A Performance Co-Created with an Autonomous Virtual System: A Symbiotic Approach

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Abstract

This paper is a case study of a performance co-created in interaction with an autonomous virtual system. Our outcomes point to an essential production period where the creative team learns to know the virtual system through indirect interactions: the match-up phase. During this step, co-creation and co-evolution moments happened, indicating a possible symbiotic relationship. We discuss the implications and the outcomes of working with autonomous scenography in a performative context. We then expand the reflection to the potential creative associations between performance arts and autonomous technology.

Keywords

Performance, Artificial Life, Autonomy, Symbiosis, Co-Creation, Unexpectedness, Real-Time Computer Graphics

Introduction

This paper is a case study of experiments carried out in the context of the project CECCI-H2M ("Co-évolution, co-création et improvisation humain-machine"). We will talk about a specific experience with a virtual ecosystem and about the creative process that enabled us to explore our research question: how can a performance be co-created with an autonomous virtual system?

We are interested in constructing virtual autonomy in the search for scenographic improvisation through the emergence of virtual patterns and behaviors. However, what is autonomy in the context of digital arts? An autonomous computational artifact, as described by Baljko and Tenhaaf: "has some sort of internal state space, it outwardly manifests information as to its internal state (...), and its behavior depends on its state" [1]. Similarly, Bishop and Erden define that "an autonomous system is typically considered to be a self-determining system, as distinguished from a system whose behavior is explicitly externally engineered" [6]. In short, we could define autonomous computational artifacts as entities with an apparent internal motivation (internal self-determining state) that guides their behavior prior to the influence of external forces.

According to Maturana and Varela, autonomy is a condition for a "living machine" and relates to the notion of autopoiesis, that is, self-fabrication [7]. The independence of the artwork from the artist's control tends to transport it to the realm of the living, at least as an artificial form of alterity or impression of Life. In the study of complex systems and within the domain of Artificial Life, the concept of emergence accounts for a surprising phenomenon, often linked to creative solutions. Using the simulation of complex systems inspired by nature, artists move from the creative process to the metacreative process: the design of autonomous mechanisms that, in turn, create artworks or artistic situations. Following this reasoning, Whitelaw [14] examines how artists have been inspired by Artificial Life to pursue emergence due to the agency, novelty, and creativity in biological, chemical, and multi-agent processes.

Within a second-order cybernetic point of view, Couchot, Bret, and Tramus defined the artifact autonomy in connection with its aptitude for self-organization and to afford interaction in different environments: endogenous and exogenous. According to them, an autonomous artwork behavior is qualified by endogenous interactivity, which handles the dialogue among the virtual objects, able to perceive specific characteristics from each other and keep relationships more or less complex. The autonomous virtual system can also be open to the perception of its environment in a "second-order interactivity", in analogy to second-order cybernetics. Beyond the engagement between the participant and the artistic process through an interactive interface, second-order interactivity would appear when the autonomous system can modify itself during a learning process by interacting with its environment to adapt to it. The participant is encouraged to explore aesthetic possibilities when embedded in a reciprocal, emergent, and unforeseen interactive context. Depending on the interaction interface setup, the means at his disposal for this exploration enables gesture experimentation, movements, and creativity, in the search for communication or understanding [13].

In our practice and research, the application and discussion around Artificial Life are considered in the performance art context and connected with unpredictability. Inspired by Edmond Couchot's question [3] about "how does the machine create the unpredictable on stage?" we intend to study autonomous virtual systems based on the simulation of complex organic systems within the performance context to promote a new sense of unpredictability and improvisation.

Bringing a performer into a confrontation with an autonomous virtual and perceptual system encourages emergent phenomena and motivates improvised reactions. Our hypothesis is based on establishing this interaction dynamic as a possible way or method of emergent narrative creation, built during the interaction in a co-creative way. This method can indicate a symbiotic phenomenon with an artistic purpose and shed light on new ways of scenic composition with new technologies. As researchers and designers of virtual systems, we imagine methodologies and concepts about the associations between autonomous virtual systems as improvising presences and the living arts. We wonder: How can the performing arts take advantage of autonomous virtual entities in the quest for new ways of imagining the stage space and the performance? How to articulate new ways of conceiving dramaturgy and being inspired? How can unpredictability be used to express contemporary emotions and concerns?

Methodology

Research Questions

The methodological problem that encouraged this project is divided into two parts. First, how to create an interactive virtual system to promote co-creation on stage? Second, how to cooperate with this system while composing a performance, aiming for a creative relationship between humans and machines?

We chose to develop an evolving virtual ecosystem to solve the first problem. This choice is due to the leads in the literature about artificial life algorithms and their potential to represent or generate emergent and unexpected aesthetic phenomena. On the other hand, we chose the performance medium to answer the second problem through the performer's persistent and attentive improvisation vis-à-vis her environment. Our main goal during the experimental phase of the artistic experimentation was establishing an exploratory exchange between the performer and the virtual system, keeping the autonomy of the two partakers and, therefore, their potential unpredictability to bring out a performance that shows a mutual improvisation process.

Research Hypothesis and Interaction Setup

The experiments of the research-creation project described in this article are the continuation of the experiments of last year described in the article [11]. Iterating last year's reflections and inspired by leads in literature and electronic digital art, such as the cases of the creative ecosystems of Jon McCormack [8], we have created an evolving virtual ecosystem as an essential tool for testing the hypothesis of a creative dynamic between human and machine. Concerning the interface, we hypothesized that an "indirect" interaction **(Fig.1)** would make the interaction dynamics more exploratory and keep the autonomous (or independent) character of the two types of entities in dialogue, real and virtual. We move from a first-order (responsive) to a second-order (adaptive) interaction. The ideas for the performance would accommodate themselves to the progressive aesthetic discoveries enabled by the interaction with the autonomous virtual system.

We based the design of our experiments on developing the foundations of an evolving interactive program to be tested and improved during the artistic residency. We then conducted interaction tests to verify how our creative expectations and the virtual behavior styles fit.

Core Co-creation Process

The main result of our research-creation residency was the provision of a methodology for developing, managing, and interpreting a virtual autonomous scenography in the context of the living arts. This methodology involves match-up phases through interaction with the virtual system in a receptive way to emerging aesthetic possibilities by the entire artistic team. We, therefore, achieved a co-created performance in 4 steps:

1. The development of an evolving virtual ecosystem (E.V.E.) considering the performer's presence and the research-creation goals (co-creation and co-evolution).
2. The match-up phase, by the art director, of the behavior and appearance of the E.V.E., understanding how it works, and exploring the various points of view and approaches to the system.
3. The phase of matching up the E.V.E. by the performer, exploring the aesthetic potential from the interaction between her movements and the system's behavior.
4. The match-up phase of the E.V.E. by the developer and stage manager once the directives of the artistic direction are established, and the intention of the performance is solidified.

Experiments with E.V.E.

The first step in exploring the issue of co-creativity was creating a virtual system capable of manifesting surprising, emergent, and "creative" behaviors and patterns regarding our expectations and concerning the initial state of the visual explorations [2]. We have envisioned the different behaviors of our virtual ecosystem through the planning methodology of an agent-based model [1]. Then, we identified some simulations that were sensitive to their virtual environment, autonomous, and with types of movement close to those we expected to perform virtually. Inspired by the idea of simulating complex self-organizing systems, we used algorithms from the field of Artificial Life, more specifically from artists and researchers who work with speculative biology or synthetic biology. Finally, we adapted the chosen biological simulations to our artistic desires and associated the resulting behaviors with a second-order interaction with the creative team.

E.V.E. Development

We experimented with the design of a first species based on the research and reports of Arsiliath [2] and Sage Jenson [3], who

[1] Complexity Explorer - Introduction to Agent-based Modeling - Summer 2022, https://www.complexityexplorer.org

[2] "arsiliath (@arsiliath) / Twitter." 2021. Twitter. Accessed October 22. https://twitter.com/arsiliath.

[3] "Physarum - Sage Jenson." 2021. Accessed September 19. https://www.sagejenson.com/physarum.

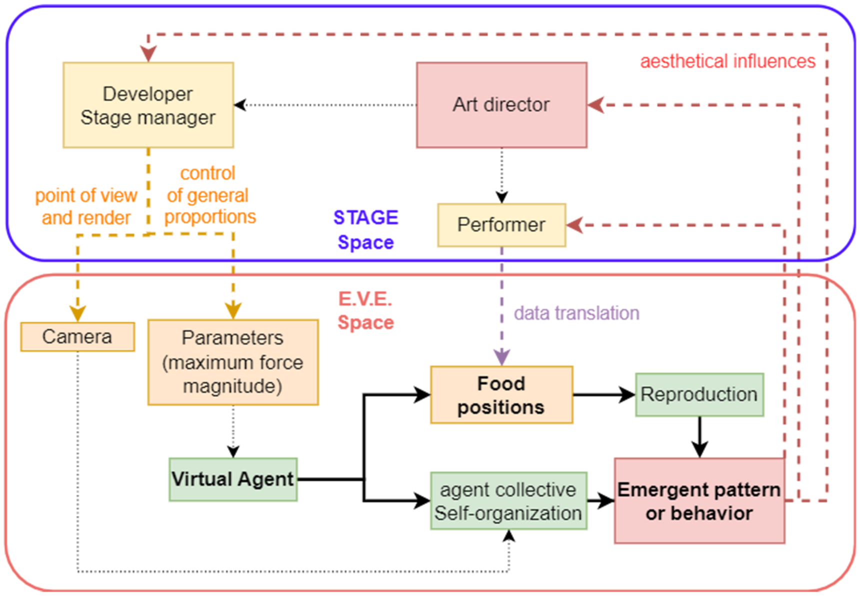

Figure 1: Indirect interactions between artistic team and E.V.E. ©CECCI-H2M.

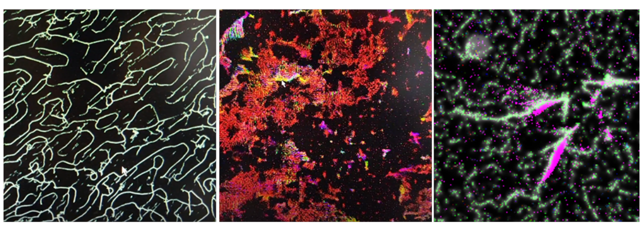

Figure 2: First, second and third species. The third one is represented in magenta on the right image. ©CECCI-H2M.

were inspired by Jeff Jones's publication on Physarum transport networks [4]. It is a combination of two behaviors: ant foraging and the movement and growth of the Physarum.

This first species can perceive its surroundings with a limited angle and distance. Therefore, each agent checks the neighboring pixels to measure the quantity of "pheromones" present, represented by colored lines left by the trajectory of agents of this species. Where there is a significant quantity of pheromones (intensity of R, G, B in the neighboring pixel), the agent will assume as its next destination, forming moving patterns of agents. The emergent aspect of the pattern created by the collectivity of entities is reminiscent of the patterns created by the movement and growth of the Physarum in search of food.

The second species was based on the boid's flocking algorithm [9] [10]. To move, the agent measures its neighbor's speed, direction, and position to calculate its speed and direction, intending to align its trajectory, separating from neighbors so as not to hit each other and maintain cohesion in the speed of movement. This technique allows agents to form concise groups according to the angle of view, the extent of perception, alignment, separation, and cohesion.

The third species is inspired by the behavior of random walkers, where agents move according to a random direction. We used a probability technique to make their movement random but biased in the direction of a target. The target or attractor, in the case of all three species, is the position of the food. First, we created food points generated according to a four-dimensional "Hermit" type noise. Food attracts agents with less energy, nourishes them, and repels agents with high energy.

Once the species' behaviors were created (**Fig.2**), we brought them together in a single virtual environment and created the interactions between them. Agents could perceive and guide each other, regardless of species. Then we set up the ecosystem dynamics with genetic algorithms. We linked the main behavior parameters of the agents to 4 genes, corresponding to the values of R, G, B, and A in a texture buffer which kept the D.N.A. of each agent. See **Table 1** for an illustration of the correspondence between each "gene" and each species parameter.

Agents had an initial amount of energy that increased with contact with food and decreased as the agent moved away. The agent needed to have a minimum level of energy (called health in the program), check if there is an equally healthy neighboring agent, and count with a probabilistic decision to reproduce. If the decision is confirmed, the two entities' D.N.A. is crossed (crossover) with a mutation rate, and a new agent is created in a free space. If an agent's energy level is too low, it is disabled and ignored in updating the parameters of each pixel of the input textures (death of an agent in the system). See **Fig. 3** for the general functioning of the virtual ecosystem.

GENES	species 1	species 2	species 3
0 (R)	neighborhood turn force	alignment force	seek random position force
1 (G)	seek target force	cohesion and seek target force	seek target force
2 (B)	seek food force	separation and seek food force	seek food force
3 (A)	type of species	type of species	type of species

Table 1: Correspondences between D.N.A. (R, G, B, A gene list) and virtual agent's parameters for each species

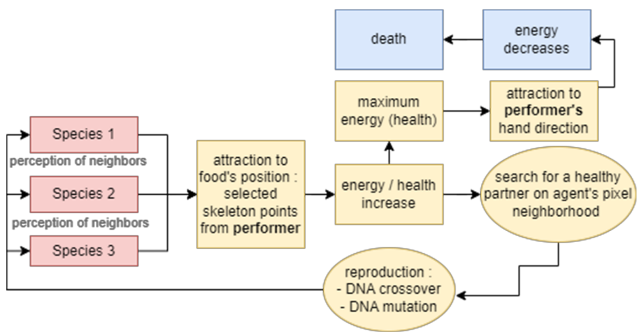

Figure 3: General functioning of the virtual ecosystem ©CECCI-H2M.

Compute Shaders

Arsiliath, in his Psychobiotik course, proposes an optimized algorithm to realize a multi-agent system with compute shaders in Unity. We used Touchdesigner to combine all the techniques we would use in the show in a single software (mapping on various video projectors, generative image, sound analysis, connection with Kinect, message management in MQTT, etc.).

To design the simulation, we used the compute shader, a parallel computing technique on the graphics card. It computes information arbitrarily and is not involved in the rendering pipeline, although it can render images. The information and properties concerning the agents were stored on texture buffers at the shader's input and output. It is a technique that uses the color information spaces of an image (texture) to store data and therefore be able to perform calculations in parallel, fast, and without relying on the computer's memory and the CPU (Central Processing Unit).

Indirect Interaction

A few types of interactions, with variable control over the system, were set up and used by team members. For example, a control interface allows the stage manager/developer to modify specific parameters concerning the virtual agents' behavior limits without intervening in their behavior directly.

During the residency, we tested the virtual system in interaction with the performer. Her joints were detected by the Kinect camera and transposed into the virtual environment as food points position data **(see Fig. 4**).

Another type of interaction was controlling the camera's position and the scene's rendering. The artistic direction employed this control to shape the virtual environment in favor of expressing the artistic intentions and sensations for the scene ambiance.

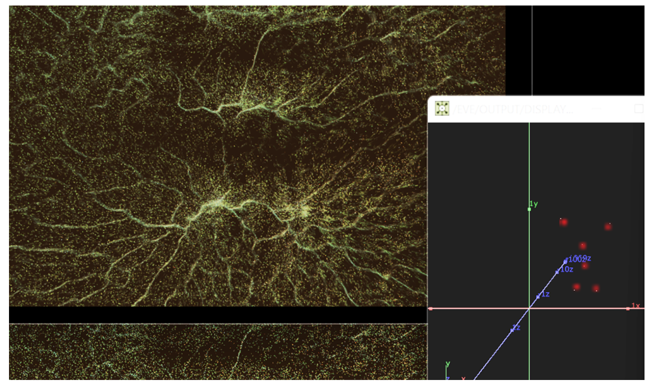

Figure 4: Performer's skeleton data translated to the E.V.E. as food position information. ©CECCI-H2M.

Match-Up Phases

Artistic Direction

First, the virtual system developer presented the system's behavior to the artistic director. We have indicated some possibilities of exploration and visualization of the virtual environment and the possibilities of indirect interaction by experimentation with the limits of the forces and quantity of visible elements. Then, the artistic direction (A.D.) chose important moments based on observing the system in action and the various emotions and sensations that its appearance engendered. The intention was to look for movements or visual structures representing three seasons: Winter, Spring, and Fall. The director identified each selected moment's specific parameters for testing on the stage. To represent the season's energy and help refine the system, the A.D. has developed keywords to communicate her ideas:

- Winter **(Fig. 5)**: sleeping seeds, resting, and rearranging,
- Spring **(Fig. 5)**: petals flying away, germination, and exploration
- Fall **(Fig. 5)**: dead leaves, picking, and meeting

Through these keywords and key concepts, both the developer and the dancer could imagine their respective means of expression to converge toward a coherent creation — the dancer with her body, the developer with the evolving virtual ecosystem. In a previous work, our experiments indicated the importance of a shared vocabulary between the different creative spheres for corresponding to the artistic intentions with visual and behavioral aspects of the virtual generative system.

The A.D.'s exploration of configurations and behaviors of interest was fruitful for experimenting beyond the developer's

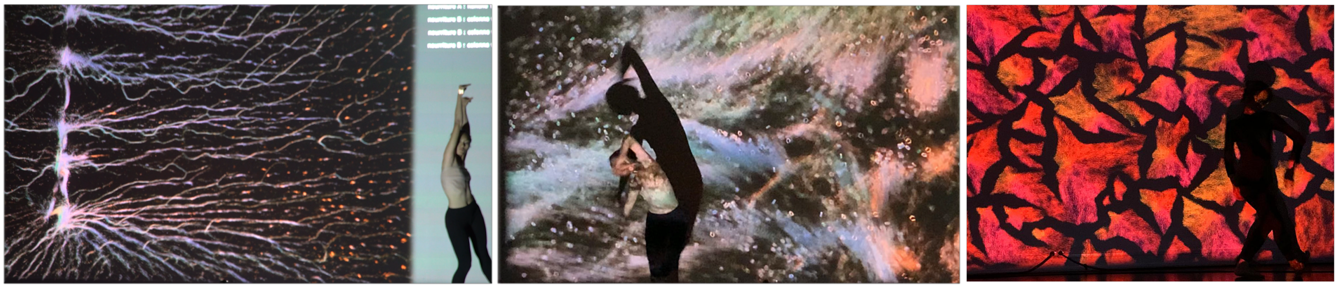

Figure 5: Winter, Spring, and Fall represented on the performance. ©CECCI-H2M.

expectations. We witnessed new visuals and behaviors by having another person with different expectations and ideas explore the system at the software level. From the various possibilities of rendering and behavior discovered during the experimentation of interaction between the dancer and the virtual system, the A.D. presented new ideas and directives of narration, choreography, and suggestions for exploring space. This phase of match-up amplified the horizon of sensations and concepts included in the performance.

Performer

During performative experiments between the performer and the evolving virtual ecosystem, it was interesting to observe how one modifies or influences the behavior of the other according to their progression over time. The method used to qualify and analyze the interactions promoted during our experiments was the examination of the videos of the rehearsals, the explicitation interviews, and the study of different visuals from the moments of interaction.

The representation of the performer's body in the form of the virtual agents' food points was possible only during the match-up tests. Before the match-up tests happened, in this specific research-creation residency, the performer's artistic style follows an all-encompassing principle that represents the natural order of the universe and emphasizes the importance of living in harmony with it. The practices of performer's dance are the cultivation of inner peace that originated from the sage Laozi: "The way (Tao) gave rise to the one. The one gave rise to the two. The two gave rise to the three. The three gave rise to all the ten thousand things" [**?**]. With the keywords (shared vocabulary) developed by A.D., the performer absorbs, internalizes, and transforms these concepts through the inner path of the body to understand and explore the visual and luminous impressions coming from the projection.

The process of understanding and exploration of the performer demonstrates adaptation progress of freedom through perceiving the environment. The performer mentioned that her ideas of movements in this experiment are no imposed figures before the match-up tests between the two partakers(the performer and the virtual system), instead, it presents a great deal of freedom of exploring the aesthetic potential for the performer herself who can, according to the intention, speed up or slow down, move or stand still, stretch or contract, using her body to create a new representation and give free rein to the imagination.

The intention of the dancers gradually changed as the match-up tests progressed. The intention changed from paying attention to the internal energy transformation of the body, to feeling the temperature and density of the performance space, and to perceiving the behavior of different species from the virtual system. We further discovered how the system reacts to the performer's specific movements and what behaviors would be necessary for the interaction to be visible and graceful **Fig. 6**.

An example of co-creation during the match-up phase was adjusting the speed of the performer's movements so that the virtual agents could adapt and have time to reach the food. The dancer's movements had to be slower, and the maximum magnitude of the virtual agents had to go up to achieve a balance between responsiveness and autonomy of each virtual agent movement. This necessity was evident in the winter scene, where the camera's point of view was far away, and therefore the movements of the agents were less evident in the short term. To make them more visible, we had to increase the agents' responsiveness and maximum speed. This decision influences the selection and reproduction of the agents that will persist in the ecosystem: only the fastest agents are selected. To balance the virtual rhythm with the performer's movements, we had to slow down the performer's movements and give the agents time to reach the food, even if they were slow. The goal was to seek a more varied selection over time.

Figure 6: Different moments of the system match-up phase by the performer ©CECCI-H2M.

Analyzing the videos of the match-up experiences, we observed compelling movements of the performer towards the virtual system — signs of imitation attempt to understand reactions and immersion in the rhythm predominant in the projection. The stage manager also experimented with system parameters to make the interaction more or less apparent.

The interaction's rhythm, speed, and power were still in the research phase. The evolution process of the two interactors fluctuated according to the power of reactivity of the system concerning the performer. The variety of behaviors and viewpoints extended the scope for imagining a story or narrative that would explain the different behaviors, such as different personalities or characters of the visible agents. The heterogeneity of behaviors among the agents made it easier to have affection and empathy towards the personalities and the representation of an environment inhabited by various autonomous and unpredictable entities. The contrast highlights this variety: when we see that over time, the agents standardize their movement towards more speed and responsiveness to reach the food points more quickly.

Unlike the procedure with the artistic direction, the matchup phase carried out with the performer was much more embodied and based on her sensitive, tactile, and energetic perceptions of the scenic atmosphere created by the evolving virtual ecosystem. This intention-in-action (in contrast to prior intention) [**? ?**] adapted by the performer focuses on the significant association with awareness and randomness. She is present and lives in this autonomous scenography through the improvisation practices of freedom. However, she did not consider the system's functioning, so we cannot say that being an evolving ecosystem, conceptually or technically, has influenced the quality of the interaction or the dynamics of co-creation. The dancer states that she had the impression of being in a space without gravity ("outer space"). We would like to know if we were close to embodied immersion in the virtual environment.

Initially, the variety of movement and the autonomy in the agent's decisions (the need or not to seek food, variety of attraction forces) moved the interaction away from the feeling of control and manipulation on the part of the performer. Instead, it became a feeling of immersion in an environment, in a cohabited atmosphere, where the influence between one and the other is relative and negotiable. In a retroactive dynamic, the ecosystem follows the performer, and the performer guides his movements through the rhythmic effects in his surroundings.

Stage Manager and Developer

The developer took notes and screen captures of the corresponding configurations at the specific moments that inspired the A.D. Nonetheless, the patterns depend not only on the system parameters (indirect controls) but, above all, on the interactions' history. Therefore, the variables captured by the developer only contributed partially to reproducing the moments chosen by the A.D. The vocabulary stipulated by the A.D. was the primary support for investigating the desired appearance. Guided by the keywords, the developer improvised and directed the agents to behaviors or organizations close to the metaphors expressed by the keywords. For example, if the intention was to have a warmer, agitated, and chaotic scene, the developer/stage manager sought to modify the parameters without knowing the exact consequence of such changes to seek a rendering close to expressing such keywords.

Though it was difficult to impose a specific appearance or behavior because the system was not controllable (and that was not the idea of the experiment), the developer mediated the dynamic between the A.D. and the system. To understand or predict the emergent patterns of the changed parameters associated with the interactions with the performer and the history of the millions of parallel interactions whose comprehension eludes us, we had to improvise and explore the system's possibilities in an almost striving relationship. The results of this match-up effort were sometimes disappointing for not rendering the desired appearance. However, it was often surprising to discover more satisfying visuals than expected.

We developed an interface to interact with the scenes and system variables, allowing the freedom to adjust parameters in real-time. During the presentations, this freedom was essential for taming, exploring, and discovering new movement possibilities and the virtual system's appearance. Since it is an evolving system, the parameters cannot be fixed beforehand but can only be tweaked by the stage manager during the performance. Therefore, desired aesthetic ambiances must be pursued and evolve gradually through interactions and temporal and spatial transformations of the virtual system during the performance.

Discussion

Symbiotic Imaginaries and Autonomous Individuations

The system did not count on physics simulation, and the agents did not detect collisions (despite a tendency for separation, according to the boids algorithm). Instead, the entities agglomerated, overlapped, and gave the impression of mass and fusion: as if the whole formed another element. This impression is also due to the agent's persistent alignment and paradoxical erratic manners between cohesion and repulsion. This behavior showed volumes of virtual matter moving in one direction, volumes presenting deformities and noises in their contours and shapes. From the more distant point of view, which shows the organizational phenomena on a large scale and collectively, we can see the paths formed by the agglomeration of virtual agents. The agent's trajectory features became visible through the effect of image accumulation and the reduction of their opacity. The patterns created by the endogenous interactions and their speed and direction adaptations concerning their neighbors become evident. This scene shows a less individualizing level of the agents. However, it makes visible the formation of agglomerations that resemble the formation of other individuals or at least other configured forms of a collective or a mass of agents **(see Fig.7)**.

The scene representing Spring is the one where the camera is closer to the agents in its scale. It reveals the entities' geometric shapes, colors, and particular behaviors. Therefore, it is a scene where the composition is more dynamic and faster, the images are beyond the control of the stage manager and

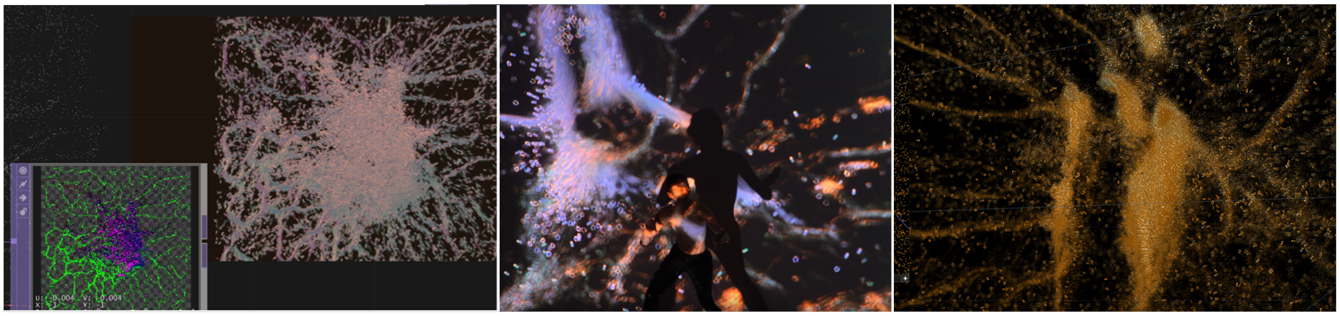

Figure 7: Volumes formed by the agents' agglomeration, forming the impression of new virtual entities ©CECCI-H2M.

the dancer, and the interaction is more mysterious depending on the area of the ecosystem focused by this point of view. Regardless, another type of empathy is produced by this scene. The dancer can differentiate each agent's life stages, birth, search for food and path, and death. That is when one understands that an association of individuals forms the previous image.

The diversity of behaviors and the multiple imaginaries inspired by the different scales of observation of the virtual system encourage us to explore performance through the evolution of interaction without having a narration or a script beforehand. The idea is constructed around and with the virtual scenography presence and by the curious exploration of its aesthetic and interactive possibilities.

While, initially, we did not have a script or description for the performance, the narrative's structure began with the virtual system's development. We manifested our imagination about a virtual performance of autonomy while constructing behavior and interactions between agents. That autonomy, in our case, is not only expressed at the virtual individual level but on the emergent collective appearances as well. It is about multiple endogenous and indirect exogenous interactions, inducing unpredictability and a sense of disobedience, resistance, or even conflict. Furthermore, the choice of losing control over the system's transformation also abstracts our intentionality. The system enacts our initial intentions and ideas, and then it is left to develop independently. Whitelaw raises these issues about the challenges of operating Artificial Life as a tool because it also carries a conceptual and cultural engagement in its expression and choices. Engagements that are narratives themselves [14].

Symbiotic Creativity

Another way of seeing the emergence of new forms than the neo-Darwinist interpretation is symbiogenesis, proposed by Lynn Margulis [5]. This theory of the vital evolutionary path intersects with McCormack's vision of creative emergence through the combination of forms and behaviors. This biological approach inspires our assumptions about appropriating natural Life with technology. As Tenhaaf indicated: we take "biology as a ready-made" [12]. The concepts and techniques of artificial life simulation guide us toward the emergent affinity between the performer and the evolving virtual ecosystem by treating the two interactors in another ecosystem where we add the scene's environment. We aim for codependent relational recombination between the parts to form a conceptual and creative symbiogenesis: an association of movements, gestures, shapes, and compositions.

As explained by McCormack, the ecosystem can be more than just virtual; the user, the system, and the environment can form it. That implies the vision of the virtual system not as a tool but as a member of the scenic ecosystem. Therefore, symbiotic creation can be considered at two levels in our project, endogenous and exogenous. The endogenous symbiotic interaction exists in the association of agents when one takes advantage of the trajectory of the other to achieve its goal. On the other hand, exogenous interaction allows the organization of a symbiotic association at the level of the stage's environment. A dynamic of cohabitation between the artistic team and the virtual system is set up in a scenographic form.

Concerning the limitations and possible improvements of the virtual system, on the other hand, the task that measures the ability of agents to survive in the virtual environment is the ability to feed. This task was revealed as a not-very-creative one. Since the food is the dancer's body, the main task is to follow the dancer's body, and it was solved by selecting the most agile individuals. Nonetheless, we identified more creative tasks in the aesthetic domain: the movement and its variety and the creation of unexpected patterns. These aesthetic observations are paradoxical with the selection process we have implemented — the current dynamic values the standardization, speed, and concentration of agents on feeding themselves.

A solution would be to reverse the agents' aptitude evaluation to appreciate those not following the performer's movements as a priority. Instead, we aim to value those who prioritize the tasks of interaction and distraction in the virtual environment while keeping their need to feed themselves. These tasks that prioritize variety correspond better to the moments when rendering and behavior were more interesting.

Our new challenge is to keep a clear interaction with the dancer and choose another dynamic to enhance the variety of behaviors and value the "dancing" aspect of the agents. It is a programming approach of an aesthetic choice in the language of the rules of the ecosystem's algorithmic way of working. This translation from an aesthetic realm to a symbolic realm is our next step and our new challenge concerning metacreation and symbiotic creation.

Conclusion and Perspectives

Adding unpredictability to the stage dynamics allows the dancer to improvise and discover new movements motivated by the virtual system. Those movements are perceived by the system and modify it, establishing a creative feedback loop. The project provides us with reflections on co-creation in a symbiotic way on many levels. The stage manager performs to acquaint the system; the artistic director draws inspiration from the behavior for staging ideas, and the dancer modifies and improvises according to the perception and reactions of the system. At the internal level of the system, apparent associations between the agents form cohesive and expressive volumes.

We have put in place since last year a system to enable co-creation, which could be used as a creative partner in the process of performative dramaturgical creation (in contrast to the notion of a tool). In a metacreative approach, we have designed a machine that generates evolving patterns and graphic behaviors. The creation methodology schematized in **Fig. 1** (indirect interactions during the match-up phases) is the most critical result. It makes it possible to adapt our team's system and creative process to other contexts of symbiotic metacreation for the performing arts.

Acknowledgments

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Isadora Teles is a Brazilian artist based in Paris. She is currently a Ph.D. candidate within the INREV research team at the University of Paris 8. Her artistic research and practice are in the fields of digital generative art, artistic modeling of self-organizing systems, and the design of interactive interfaces for live performances.

Chu-Yin Chen is an Artist and Professor in Digital Art, INREV research team at Paris 8 University. Her creations, based on Artificial Life and complex systems, develop interaction modes between audience and virtual creatures showing autonomous and evolving behaviors. Her digital artworks have been shown in numerous international exhibitions. Her research articulates two overlapping areas: 1] Digital Creation using algorithms of complexity and emergence, and 2] Metacognition and Elicitation of the processes of creation, enaction and aesthetic reception, via psychophenomenology and mindfulness.

Hui-Ting Hong is an experimental artist from Taipei, Taiwan. Based in Paris. She focuses on the interaction and transformation between the body, space, and mind. She aims to explore the existence and reproduction of the human body by expanding the boundaries of perception. Her research-artistic practice focuses on the perception of bodily movements and the hybrid human body, particularly discussing the virtual representation of the body and its energetic variation.