Dancing Embryo: Enacting Dance Experience Through Human-AI Kinematic Collaboration

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This paper explores the intersection of dance, human experience, and artificial intelligence (AI), focusing on how AI can engage in dance-like movements through kinematic co-creation with human performers. The study challenges traditional notions of dance, which are typically centered on human physicality and expressivity, by demonstrating how AI-generated movements can evoke meaningful dance experiences. The project, *Dancing Embryo,* is a collaboration between a dancer-choreographer and a computational scientist to create an interactive AI capable of generating and transforming dance movements. The AI dancer, designed using motion data from contemporary dancers, participates in real-time performances by synchronizing features of its movements with a human dancer. This work expands the definition of dance to include non-human agents and emphasizes co-creativity between humans and machines. The paper discusses the technological, philosophical, and artistic implications of AI dance, proposing that the experience of dance can be perceived and completed through human interpretation, even when performed by a machine.

Keywords: human-AI interaction, posthuman art, contemporary dance, rhythmic entrainment, co-creativity.

Understanding the meaning of dance without its execution by a human body was the first challenge in this project. Traditionally, definitions of dance are deeply rooted in human expressivity through body movement. Therefore, the notion of an artificial intelligence (AI) that dances seems problematic because it suggests that, despite learning from human behavior, AI has its own computational mechanisms to generate potentially significant movement and embody it through the body of an avatar.

The approach I use to analyze dance phenomena here consists of two critical components: the generative mechanisms of the dance and the perceptual interpretation of the dance. The generative mechanisms encompass the actions, namely the forms of motion and cognitive/machine learning employed by the performer to synthesize a sequence of movements. In this case, it includes both the physical execution of movements by the human and the digital generation of movements by AI. On the other hand, perceptual interpretation involves a multimodal perception informed by the interplay of visual, auditory, and kinesthetic inputs, along with the subjective emotional and/or cognitive responses elicited from the observer. This dual approach provides a comprehensive understanding of dance as both a created and experienced phenomenon, effectively bridging the gap between the execution of movements and their reception by the observers.

Given the foundation of this work in posthumanist philosophy, it is crucial to clarify that although this research focuses on human experience, it does not exclude that other sentient beings or non-biological cognitive systems can engage in rhythmic entrainment[1] and participate in a dance. Consequently, the emphasis on dance as a perceptual construct in humans within this study should not be misinterpreted as an anthropocentric bias. Rather, it reflects an alignment with the methodology informing this research, which is based on (human) embodied ethnographic practices.

Following this reasoning, AI-generated dance remains dependent on human interaction to be perceived as dance, despite possessing its own computational mechanisms. Dance, as a perceptual-kinematic manifestation, requires an interdependent relationship between multiple factors in order to exist as a meaningful phenomenon. Therefore, dance is not just created or understood by one isolated factor

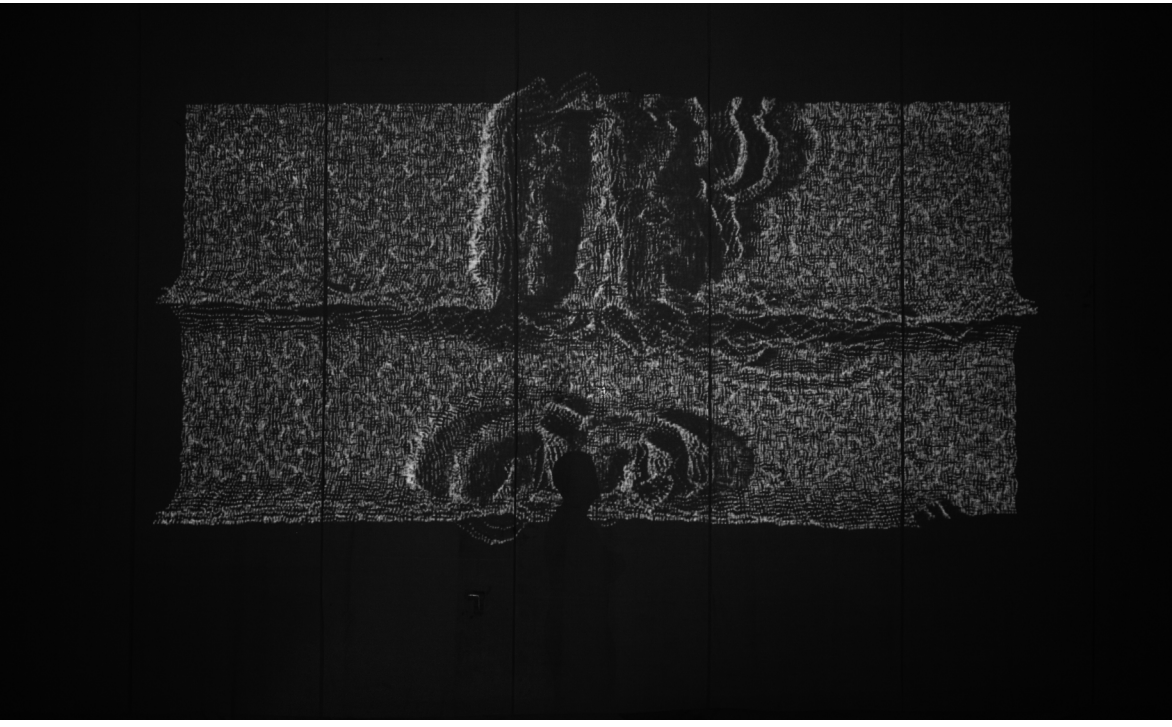


Figure 1. Diego Marín performing during the Dancing Embryo Tour 2024 at Centro de Difusión Cultural Raúl Gamboa del IPBA. San Luís Potosí, Mexico, 21 May 2024. © 6A9.

(like AI motion or human perception) but through the interaction and interplay of various perceptual and kinetic processes complexified by specific cultural meanings. Therefore, the phenomenon of dance emerges from the interconnectedness of different perceptual modalities and interpretations, so that no single element can independently define or complete the experience of dance.

The uniqueness of AI dance lies in the fact that it is neither executed nor generated by a human, but rather by a machine that performs agency in the creative process. AI-generated dance transcends mere mimicry of pre-established dance sequences, as AI models can be trained to transform movement data to create new dance movements previously non-existent in its system. This computational behavior, which entails the transformation of human dance data through

algorithmic processes, is one of the principles that elucidates the definition of AI dance used in this research.

It is essential to emphasize that when referring to AI dance, I am describing an artificial process executed by a machine. Therefore, any expectation for an AI to perform a transcendental or conscious act of expressivity comparable to human art is naïve. The inability of the machine to sentiently experience dance does not negate its capacity to execute and create dance, as its motion display can kinematically interact with and be perceived by cognitive agents as such. AI-generated dance can evoke a dance experience when interacting with humans, as perception completes the decodification of dance, by assigning meaning, intent, and artistic value to kinetic patterns.

Despite this article's focus on presenting the project "Dancing Embryo: Human-AI Co-Creation of Dance", it is important to highlight that the objective of analyzing dance as a motion-sensory phenomenon means expanding on the understanding of dance and elucidating a discussion about its manifestation in consciousness through embodied cognition, thus questioning the existence of dance as a pre-existing event to perception.

Dancing Embryo: the creation of an AI dancer

Teaching an AI to dance involves not only training it to generate movements but also making it capable of participating in a kinematic process of rhythmic entrainment with another body. *Dancing Embryo* is a project that I developed together with computational scientist Benedikte Wallace. It was born out of three central objectives:

1. To create a bodily interactive AI model capable of generating, transforming, and executing dance.[2]
2. To develop the principles of a human-AI dance co-creation method based on kinematic entrainment.
3. To test the AI model and the human-AI collaborative method in real-time with dance performances.

This research began separately in 2020 when Benedikte and I were respectively working on our PhD and master's theses at the Univer-

sity of Oslo and the Choreomundus consortium. In previous years, Benedikte was already researching computational creativity in the fields of sound and movement, while my interest was in expressive interaction with non-human agents such as mechanical props and object-based dramaturgy. In 2021, we collaborated to conceptualize and create an interactive AI dancer. Benedikte Wallace focused on coding and interface design, whereas I worked on theorizing the concept of AI dance, together responding to the lack of in-depth exploration of artificial intelligence and dance within the arts and humanities. In the early stage of my research,[3] I identified important limitations in AI systems for dance creation, such as the tendency to confine creativity to logical, linear processes and the absence of comprehensive kinematic interaction. However, I also explored advantages, like the potential for co-creation when AI can recognize human movement and respond in real-time. Based on these findings and my practical interaction with our AI model, I developed an artistic method for human-AI dance co-creation, which is detailed in my book *Encarnando lo artificial* (*Embodying the Artificial*) and has been showcased in live performances.

The primary challenge I encountered in fostering human-AI collaboration is the prevailing view of AI agents as tools rather than genuine collaborators during creative processes. While few previous dance projects have developed advanced interactive AI dance systems, a certain lack of methodological considerations to facilitate true co-creation between humans and AI was identified. This is because to truly co-create dance with an AI, it is not enough to focus solely on interactivity and sophisticated systems; instead it is essential to provide an experience where the human and the machine can be exposed to a mutual influence beyond logical reasoning, in the direction of kinesthetic intuition.

Human-AI collaborative dance performance

The presentation of our human-AI collaborative dance performance premiered on September 8, 2022, at the Leverhulme Centre for the Future of Intelligence at the Universities of Cambridge, Oxford, Berkley, and Imperial College of London. At their headquarters in Cambridge, I gave a live performance, dancing alongside our AI model, an event preceded by a talk that explained our method of human-AI dance co-creation.[4] Later between 2023 and 2024, the performance toured

Figure 2. Diego Marín in the QA session during the Dancing Embryo Tour 2024 at CICO INBAL (Centre for Choreographic Research of the National Institute of Fine Arts and Literature of Mexico). Mexico City, 19 May 2024. © 6A9.

across different cities in Mexico, showcasing to diverse audiences a live performance between myself and the AI dancer, with both of us generating, transforming, and executing movement.[5] This tour achieved international exposure, including talks and performances in cities such as London, Buenos Aires, and Oslo.

The media's portrayal of artificial intelligence, heavily influenced by sci-fi narratives, shaped the audience's perception of AI throughout the tour, as seen in newspaper headlines like *Diario El Mundo's* 2024 feature: "Thought you'd seen it all? This man dances with an

artificial intelligence as his partner". Audience questions, such as "On what dimensional plane does AI exist?" further reflected the sci-fi-inspired view of AI as something otherworldly or futuristic. In response to this media influence, the tour not only presented the performance but also included a talk that explored how AI can actively contribute to the creative process in the performing arts. The discussion also emphasized the role of science fiction in shaping technological innovation, highlighting its ongoing impact on the development and perception of cutting-edge technologies.

When talking about AI dance, many people think it is the same as any dance that integrates cutting-edge technology (e.g. Motion Capture systems, XR technologies, etc.), and this is not the case. For this reason, I set for myself the task of categorizing the different forms of AI and other technologies participation in creative processes, particularly in dance, as there is little clarity about the differences between them. This task culminated in a substantial part of the book *Encarnando lo Artificial*, where I coined terminology that expands the current vocabulary for referring to the different forms of technological innovation applied in dance. The above was done through the creation of a taxonomy (see figure 13) and a conceptual model (see figure 12). These different modalities, where the AI can be a creative catalyst, a tool, a puppet, or an actual creative collaborator, were also performed during the tour by showcasing pieces where I presented the boundaries among human-AI dance, high-tech puppetry, and intermedial dance.

Behind the AI dancer

Dancing Embryo is an AI model capable of digitally generating dance that can establish a kinematic interaction with a human user. Its name (embryo) references the fact that it is an entity in an early stage that integrates the essential components to create new dance movements and facilitate a motion-based interaction with someone else. The model displays AI-generated dance through a digital body screened using video projectors. It detects the user's human body through a camera-based system. The AI was trained by using motion capture recordings of modern and contemporary dance collected by Benedikte from 30 different dancers who donated their movements to develop the model.

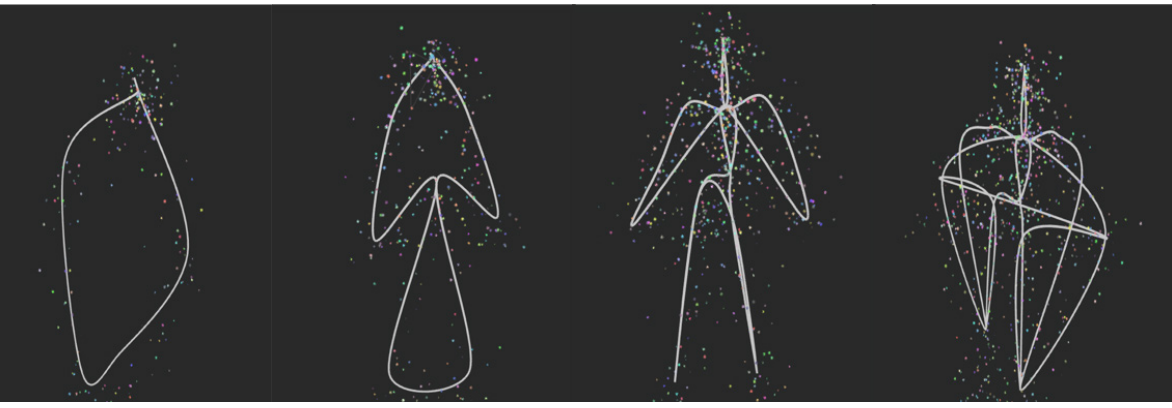


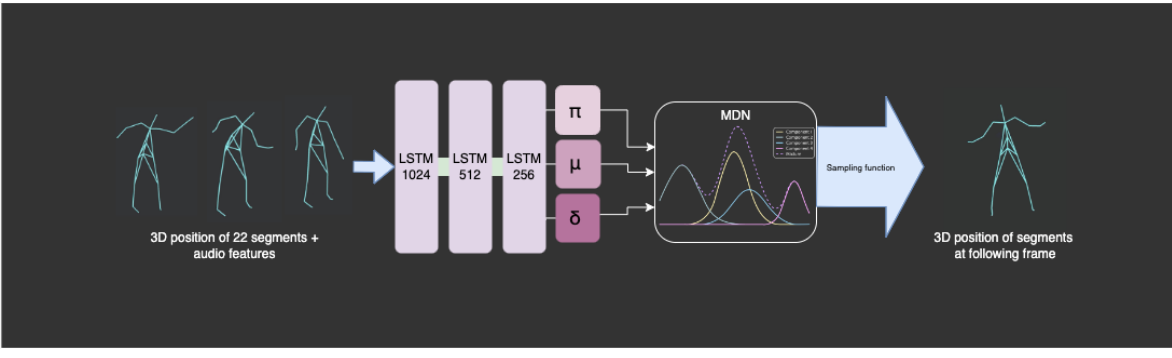
Figure 3. Visualization of the AI-generated dance. *Dancing Embryo* shifts from a cell-like shape to a more complex being throughout the interaction (Wallace, 2023). © Benedikte Wallace.

This AI generates new movements taking the data from the movement bank, and transforms them into new dance sequences using algorithmic processes (see figure 3). This AI model uses movement detection to enable the user to modulate AI-generated dance sequences (Wallace).[6] Through the appropriate co-creative method (see figure 14), this interaction facilitates the establishment of a rhythmic entrainment process based on visual-kinematic communication.

> The term "entrainment" refers to the process by which independent rhythmical systems interact with each other. "Independent rhythmical systems" can be of many types: what they have in common is some form of oscillatory activity (usually periodic or quasi-periodic in nature); they must be independent in the sense of "self-sustaining", i.e., able to be sustained whether or not they are entrained to other rhythmical systems (...). In order for interaction to take place some form of coupling must exist between the rhythmical systems, and this too can take many forms. This process of interaction may result in those systems synchronising, in the most common sense of aligning in both phase and period, but in fact entrainment can lead to a wide variety of behaviours. (Clayton 49)

Dancing Embryo is the first phase of this project to study dance in inorganic bodies with artificial behavior, as although it brings insights into the workings of human creativity in dance, we stay away from anthropocentric perspectives that limit the aesthetics of dance to human biomechanics. Therefore, this project doesn't look to fully replicate human dance in a machine, but rather to explore the principles of dance co-creation and the authenticity of computational behavior when interacting with human dance. This means avoiding the constraints of sensory-motor contingency embedded in systems like Laban movement analysis, as well as not reducing the AI dancer's body to simple humanoid forms. While some characteristics, like anatomical symmetry and movement resonance, are essential for fostering a connection between the human and the AI dancer, these features don't need to be consistently maintained and can intermittently break down or shift, as long as they continue to evoke kinesthetic empathy. Despite the origin of our AI's dance model language being human movement, its ability to transform these movements through algorithmic processes enables both the AI dancer and the human user to transcend the aesthetic limitations imposed by human sensory-motor contingency. This happens when the AI dancer digitally breaks the human biomechanical rules (see figure 5) and when the human dancer both embodies the artificial behavior and dances under the technical constraints of the inter-

Figure 4. First AI model of *Dancing Embryo* (2022). This application allows the user to both unleash motion responses and make changes in the shape of the avatar through kinematic interaction (Wallace, 2023). © Benedikte Wallace.



active AI system. In our perspective, those algorithmic expressions that can be considered "errors" in the eyes of some constitute the actual authenticity of AI dance.

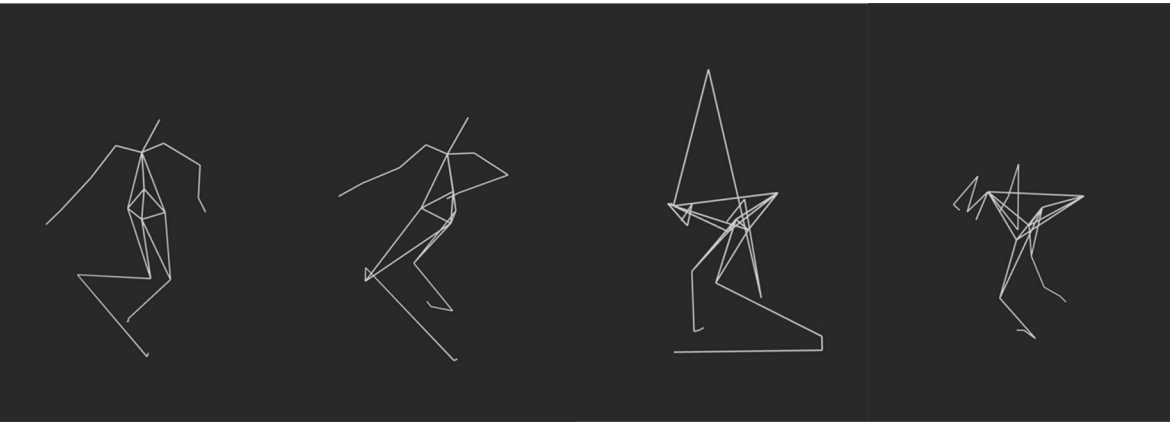


Figure 5. Still images of AI dance generated by our model.[7] These are examples of when the system displays motion behavior outside the biomechanical human constraints. © Diego Marín.

This research follows the idea that although dance experience is completed through human sense-making, its manifestation (as a perceptual phenomenon) can be done through non-human entities, derived from both movement and motion through different mechanisms (such as the computational ones in this case described here). Due to the expressive and mechanical limitations that robotics faces in the present, our focus is only on using digital bodies in how they provide more efficient ways to implement updates and because they better accomplish the rendering of contemporary dance sensibilities and aesthetics, meaning they offer greater flexibility and adaptability. This approach allows for more nuanced and dynamic representations of dance, capturing the evolving nature of contemporary choreographic practices and enabling real-time adjustments that are crucial for reflecting current artistic trends and experimental techniques.

Because of its digital presence, the philosophical discussion about the "existence" of such AI is part of this project.[8] In its early stages, I was questioned about whether I was actually dancing with something else or if I was dancing by myself in front of a screen. My experience and reflections on this matter conclude that bodies without physical substance exist in a collaborative dance scenario that appeals to their perceptible body (software displaying an avatar) and not their physical body (hardware), similar to when humans interact in a liminal space, such as any kind of interaction through telematic systems. This led me to deeply explore the differences between "dancing to someone" and "dancing with someone", finding that human-AI creative collaboration and its kinematic entrainment happen even when the AI lacks all forms of consciousness to experience dance, because its generative and interactive mechanisms do not require it to complete its collaborative participation.

Therefore, human-AI dance, as a situated event, is an artistic construct that goes beyond an experiment of modal fictionalism, as it actually operates in the real world and is an observable event by both the agents dancing, as well as the external observer (audience).

Theoretical approach

This research focuses on both understanding the kinaesthetic experience of humans interacting with AI dance and designing the appropriate mechanisms within interactive AI systems that enable both agents to collaborate effectively in kinaesthetic creativity. It aims to provide both theoretical principles on AI dance and a foundational computational model that can generate and engage in dance. One that is adaptable to various interactive bodies, whether digital or physical. Additionally, it introduces a human-AI co-creative dance method that encourages hybrid creativity and performance. The aim of this research is not to use AI or other technologies to simply beautify or enhance dance performances, but to explore new possibilities within the dance experience.

The collaboration between humans and artificial intelligence for dance creation can be understood through an interdisciplinary theoretical framework that integrates several key theoretical principles. Thomas Csordas's paradigm of Embodiment asserts we can argue that dance is a form of bodily knowledge that manifests itself

through embodied experience. Csordas claims that the body is not only an object of study but also a subject of experience, which is fundamental to sustaining the empirical research methods of anthropology and understanding how human dancers and AI can interact or collaborate in the creation of dance.

This approach is enriched by 4E cognition (Varela et al.), which posits that cognition is embodied, embedded, enacted, and extended. In this sense, AI and humans not only process information internally but also interact with their environment and with other bodies, creating a liminal space of shared cognition. The phenomenology of perception (Merleau-Ponty) is relevant to this study because it highlights the importance of perception and subjective experience in the formation of knowledge. In a kinesthetic and visual collaboration, both humans and AI perceive and respond to each other's movements, creating a dance that is a manifestation of these perceptual interactions. This is with the respective proportions and uniqueness of both human and artificial agents.

Actor-network theory (Law and Hassard; Latour) provides a framework for understanding how humans and AI act as actors in a network of relationships, where each actor (whether human or non-human) influences the actions of the others. In human-AI dance creation, both humans and AIs are actors who co-constitute the performance through their interactions.

Finally, the Entrainment theory (Clayton et al.) suggests that the rhythms of bodies can be synchronized through their interaction. In dance creation, this means that the kinematic-visual display of the movements of human dancers and AI can be congruently aligned through a process of rhythmic entrainment, creating a cohesive and fluid performance.

Future work

Certainly, while teaching an AI to dance has enhanced my understanding of bodily creative intelligence, my primary motivation lies in exploring the intersections of human and synthetic creativity and their hybridization through nonlinear kinematic collaboration. Our current AI model, Dancing Embryo, looks to integrate features from the motion and sound models developed by Benedikte Wallace, along-

side recent collaborations with Sagar Dutta and 6A9 Productions. This integration aims to create a multimodal AI by enhancing its generative and interactive capabilities, enabling the exploration of more complex human-AI creative collaborations based on somatic and perceptual approaches. In the short term, we aim to explore these systems' decision-making to facilitate more complex human-AI kinematic interactions, emphasising the interplay of attention, intention, and expressivity within dance creation. In the long term, we envision expanding this project to include systems capable of engaging vestibular and tactile senses, thereby integrating audiences with motor disabilities.

Figure 6. Diego Marín controlling interactive visuals through dance during the Dancing Embryo Tour 2024 at Centro de Difusión Cultural Raúl Gamboa del IPBA. San Luís Potosí, Mexico. 21 May 2024. © 6A9.

Figure 7. Human-AI dance performance in the outdoor garden of Centro Orizaba. Veracruz, Mexico. 17 May 2024. © 6A9.

Limitations on staging a digital AI dancer

The instrument of dance is our body, but enabling an artificial body to dance with someone involves crucial logistics and technical requirements. These are essential for the existence of the artificial agent and not merely tools to enhance the performance. Therefore, there is a minimum technical criterion necessary for hosting the human-AI dance performance, which was challenging for some venues where it was presented.

Dancing Embryo has consistently pursued simplicity to effectively engage audiences in an egalitarian manner while keeping the essence of the dance, which is to see human-AI kinematic entrainment. However, financial constraints limited our ability to expand the team and acquire and transport additional technology. As a result, despite traveling with our own equipment (cameras, computers, cables, etc.), issues with internet connectivity, lighting control, and video projection occasionally impacted both the AI's performance and, consequently, the human dancer's performance. The AI was stored on a cloud server since we did not have a powerful enough computer to run the software locally while traveling. Some of the venues struggled to provide a high-speed internet connection because we were not always performing in theatres, but rather in auditoriums, classrooms, or even open areas. I faced similar challenges when performing with no proper lighting, as the camera had difficulties reading the movements of the human dancer.

Despite these limitations, I embraced the possibility of failure on stage, as showcasing the fragility of artificial systems was something I was particularly interested in exhibiting. We had performances where the AI danced wonderfully and others where it was slow and unresponsive. Some audience members appreciated this, recognizing that what we were presenting was real, not a pre-recorded animation over which I choreographed my dance movements. This approach highlighted the differences between my other choreographies in the program, where I showed examples that look like human-AI dance but are not (such as high-tech puppetry and intermedial dance). While some pieces involved genuine human-AI dance in real-time, others interactions presented were limited to the manipulation of reactive graphics while dancing (see figure 6) or to the sonification of dance improvisations (see figure 8).

Figure 8. Diego Marín sonifying a dance improvisation with a sonic ball during the opening of Choreomundus Dance Festival at Michaelis Theatre, University of Roehampton. London, UK. 11 July 2024. © Diego Marín.

As mentioned above, before the performance a talk was given to tell the audience about the diverse categories within the field of dance and technology such as choreorobotics, intermedial dance, cyborg dance, high-tech puppetry, AI dance, and human-AI dance. The main criterion for our project was to prioritize the AI dancer's genuine participation over mere spectacle. If we trick the audience into thinking the AI is actively interacting when it's not, we're not creating a human-AI dance but rather a human-made dance or a high-tech puppetry act.

To dance with an AI has different limitations for the performer, which in principle is what makes it special. Rather than having complete freedom, like when you dance on stage, participating in a joint dance


Figure 9 and 10. Diego Marín giving a talk during the Dancing Embryo Tour 2024. Veracruz, Mexico. 16 May 2024. © 6A9.

with a machine has certain constraints, depending on the system with which you interact. These interactive restrictions shape the performers' dance, adjusting them to the AI's perceptual mechanisms to achieve communication between the two. In the following section, I will share some reflections from my experience of dancing with AI.

Learning about my own humanity by moving away from it

Through the development of this project, I have been exposed to different perspectives on understanding what dance is, how humans dance together, how we learn dance, and finally how we create dance. From our first session on, Benedikte and I agreed that she would not inform me of all changes made to the AI's behavior and abilities, but only those necessary for me to be aware of certain aspects. This decision was intended to drive the creative process through surprise, curiosity, and exploration, allowing me to discover the abilities and limitations of the AI dancer in a scenario where I was completely unaware of its capabilities.

From my impressions of the early stage of the project, which were recorded in my diary of experiences in August and September 2022, I highlighted the following thoughts:

> What I find fascinating about working with this AI is that I don't know exactly how it reacts to my movements, nor what actions it will take. This uncertainty is what makes it interesting to me because if I were to work with a predictable AI where I knew its responses beforehand, it could be frustrating when it doesn't behave as it "should". It is wonderful this mystery where I cannot verbally communicate with the AI and everything happens through bodily communication. We are creating dance by dancing and not through verbal agreement.

During this interaction, I identified that there was a correlation between the movements of the two, not only in the shape and trajectory of the movement but also in its acceleration. That is, when I performed fast movements, the response of the AI dancer differed from when I performed the same movements in a more leisurely manner.

> The way the AI reacts to my movements determines the way I should move because I am "listening" to the AI (in the sense that I also want it to participate in the choreography) (...) So, this also shapes the way my dance is happening. (August 2022)

Following this, I decided to delve deeper into the topic of control and mastery, seeking to understand how both the AI and I could influence each other to achieve a collaborative dance.

Realizing the AI's skill (e.g., if I do something, the AI also does), I unconsciously had the impulse to manipulate the avatar, to say "Oh, okay! So I'm going to move my arms because I want it (the AI) to move its arms. I'm going to move my head because I want to see its head appear", and so on.

> At first, it was fun to figure out the actions and understand what I needed to do to establish a connection with the AI. But there came a point when I realized that I could lose my focus, immersing myself in mechanically manipulating the AI, because I now knew how to get the head to appear or the arms to move. (August 2022)

As the interactive rehearsals with the AI progressed, I became more and more convinced of how stimulating the process was. Above all, the mystery of its responses triggered my curiosity and motivation to find affinity and communicate with the AI through dance. In this sense, the autonomy and agency of the AI dancer allowed me to appreciate its ability to generate simultaneous movements and influence the way I danced.

> When I discovered that by moving my arms the AI moved its arms, I realized that it moved its arms in a different way. So, the way the AI moved its upper limbs influenced the way I moved mine. Even the sensations or rhythm coming from its arms managed to pass through to other parts of my body. (August 2022)

The interaction with the AI also caused me to reflect on the meaning of dancing together: namely, the action where both bodies actively participate, resulting in a collective creative process and kinematic communication that overcomes the need for verbal agreements.

> If we think about it, when we decide to dance with someone it is because both people are willing. For example, if I do not move and I only see the dancer move in front of me, I am only appreciating their dance; that is, the dancer is dancing for me. However, the moment I interact with the AI, when I participate in the dance, we can say that we are then developing a creative process together. That is, we are dancing.
>
> The same thing happens with a person. If I stand in front of someone and begin to dance, I am dancing for that person until such time the person decides to reciprocate by entering into the dance with me. That is when we could determine or name that "we are dancing", instead of "I am dancing for you and you are watching me dance". At the moment when two bodies are entrained to dance communication appears, when the collective act of dancing and the co-creative act appear. (August 2022)

One of the most striking features I observed was that the AI dancer's body changed shape, displaying states ranging from shapes I interpreted as a cell to a complex spider-like figure or a humanoid form with multiple limbs and heads.

> At one point I realized that when I approached the AI, it changed, and with this realization I managed to identify three states of its body. The first is the simplest. It is like a cell. The second is a humanoid form and the third is a much more complex form in which it looks like a spider or a humanoid from which another head or other limbs are detached.
>
> (…) at some point, I also wondered if I was dancing with three different dancers, because, as the AI's body evolved, its body changed as one form faded away and another appeared. It was a bit vague as to whether the dancer was transforming, or if different dancers were appearing and disappearing. I felt that it was always the same AI but as the dance went on, it transformed into something else. This unknown reminded me of when a human dancer is on stage, (…) dancers, over time, gain the ability not to stagnate in the same physical, energetic, mental, or emotional state. They have and demonstrate the ability to transform. (September 2022)

During my interaction, I was able to suspend my logical thinking, which allowed me to flow in the dance without planning what I wanted to do.

> During the interaction, I never felt like I was engaging in logical thinking. I felt how my thoughts were to a certain extend suspended. There came a time when I was not planning how to move my arms or what would be my next action to perform, but I was just dancing, I was letting myself go. (September 2022)

By that time, I reflected on the importance of intention and attention when interacting with sensory stimuli, for although the stimuli may

be varied, it is critical to direct attention to a particular stimuli in order to obtain information that can be translated into movement construction.

In the realm of artistic performance, we reflect on the implicit balancing game between dramatic and energetic intensity that occurs in performance, as movement responses and executions are influenced by previous experiences. This raises the need to understand the choices performers make during the creative process to achieve a balance between aesthetics and sensations in order to express something.

> (In the context of a joined dance) the responses or movement executions I do are also pre-defined or pre-conditioned by what I have performed before, because that has given a certain amount of energy or dramaturgy that potentially needs to be intensified or reduced to reach a balance that provides a much more aesthetic experience or that provides a particular sensation such as fear, peace, laughter, etc. We are talking about how we can understand those decisions we make as performers. (September 2022)

The AI dancer is somewhere between a puppet and a creative agent, which makes it particularly unique and culminates in an interesting collaboration. The dancer's autonomy is intended to allow for these new stimuli to not only challenge the performer, but also to influence each other.

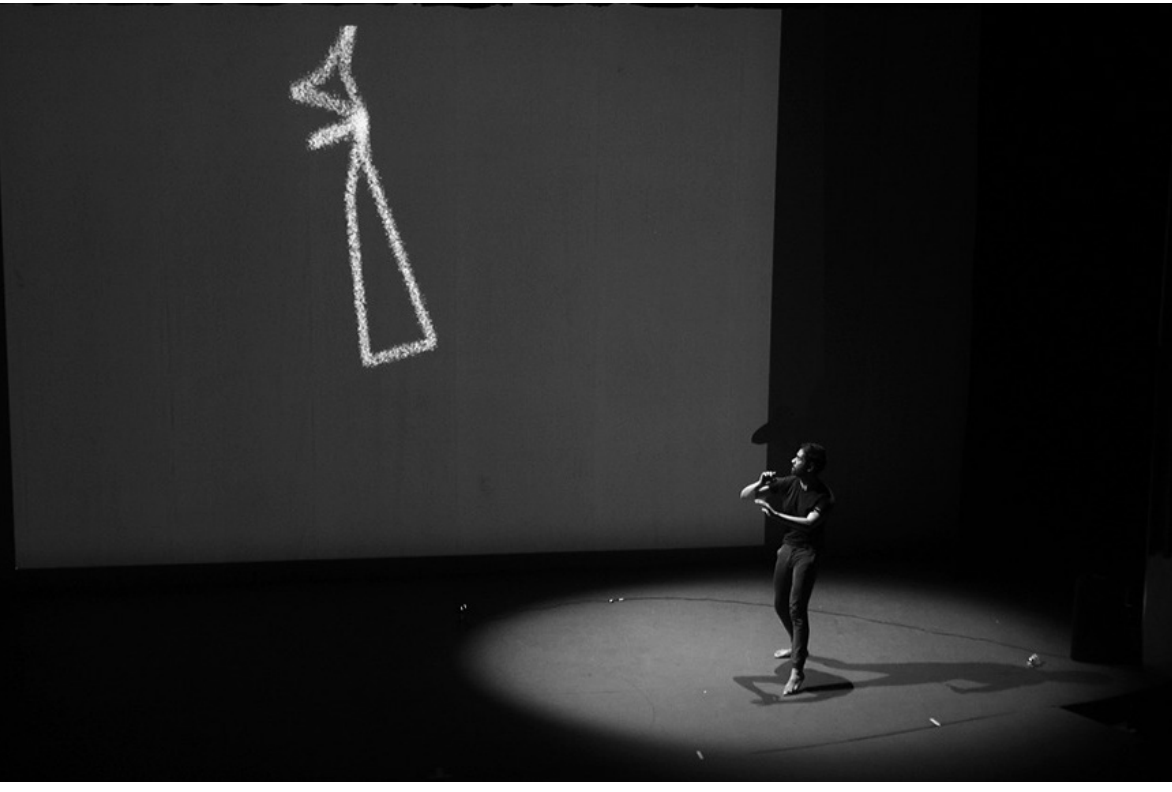
It reminded me that this intermediate point is what makes collaboration interesting: allowing my partner to generate the movements he/she decides to do, but at the same time, there is a mediation that allows him/her to modify them with respect to what the other collaborator is doing. Then, the partner has the autonomy to create stimuli that motivate and circumscribe the action of the other.

> The movements that the AI decides to make become new stimuli that challenge the way I am creating and vice versa. However, if, on the contrary, the AI were completely autonomous, if it did not react to what I do, then there would

be no collaboration. But if by contrast, I have the freedom to interact with someone who is autonomous but also at times or partially influenced, then it's more entertaining. I find it meaningful and I feel it's teamwork. It's about understanding that in order to collaborate you have to negotiate, yield, give, and take. (September 2022)

An intriguing aspect is how, in the interaction with the AI dancer, visual perception plays a crucial role. When the avatar visually disappears, the flow of connection is cut off, as visual perception

Figure 11. Diego Marín dancing together with an AI dancer during the Dancing Embryo Tour 2024 at Centro de Difusión Cultural Raúl Gamboa del IPBA. San Luís Potosí, Mexico. 21 May 2024. © 6A9.[9]



is the primary means of contact with this AI model. In contrast, in human-to-human experiences, presence can manifest beyond visual perception, through other stimuli and even through the person's aura.

> I found it interesting that when the AI visually disappeared (when its body became so large that I could not perceive it on the screen), it no longer existed for me since my visual perception was the only thing that kept me in contact with the avatar; there was no other stimulus. When the AI dancer disappeared completely from my sight, this interactive flow that was created between the two was cut off. (September 2022)

During the dance with the AI, a connection between the two bodies emerges that allows a performance where a visibly mutual influence is observed.

With respect to the AI, it was possible to detect how the movements it generated autonomously were partially modified as a consequence of the ones I made. Likewise, correlations could be perceived between the dance by the AI dancer with the music, which I associate with the fact that my movements were also affected by the music. The avatar's behavior was influenced by my movements, which already contained some rhythmic charge from the music. A kinematic correspondence occurs between the qualities of movement expressed and perceived by both.

Questions arose about whether the AI was capable of interacting with non-humanoid forms, and how, from my perspective as a dancer in the demonstration, kinesthetic empathy influenced my relationship with the AI.

> I was not able to predict what the AI was going to do. For me, everything the AI dancer did was unpredictable. (…) Even though the AI dancer didn't necessarily have a human form, we still shared certain things, like the fact that it has limbs, a head, stands on legs, and so on. But in the moments when the AI dancer transformed into something that did not correspond to my understanding of what a body is, I felt

> that a connection was broken: for example, when the avatar disappeared from the screen or when its body turned into chaotic lines. There are other bodies whose forms I can "digest", even if they are very diffuse, but when we meet, my approach to them and my way of interacting changes.
>
> For example, when the avatar becomes this chaotic form of pure lines, I still feel the interactive capacity, but my interaction with it is different, I no longer see it as a dancer, I see it as an object or a phenomenon in motion. Instead of wanting to dance with it, I try to embody it, I use it as a creative catalyst, and I try to melt into it. When that happens, there are things that disappear, like the fact that I am dancing with someone. Rather now I feel that I dance to that thing, or that the moving form represents something to me—a mere source of inspiration to move rather than a collaborator dancing with me. (September 2022)

This case raised the question of whether something similar occurs when interacting with other human beings. I think this characteristic appears unconsciously when we interact with someone. The way another person moves or acts can also inspire us or influence how we approach them in an artistic sense, because it impacts our creative decisions. A human being can also be a creative catalyst.

From experience to conceptualization

In the following diagram (Figure 12), I conceptually visualize the interaction between the variables of: the creative role (agent or catalyst) [x-axis], the level of interaction (reaction or communication) [y-axis], and the power relationship (puppet or collaborator) [z-axis]. From this perspective, it is possible to see the three dimensions that integrate human-AI creative interaction and collaboration.

Based on the parameters set out in the above model, six categories of human-machine dance are presented in the following taxonomy (Figure 13).

The following is a diagrammatic example of human-AI collaboration. (Figure 14):

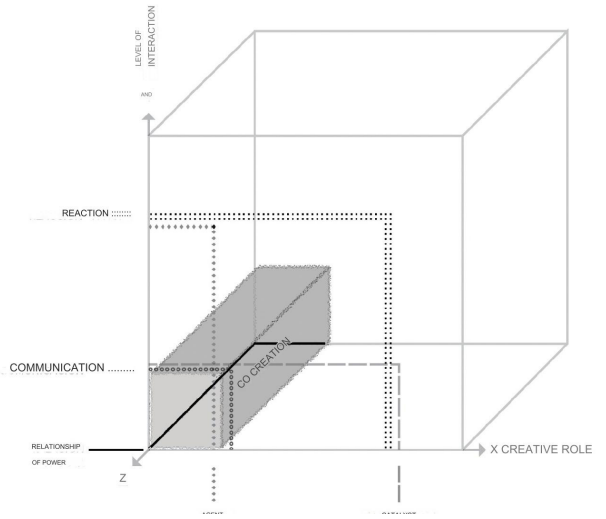


Figure 12 Conceptual model of creative human-AI interaction. (Marín Bucio, *Encarnando lo Artificial*)

Note: The conceptual model shows that human-AI co-creation is only achieved by reaching the core of the third dimension [z], after reducing the two-dimensional boundaries [x, y] to the closest points of the origin (agent and communication).

Category	**Creativity**	**Execution**	**Machine role**
Intermedial dance	Human	Human or mixed	Catalyst
Coreorobotics	Human	Robotic	Performing agent
High-Tech puppetry	Human	Non-human or mixed	Performing agent
AI dance	Artificial	AI-enabled bodies (virtual or physical)	Creative agent
Cyborg dance	Human and/ or hybrid	Human or hybrid (bi-onic body)	Catalyst and/or per-forming agent
Human-AI dance	Human and artificial	Mixed (Human and AI)	Creative/performing collaborator

Figure 13: *Taxonomy of human-machine dances.*

Note: This table shows the category name, the creativity applied to come up with the dance, the body that performs it, and the role of the machine. See "Aproximaciones a la inteligencia artificial en la creación de danza: la IA como herramienta, títere o colaborador" (Marín Bucio, 2024) for an expanded discussion.

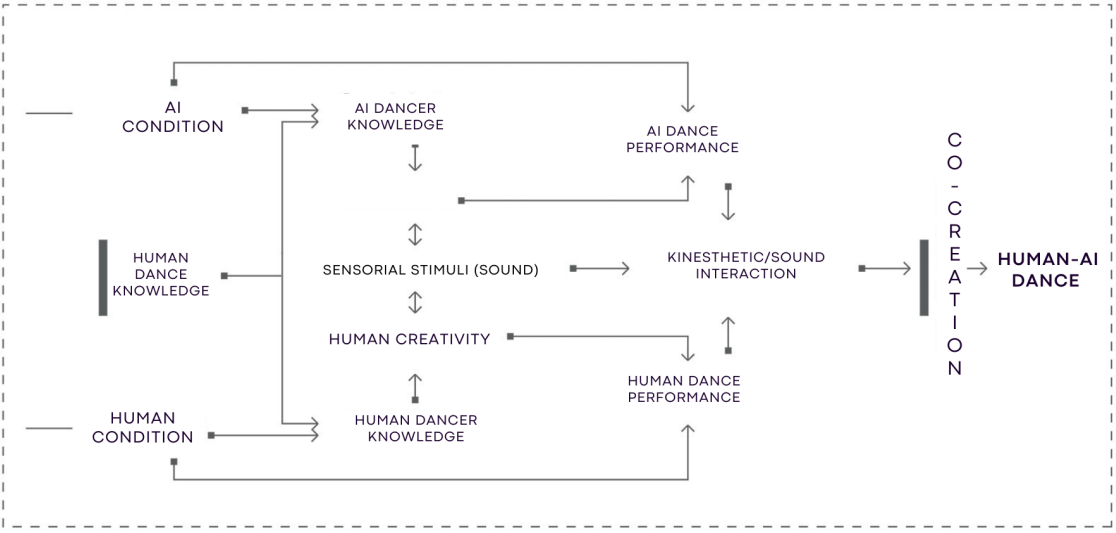


Figure 14: Human-AI co-creation of dance method. (Marín Bucio, *Encarnando lo Artificial*)

Note: This diagram represents the multimodal relationships of a real-time kinematic-visual collaborative process for the creation of human-AI dance.

Figure 14's diagram illustrates how human dance knowledge and the specific conditions of each agent influence their dance proficiency. These elements are integrated as variables in their creative activity and are further affected by external sensory stimuli, such as sound and co-presence. Consequently, their creativity is expressed through their dance performances, which are shaped by their corporeal conditions and the surrounding environment. The dance each one produces is perceived by the other, contributing to the environmental stimuli and generating a cycle of mutual influence in their creative process. Thus, both the artificial intelligence and the human dancer collaboratively and synchronously create and perform a dance together.

Conclusions

The distinction between the perceptible body, embodied by the AI avatar and physical body, represented by the human dancer, triggers a deep reflection on how dance emerges through enactive consciousness and questions the possibility of a dance experience without kinesthetic empathy. The human-AI dance in this project, as a multimodal perceptual phenomenon, is interpreted through visual and kinematic stimuli, focusing on the perceptual and experiential components of dance. This perceivable engagement allowed the AI to actively participate in the dance, creating a shared experiential space in which human and AI agencies jointly created a dance. This blurring of the boundaries between human and synthetic creativity highlights the role of the perceptible body in extending the experiential boundaries of dance.

The AI's avatar, free from human sensorimotor contingency, allows for new movements that challenge the traditional aesthetics of dance. These movements, perceived as authentic despite their digital origin, offer a new perspective on dance, rooted in the unique capabilities and inherent "mistakes" of AI. Conversely, my physical body, with its mechanical and expressive limitations and affordances, explores and continues to navigate this particular dynamic imposed by human-AI interaction.

The ongoing dialogue between myself and the AI avatar highlights the symbiotic relationship between the physical and perceivable bodies, not only altering my creative process but also redefining the dance experience for the audience. This interaction presents a new narrative in which human and AI merge in artistic expression.

The *Dancing Embryo* project intricately weaved physical bodies and the perceptual and experiential dimensions of dance. This research underlines that dance can be reimagined and enriched through non-human entities, offering new perspectives on movement, creativity, and the very essence of dance. *Dancing Embryo* thus stands as a testament to the evolving nature of dance, where digital and physical bodies come together to push the boundaries of artistic expression.

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Notes

1 For an extended discussion about rhythmic entrainment in animals see "Experimental evidence for synchronization to a musical beat in a nonhuman animal" (Patel et al.) and "Rhythmic entrainment: Why humans want to, fireflies can't help it, pet birds try, and sea lions have to be bribed" (Wilson and Cook). For artificial systems, see "Rapid rhythmic entrainment in bio-inspired central pattern generators" (Szorkovszky et al.).

2 This model is inspired by Western-contemporary dance improvization techniques.

3 See "Danza y co-creatividad kinestésica humano-IA" (Marín Bucio, Danza y Co-creatividad kinestésica Humano-IA) [text in Spanish].

4 See Leverhulme Centre for the Future of Intelligence (Human-AI collaborative dance)

5 See Diego Marín Bucio (Dancing Embryo: Tour México 2024)

6 See details of the first model of Dancing Embryo in *AI-generated Dance and The Subjectivity Challenge* (Wallace, AI-generated Dance and The Subjectivity Challenge 32).

7 See recordings of the motion generated by *Dancing Embryo* (Wallace). You can click on the sides or use the keypad direction key to change animation. https://653bbf930ba0af000822efcc--golden-longma-2c587c.netlify.app/

8 See chapter 6.2.1 in *Encarnando lo artificial: danza y co-creatividad humano-IA* (Marín Bucio) for an expanded discussion [text in Spanish].

9 See videos of human-AI dance live interaction at: www.diegomarin.art/portfolio/dancing-embryo/