Emergent Relationships

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Abstract

Through the development of new languages, artificial life is going to be a new creative area of interference between art and science. This paper describe the background of an interactive audio-visual installation based on an artificial life environment where individuals can interact, reproduce and evolve through the mechanisms of genetic mutations. The people can interact with the artificial individuals creating an hybrid ecosystem able to generate emergent shapes, colors, sound architectures and metaphors for imaginary societies, virtual reflections of the real world.

Introduction

The ideas of evolution, complexity, intelligence and life reproduction, stimulated since long time the collective thinking, mainly driven by art, philosophy and religion. Scientific approaches then become predominant on the formation of hypothesis and practices to answer to these basic and ancestral questions. Research and developments carried out around mathematical and physical models of the intelligence (Artificial Intelligence) and more recently of life itself (Artificial Life), and the appearance of engineering practices for manipulating the biological dynamics, left us with a tremendous need of a cultural and theoretical basement to drive scientific achievements towards a new ecosystem based on the interpretation of the basic questions, and towards a new ethic code to be adopted.

Artificial life and art

In the last few years, several artists started exploring the potential of artificial life concepts in artistic and cultural fields. The development of a new basic language and tools needed is transferring their visions into tangible objects (artworks, entertainment systems, games, technologies). In this framework, artificial life is going to be a new area of interference between art and science.

Different personal ways are emerging in the approach of the *artlifers* to these environments. One of the expressive dimensions is the idea of *evolution* viewed under different aspects: a progressively increase of aesthetics (1) or development of intelligence or emotionality (2) or adaptation to the environment (5). Also the development of complexity and the biodiversity (3; 7) are fascinating aspects with own aesthetics. Another interesting dimension is the amplitude of the living population. In most of the cases, the suggestion is focalized on the evolution of one (2) or few artificial individuals, other times on a restricted number of species (6). Finally, other approaches are based on the dynamics of large population (*artificial societies* (9)). Also the *evolution time* is an important aspect in the alife art expression. It means the consistence of the *evolution window* presented in the artwork in respect to the global evolution time. A well developed individual (5) is often taken as a suggestion about the result of the evolution. Different artworks enhance the *evolution dynamics* showing the whole process of evolution in short times (7).

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* (8). For this reason we would like enhance this concept in the definition of *art of emergence* (10). 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 comparison 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 (6) or with the web community (4; 11) can open the evolution to an high dimensionality. The interaction can transform the artist-artwork system in an *emergent relation* between the artist, the *actors* and the artificial individuals. That means an hybrid - really living- ecosystem where real people and artificial beings can start up new imaginary worlds.

Relazioni Emergenti

Now we have the basic ingredients to enter in the description of the interactive installation which is the topic

of this paper. *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 retroprojected 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.

The main objective of the artwork is to build a metaphor of the world of the communication webs and the mechanisms of formation of *collective messages*. In the paradigm of the complexity, complex systems constituted by multitude of individuals develop global behavioral properties on the base of local chaotic interactions. Under this point of view one of the goals of the installation is to generate *metaphors* of dynamics mechanism of the development of interaction and complexity which the observer can perceive as an hidden order without necessarily have a clear consciousness of it.

The alife environment

The life context is a two-dimensional space (3200x2400 cells) 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.

During an evolution cycle, the filament can growth on the *head* and decrease on the *tail*. In the following, we refers to the term *movement* as the modality of growth of the head of the filament. 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 *unforeseeable* is related to a movement with an homogeneous probability in direction changes. For the character *constant*, a higher probability is associated to pre-fixed curvature. 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.

We developed several models for the probability of reducing the filament length. Some models are related to a most probable length or to a fitness of the individual or finally to the filament age. The reduction of the filament length frees space and the life is continuously sustained. The choice for models excluding the tail reduction causes the decreasing of the free space during the evolution, increasing the probability of death for clash with other individuals. The consequence is the end of the evolution. By an esthetical point of view, the second choice is preferred in order to have a picture of the complete spatio-temporal evolution. In the first case the past is continuously cancelled and the dynamics is enhanced. Anyway this choice affects deeply the evolution and the esthetical result.

There are two models of reproduction: asexual and sexual reproduction. In the first case the son has a genetic map similar to that one of the father. In the second case, activated on the mating of two individuals, a crossover is carried out. In both of the cases, some mutations in the genetic parameters can occur 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.

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. The color is treated with a HSV space. 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 codified in the MIDI protocol which changes at each evolution step. The best individuals of any species are selected on the base of a *fitness* indicator depending on the age and level of generation. These individuals access to the sound channels playing their notes. Up to 32 individuals can play together. Like the color modeling, the note amplitude of every individual is coded on the base of the individual 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...). This information is recorded in the genetic map, as well as a general *tonality* (A,B, ..., F) information. The global result is the development of many parallel melodies with similar characteristics but different scales, timbres and sometimes modes or tonalities.

Changing the musical mode, the global emotive impact is very different. It is interesting to note that the different phenotypes developed during the evolution (i.e. the reproduction rate or the average life or the movement randomicity) are clearly apparent in the acoustical dimension where the human ear has an incredible power of dynamics perception. The translation of the graphical phenotypes into the sound dimension produce a strong synergy of the two perception media which enhance an evolution of the perceived stimulus.

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 (see previous paragraph) in terms of higher filament dynamics and higher reproduction rate.

Figure 1: Interaction between real people and artificial individuals

In this way the real people can interact with the artificial society influencing the path of evolution and pushing some specific specie of individuals. In the metaphor, the observer cannot operate a control of the society but only stimulating the society which answer in an own typical way, depending by the character of the individuals mostly solicited. Also the observer can push some specific colors or shape or in general favor (or experience) the emergence of some specific graphical and acoustical phenotypes.

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, ani-

mals) or simply emotional attitude. 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 changes in the individual phenotypes during the evolution due to an emergent selection. At the beginning, the smooth curvatures are favorite 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 very little and the most favorite phenotypes are micro-societies characterized by 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 patterns in colors and in the sound organization during the evolution.

Conclusions

It is interesting to note that the interaction of the participating people open very much 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 consideration is the harmonic appreciation for a hidden fundamental aspect of the life: the biodiversity (..it could referred as the *aesthetics of biodiversity*).

The audio-visual emerging contexts are open both in the sense of esthetical shapes, either in terms of relations between the people and the artificial individuals, either in terms of emerging metaphors for artificial worlds as virtual reflections 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. 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.

Figure 2: *Solo*: society generated by the evolution of a single lineage

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