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Mutations : Plastic and Musical Improvisation by Distributed Agents

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ABSTRACT

In this article, we study the creation and perception of pictures and melodies as the result of the interaction of distributed agents. In some complex systems, one can see the elaboration of global patterns by the interaction of distributed local entities. Following first abstract painters such as Kandinsky or Klee, and Gestalt theories of perception, one may also consider that pictures are composed and perceived as the result of the interaction of sets of colored graphical elements. In a similar way, one may consider that music is the result of the adequate composition of distinct sounds and that it is perceived as the interaction of sets of musical elements. In this article, we develop the idea somewhat further and show how we can take advantage of it to create computer-generated artworks. Computer-art projects such as The *Garden of Chances* and *Mutations* have been designed using these principles, and rely on a versatile multiagent platform dedicated to the real-time visualization of complex data streams.

Keywords: complex systems, multiagent systems, painting, music, gestalt theory of perception.

1. INTRODUCTION

Music playing by an orchestra or a band is a live collective performance during which musicians have to follow the musical writing of the piece and also have to listen to one another and react to what others produce. The global composition is the result of the behavior of individual musicians, as written on the score, but it is also the result of the interactions between them. During improvisation sessions, there's no written music, only rules describing what can be played (what is musically acceptable), and what can't, depending on what is played by others and on the general desired mood. This is only possible because music is well fitted to some kind of formalization and syntactic description.

As far as painting is concerned, the problem of collective composition is entirely different. Naturally, this is mostly due to the fact that painting is not an art of performance. What is most valued is the resulting artwork, not so much the process by which it was created. If we draw a parallel between music and painting, we can say that the painter is like a composer, which organizes colored graphical elements instead of musical notes. In painting, the performance by musicians is replaced by the confrontation between the artwork and the spectator. "*The work of art is born of the movement, is itself fixed movement and is perceived in movement*" [16]. The "performers" are the plastic elements that reveal their "inner life" through their shape and their color. Just like musicians, they don't produce isolated effects: their effect is modified, stimulated or inhibited by the presence of other plastic elements nearby or at the other end of the picture.

This dynamical and interactive view of perception was first introduced by the Gestalt theory of perception [1] and was studied in painting by the first analytic painters (W.Kandinsky [13], [14] and P.Klee [16] in particular) and the first constructivist painters (K.Malevitch [10]). They all tried to understand the basic properties of colored shapes, and the way they could be associated with one another in order to produce specific effects. They tried to give syntactic and semantic rules to painting similar to what already existed in music. More importantly, they considered pictures as ecosystems of plastic elements, which reveal their coherence through the interaction of these elements. "*There's a law of construction the analysis of which shows that it is followed by nature as well as by art: the different pieces become alive through the all. Indeed, construction is an organization*" [14].

In natural systems also, animals behave collectively and interactively which sometimes result in global visual or sonorous patterns [15]. One can find examples of collective "improvisation", in which the song of individual animals respond in a predetermined way to the songs of other animals. That's the case when frogs "sing" in the surroundings of a pond: the global song is the result of complex interactions between all the different individual frogs that respond each other.

We can draw a parallel between plastic and musical composition, and between artistic composition and natural complex and auto-organizational processes. Therefore, we chose to explore how computer-simulated dynamic complex processes inspired by natural ecosystems could be used to generate artistic compositions, never-ending and with endless unpredictability and novelty, yet esthetically pleasing. This will be exemplified with the project called *Mutations*, which is based on a previous project called *The Garden of Chances* [11]. This artistic project is based on the idea that distributed virtual agents designed with a biological metaphor may be used as composition elements in virtual plastic and musical improvisation.

The first part of the article is dedicated to the plastic aspect of the work (section2). The musical aspect is then presented separately in section3, and the interactions with the plastic aspects are explained, before drawing perspectives towards the creation of a total form of art.

2. PLASTIC COMPOSITION

The issue of plastic composition has first been explored with the project *The Garden of Chances* for which the aim was to build an ever-changing representation of meteorology, connected to real-time data retrieved through the Internet. The basic idea is to compose the picture as a virtual garden whose evolution is related to the more or less favorable meteorological conditions. The space of the picture is assimilated to the ground of the virtual ecosystem and colored shapes have to compete in order to survive in the picture and to get the attention of the spectator. On a technical point of view, each colored shape corresponds to an agent [23] with internal resources and interaction capacities with the other agents.

Internal specification of shapes

Some of the shapes are linked to the representation of the meteorological ambience whereas others make up together a virtual ecosystem, which evolves under the influence of the weather conditions.

In the virtual garden, some of the shapes evolve like leaves, some other like vegetarian animals, some like carnivorous animals. The aspect of each shape is in direct relation to the family (figure 1) it belongs to. In addition, the shape may be modified by internal characteristics of the corresponding agent. The level of energy, for example, will influence the size of the shape, giving visual clues about the health of the different agents composing the picture.

Agents representing meteorology are also associated to distinct shapes and their color is also linked to the meteorological data of the moment. For example, some of the agents get darker and bigger as clouds coverage increases, and they move along the wind direction, faster when the wind blows. Similarly, dot agents are used when the rain is falling, bigger and appearing more frequently when rain is heavier.

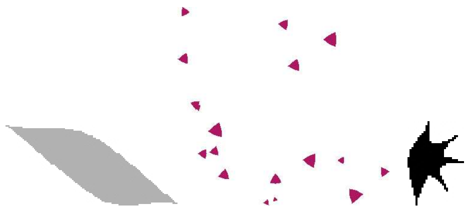

Figure 1. Different families of shapes (from left to right: leaf, vegetarian animal, carnivorous animal)

The color of the shapes is specified explicitly, using curves that indicate the color to be used depending on the season, the moment of the day, the current meteorological conditions, the health of the shape. This color is specified using the HSV model (Hue-Saturation-Value), with distinct curves for the three components.

Interaction between shapes

The shapes representing the agents are specified individually based on the characteristics of each agent but they are also dependant on the other agents in the surroundings. The basic idea is that the picture space is a limited resource, just like the ground is a limited resource for plants to grow on it. Therefore, if too many agents are present simultaneously in the picture, some will have to disappear to let others develop satisfyingly.

The principle is easy to imagine for agents participating in the ecosystem because the analogy is direct. Leaves need some space around them to get enough light and enough mineral substances. When too many of them are present, the sanction is immediate and some will decay rapidly. On the opposite, if few are present, their development accelerates and they can rapidly multiply. On a second level, the development of herbivorous agents is strongly linked to the quantity of leaves that is available at a time, and on a third level, the development of carnivorous agents is linked to the quantity of preys that they can find. We can see in figure 2 that the populations of the ecosystem (leaves, herbivorous and carnivorous creatures) evolve following more or less regular alternating cycles.

The development of cloud agents follows similar principles: when the sky is cloudy, the development of these agents accelerates so that the screen becomes rapidly full of them. When the screen gets saturated, the regulation principles operate and make some of them disappear or become smaller, so that there's no indefinite multiplication of these cloud agents. This also guarantees that the picture is not fixed but that it constantly evolves. The agents related to the rain are constrained by very similar principles.

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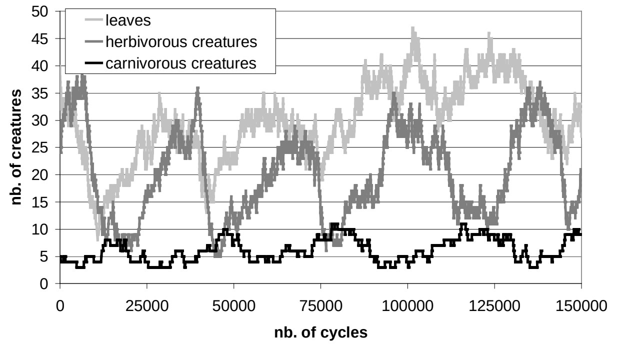


Figure 2. Evolution of the populations of creatures in the simulated ecosystem. Populations of leaves, herbivorous and carnivorous creatures evolve respecting alternating cycles

Global composition

The global result of the dynamics which occurs at the agent and inter-agent level is a plastic composition which is directed by two complementary principles: some control is obtained over the aspect of the pictures by giving predefined rules to each of the individual agent, and by specifying one or several aspects of their visual appearance (shape, size, color, etc.); some unpredictability and creativity is allowed by establishing various interactions between the colored shapes composing the image. The result is organized chaos, dynamically evolving along with the meteorological conditions of a distant place. The preservation of some order and the link to the real weather are very important because they allow spectators to make sense of what they see. Figure 3 shows a screenshot of the project called *The Garden of Chances* during fall.

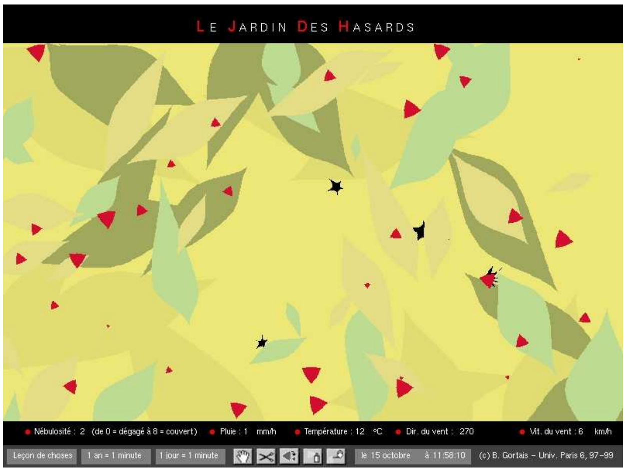


Figure 3. A view of *The Garden of Chances* during fall. Weather conditions are as follows: the temperature is 12°C, the wind is blowing from the west at 6km/h, the sky is partly clouded with no rain.

3. MUSICAL COMPOSITION

Musical composition was approached with quite the same philosophy: controlling the individual characteristics of agents and studying how several agents placed in a common environment could behave globally. This was done in the context of a second artistic project called *Mutations*. On a plastic level, this latter project is based on the very same rules. But the musical rules are somewhat different (due to the different nature of painting and music) and deserve a specific presentation.

Single singer

The level of energy characterizes the agents composing the virtual ecosystem. When this energy level is high enough (above the value `highThreshold`), an agent is able to "sing", which means that:

a) a sound file is played, will a level depending on the agent's energy and with a stereo effect depending on the agent's position on the screen;

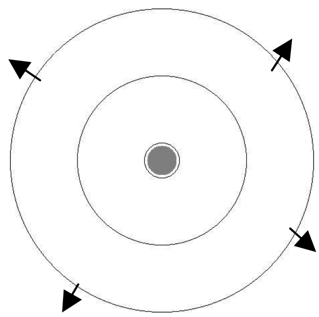


Figure 4. When an agent (gray disk in the center) "sings", a virtual sound-wave is propagated around the agent (circles); if the agent has enough energy, he can emit successive sounds.

b) a virtual sound-wave is propagated around the agent (see figure 4) with a given speed and at a given distance which depends on the level of energy of the agent;

c) the energy level is decreased by a specific amount;

Interaction between singers

After an agent has sung, it has less energy because it had to consume some of it to sing. Therefore, it will not spontaneously sing again until it reaches the required level of energy again. Although it doesn't sing spontaneously, it still has enough energy to be able to sing anew (level of energy above the value lowThreshold). That's precisely what an agent will do when it perceives the virtual sound wave emitted by another one (see figure 5).

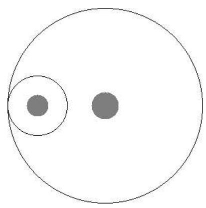


Figure 5. When an agent perceives the singing of another agent, it triggers its own singing which triggers the first one's singing and so on

When two agents are close enough, this will result in successive singings by each agent, with decreasing intensity as they lose progressively some of their energy. If the two agents play the same sound file, this will result in a reverberation effect, each agent playing with some attenuation what the other had played just before. If the agents play different sound files, the result will more resemble a kind of dialog between the two agents.

Naturally, the possibilities of interaction are multiplied when three or more agents are involved. The system becomes chaotic, which makes it unpredictable but also more interesting, raising the strain of the hearer waiting for the next interactions (see figure 6).

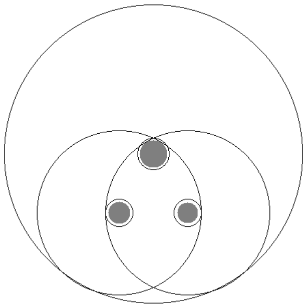


Figure 6. Example of interaction with three agents

Propagation of songs

Since the sound-wave emitted by an agent makes other agents sing, this means that when lots of agents are close to one another, the singing of the first agent will propagate from one another at the speed of the sound-wave (see figure 7). If all the agents play the same sound, the spatialization of sounds gives the illusion that a single sound is moving across the screen.

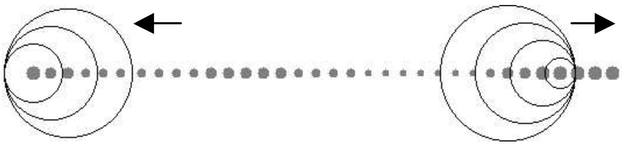


Figure 7. Example of the propagation of a "song" from agent to agent, in a population of closely aligned agents. The singing propagates in each direction, starting from the central agent (the size of the agents is proportional to their energy)

By lowering the amount of energy lost when an agent sings, we can have them sing several times in a short lapse. This allows the propagation of several waves at a time and produces more complex sounds by the addition of elementary sounds (see figure 8).

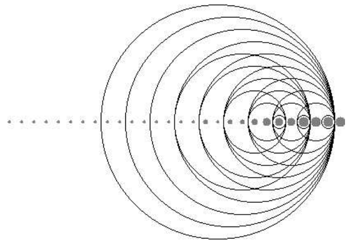


Figure 8. If the energy lost when singing is low, several waves can propagate simultaneously

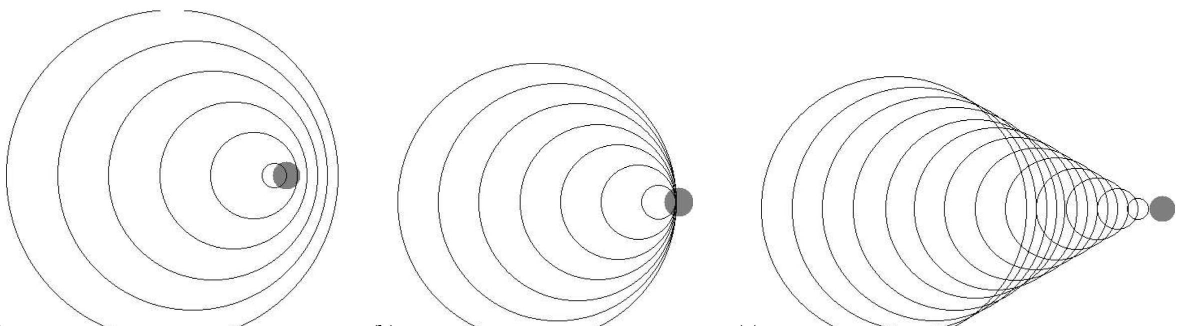
Moving singers

Up to now, we only addressed static "singers" which distantly interact thanks to the sound waves they emit. In the global *Mutations* artistic project, agents are not static. As in *The Garden of Chances*, agents can move freely, blown off by the wind or pursuing one another. This implies more dynamic interactions between the different singers and raises specific problems related to sound playing.

In particular, the relative speed of agents and sound waves is fairly important. Indeed, we explained that the perception of a virtual sound wave could trigger the singing of an agent. Then, if an agent is moving at the same speed as the sound waves it emits, it can self-sustain its own singing. One can compare it to a plane breaking through the sound barrier (see figure 9). If the speed of the agent is slower or faster than that of its sound waves (figure 9 (a) and (c)), it never crosses them. On the contrary, if the speed is exactly equal (figure 9 (b)), the agent constantly perceives its own sound waves and is constantly driven to sing, losing rapidly all of its energy with this singing.

Global composition

We analyzed some of the basic situations that can occur within the global composition. However, the dynamics of the whole system when a population of agents evolves in a common environment is too complex to be reduced to the sum of local



(a) (b) (c)

Figure 9. The three different situations concerning relative speeds of a singer and the propagating sound-waves (singer with speed respectively slower (a), equal (b) and faster(c) than the sound-waves). In this representation, the agents continuously emits sound-waves

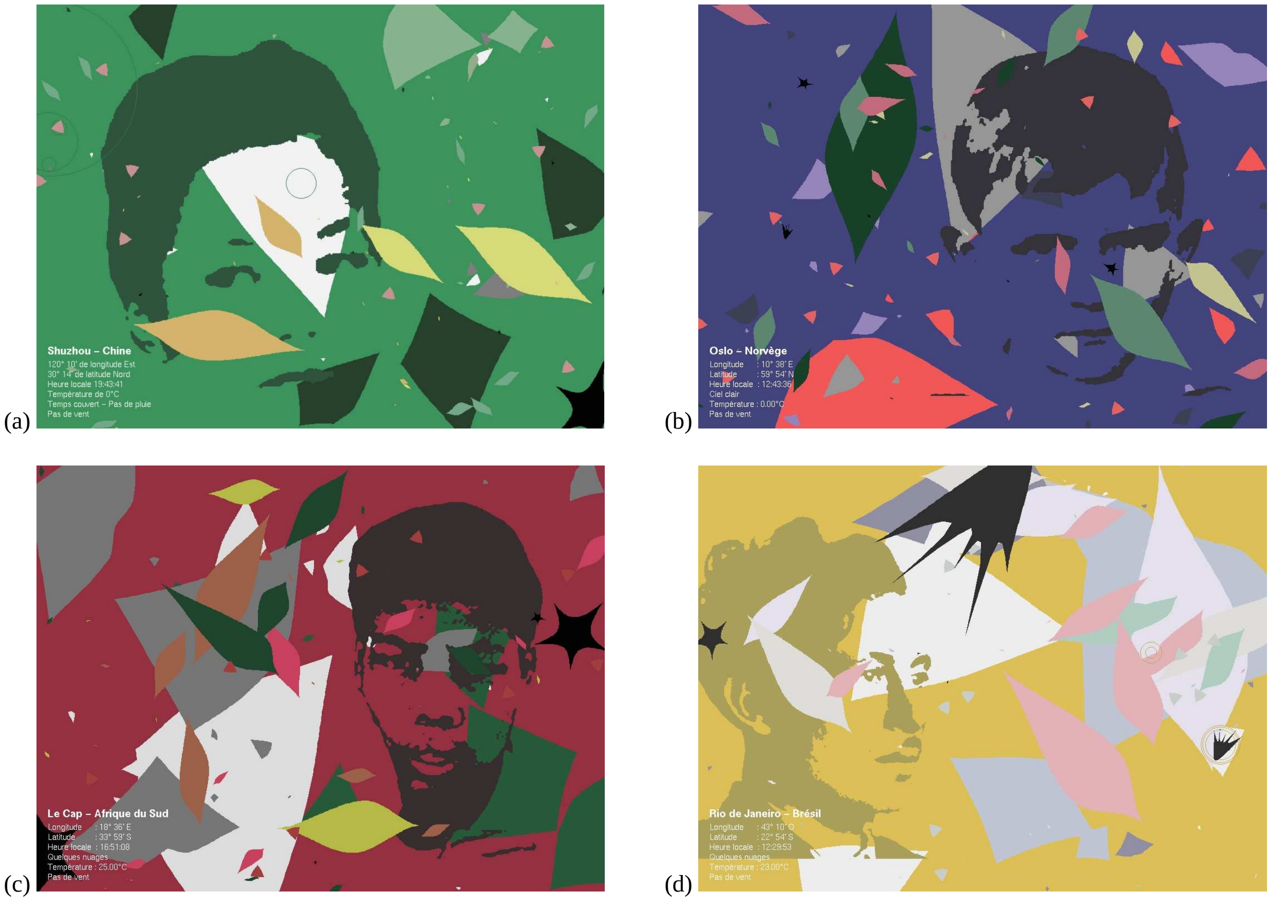


Figure 10. A view of *Mutations*, connected to the meteorology of Shuzhou in China (a), Oslo in Norway (b), Cape Town in South Africa (c) and Rio de Janeiro in Brazil (d)

situations. The analytic work however, was necessary to explore the very large parameter space of this kind of system. By so doing, we made it tractable for a composer to find a satisfying tuning of the various parameters involved, so that the resulting dynamics is interesting on a musical point of view.

Finally, the plastic and musical aspects had to be integrated so that the graphical aspect gives indications about the desire of the agents to sing. This has been achieved mainly in two ways: firstly, by having the agents grow as their energy increases, we give a visual clue of the growing desire of the agent until the singing finally occurs; secondly, the visual representation of the virtual sound-waves allows the spectator to anticipate the singing of agents responding to each other. Like the visual clues to the meteorological conditions, these visual clues to the singing of agents are fundamental to help spectators make sense of this chaotic yet organized artistic complex system.

4. CONCLUSION

This work is very close, in its spirit, to the first analytical researches on abstract painting done by W. Kandinsky [14] in the beginning of the 20th century: studying the essential qualities of simple shapes or primitive colors, before moving on to study how the qualities of a single shape are modified when the shape is placed behind another one. The main difference is that we now have, with the computer, a very powerful tool that enables to systematize the approach and explore new directions.

Furthermore, it gives the possibility to explore in parallel the two domains of plastic and musical composition. When Kandinsky could only draw abstract and theoretical analogies between the two domains, this tool gives the possibility to really study how painting and music interact, how they are related, and how they influence one another.

This is only a first approach and it need to be explored still further and to be systematized. But we see it mainly as a preliminary step on the way to a total form of art, incorporating plastic and musical composition, but also other forms of art, especially the arts of performance, and incorporating actions from human performers. The works we presented evolve continuously in relation to meteorological data; future works will have to evolve in reaction to data measured from human performers like dancers or actors, or even from the spectators whose physiological reactions will be measured. The work of art will then be able to establish a real dialog with the spectator, the system and the spectator responding to each other's reactions, thus indefinitely coevolving.

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