# *The Trained Particles Circus*: Dealing with Attractors, Automatons, Ghosts and Their Shadows

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## ABSTRACT

*The Trained Particles Circus* proposes an improbable, precarious and potentially dangerous meeting place caged between the real and the virtual worlds. Embodied in the relationship between synthetic biomechanics and an automaton, it recreates the figure of the circus artist, the puppet with its own life or the fantastic animal; and it places us as spectators into a contemporary spectacle of hybrid and augmented subjects that conjugate light and shadow, fake and magic, virtual and physical reality, machine and organism [1].

*The Trained Particles Circus* attends to two lines of convergent research. In the first place, it approaches the elaboration of algorithms and programming from creative speculation. While algorithms are logically described step-by-step procedures in the context of computing and programming, being the way we communicate with machines and computers, artistic thinking appears to be governed by other mental processes, sometimes even totally removed from logical access. Even if it turns out to be the elephant in the room, there's a hovering question related to technological art, about art made by digital machines: Is an artistic algorithm possible?

We could be reminded that we have built rational explanations of the world with systematic strategies 100 times before. And every time, we have hacked these explanations with uncontrollable fantasies. Maybe because we know, as Serres said, that what exists (the most probable) is the disorder, the chance and the exception. That the real is not rational. That there is only science of the exception, of the rare and of the miracle [2].

*The Trained Particles Circus* evolves in the chaos of creativity and in the rules of algorithms, in a real coproduction, as reversible routes, as universal joints between humans and machines, between knowledge and disciplines, between logical explanations and poetic insights.

*The Trained Particles Circus* embodies the corporeality of a software entity as a virtual and physical machine. This digital-physical ecosystem feeds on elements and metaphors coming from the context of the circus (and by extension, the trick, the stage and the show) and the symbolism and physicality of its hardware elements (the cage and the automaton).

## An Archaeology of Technological-Artistic Media

*The Trained Particles Circus* is linked to an archaeology of technological-artistic media and belongs to a tradition of artifacts, devices and elaborations of speculative nature about the gist and functioning of the machine. Although it borrows its name from the flea circus [3], it is also a nod to Alexander Calder's Miniature Circus [4] and to the metamechanics of Dada, Marcel Duchamp or Francis Picabia. Like them, it refers to a production of imaginary worlds driven by the force of the virtual and revolving around a singularity (an element of chance or "straying cause") that always exceeds the structural relations put forward by mechanical laws [5]. As an object of augmented quality, as a meeting between real-physical dimensions with others of a virtual nature, the Circus is also linked to other devices that pursued, through more or less advanced technologies, the inclusion of the fictitious in the real, related to the spectacle of the theatrical—from Pepper's ghost, through soft-tricks, mirror games and sideshow illusions—to reach contemporary digital augmented realities (Fig. 1).

Fig. 1. Emmy Hennings on stage as "truth-speaking" spider, 1915 [13].

## A Scientific-Artistic Object

By developing a software entity based on the behavior of particles subject to the laws of attractors, *The Trained Particles Circus* works with the simulation of physical laws. In addition, particles' visuals and their relationships are constructed in a context that deals with the nature of light through a beam splitter (a Pepper's ghost device). Its peculiar location between an artistic object and a scientific one, as an artifact and as an instrument, refers to both an aesthetic of the invisible and to data visualization; to a protected place like a Faraday cage; or to a place sensitive to invisible objects, bodies or phenomena (Fig. 2).

But here, the implicit leap of faith that gets hidden behind instruments of scientific vision becomes a place for the management of the impossible. The scientific reason that constructs objects in order to know how the world works becomes, in art, an objective resolution of the very enigma that the same objects pose. From this experimental condition, *The Trained Particles Circus* relativizes the specific objects of artistic and scientific research, as well as those related to technological magic, to bring materiality and context to digital data as part of a need for contemporary artistic practice.
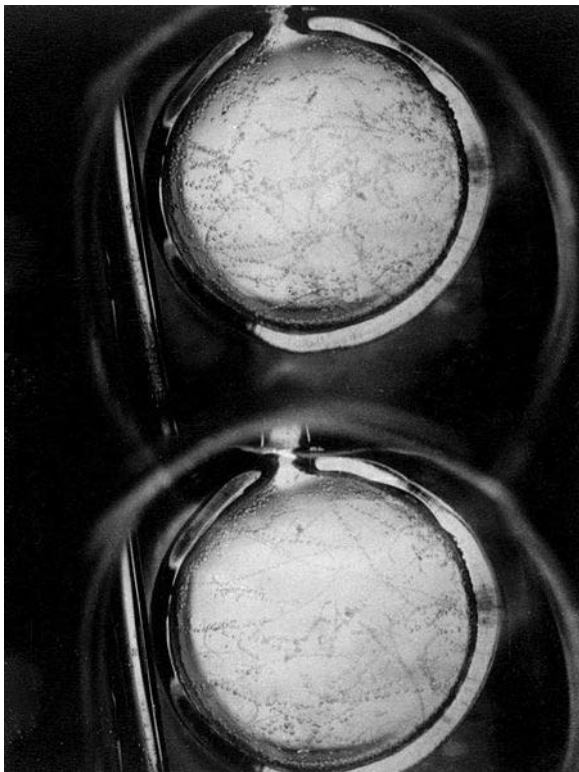


Fig. 2. The scientific object as a visualizer of the invisible. First tracks observed in liquid hydrogen bubble chamber by John Wood, 1954. (English Wikipedia, original upload 25 December 2004, public domain.)

## Related Works and Approaches

From a technical approach, Blair Neal's *Survey of Alternative Displays* (2016) exhaustively documents the different ways of combining light and image from a contemporary perspective of electronic displays, suggesting the search for new ways to construct images, creating portals into other humans' imaginations [6]. *The Trained Particles Circus* is linked to these portals in order to generate new poetic correspondences embodied in different actors and materialities. In these augmented worlds, beyond their technological approach but always melted in the digital crucible, different materials and concepts are shaped mutually, translating their meanings through blurred borders. This is the case, for example, in Chris Sugrue's *Delicate Boundaries* (2007) [7] in the early territory of expectations and understanding of interfaces, showing the possibility of the translation of the digital worlds into the physical world. *Pixel* (2014) [8] presents a virtual/physical dialogue on stage through dance, mime and also circus keys. But the most relevant link is established through the artistic processes involved in the realities generated technically, seeking interaction between poetic thought and technical action. Just like Georg Trogemann [9] points out about Ralf Baecker's works, they should not be considered exclusively as finished artifacts, but as intermediate states of aesthetic and cognitive processes. States that remain in evidence in Quayola's unfinished objects (*Sculpture Factory*, 2016) [10] in which having injected algorithms of sculptural processes to large industrial robots, these reflect the inability of the machine to ever reach the end and the aesthetics of those objects.

## The Circus

Technically explained, the work happens in a metal cage (Fig. 3) that shelters the virtual and physical body of the Circus. The particles and their connections, dissected through a Pepper's ghost in light and shadow, dance alongside an automaton that is composed of umbrella rods and servos in an illusory common space.

All its movements, images and sounds respond to the activity of a software entity, constrained to interaction through attractors. The data generated by the attractors is visualized in real time by means of a particle system, to the movement of small mechatronic arms through 10 microservos and to their sonification by a sound synthesis. The show offered by the Circus lasts approximately 20 minutes and it is composed of different acts or scenes. The show is always the same, but the inclusion of a random factor in the programming makes each interpretation slightly different from the others. The core of programming, that is, the attractors, is arranged in the manner as follows.
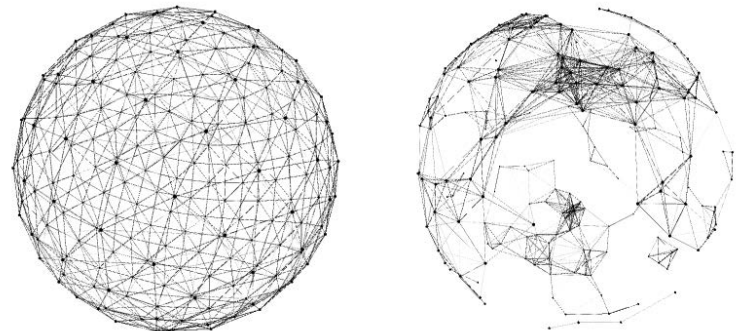


**Fig. 3. The metal cage of the Circus, showing the disposition of the monitors, the semitransparent mirror and the rods. (© and Photo: Patxi Araujo)**

## The Physics (an Artistic Research into the Nature of Attractors and the Sphere)

Given a sphere whose points are equidistant and ordered in a three-dimensional space of spherical coordinates $(r, \varphi, \theta)$, its points are defined by the distance to the center $(r)$ of a given length $(\varphi)$ and latitude $(\theta)$. If the values $(\varphi, \theta)$ are substituted by others belonging to a random series and when we feed back that primal sphere with the result of this operation, we will obtain another one whose points are ordered erratically. By joining the points closest to each other, like constellations in the celestial vault, we will obtain an order or structure of proximity in its sky.

This order does not mean that there is communication between its points. As shown in Fig. 4, the intensity that we perceive is due only to the geometrical proximity configurations. In fact, changing the starting point of that randomness, we will build different night skies of fixed stars. We look at nonmutant universes, where beyond possible interpretations that we may venture about their forms and meanings, there is no communication between points, no real interaction.

But if we convert each of those point-star-vertices into attractors, and act in the same way (refeeding that sphere with this new information), we will be facing a dynamic



**Fig. 4. Connections between points of a sphere through geometrical proximity configurations. (© Patxi Araujo)**

geometric body that occurs inside the potential universe of the sphere, one that no longer allows it to be a sphere again. By injecting force into the points that constitute its structure, and varying the parameters of these point-attractors (in terms of their direction, force and radius of attraction), this geometric body will begin to look for itself in a sort of emerging behavior. Without possible anchoring beyond the boundary of that expanded sphere, it will alternate between stability and disturbance scenarios, sometimes developing periodic and mutant orbits, unstable or subtly suspended from invisible magnetic structures. Generated
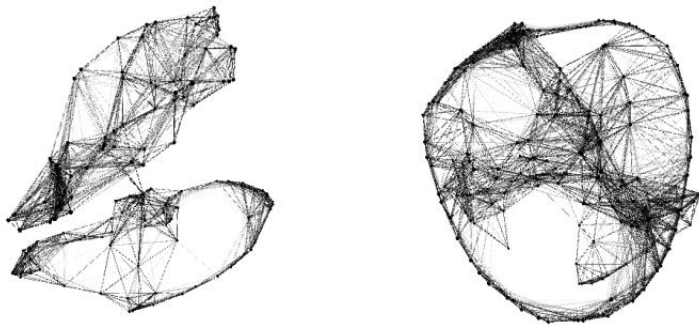
Fig. 5. Possible configurations of a sphere after feedback of its points as attractors. (© Patxi Araujo)

in real time, and like any dynamic system, it cannot repeat itself because any difference in the start state of a single variable (or even due to the state or nature of the hardware that hosts it) will make its subsequent development vary substantially. However, after an indeterminate number of cycles without changes in the parameters of the attractors, that structure may find accommodation in a specific configuration, such as those shown in Fig. 5.

By adding different radii (r) to an attractor's sphere, and in the search for continuous adaptations to different force-balance scenarios, the system can leave behind similar configurations to rhythms, to organic flows, to imaginary engines of fantastic mechanics, in a weightless dance that is nevertheless subject to the interrelated forces of each of its vertices. These alliances are based fundamentally on the principle of proximity between particles, so that, as it would happen in a magnetic field, two adjacent particles generate a bond of attraction or repulsion, which is stronger the closer they are to each other. But sometimes, the particles behave strangely: The magnetic intensity of these virtual attractors establishes connections with distant particles, like vortices, violent ejections or stable links. In other cases, adjacent particles do not respond to proximity, remaining unlinked or even disconnected from any movement or relationship.

### When the System Is Juggling

This strangeness in the way that the system decides which of those particles will release links to others, and how they will be visualized, is a matter of graphics processing unit (GPU) computing [11] and, mainly, of small "synchronization errors" in the programming. But we are not interested in its logical explanation; it is not relevant as far as this research is concerned. What is relevant is the circus metaphor that emerges from the core of the machine, the one that suggests that the system is playing, that it seems to be juggling. This consideration of binary logic as a playful whim of the digital is understood as a creative link between the artist and the machine, or what is the same, as a process of cocreation. If the license is allowed, the machine and the human are playing, not because they know the rules of the game, but because they enjoy it. Until this moment, that is to say, the one of the appearance of the metaphor of juggling, the visuals of these attractors had neither body nor context. But since the inclusion of that playful sense in the ingredients of the system, not expressed as an algorithm but as a desire for meaning, it was decided to give that software entity the category of circus artist. From now on, its raison d'être will be explained from the concept of a show.

### A Digital Puppet

Figure 6 shows how all links between particles are visualized as threads of a complex synthetic web. It exhibits characteristic behaviors of a living being, not restricted to particular examples that may have evolved in a natural environment, but to native digital evolutions or even to purely theoretical approaches. In any case, the digital object of unions created by the particles turns out to be disturbingly organic. The structures that underlie those movements and changes present a living (or nonliving) organism, which develops



Fig. 6. The image that emerges from this algorithmic game and graphics computing imitates structures of the organic field from a strictly digital nature, appearing to have a life (or a nonlife), insofar as we refer to it as an autonomous synthetic creature or as a digital puppet. (© and Photo: Patxi Araujo)

adaptively in a medium governed by its own physical laws and whose survival (as a metastable equilibrium) is in perpetual question.

## A Shadowed Ghost

The digital body of the particles unfolds inside a closed cage, in a space dramatically illuminated by a zenith focus. There is no escape neither to the theatricality of that scenario nor to the metal bars of the cage. Just as an experiment arranges its elements to trigger a certain reaction, the Circus arranges its lights in its sheltering space. As an object of augmented nature, the Circus combines virtuality with physicality. It exists as a physical body that houses in its inner space another virtual nature through the use of an alternate reality (AR) device (a Pepper's ghost), allowing a coherent dialogue between its parts. However, in order to enhance its virtual element with physicality, or better, in order to invest magic with reality, the Circus proposes the paradoxical vision of a virtual body with attributes of a physical world. In the conviction that every object with the capacity to project shadow would be welcomed into the realm of the real, the virtual image of the particles owns its shadow, as shown in Fig. 7.

## Surrounding an Optical Effect

Every Pepper's ghost allows light to travel as a reflection, paving an optical path to a fictional place; in fact, what is hidden behind a Pepper's ghost (behind all augmented reality by extension) is an image of reality as a mental product, as the implementation of a fictitious element capable of endowing the real with coherence (or madness). In this case, joining the particle-light object with the particle-shadow object also allows us to visualize its separation, its belonging to different realms. But, unlike other Pepper's ghosts, the Circus allows itself to be surrounded and observed from any angle, which means that the magic of the optical effect vanishes, revealing, at the same time, its stage mechanics. This game links us and separates us at once both from reality and fiction, leaving in our hands the decision to place ourselves on either side of the mirror (Fig. 8).

## The Automaton

The particles constitute a precious object, subtle and fragile at the same time, mutant and ephemeral. Its image and movement respond to the ideality of the bodiless bits in the perfect abstraction of the code that generates them, where there is no friction, no noise, no wear. To its synthetic nature corresponds a projective space into the nonspace of a Pepper's ghost. However, they share this virtual space and protagonism in the circus arena, with an automaton whose mechanical essence reveals that it is subject to a different physics. It is the physics of engine noise, the friction of its articulated mechanisms, the wear of time, the exhaustion of work and the possibility of error and collapse. Its movement accompanies the elegant particles, scratching them without touching them, seeming to sew and undo the tangle of the synthetic fabric from its mechanical nature (Fig. 9).
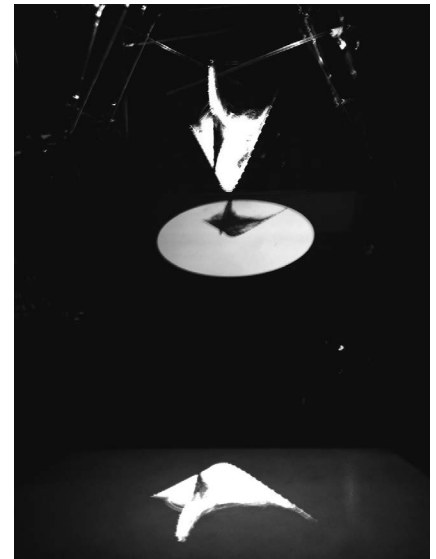


Fig. 7. The visualization of the particles has been dissected by software in particles-light and as particles-shadow; while the light is presented under the gaze of a frontal camera, the shadow is viewed from a zenith camera; the light-image of the particles are projected virtually through Pepper's ghost over the shadow-image of the particles, which are housed in a monitor. (© and Photo: Patxi Araujo)



Fig. 8. The light particles disappear if the work is observed from its back. This allowed view from the other side of the mirror brings us to the quantum and philosophical doubt of the existence of the not perceived reality. If a Pepper's ghost is continuously transferring the light-image of the particles to that stage: Are they there if we do not look at them? (© and Photo: Patxi Araujo)
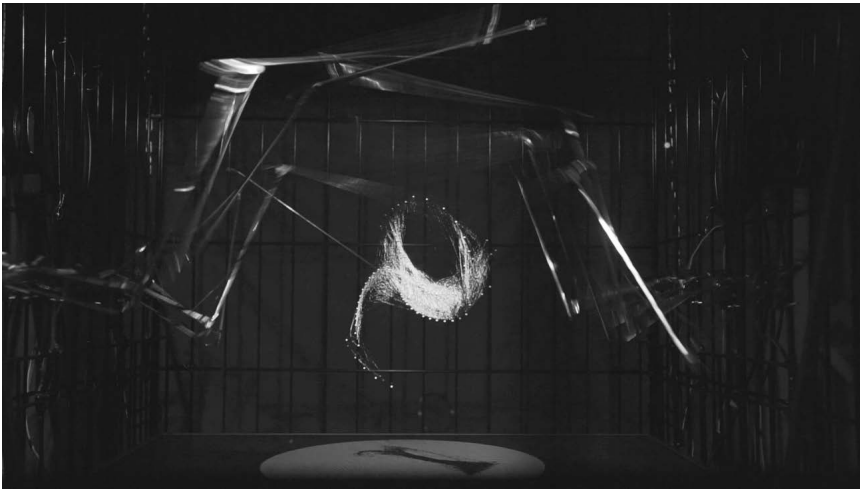
Fig. 9. The automaton and the particles are fed with the same data so their movements are synchronized, and both share the illusion of a real encounter in that protected space-time. The logic tells us they are separated by an invisible border, but their dialogue is the work. (© and Photo: Patxi Araujo)

## The Sound

In order to better understand each set of movements between particles and the relationships that are established between them, the Circus interprets its own musical score in real time. The same forces that govern its visuals are taken into sound synthesis, so that we listen to the activity of the system, to its tension and to its resolute search. The sound projection system uses the metal structure of the cage as amplification, so that the sound is emitted structurally from the physicality of the work. From here, *The Trained Particles Circus* becomes its own electroacoustic orchestra, whose interpreters are the particles and whose score is written in the drawing of their movements.

## Conclusion

This paper identifies the nature of the circus as an ideal place to host a possible scientific-artistic-speculative symbiosis. In it, reality and fiction are found to be precarious, almost outsider, hardly exportable, halfway between the credible and the fake, between amazement and extravagance, science and simulation. The circus, like programming, generates universes that house possible worlds, games of mirrors where the final result of their potentialities is not programmed (something on the other hand exponentially complex) but is the structure that allows these possibilities to happen. Attending to the unwritten rule *el más difícil todavía* [12], *The Trained Particles Circus* intends an implementation of variables of poetic order toward the logic of binary data and the substantial contagion between entities of a synthetic order with others of a cultural human nature. Although we know of the fragility of this territory, we consider it inhabited by arguments worthy of being defended and that we consider a fundamental part of our ongoing research.

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