Boidance

Software Expanding Dance Using Virtual Reality, Boids and Genetic Algorithms

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ABSTRACT:

Boidance is a software tool that brings together Performance, Virtual Reality, Swarm simulation and Genetic algorithms. We discuss a tool that enables performers to move with(in) a swarm of virtual geometrical shapes, developed in a collaborative process between dancers, choreographers, and computer scientists. Boidance creates new possibilities of expression for dancers using Virtual Reality, generating a non-static swarm movement simultaneously independent but influenced by the dancer. A Dancer performs inside a VR environment populated by a swarm of pyramidal elements behaving in a similar way to the group movement of a flock of birds, a school of fish or a swarm of insects. Performances can be recorded or viewed live through virtual cameras on stage. Boidance is configurable through two interfaces: in VR and on desktop. Finally, Boidance allows spectators to explore the dance scene with virtual cameras. Boidance is an open-source software available at: CHANGE ME. Boidance is intended to be used as a tool for dance exploration and performance.

ARTEFACTO'20, November 2020, Faro, Portugal

https://doi.org/--.----/----------

CCS CONCEPTS

• Applied Computing~Art and Humanities~Performing Arts • Computing Methodologies~Computer Graphics~Graphic Systems and Interfaces~Virtual Reality • Computing Methodologies~Computer Graphics~Animation~Procedural Animation

KEYWORDS

Dance; Virtual Reality; Boids; Swarm Behavior; Performance; Emerging technologies.

ACM Reference format:

Clément Caporal, Cecília de Lima, Rui Filipe Antunes. 2020. Boidance: Software Expanding Dance using Virtual Reality, Boids, and Genetic Algorithms. In *Proceedings of ARTEFACTO conference (ARTeFACTo'2020). ACM, New York, NY, USA, 8 pages.* https://doi.org/--.----/-----------

INTRODUCTION

From its early days in the 1980s Virtual Reality (VR) technologies have raised the interest of experimental artists exploring the possibility of playing with the change in perceptions of the body, space, and time the systems would endow. The 1990s have witnessed a wave of explorations on the use of VR in performative contexts (e.g Eduardo Kac, ieVR, Blast Theory). However, until recently, the potential of VR to dance has been largely unexplored.

We could speculate about the reasons for this fact, but the richness of traditional dance performance, which can bring two or more performers together in physical dialogue speaks for itself. The headset is a huge barrier, perceptively confining the performer, inhibiting visual cues about the surrounding environment. However, VR brings us the challenge to think about dance, not from a traditional perspective but to rethink what dance could be.

Recently, a combination of factors has revolutionized the technology of VR making it available to the mainstream market. On the one hand, the audience can get immersed in scenes with high definition using headsets with great resolution combined with off-the-shelf powerful VR-Ready computers that are able to deliver high definition graphics rendered in real-time. On top of this, fast network technology allows multiple users to enter and share the same scene. On the other hand, the audience can now deploy VR scenes in their mobile phones using light 360 degrees visualization techniques. These aspects have brought great attention to VR attracting artists and content developers to this medium. Can the nature of dance be altered by this potential?

Boidance is part of TEPe (Technologically Expanded Performance - https://tepe.estudiosdedanca.pt/) a research project that amongst other objectives, is focused in expanding and challenging the field of dance and performing arts by investigating new technologies in relation to the bodyscape in the city. With Boidance, we want to question the nature of the movement itself. What can we learn from dancing with flying insect-like entities behaving in a swarm? Boidance is a choreographic tool that produces an immersive interactive environment inhabited by a swarm of autonomous elements designed as pyramids. These elements have a bio-inspired behavior as they act as an insect swarm. They have autonomous behavior. However, when the performer enters the environment, they start to dance with him/her, taking into consideration his/her movements and integrating these with their own behavior.

1.1 Description

Entering the system, the performer -using a VR wireless headset and two handles, one on each hand- sees a series of pyramidal shapes. These, act autonomously moving as if a swarm of insects, or a flock of birds. Depending on the existing configuration, moving the head or his/her hands (position, rotation, acceleration), the performer impacts on the behavior of the swarm which keeps trying to reach an equilibrium. A video projector allows the visualization of the scene in a large screen. An operator can switch the position of the camera. The operator can also adjust parameters of the swarm (Behaviors, explained below), changing the properties of its movements as well as properties such as colors or shapes.

For ARTEFACTO we propose two modes for our presentation: a short paper presentation and a performative presentation. To demo this system, we will have a performer interacting with the virtual environment, with the audience watching the action shown projected on a screen.

STATE OF THE ART

VR was built on the idea of creating a fabricated artificial environment that is in fact perceived as real by the physical body of the audience when wearing the equipment (typically a headset enclosing the eyes, and a joystick or handles to manually interact with the virtual world). From its inception in 1980, and given the explorative potential, experimental artists have explored the technology in a wide range of creative approaches.

Placeholder, a work from Brenda Laurel, makes use of VR technology to play with the perception of the audience. Immersed in the virtual environment, the viewer can experience the world from the perspective of different animals and birds [9]. VRs have also been used to engage with languages closer to socio-political commentary, for instance Desert Rain from the British group Blast Theory, plays with the idea of the growing virtualization of reality, denounced by French thinker Jean Baudrillard, in particular the work focus on the second Gulf War when the aggression processes of war become clearly more disengaged, virtualized and game-like [7].

Recently, the technology became relatively accessible to the broad consumer market. In the sphere of dance, this possibility gave rise to a number of works creatively exploring the aesthetic potential. In the words of renowned choreographer Akram Khan, talking about Giselle VR: "I think VR is unchartered territory. And in a sense the possibilities are immense. Your awareness is heightened because suddenly the reality is what you're seeing all around you, and there isn't something in between – there isn't space in-between, so you look down and you're on the ground where this film in taking place – it's surreal" (Akram Khan cited in [14]). GiselleVR plays with the concept of placing the viewer within the action, next to the dance performers. This approach, of bringing in the spectator to the scene, is something seen in other recent works (e.g [13], [6], [3]). When the audience member is in the center of the show, she can also play an active role in the act. In Stuck in the middle, the spectator can become part of the performance, as the dancers offer to teach them sections of the choreography. Recently, in VR_I, five virtual performers danced together sharing the virtual stage. Gilles Jobin addresses the concept of spatiality playing with effects on the scale of the performers who can become giants or tiny elements in the scene bringing a twist to traditional scenography [6]. Another example of new scenography possibilities introduced with VR is Dust, a work from Andrej Boleslavský and Mária Júdová and choreographer Patricia Okenwa, where the audience is also virtually placed in the immediate presence of the dancers, however becoming dust particles that can float around freely, even stepping inside the dancers [2]. Because the elements are not bound to a strict physicality objects in the virtual scene can show intelligence and dynamism. In Virtual Reality on 5 dollars a day, by Ron Kuivilla, a group of flying helmets are attracted to the trail of lights that follow the audience/performer movements [8]. In Bar code hotel, by Perry Hoberman, the audience activates objects that exist as semi- autonomous agents that are only partially under the control of their human collaborators. They also respond to other objects, and to their environment [4].

Taking this scenario into account, Boidance brings in a minimal scenography, introducing a virtual swarm that dances and interacts with a performer.

METHODOLOGY AND IMPLEMENTATION

To develop Boidance, we have put together a multidisciplinary team composed of computer scientists, software developers, dance teachers, choreographers, and performers. We have followed an Agile iterative process of development in iterations with mini increments of new functionalities and refinements based on the feedback provided by the performers.

2.1 Implementation

We make use of Virtual Reality to connect *a)* a dancer, with *b)* a natural swarm generated from two algorithms (genetic algorithms and boids). This section details the implementation of the swarm of pyramids. Boids is an algorithm developed by Craig Reynolds back in 1986, which simulats the behavior of flock of birds, and schools of fishes. Bois are implemented with each particle composing the swarm structuring its behavior based on three rules, i) separation from the neighbours, ii) avoidance of the neighbours, iii) cohesion of the group [12].
Genetic algorithms is a search heuristic that is inspired by Darwin's theory of natural evolution. This algorithm reflects the process of natural selection where the fittest individuals are selected for reproduction to produce offspring of the next generation. [5].
We will close this section describng the implementation of the interactions between the dancer and the swarm.

2.2 The swarm

It is composed by independent agents visually represented by pyramidal shapes. Each agent is defined using two types of information: i) Behaviours, and ii) Genes. Behaviours govern the movements of the individual in space and are implemented using the rules of the algorithm *Boids.* This juxtaposition of rules creates a “Composite Behavior”, which we will explain next. Genes govern the phenotype of the agent (its physical characteristics) and are implemented like genetic algorithms as “Plasmid”, which we also will explain below.

$$F_{composite}(X_i^t) = \sum^{behaviors} F_{behavior}(X_i^t) * w_{behavior}, X_i^t \text{ agent } i \text{ at frame } t$$

Equation 1 - Composite Behavior F is a function that outputs a 3-dimensional Vector, with *behaviors* as a list of behaviors and w as the list of weights associated with each behavior.

2.2.1 Composite Behavior. A Composite behaviour matches a list of behaviours and a list of weights. At each time t, Behaviours produce a force vector. This force vector is multiplied by the associated weight and then added to the other force vectors as a weighted sum. This weighted sum results in a composite force vector that will be the next destination of the element *(Eq. 1)*.

Available behaviors are *a)* cohesion, *b)* alignment, *c)* avoidance, *d)* obstacle, *e)* stay in radius, *f)* follow device, *g)* stay out of sight, *h)* stay in sight, i) match axis *(Fig. 1)*. These behaviours are combined by the composite behaviour which makes a weighted average of the strengths of each behaviour. The forces generated from the behaviours may depend on the environment of the agent under consideration. For instance, if the behavior *obstacle avoidance* does not detect any obstacle, the force generated will be non-existent (null). Thus, even if all agents have the same composite behaviour, their movement will be distinct if their immediate environment (their context) is distinct.

2.2.2 Plasmid For the genetic algorithm, we have opted for a model of gene transfer that is less commonly used. The dominant evolutionary model is Vertical Gene Transfer, where the children inherit the genetic information from their parents. However, Horizontal Gene Transfer is also present in nature, for example in unicellular organisms through plasmid (circular DNA). Here individuals transfer genes directly to other non-related individuals. This mode remains less studied, that is why we were interested in its implementation in Boidance. Following this biological inspiration, each element has genes defining its phenotype. The user can then choose to create a plasmid for a gene, allowing the gene of one agent to be released into the environment and transformed (integrated) by another agent. The phenotypic expressions of the genes available in Boidance are *a)* scale, *b)* shape, *c)* color, *d)* sight radius, *e)* avoidance radius, *f)* maximum speed. Not all genes can be transformed into plasmid. In the current implementation only the speed plasmid and color plasmid are available.
A plasmid is represented by a numerical value. When the user transforms a gene type into a plasmid, a target plasmid value must be specified. This target plasmid is the "ideal" value towards which agents should evolve. The numerical value of an agent's plasmid is determined by a fitness function that calculates the fitness value of this agent. The function determines the score according to the absolute difference between the numerical value of the plasmid and the numerical value of the ideal plasmid.
The evolution of the plasmids is governed by several parameters. The *mutation rate* is the probability of occurring a mutation in the plasmid when a frame is rendered. The *mutation range* is the maximum a plasmid can mutate from its original value. The *insertion rate* is the probability of integration of a plasmid released from a neighbouring agent. The *elitism threshold* prevents agents with a fitness value below the threshold from releasing their plasmid into the environment. The *lerp time* corresponds to the speed of the linear interpolation between the values of the old plasmid and the new plasmid expressing a new phenotype.
Plasmids are released into the surrounding environment. Thus, only nearby agents can transform (integrate) the released plasmid.

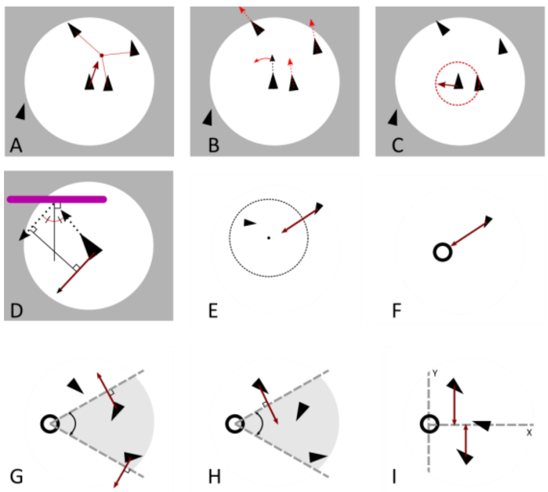

Figure 1: Available Behaviors in Boidance. Gray zone is out of sight zone. Centered agent is the considered agent for the behavior. The dark red arrow is the result force vector determined by the context of the agent. *(a)* Cohesion: stay close to others, *(b)* Alignment: match direction and speed of others, *(c)* Avoidance: avoid being too close from others, *(d)* Avoidance Obstacle: avoid hit contact with object, *(e)* Stay in radius: repeal force when too far from the center of the room, *(f)* Follow device: follow the position of a given device, *(g)* Stay out of device sight: avoid being insight the field of view of a device, *(h)* Stay insight of the device: repeal force when the agent is not in the field of view of a device, *(i)* Match device Axis: match the position on only one axis of a given device.

2.3 **Interactions**

By defining the Interaction parameters dancers can play directly with the parameters of the agents. These parameters can be the weight of the behaviours or the parameters of the plasmids. Dancers use the VR equipment to send information to the computer. This information is depndent on the dancer's actions and is characterized by a specific device and its state. A VR action is defined as the identification of a *device* and a *state*. Each VR Action is transmitted to the computer in digital form that describes the device and state. For example, the device right-hand in the state "trigger is pressed" is transmitted to the system by the combined variable (RightHand, triggerPressed = 1). This numerical VR action value is stord in Boidance as a four-dimensional vector. This allows complex information - such as quaternion rotation or position in 3D space- to be recorded. The user can also define these values. For example, defining when the left-hand trigger is pressed, the alignment behaviour has a weight of 10, and when the left-hand trigger is not pressed, the alignment behaviour has a weight of 0.
The definition of these interactons makes it possible to play and change the overall gestalt of the swarm according to the VR actions and therefore according to the dance movements.

INTERACTIVE PROCESS WITH PERFORMERS

After the first phase, where swarm behavior as well as graphics, VR interaction and the Desktop interface were developed and implemented, a second phase consisted in the development of an interactive process with dancers/ performers, which aimed to test Boidance choreographic potentialities. In order to do so we planned several experimental sessions with two dancers (Cecília de Lima and Michele Luceac). In these sessions we considered the behavior of the swarm in relation to the interactive potentials of the dancer's movement focused through the perspective of Laban/ Bartenieff Movement Analysis (L/BMA) [10], [15], [1], [11].
Movement is so intrinsic and fundamental to human experience and cognitive process that most of the time becomes ignored within our awareness. The nature of human movement is inherently ephemeral, continuous, ever changing, interactive and relational, therefore it becomes a very complex phenomena to describe and analyze into verbal concepts; furthermore it always involves an intense subjectivity, a contextualization and it is inscribed within a sequencing. Although such undertaking might be almost infeasible, it is an embedded enterprise within the practice/ theory of dance and choreography. The Laban/ Bartenieff Movement Analysis (L/BMA) is one of the most consistent and recognized movement analyses in the field of dance studies, offering a framework and a verbal mode for understanding and perceiving human movement.
"In the L/BMA framework, the elements of Body, Effort, Shape and Space come together in Phrases, within a specific context in unique and constantly changing ways to create infinite relationships through and in movement" [15] p.4. Fig. 2 illustrates a simplified overview perspective on L/BMA movement analysis; yet it is crucial to look at all these four areas of analyses as interdependent and interactive features. E.g.:"Even when focusing on the BODY area, the support of the other areas is always available to aid the learning process. It is in the PHRASING of the elements — how they are patterned and sequenced together — that the individual is personally expressive and forms RELATIONSHIPS" [10] (p. 238). As Bartenieff [1] underlines it is critical to understand that although considering these four concepts as a base to analyze movement, L/BMA works "with constellations of qualities rather than with isolated facts or single aspects" (p.37).

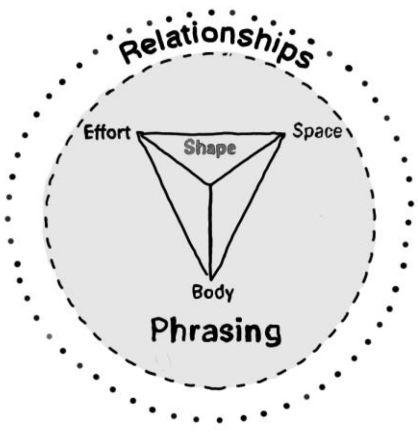

Figure 2: Basic overview on Bartenieff/ Laban Movement Analysis

To explore the choreographic potentialities of Boidance we took in consideration the L/BMA categories of Body, Space, Shape and Effort and outlined four triggering questions for each category:

- How can Boidance play with each L/BMA category at the level of the dancer VR actions?
- How can Boidance play with each L/BMA category at the level of the swarm?
- How can we improve the Boidance interactions to become more interactive within each category?
- How can we challenge choreographic thought through the limitations and potential of Boidance?

Here we present a resumed overview of such analyses.

Body category – According to Hackney [10] the analysis of Body category departs from the following questions: "How is the whole body organized/connected?" "What is consistently maintained in the body?" "Which body parts are moving?" "Where in the body does movement initiate?" "How does movement spread through the body?" (p.238).
In considering the Body category it is relevant to recall that, as mentioned before, the interaction happens through the diverse knobs existing in two hand controllers (one for each hand) and through the VR glasses, therefore the direct movement relation of the dancers with the swarm can occur only at the level of the hands and head. This condition does not allow a wide range of interaction in terms of playing for example with Bodily Sequencing, with a variety of Bodily Active/Held Body parts, or with Patterns of Body Connectivity. However, it is well acknowledged that creativity and deepening knowledge often derives from limitations. By restricting interaction to a simple movement of the fingers that causes, for example, the swarm to spread out into space, the dancer becomes invited to focus more clearly on the sensation of such impact - how the movement of the swarm spreading will affect his/her own body and provoke new movement. Although the direct interaction is very limited in terms of how the dancer uses all his body, a net of sensorial indirect interactions starts to occur deriving from the dancer's perception of his relationship with the swarm's movement.
The Body category was also a critical consideration to implement possibilities of transformation within the body of the swarm, like color and their transformative capacity.

Space category – A basic analysis of Space follows the questions: ""How large is the mover's Kinesphere and how is it approached/ revealed? Where is the movement going? What are the active Spatial Pulls? What crystalline form is being revealed?" [10] (p.243). Hackney [10] exposes spatial dynamics as:

- Directional movement - considers a directional line through opposite poles: up/ down, front/ back, right/left.
- Planes in space - combines two directions simultaneously: Vertical Plane - combines Up/Down and Right/Left; Sagittal Plane - combines Forward/Backward and Up/Down; Horizontal Plane - combines Right/Left and Forward/Backward.
- Diagonal movement - consists of three equal spatial pulls; for instance, left-forward-down or right-backward-up.
- Transverse or spiral movement - involves three unequal spatial pulls constantly changing their relationship to each other.

By placing the controlling setts at the hand and head Boidance VR can interact with the three cardinal dimensions in space. The Kinesphere is also a relevant aspect to consider in Boidance. It is defined physically by the distance that can be reached all around the body without taking a step, but can also be described as the space the mover senses is hers or his, the space s/he effects. The Kinesphere movement can be considered as small - at the distance of the spinal motion, medium – at the distance of the elbow motion and large – as far as the mover can reach [10]. In Boidance the dancer's physical play of the kinesphere can become a direct interactive factor considering the movement of the head and the movement of the arm. However, in our understanding, the most relevant feature relates with the sensorial experience of "corporal trespassing": the dancer's body trespasses the body of the agents and is trespassed by them. These might be considered as a novel phenomenon in dance creation and practice, which proposes a perceptive, esthetical, and dramaturgic innovative potential.
At the level of the swarm's movement we can consider that there is a swarm's Kinesphere. Depending on its equilibrium, we can consider a single Object-kinesphere for all the swarm-

agents (Fig. 3 - line 1) or several Object-kinesphere, one for each sub-swarm (Fig. 3 - line 2).
Furthermore, swarms can be programmed to move through the different spatial dynamics.

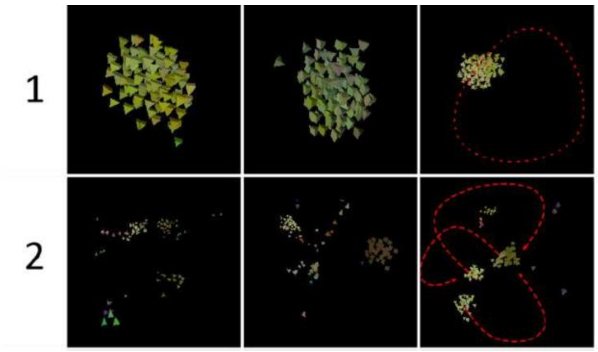

Figure 3: The Kinesphere of the swarm. Simulation with 120 agents. Line 1, on top, shows different moments in time where the agents are all together. This equilibrium leads to a circular path around the center of the room. Line 2, in the bottom, shows multiple sub swarms that similarly to line 1 orbit around the center of the room but independently from the other sub swarms.

Effort category – "addresses the energetic dynamics manifested outwardly in movement" [15] (p. 224). "can be both physical and mental – in this sense, Effort is the deployment of human energy in the pursuit of a particular task. But we shall see how Laban refuses to limit the analysis purely to external movement: to understand the outer movement, one has to grasp the inner intention behind it. One way of describing Laban's work on Effort is that it deals with different qualities of movement". [11] (p.198). In Effort, Laban writes about every movement consisting of four Motion Factors (Space, Weight, Time and Flow) each of which has two opposite poles (indulging and contending) combined in eight basic Effort Actions, as in Fig. 4.

EFFORT ACTIONS		
	Indulging	Contending
Space	Flexible	Direct
Weight	Light	Strong
Time	Sustained	Quick
Flow	Free	Bound

Figure 4: The eight basic actions of the Effort Category from B/LMA

Although the dancer can interact with the swarms through the speed of the arm movement, in Boidance the dancer's effort has no direct interactive relation with the swarm's movement. Nonetheless, L/BMA efforts can be found in the indivdual path of an individual agent as well as in the global swarm. Depending on the genetic algorithm and the boids algorithm parameters, different modes of relating with flow, time, weight, and space can be achieved. Thus, playing with B/LMA effort parameters can be done using the desktop and the VR interface.

Shape category – emphasizes the form and forming process of the body; although linked to space, it is nor about space. Shape sub-categories are described as [2]:

Shape Forms: referring to the static shapes taken by the body, like linear, flat, round twisted, pyramid etc.

Qualities of Shape: attitudinal process of changing the shape of the body in relation to space, like opening and closing, rising and sinking, advancing and retreating.

Mode of Shape Changing: describing the change constraints and how the body is related to the environment, like: Shape Flow (mover's changing body part relationships self-to-self); Directional (direct relationship towards the environment) and Carving (creating or experiencing volume in interaction with the environment).

The dancer's direct interacton with the swarm can be experienced at the level of qualities of shape once the movement of the arm and head can be implied in changing the shape of the body in relation to space. Qualities of Shape and some Modes of Shape Changing can become part of the dancer's interaction through the Convex Hull. A Convex hull is the smallest convex shape that contains the whole of a point cloud. In VR, the dancer's space is recognized by the system which is only known through the devices he or she is wearing, such as the HMD, and the right and left-hand controller. In order to obtain a three-dimensional shape, a fourth fictive point is deduced from the projection on the floor of the position of the HMD. These four points create a convex hull that represents the dancer to the spectators on the desktop. When the dancer moves, the convex hull adapts its shape in real time and this shape might be transposed to each of the swarm-agents using specific functions: match shape and match scale. This allows the dancer to control the shape and size of the elements as he or she dances. This change in the shape that is a copy of the dancer's body position allows each individual to be individually characterized by the shape category.

Considering the movement of the swarm: the shape in Boidance can be considered as the shape of the agents (which can change their pyramidal shape) or as the global shape of the swarm: The swarm's movement can be programmed to play with Shape Forms, Quality of Shape or even some Modes of

Shape Changing. For example: changing the avoidance parameter can change the flow of the shape by shrinking or expanding the swarm.

DISCUSSION OF THE RESULTS

The boids framework is a natural computational artefact to play with the movement of a performer, as the featurs the complexity of boids arises from the interaction of individual agents among themselves and responding to changes in their environment. In Boidance, the coordinates and position of the handles and headset were interpreted as spatial input to be read by the swarm thus smoothly integrating the movements of the dancer in the behavior of the virtual entities. Boids have a relatively simple implementation and are often used in computer graphics, providing realistic-looking compelling representations of flocks of birds and other creatures, such as schools of fish, herds of animals or swarms of insects. Because boids are so flexible and sensitive to parameters permanently trying to reach an equilibrium that can be disturbed by the performer, Boidance takes advantage of this semi-periodic behavior to create a compelling playful environment that we call swarm equilibrium.

The VR configuration used in this system, with wireless headset and two handles, provides a high degree of freedom of movement to the performer. However, being alienated from the real world by the headset is still a major factor of disenchantment.
In the test scenario, the audience members could visualize the scene with multiple camera points of view via a projection displayed in a wall behind the dancer. Right now, this solution feels a bit rough and could be further developed for example by integrating the projection in a physical scenography.
From one of the performers perspectives: "entering into the Boidance VR world is an overwhelming experience. The sensation of dancing in Boidance is like moving on the verge between two overlapping worlds: closing the eyes to the physical world and opening the eyes to an immaterial reality. Not only the perception of space is altered but also the perception of weight. Although the support of the ground remains always present, it is as if for some moments the body could be floating with the swarm." Kinesthetic perception and the sense of weight become challenged by interacting with the lightness and sequencing quality of the swarm.
Becoming involved with the swarm movement - a movement generated by a myriad of small elements coordinated as one, which search for a dynamic equilibrium – provoked a challenge to the traditional sense of kinesphere. When the swarm reaches a dynamic equilibrium state and starts moving in a repetitive pattern they create their own object-kinesphere, however, differently from a material and static object, this is a kinesphere that can be trespassed and that trespasses the dancer's body and also that can move as an extension of the dancer's body.
Furthermore, in Boidance the semi-periodic behavior of the swarm is like a homeostatic organic condition, allowing some level of disturbance and therefore functioning through a dynamic sensitive interaction. In this way the interaction with the Boidance swarm can be perceived as the interaction with a "living immaterial body": it has its own improvisational or not pre-programmed mode of reactng to the dancer's movement [1]. In this sense, Boidance could become a Contact-Improvisation dance, where two dancers react in the moment to each other's movement dynamics. Although the sense of weight is not present, the perception of contact is replaced by the perception of body trespassing or the perception of body extension.
With the body extension and the trespassng features of Boidance, the dancer starts to develop what we call a "immaterial somatic perception". To our knowledge, such paradoxical perception between a simultaneously material and ethereal body provided by Boidance is an innovative aesthetic experience. Such aesthetic immersion might become a critical trigger contributing as an original insight into the discussion of body/ somatic perception within different fields of human and social sciences, such as the arts, philosophy, cultural studies or embodied cognition sciences.

[1] For example, by setting the obstacle as the convex hull of the dancer but wanting to follow its head, the Boids will play with the physical presence of the dancer.

CONCLUSIONS

In this paper we have described Boidance, a software tool that enables a performer immersed in a VR experience to interact with a swarm of autonomous and dynamic pyramids that react to his/her physical movements. We have departed from introducing the field emphasizing the lack of substantial work from practitioners on the use of VR in the context of Dance. Following, we have made a portrait of VR and dance, focusing on the directions of a) the audience entering the scene and becoming part of the performance, and b) in the autonomous behavior of the scenographic elements.
The innovative features of Boidance in the VR world relate mostly with two aspects: a) the capacity of interaction of the dancer in relation to the swarm movement; and b) the ability to program the quality of the behavior of the movement of the swarm in VR before the performance and on the flight.
Then we have described the implementation of the system, which integrated the algorithm Boids [12] and evolutionary techniques. We have explained how the system was built step by step in a collaborative process with three performers. From such collaborative processes we started to develop the concepts of "living immaterial body" and of "immaterial somatic perception".

Future work will include the introduction of sound, as well as further performative experiences with a physical audience to have feedback on the screening artefact.

ACKNOWLEDGMENTS

This paper was produced within the context of a collaboration between Institut Polytechnique de Paris, Faculdade de Ciências da Universidade de Lisboa, and Faculdade de Motricidade Humana da Universidade de Lisboa. As part of project TEPe (Technologically Expanded Performance) it had financial support from Fundação para a Ciência e Tecnologia from Portugal contract reference PTDC/ART-PER/31263/2017. We also would like to show our appreciation to Professor Luís Correia, Professor Maria Beatriz Carmo as supervisors of Mr. Clément. The inputs from Ms Michele Luceac were invaluable during the development and testing phases of the system.

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