *punctuated equilibrium* theory of Kauffman [CAP96]) evolution proceeds through large steps. The most important steps are connected with the availability of new lands, new technology, new environmental conditions. One of the biggest known steps is often associated with moving of living beings from sea to earth. The development of language technology was another important step, allowing the bases of *cultural* development (the possibility of a collective memory). In this sense we identify the computers and the internet network both as new technology and new land available for a further step in evolution.

4.The Digital Plancton

The vision exposed in the previous paragraph is clearly a subjective imaginary projection of observed results in the cultural domain of today. We imagine our work of artists as explorers and founders of a *digital plancton* which, combined with efforts of many other people, will

contribute to this evolution. We started with an experiment, producing black-white images exposed the first time in '94 [Viterbo, Italy, ONOFF Gallery] and published in the first paper in '98 [ANN98] with autonomously growing filaments. This experiment was impressive for the possibility to show social dynamics like the development of cultural biodiversity, islanding, pioneers, unconscious cooperation, development of social classes stratification. Furthermore that images showed an incredible emulation of natural shapes. From this experience we understood that these kind of environments contain a massive potential for expression of the social/communication dynamics. In few words the artificial societies work as generators of *virtual metaphors* for the real world.

Fig 3: Solo. Generated from the alife interactive installation "Relazioni Emergenti".

This concept could be considered one of the key themes of Plancton artworks: exploring the artificial being and artificial societies as a digital mirror in which the human beings culture is reflected. Creativity, imagination, aesthetics, language can be extended/explored in artificial beings, built on the personal vision of the artist, and modified during the digital life evolution. In order to carry out this exploration there are is a fundamental problem to solve: how we can communicate with artificial beings ? Or better how humans and artificials can develop a creative inter-contamination? This is one of the central items of Plancton research, i.e. *interaction in an hybrid ecosystem*. Our effort is concentrated to experiment audiovisual interactive installations which explore the suggestions and visions aforementioned. In the

following we report an example of an artwork (*Relazioni Emergenti*) which represent today the state of the art of the Plancton research.

5.Emergent Relationships

Relazioni Emergenti (Emergent Relationships) is an life environment of artificial individuals endowed with own autonomy and character. They can interact, reproduce and evolve through the mechanisms of genetic mutations. The installation consists in one retro-projected screen which represents the artificial life environment. In front of the screen the observers can interact with the environment itself. A video-camera detects the positions of the observers which become zones of life germination. The observer can sees filaments growing from his location and interacting with that ones generated by other observers. Every filament is a bearer of a sound message sent to a sound synthesizer. The global result is a whole of parallel sonorities creating coherent sound architectures. The population evolves developing emerging behaviors rendered as continuously new shapes and graphical/acoustical patterns.

Fig 4: The real people give the life to the artificial ones. (from "Relazioni Emergenti").

5.1 The Alife Environment

The alife context 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 models of movement and to a rate of growing. All the parameters for the dynamics, reproduction and death are recorded in a genetic map which is defined at the individual birth and remain constant during the individual life. The movement is the composition of a deterministic component and a random component. The reciprocal importance of the two components is regulated by a parameter named *irrationality*. High values for this parameter cause a totally random movement; low values cause a totally deterministic movement. Different models defined *characters* have been developed for the deterministic component. The character *unforeseeabl*e is related to a movement 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 *evolutive* character is related to a movement 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 rational-analytic thought or an unexpressed creativity. Lines with a constant bending evoke a constant foreseeable behavior, while the chaotic variability of the paths is referred to the irrationality. A line changing progressively its features induces the idea of a slow evolution. Finally a global environment parameter, *freedom*, constitutes a constraint for the movement. A high environment freedom allows the individuals to follow their choices for the movement; a low value pushes the individuals to reduce the curvature of their movement. The velocity of the movement is affected by an environment parameter: the *energy*. High energy means the maximum probability to move at every cycle. In this context, energy is a feature of the environment and its value is different cell by cell changing during the evolution. In this sense, the energy is related to the survival probability. As explained in the following, this parameter is used for the interaction between the artificial individuals and the real people. The death of the individual can occur for accidental or natural reasons or for total reduction of the length. Furthermore, if the trail of an individual clashes against another individual, generally he dies. A very little probability of survival is allowed depending by the clash angle. The reproduction model is asexual. The offspring has a genetic map similar to that one of the father, except some mutations in the genetic parameters depending by the mutation rate. Through this mechanism, the population evolves and different phenotypes can be developed

in the same evolution. The reproduction is regulated by a reproduction probability and it can occur only if the number of living individual is less than a maximum number. This position causes a very strange behavior in the development of the society in the sense of not-homogeneous colonization of the space and development of a spatio-temporal complexity.

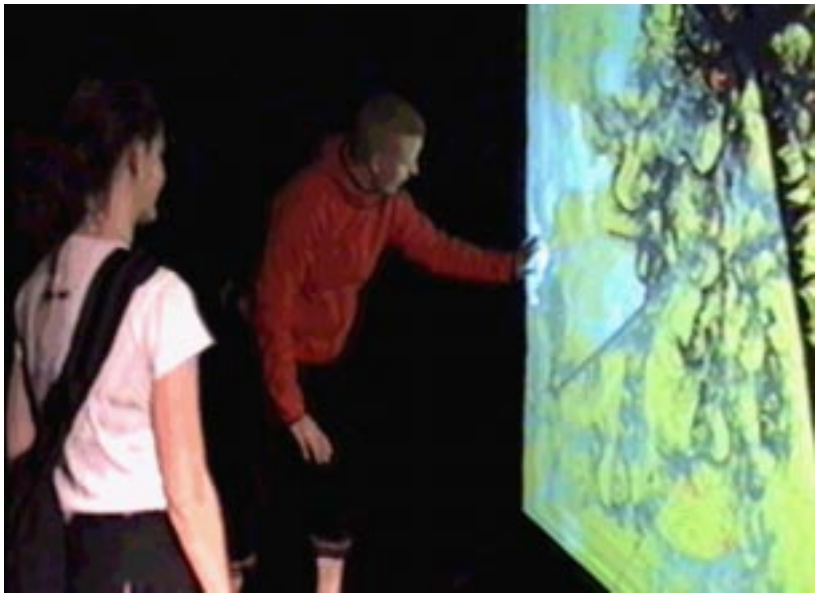

Fig 5: The real people give the life to the artificial ones. (from "Relazioni Emergenti").

5.2 Color and Sound Synergy

The images represented on the screen are the rendering of the 2D life space where the individuals move and live. In addition to the filament position, also the color is redefined every cycle. Every graphical variable (hue, saturation, value, width of the line) is connected with some specific features of the individual like: specie, character, irrationality, curvature, direction, position, age and level in the genealogical tree. The different combinations of the models allows an impressive variety of colors, tonalities and patterns. The global graphical result depend very much by the filament dynamics and society evolution. Some phenotypes are able to develop a very intense vibration of features in little space producing an impressionist style of color deposition. In other cases very smooth color shading are produced by phenotypes slowly evolving in large spirals. Every individual is bearer of a sound which changes at each evolution step. The best individuals of any species are selected on the base of a *fitness* indicator depending on the energy they catch from the interacting people. These individuals access to the sound channels playing their notes. Like the color modeling, the

sound characteristics of each individual are coded on the base of the individual genetic and environmental features. For each specie a different instrumental timbre is assigned. In addition, a dynamic relation is established on the base of different models corresponding to some standard musical modes and chords (Chromatic, Major, Minor Melodic, Minor Harmonic, Pentatonic Major, Pentatonic Minor, Blues, Major, 7th, 7th dominant, Diminished, etc...). Changing the musical mode, the global emotive impact is very different. This information is recorded in the genetic map. Other important sound features as amplitude, roughness, pitch etc. are directly tied to the local dynamics of the evolution, i.e. to the path followed by the individual as a result of the environmental constraints. The global result is the development of many parallel melodies with similar characteristics but different scales, timbres and sometimes modes or tonalities. It is important to note that the different phenotypes developed during the evolution (i.e. the reproduction rate or the movement randomness) are clearly apparent in the acoustical dimension where the human ear has an incredible power of dynamics perception. The translation of the alife phenotypes into both image and sound dimensions produces a strong synergy of the two media, thus enhancing the perception of the system evolution.

5.3 Interaction

A video-camera is located at the bottom (central line) of the screen with the central view axe tilted in order to look the interaction area from the bottom. The signal of the camera is sent to the computer and a continuous difference with the previous image is computed in order to detect only the observer instantaneous movements. From this image the distance of the observer from the screen for every vertical line is computed. A second camera located on the left side of the screen (central line) can detect the distance for every horizontal line. The composition of the information coming from the two images gives the two dimensional map of observer activity in front of the screen. The observer activity is normalized and transformed in the energy map which determines the life activity in terms of higher filament dynamics and higher reproduction rate. In this way the real people can interact with the artificial society influencing the path of evolution and pushing some specific specie of individuals (fig. 5, 6). In the metaphor, the real people gives life chances to some of the artificial ones. The interacting observer cannot operate a deterministic control but only stimulate the artificial society, whose answer depends by the character of the individuals mostly solicited. Also the observer can

push some specific colors or sounds, experiencing the emergence of some specific graphical and acoustical phenotypes.

Fig 6: Cooperative creation between people and artificial individuals.

5.4 Emergent Behavior

The first observation is that 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. 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. The evolution process generates strong changes in the modality of the colonization of the life space. This mechanism is due to the dynamic action of dominant individuals which act like *pioneers* pushing the life in the void space. During this colonization they create strong divisions in the space and the subsequent colonization develop local communities of individuals (*micro-societies*). The action of the pioneers creates a mechanism of *islanding* which appears in the images as the coexistence of close different graphical and acoustical phenotypes with a limited contamination. The global result is the development of biodiversity in terms of colors, patterns and sound. Another

interesting aspect is the change in the individual phenotypes during the evolution, due to an emergent selection. At the beginning, smooth curvatures are self-selected due to the higher average life they are able to reach. During the evolution the micro-societies characterized by straight lines are filtered because of they are not able to bypass obstacles (high coherence, low flexibility). Too much chaotic micro-societies (high level of irrationality in the curvature changes) are filtered because of the individuals clash each other (internal fight 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. This mechanism produce interesting evolving sound and graphical patterns.

5.5 Experiencing the interactive installation

It is interesting to note that the interaction of the participating people, widens the possibility of evolution. Generally the people, with their movements, try to push a specific phenotype at a time using the hands as a sort of *life brush*. During the interaction, they alternate the balance of the development between several phenotypes, influencing the evolution and composing vibrating patterns and sound architectures. The apparent fact is the appreciation for a hidden fundamental aspect of life: the biodiversity, or in more general terms the *aesthetics of biodiversity*. The audio-visual emerging contexts are open both in the sense of esthetical shapes, and in terms of relations between the people and the artificial individuals: this could be a mirror of the real world. We imagine the cultural systems and the communication webs as systems where nothing is pre-determined, but the system evolves through local mechanisms of interaction and fundamental events. With a jump in lower scale, intelligence, consciousness and psyche can be revised as self-organizing phenomena inside of a complex system like a natural being. Starting from the idea that the individual context is the emerging own configuration of psychic fragments, the interaction between two or more individuals is revised as the interaction of two or more micro-societies.

6.Conclusions and future directions

Relazioni Emergenti was built in several versions. One of the most interesting regards the first step of the implementation of the idea of *communicating worlds* [APV00]. We realized two separated and autonomous interactive installations based on two computers, two projection

screens, and two interaction areas. Then we established a data link between the two computers. Trough this communication channel some individuals can travel and migrate from a world to the other. The travelling individual diffuse his genetics and features to the other world through the offspring. In this way a contamination between two different evolutive paths is established (fig. 7), not only in terms of graphical patterns and sound, but also in behavior.

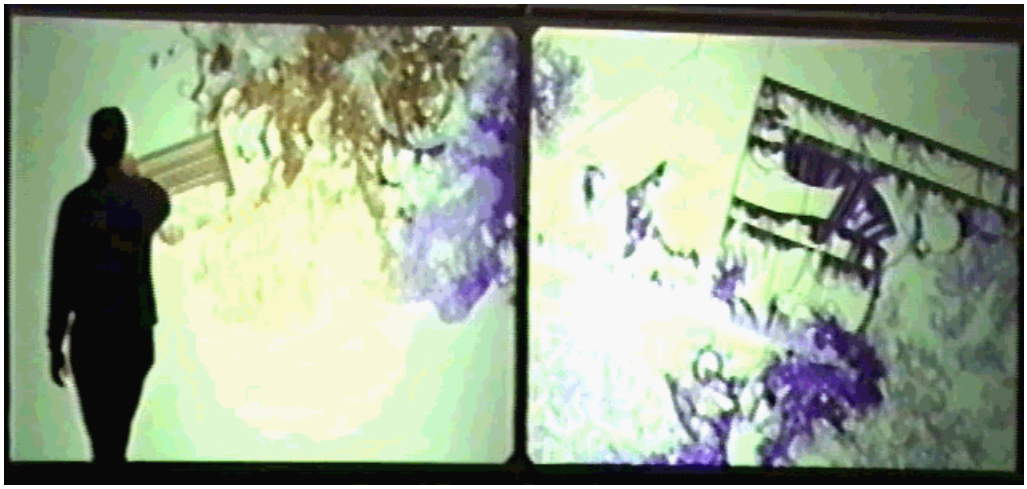

Fig 7: Contamination in two connected artificial worlds

An important problem we had to face at this stage was the relation between the individual and the environment. In a general way an individual, developed in a world with a specific set of environmental constraints (rules), could appear (*manifest itself*) different in another world with a different set of rules. In some way the aesthetic and behavioral identity of an individual is related to the specific environment where he lives, and changes in other environments. This is a interesting open problem. Another effect which was quite evident in the *connected worlds* installation was the following: the evolution dynamics at the beginning of the diffusion in the void space are very different with respect to second phase of evolution, when the space is very dense of individuals. After a migration, a sort of transition to the beginning is induced and the new specie changes rapidly its social characteristics. The concepts exposed in this first pilot artwork are easily extensible to a network of computers. In this not deterministic network, the migrating individuals can transport any kind of information like sound strings or signals, images, movies, texts, colors, voices, etc.. The interesting aspect is that the people interacting on the network nodes, communicate not only with their own world but with all the network. The media we have described is still a closed environment in sense of a fixed number of nodes

in the network. This limit can be removed using a different approach, under investigation at Plancton Art Studio. The idea is to establish a sort of a *life network server* and open new temporary remote worlds to people connecting with the server. The life flows partially to/from the new world, and stops when the connection is concluded. The final step in this imaginary path could be the removal of the server, by allowing each local world to act like a server on its own, to self-sustain the life process with the temporary connection events of people interacting on the network. This last step seems really difficult and a strong effort is required not only in terms of technology but also in terms of the ability of the individuals to adapt to very fast changes of the environment. This last aspect introduces one of the more fashionable and complex aspects of the artificial societies: the evolvability. The concept of *evolvability* is connected to the potential of evolution of an artificial society. Most of the simulations in the scientific field are built in order to explain natural mechanisms of evolution, or animal behaviour, or to solve practical problems (robots, toys, chemical, control etc..). In these cases we have no need to build an extremely fast evolving system. At the contrary, when we want to use alife for creativity and aesthetics, the needed degree of evolvability corresponds to the dimension and richness of our language. The first degree of freedom is the possibility to evolve the information transported by the individual itself (color, sound, images, shape, text, etc..). The aesthetics manifestation of the single individual is exactly the appearance of the information contained in temporary status or in the genetics of the individual itself. The next degree is the possibility to evolve the behavioral parameters written in the genetic map (dynamics, interaction, reproduction, life & death, etc...). This is important in order to generate different relation and different modalities of aesthetical self-organization. A third level of evolvability is driven by the people interaction. With their instinct and personal harmony, the interacting people can drive the society in absolutely not foreseeable situations. This is the level reached at this moment with the installation *Relazioni Emergenti*. The technological complexity of this implementation is not high. Much more difficult is to give an aesthetical sense to the evolution-interaction environment. These level of evolvability could be sufficient to develop cooperation, sexuality, coevolution, biodiversity, high level of complexity and rich metaphors of social dynamics. One of the most interesting aspects to explore is the communication dynamics. With these instruments it is possible evocate some mechanisms like emulation, selection, pushers or transporters of messages exploring the culture genetics. Finally, a fourth level of evolvability, which is much more difficult to implement and control, is to give to individuals the possibility to evolve the behavioral and

phenotypical models and the genetic structure. This possibility enlarge incredibly the possible complexity of the future generated creatures. This could be a good base to open really the evolution and give to the individuals the possibility of develop some features like language, culture, affection, imagination and, last, intelligence. Some middle way solutions are more easy to implement (lists of models, genetic programming, etc..) but paying a lot in terms of evolvability.

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