Autonomous Systems for Interactive Digital Art

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Abstract

Being an artist as a researcher, the main author searches a *magic wand* to compose a *visual* symphony through her pictorial forms in motion. How could these shapes self-organize, evolve, and keep up themselves perpetually together in such a way that the space-time composition of the artwork emerges from the system?

This paper presents some digital and artistic creations centred on Artificial Life where autonomous virtual creatures form a virtual ecosystem. Through the interactive installation *Quorum Sensing*, these virtual creatures embody themselves into reality; visitors can contact them and become an integral part of this virtual, imaginary and artistic world. Another artwork, entitled *Light Alive in situ*, they quit the "camera obscura" to enact itself within the great Nature and closer to a larger audience!

1 About Digital Art

1.1 Artists and Researcher

It has been years that artistic creation has entered an era where everything is digital. Back to the root of the word 'Art', the artist becomes again a researcher and a scientist. For, their art creations come from the osmosis based on two complementary approaches, on two differential attitudes. The scientific mind is an adventurer of the unknown, which draws this open mind to explore new universes and use them to go ahead. On the other hand, the artist's mind operates in a sceptical and revolutionary tendency to be against the social conventional codes. This reverses surprises and sparks off our perception. The artist's subversion alarms/warns our conscience of the world and compels it to reorganize itself: A new meaning, emerging from our old unconscious (instead of background) conceptions are stirred by this creative attitude of having "untamed eyes" [1].

During the 1990s, the computer expanded enormously with the improvements of the computational and representative capabilities, and the access of general public to the telecommunications networks. Therefore, there was a spreading wave of new expressions using the prefix “Cyber-”, such as Cyberspaces, Cybersex or Cyberart… etc.. This new trend suits to the artists who remains bounded to their sensitive world. They appropriated these media and these researches to create a new form of expression — Digital art which integrates a widened sensitivity due to the external sensors – data glove, 3D glasses and so on. Further more, they established a new aesthetics connecting Arts, Sciences and Technologies. All above provide a “technesthesic [1] experiment” (Edmond Couchot [11]). For this reason, human perception and man-machine interaction which are now combined into a space where reality, virtuality and artistic imagination hybridize themselves.

1.2 Machine’s Intelligence

With the improvement of computers, two fields of researches encounter nowadays within the new technologies. These are Artificial Intelligence and Artificial Life.

In the mid 1980’s, new models providing a better answer to the contingencies of a real environment appeared in cognitive sciences, such as Bottom-Up or Situated Artificial Intelligence (Rodney Brooks [2][10], Jean-Arcady Meyer [3]), Connexionism (Hopfield and Kohonen [4]) and Genetic Algorithms (John Holland [5]). This concept that addresses the entity’s embodiment sets cognition within the mutual influences of perception and action. It tries to reach, through training and self-organization, the flexibility and the improvisation needed for the emergence of clever behaviours within a sensitive world that is physically embodied. Methods that take advantage of the plasticity of Neural Networks and the evolutionism of Genetic Algorithms can be found into the virtual world and the art. Such artistic researches have produced virtual creatures (Karl Sims [6]) or Artificial Beings who interact with spectators inside a virtual environment (Michel Bret [7]).

Artificial Life grows up into silicon, the new substrate of today’s technologies, to give birth to artificial entities located into our real universe or within the cyberspace. Originated from J.H. Conway’s game of the life [8], Artificial Life brings together the principles of natural sciences and cognitive sciences. Its essential field activity probes the origin of the identity of the living and aims to construct autonomous entities. According to the definition Christopher Langton, who created the term Artificial Life: “Artificial Life relates to the study and the realization of systems conceived by men that show behaviours characteristic of living systems”. [9]

[1] The french word *esthesie* means how the body perceive the outer world. Combined with the prefix techno, it hightlight the idea of extented perception.

2 The quest of Artificial Life

In parallel with this comprehension towards the beings, Artificial Life simulates and helps to understand the nature of autonomy. This concept of autonomy constitutes the main thread of our artistic work. This step towards Artificial Life thus exceeds the mere simulation of biological phenomena into silicon. Computer Animation of each entity of this "unknown life" can no longer be satisfied with a simple interpolation between two positions fixed in advance (like in key framing), but permanently require an extrapolation on the future, continuously questioned by its own contents. Our researches aim at conceiving a complex system that generates forms that are in motion and filled with emotion. Gifted with autonomous behaviours, how could these silhouettes be able to self-organize, to evolve, and to keep them up perpetually together so that the space-time composition of the artwork emerges from the system?

2.1 The virtual world ontogeny

As biologists make cultures out of living matters in Petri dishes, we make "*cultures of artificial life*" inside the computer with our programs. These researches are directed towards the creation of a virtual world where "*autonomous creatures*" live on resources they draw from an environment conceived like a substrate.

These virtual creatures are born from the implementation of a morphogenesis process that involves genetic algorithms which enables them to self-generate. Their morphology has a simple or an articulated body. They are endowed with a virtual metabolism that controls their capacity of action and their behaviour. Immersed into a virtual environment, they are able to move, to grow up, to perceive the world that surrounds them, and to communicate either directly with the other entities, or indirectly through the environment that diffuses the signals they emit. The environment of this virtual world looks like a micro-organic substrate. An autotrophic process regenerates this substrate. It grows according to a nonlinear law taking into account its state in the neighbourhood and the actions of the virtual creatures. Thus, the regenerative behaviour of the environment is a compromise between the dynamics of cell automata and the dynamics of a diffusion process.

When an organic part does not assume any more its function, this degradation leads the organism to death. Implied into a process called the "migration biogene"[2] [14] by Vernadsky, its body decays and becomes a nutrient or a resource that can be assimilated by other life forms. After death, a "spontaneous genesis"[3] emerges and Life continues to proliferate. This idea has been integrated into the virtual world. When a virtual creature dies, its body narrows to only one line, and then, spontaneously, new organic forms appear: Its corpse breaks up into effervescent

[2] The term "migration biogene" represents the process by which, the organisms transform the atom and the organic molecules within the biosphere.

[3] This term, introduced by Pasteur, is used to describe the development of micro organism into a dead body.

bubbles. They fly away, then burst out and project on the ground their “biogenic” matters - source of regeneration for the environment. These three elements form a food chain: A society of agents, who live on and respect their vegetal habitat coming from a self-regenerating environment. Among them, an intermediate form coming after the virtual creatures’ death, considered as the “biogenic mass” returned to its host. This metaphorical association creates a reciprocal connection between the creatures and their environment.

While observing these interdependent cycles of life which are regulated by the alternation of death and birth, we wondered how long will these cycles ensure the permanence of this virtual world, according to which evolutions and under which conditions?

Figure 1: ***A Virtual Biosphere***

2.2 Towards an evolving adaptive system

Within an Artificial Life system, the first virtual creatures appear in a virgin world without any legacy from the past. It is up to its originator to set the initial conditions and the processes that will start the ontogenesis and the epigenesis of this virtual world’s inhabitants. As a first approach, it seems necessary to us, that several embedded layers of complexity have to coexist, at the virtual creature individual level but also at the level of creatures groups. We tried to design a network of concurrent processes, either co-operative or antagonistic, whose results and particularly the interactions set up and self-organize the virtual world, by giving it, its own structure.

2.2.1 The virtual metabolism

The behavioural engine of the virtual creatures is built around a concept of virtual metabolism. Based on an autopoietic principle, this metabolism is a set of

constructive and *dissipative* processes. The constructive processes control the creatures' capabilities for mechanical actions or for the absorption of the external elements coming from the environment and their transformation into energy-giving resources. They determine the rate and the conditions of realization of their morphogenesis, and which also influence the reproduction mechanisms. Thus, since their birth, their body grows and metamorphose itself depending on their living conditions. Conversely, the dissipative processes tend to degrade their own resources into external products that are then excreted. To survive, the virtual creature must maintain a relative balance between the processes that make it grow and those that destroy it.

The introduction of this characteristic of living organisms gives a survival instinct to the virtual creatures. These processes take part in the making of indicators symbolizing their challenging desires and influence the virtual creatures' behaviour. Similarly, the availability of energy resources conditions the possibility to perform elementary actions and their efficiency. In this way, the variations of the parameters in the model of metabolism feed the behavioural engine, internal to the virtual creatures, and become the source of their actions.

2.2.2 The behavioural engine

The control architecture internal to the virtual creatures aims at satisfying the metabolism needs, by organizing sequences of regular actions that highlight an autonomous behaviour. Based on the concepts of genetic programming and classifiers, this internal control architecture includes a set of rules, designed as short programs made up from a sequence of elementary instructions connected by logical operators. These elementary instructions execute sensing actions such as perceiving the state of the inner or outer world, physical action as body movements, or virtual biochemical acts simulating the absorption and secretion of products and the synthesis of resources. Using a syntactic structure, rules are subject to an evolution mechanism, by application of genetic operators such as crossover, mutation and inversion. Thus, by applying genetic operators during breeding, a creature will get new aptitudes that its parents do not have.

2.2.3 A virtual biosphere in symbiosis

Each virtual creature is a small complex system that attempts to survive by maintaining its balance at every moment. The dynamic composition between metabolic needs of the virtual creatures and the environment's local state creates a network of complex interactions that always involve reactions within this virtual world.

When their exchanges and their concurrent or divergent actions take place, these small subsystems succeed in creating and maintaining group behaviour globally organized when their interactions. An ecosystem is formed, a higher level system emerges: a biosphere similar to a living organism appears! This emergent property, as the biologist F. Varela underlines it, comes from "the global states of your

variables set, because there is an intrinsic interdependence. There is no need for hierarchical level or a conductor to coordinate the thing. It is the dynamics which will carry it". [15]

Creating a *visual symphony* through the space-time composition of the pictorial shapes was one of the initial ideas of this research. Within this virtual biosphere, the musicians are the elements of this ecosystem. Endowed with artificial life and with autonomous behaviours, they play together, self-organize, self-compose, and take part in the music -- a rhythm *tuned* with life!

3 Embodiment of Virtual world

3.1 The Interactive Installation *Quorum Sensing*

3.1.1 A free and sensory space

Through my interactive installation *Quorum Sensing* [12], these virtual creatures embody themselves into reality; visitors can contact them and become an integral part of this virtual, imaginary and artistic world. The installation "*Quorum Sensing*" is laid out in a rectangular room. A video projector hanged at the ceiling. The room floor is white and serves as a projection screen. An electronically sensitive carpet, containing sensors, enables the computer to capture and to determine the position of the visitors. When visitors enter this space, virtual creatures immediately jump forward to greet them and follow their steps. The slightest act of the spectators influences the virtual world's conformation that changes and retracts fugitively on the ground where the abundance and the fleetingness of Life unveil itself at their feet. Likewise, their footsteps transgress the quietness of the place and trigger series of strange cries yelled by these creatures… Although being present but in the background, the new technologies are hidden in favour of artistic creation. This installation wants to be a free and sensory space. Visitors are not constrained to wear sensors or to handle buttons. They are simply there, quite naturally. Only by their presence, they discover together the virtual biosphere.

Figure 2 & 3: *Quorum Sensing* -- An Interactive Installation

3.1.2 Entwined behaviours

Let us imagine a visitor entering this installation: he will be surprised by the virtual creatures that follow him incessantly. Depending on the reactions of these creatures, the spectator tries every means to communicate. Since this space is empty, body motion becomes so free and so expressive that, going beyond simple footsteps, his feet trample on the spot, lift up while shaking themselves, and slip or stamp the floor while attempting to catch or reject these creatures. Or else, with his hands and body, the visitor turns round on the ground or jumps in the air, to seize them or allure them. A kind of body language is outlined, almost like a solo dance, taking place within the coloured substrate where these small virtual creatures survive.

The discovery of this biosphere engages the visitors to multiple body motions, going from the simple gesture to almost ritual dances when mutual comprehension occurs...

This interactive installation can be a very intimate experiment for one or two people, or several in a shared way. The wealth of its interactivity modes weaves links between the participants and the virtual world, and especially between the participants themselves. The plasticity of this interactivity relates to a collective interaction mode fully and freely built by the spectators. This causes the emergence of a shared behaviour. This interactive installation *Quorum Sensing* establishes an “in & out” communication between the virtual world and the real world, echoing back the biological process called "Sensing Quorum"! ([13])

3.2 *Light Alive in Situ*

After the meeting between the spectators and the virtual biosphere through the installation *Quorum Sensing*, our team had a dream similar to the impressionist painters who left their workshops to embrace the great light of Nature: We wished the virtual world not only appear in projection room darkness but also that Artificial Life leaves the darkroom – the “camera obscura" – to act and enact itself within the great Nature and closer to a larger audience! Taiwan’s government on-going construction of a scientific park in Taipei gave us the opportunity to create an interactive digital artwork. This piece of Public Art, still under construction, will be installed in front of an exhibition hall dedicated to biotechnologies and computer science, and will last for ten years.

How digital art, with all the assets of new technologies, their magic and their power, can help to the metamorphosis of public art into such a significant site? This project leads us along three research orientations resulting into the artwork *Light Alive*. This digital artwork is shown on nine triangular columns, in stainless steel, laid out in arc of circle and equipped with a LED screen on one side. This architectural composition adds a singular note, almost abstract, in unity with the site’s urban landscape. By

putting emphasis on simplicity, sciences and technologies are in harmony with Nature, and gives place to imaginations, to men's thoughts.

3.2.1 A Permanent Interactivity bounded to Nature

The LED screen, displaying the artwork, takes part in problems of outdoor installation such as night and day visibility, energy saving and resiliency to bad weather. The lights of these LEDs get their life "in situ" into this public art, thanks to the implementation of virtual agents endowed with Artificial Life. Previously described Autonomous Systems has been adapted to generate the behavioural engines of these agents considered as virtual cells. They communicate between them through networks, similar to cells automata. Inspired by the principles of autopoiesis, they grow within this scientific park. From meteorological sensors, they retrieve weather data about their climatic environment. These atmospheric parameters constitute elements promoting or degrading their artificial metabolism. Through their growth and their metamorphoses, the public perceives the quality of the park's environment. Born from a marriage between Science and Art, these virtual cells watch, in return, over Nature, which is at the origin of arts and sciences.

Figure 4: *Light Alive* -- A Digital Public Artwork

3.2.2 A Spontaneous Interactivity with public

The other kind of interactivity of this artwork resides in its ludic style: The virtual cells react spontaneously to the audience's presence and to its distance to the artwork.

Tied together, they form a colony akin to a cellular tissue. Their twitched or peristaltic reactions spread by diffusion of rotational moves over the whole colony's surface at various paces.

On a bright sunny day, the steel surface of the triangular columns mirrors the passers-by and their bustling surroundings; the electronic display shows the "*Light Alive*" interactive artwork. *Light Alive* consists of rolling cells that resemble a Rubik's Cube. Endowed with Artificial Life, *Light Alive* will change its colours as the season's change. It also sense time and natural lighting. For instance, all cells will ring and dance on the hour. The Lights Alive shown on the display will elegantly dance when the audience outside the hall moves close to the nine triangular columns outside.

"*Light Alive*": the name of this 3D interactive animation artwork was inspired by two Chinese ideograms meaning "brightness, chip" and "mind, spirit." Chip symbolizes the today's computer technology into our civilization, while spirit is related to the presence of Artificial Life and Natural Sciences into this artwork, thus conferring it its own soul.

This artistic project aims at promoting scientific culture, social communication and respect of the environment into a long lasting perspective.

4 References

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