How Digital Anthropomorphism Enhances Creativity in Human-to-Robot Dance Interactivity

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Abstract

Through our research-creation experiments, we imagine movement sequences that challenge the concept of anthropomorphism in digital twin robots. While considering the term of interactivity to better define their interaction, we observe how different movement material is stimulating creativity through a hybridization process between human and machine. From this perspective, we determine how users experience *qualia* while learning through imitation a dance sequence consecutively demonstrated by a humanoid robot, an industrial arm and a human. Their feedback and our own practical experimentation allow us to better understand the impact of digital anthropomorphism in the making of a sustainable human-to-robot interaction.

Keywords

Digital Anthropomorphism, Dance, Interactivity, Social Robots, Hybridization, Symbiotic Individuation.

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Introduction

Since the 6th century BCE, when the term was firstly employed to describe religious phenomena [9], anthropomorphism has accompanied humanity's intention to replicate its characteristics into different environments. Anthropomorphism (from the Greek word ánthrōpos meaning "human" and morphē meaning "form") is described in [10] as "the tendency to attribute human characteristics to inanimate objects, animals and others with a view to helping us rationalize their actions. It is attributing cognitive or emotional states to something based on observation in order to rationalize an entity's behavior in a given social environment." As discussed in [31], an essential component of the human spirit is to lend certain characteristics of our psychic life, by projecting our physical and psychological functioning into objects. According to [1] "humans attribute, often unknowingly, personality traits to machines based not only on their external appearance, but also on their functioning and skills." In the present paper, we refer to anthropomorphism in a broader humanistic perspective, as a characteristic of an autonomous system's behavior that allows ascribing human-like characteristics and intentions to non-human entities like robots. Recently, the literature has integrated an interpretation proposed by French philosopher Bruno Latour where the meaning of anthropomorphism is defined by "that which has human shape" and "that which gives shape to humans"[30] encouraging scholars to envision digital anthropomorphism as the concept that integrates both views. Using these grounds, we explore key notions like agency [15] and autonomy [2] for our particular case of dancing with robots, to better outline the link of these notions with digital anthropomorphism in establishing a sustainable human-to-robot interaction (HRI). Lately robotics has enhanced these perspectives, developing artifacts that challenge the idea of humanity.[26] We rely on scholars [5, 4] to define the place robots can occupy in our study, considering them as tools (helping human to accomplish a task—in our case develop a choreography), as avatars (since the robot engages in a certain social presence with other people—in our case the spectators of a dance performance) and especially as partners (establishing a co-working process with a collaborator—in our case co-creating a dance performance). From [10] we note that a social robot "can be perceived as the interface between man and technology. It is the use of socially acceptable functionality in a robotic system that helps break down the barrier between the digital information space and people." As robot design becomes modular [27] and body extensions inspire art performances that question human capacities,[16] an anthropological study [32] compares HRI to the type of connection expressed in earlier religious rituals between gods and humans, pointing out the influence robots could have on us in the near future. As we are currently shifting into a post-humanist technologized era, where humans are extending their capacities using exoskeletons and various connected devices, the definition of the human body and how it interacts with its environment changes accordingly. Our paper investigates how these paradigms affect our creativity and their impact in collaborative social practices like dance.[33] mentions the etymological analogy between dance (from Indo-European ten, root for tension) and emotions (from latin *émovere*: or set to motion). In our quest for a meaningful interactivity between performers and robots, we analyze the impact of these anthropological projections on dance. In the following pages, we describe how we create our movement sequence by discussing our working hypotheses and methodology and explaining our working phases leading to the concept of human-to-robot (H2R) hybridization. We then adapt and test the sequence on several human performers. We later discuss the results and perspectives of this experimentation and its implications into current dance practices.

Questions and Methodology

Our approach focuses on the process of creating an original choreographic language inspired by robots, influenced by somatic practices and embodied intelligence. According to artist Louis-Philippe Demers, any abstract inert shape "can become fluid, organic and eventually anthropomorphic by the sole means of contextualization and movement."[9] Our goal is to check to what degree the concept of anthropomorphism enhances creativity in HRI and influences artistic research. Among our working hypotheses, we investigate how the shape of a robot can influence the performer in generating unintentional movements similar to kinaesthetic responses [3] (1) ? How can a dance sequence be reproduced more easily depending on the type of robot? Does the feedback of the performer change once the robot type has changed? Another area of investigation concerns the creative process, supporting the idea that working with an avatar substitute of a robot that we define later as its digital twin, can favor a hybridization state between the body or the performer and the robot's virtual body. In this way, we underline the process through which the role of the robot shifts from tool, to working companion. Further

on, we wonder if this new symbiotic individuation between robot and human can influence the output of artistic performances. The robots involved in our study have similar dimensions, although initially built for different outcomes. As a starting point, we use the movement material implemented in the HRP-4 robot for the *Le mythe d'Immorta* (2022) performance, part of the *Co-Évolution, Co-Création et Improvisation Homme-Machine* (CECCI-H2M) project. The humanoid robot and an industrial arm are programmed in an analogous series of movements based mostly on the rotation of upper limbs and head for the humanoid robot. We then test the dance sequences through a case study within a group of dance students.

Digital twin robots as interactivity facilitators

The students are asked to memorize, then improvise the analogous movement sequence indicated through video projection by different dance partners. The filmed sequences have the same format and duration (approx. 1min). First sequence is taught by a humanoid robot, second one by an industrial arm and the last one by a human performer. The sequences have the same structure but differ in the quality of movement, depending on the teacher. Next the dancers are asked to freely interpret the movements and collectively improvise a free dance sequence, recycling the movements they considered the most inspiring. The method of analysis is a question form of 23 questions that the participants are asked to fill in at the end of the experiment.

Figure 1: Human and HRP-4 digital twin teaching movement material.

Experimentation Phases When the tool becomes a partner

In the West, robots are often designed to mimic human behavior, mostly as tools [14] replacing human labor or assisting humans in complex tasks. However, in creative contexts their function is more ontological in the sense they might contribute to a certain creation of meaning in inference with the art process that contains them. For artist and researcher Simon Penny, cognition does not occur exclusively in the brain, being "far from a logical manipulation of symbolic tokens."[23, 25] Arguing mental processes like inspiration are embodied, integrated within non-neural bodily tissues (thus extended into artifacts, social systems and cultural networks), he also points out its dynamic nature. Through our research-creation experiments, we imagine movement sequences that challenge the concept of anthropomorphism in intelligent interactive robots. As the stage mediates their encounter, it brings new possibilities of expression, and consequently of interaction. In our particular case, we apply the term of interactivity [6, 7] to define the relation between humans and robots. Initially inspired by human interaction, interactivity appeared with the development of new technologies and media, setting up the premises for an ongoing process of transformation between man and machines. Mixing living and nonliving, reality and simulations, physical and virtual, interactivity facilitates a permeability between human and technology. As stated in [1] , contemporary interactive interfaces "escape the total control of man and create a new situation where the latter no longer has an exclusively active role in front of his tool. It is rather an exchange, an interdependence characterized more and more by their interactivity."

Confronting paradigms concerning embodiment

[1] makes an analogy between the way technology, especially virtual interactions, shapes the understanding of the human body. Individuals seeking to expand, alter or fragment their body, are indicators of the ongoing shifts operating through our daily interactions. The identity being multiplied, diluted or absorbed into the digital world, the tendency is to project the same expectations onto the human body. Neuroscience, robotics or art do not consider embodiment and anthropomorphism in the same way. In [18], the body is defined as a set of organic processes that go beyond the experience of sensation and movement. It might include social networks such as families and culturally constructed artifacts. In parallel, anthropological terms

like “body domestication” [17] analyze how the body is being segmented in units according to the field of research that address it. In arts, pioneers like Stelarc have always considered their body as a playground for technological experiments [29]. With his third arm or spider legs performances, the artist blurred the lines between what is human and what is machine through very original settings. Whereas roboticists design robots that can “emulate” humans through their resemblance and collaborative skills [11]. Researchers demonstrate how the overall shape of a robot plays a key role in invoking desired emotions in users [14], with studies measuring the degree of acceptance of humanoid robots [22, 19], influenced by the awareness of our own “body schema.”[13] Additionally, concepts like “social uncanniness” [12] examine how our need to be unique and to engage in authentic interactions is being impacted by the development of social robots.

The idea to start experimenting with a robot’s virtual avatar, appeared while working in the laboratory with the roboticists of the Interactive Digital Humans (I.D.H.) team in Montpellier. The HRP-4 robot being little available at that time, we had an artistic residency in which its virtual double was representing the real one. The robot executed a series of movements inspired by power postures of political leaders sitting on chairs. While improvising, its imaginary corporeality triggered different kinetic responses in the performer, so we were curious to look further and understand this phenomena. In [28] we note the distinction between virtualized robots and the simulations that are necessary for the functioning of robots in the real world. To go further, in our current study we employ the term of “digital twins [(2)]” over simulations, due to their real-time data processing and possibility to study multiple processes in various simulations.

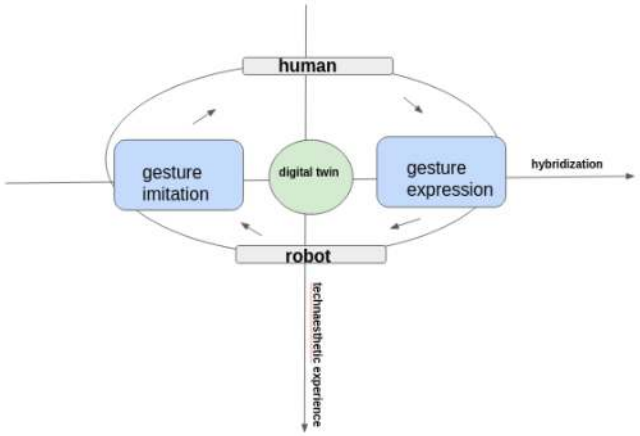

Figure 2: Graph illustrating the link between hybridization and technaesthetic experience in dance HRI.

Hybridization as a result of creative interactivity

[17] traces back the hybridization process between the human body and the technological objects from as early as prehistory, when the anatomy of our hand adapted to the manipulation of objects like carving tools. He argues that the notion of reflexivity occupies a central place in the way anthropomorphism operates, citing the cultural anthropologist Victor Turner for whom the human is more than a performative animal, being something close to an animal that performs oneself. In analogy, creating a robotic dance sequence is also a reflexive process. The human plays a double role-movement initiator and receiver (in the sense she/he responds to the proposal done by the robot) whereas the robot becomes a medium-translating with its mechanical constraints the body architecture it is supposed to embed, without much alternating the initial model. To deepen our understanding of the concept of hybridization, we define it in relation to the work of numeric artist Edmond Couchot. For him the hybridization is always located in the experience, “more precisely in the relationship between the sensitive, the body and its environment.”[28] The author of the paper points out the work-in-progress nature of hybridization or, to cite the artist, “an evolving state, from human to artificial and from artificial to human.” In his classification of artificial agents, Couchot makes a distinction between robots and artificial humans, using the concepts of materiality and autonomy to distinguish between the two. For autonomy his classification is orientated around two polarities: the puppet avatar (minimal level of autonomy) and the autonomous actor (maximal level of autonomy). Concerning its definition of materiality, he structures his observations around the technaesthetic experience from french “expérience technesthésique” as being “a sensitive experience lived in the technical act [which] constitutes a kind of perceptual habitus, sensory knowledge, shared by each member of a society and shaping his ways of being and acting, of thinking, by ways different from those of language and symbolic thought.” It is interesting to note this experience is implying the dissipation of the self, relying on the remains of other people’s experience with technology. This relates to the observation of Becker [17] for whom the history of shared gestures, traces back the evolution of humanity in its relation with technology.

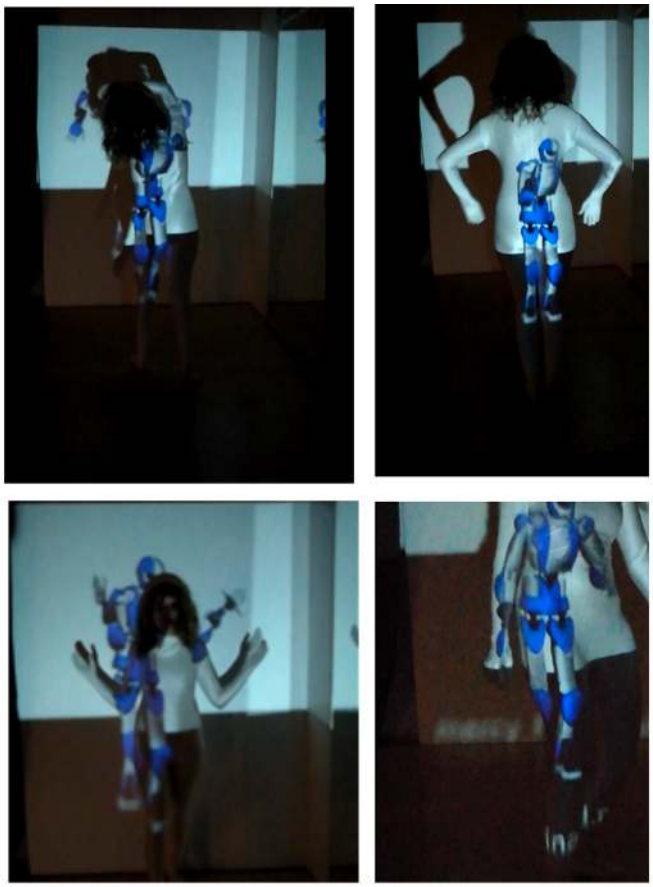

Figure 3: Image morphing between the performer and the digital twin of the HRP-4 robot.

The Human in the loop

One of the challenges of our research-creation is to explore this intermediary dimension that operates between the quality of movement of two distinct entities (human and robot). In [33] an experiment done with a Poppy robot, favors the emergence of the concept of kinaesthetic empathy-illustrated by the gap and tension that operates once the gesture is being transmitted from the human to the robot. In our particular case, in real-time improvisations, once the HRP-4 robot is programmed to reproduce a dance sequence, the choreography might be altered according to the technical characteristics of the robot-state of actuators and battery, code glitch, joint limitations. We call this type of inference “parasite movements,” requiring a sensory-motor adaptation both from the machine and from the human. In comparison, while working with digital twins, the adjustments are done at the video-projection level. The concept of morphing [33] borrowed from image processing offers an interesting analogy to movement production, defining a process of continuous rehabilitation and readjustment of the bodies and their transformation into shapes. For one of our research-creation experimentation trials, we projected the figure of the robot on the body of the performer. To our surprise the image overlapped, resulting in a hybrid figure of both robot and machine. After several trials, the performer adapted to this unexpected robot specificity, like in a taming process and a symbiotic figure, half-human, half-robot resulted.

Case study of a human-to-robot dance interaction involving anthropomorphism

Through our case study we investigate how different movement material is experienced by performers while dancing with robots. The focus of our paper is to determine how users experience ”qualia” [(3)] while learning through imitation a dance sequence consecutively demonstrated by human and non-human agents. Arguing that body and mind are the same expression of an organic process, [20] describes arts and aesthetics as the culmination of humanity’s attempts to find meaning. After working with the double twin of the HRP-4 robot for the *Le mythe d’Immorta* performance, we wanted to understand how robots are being perceived by their human partners during creative practices. Engineers can easily pre-program intentions related to specific human emotions or behaviors in robots using an affective loop approach [8]. This approach focuses on the robot’s capacity to engage humans into affective exchanges and therefore attribute meaning to their behavior. In 2010, a simplified user interface that creates body motions [21] was implemented in an HRP-4C robot for a dance performance. The robot does basic synchronized dance movements surrounded by four dancers, giving the impression of a perfect copy of the human performer. As stated by [24], we expect from intelligent, self-conscious artworks to surprise us. To tackle this expectation, we imagine interactions that focus on spontaneous, ”parasite” movements and unexpected behaviors in robots, questioning an “effect of presence” [34] on stage. To explore the potentialities of these creative evolutionary interactions, different scenarios were programmed and tested, involving imitation and random movements. This approach enables us to understand how artificial and organic bodies may adapt to one another and reach a hybrid state, specific to our working environment.

While conceiving our first dance sequence with HRP-4, we had to take into account different constraints: how the robot stabilizes its center of mass, its autonomy while standing and the safety mechanism that allows it

to move. This context made us initially consider a seated dance interaction. Inspired by work of famous choreographers like Ohad Naharin's *Echad mi Yodea* (1998), Anne Teresa De Keers-maeker's *Rosas danst Rosas* (1983) or Anna Halprin's *Seniors Rocking* (2005) who used chairs in their choreography, we chose to work on the postures of famous political leaders. The fact that they were sitting, thinking, but through their reasoning they influenced the outcome of our daily lives transformed the figure of the robot into a totem-like figure inhabited by power gestures. The dance sequence was transposed into the HRP-4 digital twin, on stage during the CECCI-H2M project. In a different setting of this project, the performer interacted in real time with both autonomous systems of the performance-using the same dance sequence with the performance's virtual environment E.V.E.(non-anthropomorphic) as well as the virtual HRP-4 (anthropomorphic). The out-come of this experience was that the repetitive movements of the HRP-4 generated a feeling of oppression and limitation in the performer, triggering the need to deconstruct them in various movements similar to the kinaesthetic responses we mentioned earlier. Whereas the responsiveness of E.V.E. made her easily forget the initial sequence and follow the rhythmic proposed by the artificial agents. Both systems were identified as stage partners by the performer, with the robot evoking a feeling of absence or "ghost in the shell" (4) phenomena. Once having these insights developed through our creative process, we felt the need to confront them to a broader context. The next part of your experimentation was a case study proposed to 25 dance students who tested a dance sequence conceived for the humanoid HRP-4 robot and taught by it, as well as a FRANKA industrial arm and a human performer. Compared to the version inspired by power postures, the HRP-4 robot was moving its upper limbs, hips, head and torso, but this time standing. New movements, corresponding to unintentional movements similar to kinaesthetic responses were added in the loop to simulate what we defined earlier as parasite movements. Participants were initially asked to reproduce the movements then improvise freely applying some of the gestures they remembered. They were encouraged to explore their senses (including the proprioception) and forget any personal projection regarding aesthetics and how the sequence should look like.

Figure 4: Stage interaction with different types of embodiment.

Discussion

In [15], [10] scholars link the notion of agency to the question of anthropomorphism, citing D.C. Dennett's theory on "intentional systems". In art contexts, besides the object's kinetic behavior, another factor of influence is the spectator's strategy to understand and predict the behavior of the performing object. We wanted therefore to open up our research-creation process to external participants, organizing a practical experimentation with dance students. Among the questions the 25 participants in our study were asked to respond to, some concerned the movement imitation learning process. Most of the participants found no significant differences in the way the robot (56%) presented the movement, compared to the human (76%). However, most of the participants strongly agreed it was easier to follow the movements of the humanoid robot (64%), compared to the industrial arm (8%). Concerning the quality of movement, most of the participants believed both the humanoid robot (44%) and the robotic arm (44%) had intentional movements. Whereas 56% agreed it was easy for them to detect the "parasite movements" of the sequence. A slight difference was observed when participants were asked if they could distinguish intentional from unintentional movements, with 28% of the participants agreeing and 24% strongly agreeing it was easy. A significant part of the participants was undecided (36%) whether robots are strange creatures, with 24% strongly agreeing they are and 20% somehow agreeing they are not. Similar distribution considering whether robots have consciousness, with 28% somehow disagreeing and 24% somehow agreeing. As for the creative interactivity, the majority of the participants-(68%) felt the need to add other movements, once the sequence became repetitive. None of them agreed that they usually apply the imitated movements when dancing, while very few some-how agreed the movements were natural for the HRP-4 robot (8%) and Franka robot (16%). It is interesting to note that for the

Franka robot, 4% of the participants strongly agreed its movements were natural, while none for the humanoid robot. Regarding emotions, only 12% of the participants somehow agreed the HRP-4 robot communicated emotions through dance with a majority (64%) disagreeing and 24% being undecided. As for the Franka robot's emotions, 80% of participants disagreed it expressed them through dance while 8% were undecided and 4% somehow agreed. Interestingly enough 8% of participants believed the Franka robot communicated emotions through its dance. Most of the participants of our study (64%) could spend more time understanding movement through robotic interaction. A hybridization process was also noticed after the sequence, when the participants were asked to freely interpret the robot motions they experienced earlier. This facilitated the exploration of a state where senses were more present and spontaneous movements appeared more easily. A state that we define as creative, in the sense that it allows body expressiveness inherent to the specificity of the embodiment - where by imitation they appropriated and transformed the robotic dance sequence. While moving, their bodies seemed inhabited by the robotic presence. Experimentation output is available before (5) and after (6) the robot trial.

Limitations

Regarding our intention to slightly modify the sequences, getting to see them in a particular order (HRP-4, followed by the Franka robot and the human performer) might have influenced their answers. Some of the participants were already familiar with the movement of the HRP-4 robot due to previous working sessions organized earlier that year. Compared to working with digital twins, the results might also be different when working in real time with the physical robots.

Figure 5: Learning phases, from imitation to improvisation.

Moreover, by applying the notion of digital anthropology to the digital twins of the robots used in our experiments, we might have omitted some interesting results depending on other shapes and dimensions. We should also not forget that even though artificial agents can simulate intentions and affects, our way of interpreting them—or the notion of qualia we mentioned earlier—is always different. Having implemented the analogous dance sequence of the humanoid robot on the industrial arm, we experienced differences (especially in relation to posture symmetry but also speed and jerk) with the industrial arm proving more compliant given the type of actuators that executed the movement.

Future perspectives using emerging robotic technologies

The next phase of our research will be testing the same scenarios with the physical version of the robots. In this way we can determine whether the perception of the performer, as well as his/her quality of movement can be impacted differently when working in the same conditions, with the real, mechanical body of the robots. This will also allow us to understand how the hybridization process is influenced by movement imitation phases. Our first empirical results encourage us to establish a scientific laboratory study, measuring kinaesthetic empathy through the detection of mirror neurons, using electroencephalogram (EEG) signal processing.

Conclusion

Learning by imitation, then establishing a creative interaction using digital twins allowed us to research on the qualia each participant experienced and improve the overall quality of movement through dance improvisation. This type of creative interactivity involved the hybridization between humans and robots, generating new visual shapes when video-projected, as well as an original type of movement material. Hopefully our remarks on digital anthropomorphism will further stimulate exchanges between roboticists and artists, anticipating a new individuation phase in the overall robot-human relation.

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(1) a spontaneous reaction to motion which occurs outside you; the timing in which you respond to the external events of movement or sound; the impulsive movement that occurs from a stimulation of the senses: ie. someone claps in front of your eyes and you blink in response; or someone slams a door and you impulsively stand up from your chair., Bogart, Anne, Landau, Tina. The Viewpoints Book, p. 11

(2) acc to IBM, while a simulation typically studies one particular process, a digital twin can itself run any number of useful simulations in order to study multiple processes.

(3) acc to Stanford Encyclopedia of Philosophy, "philosophers often use the term 'qualia' (singular 'quale') to refer to the introspectively accessible, phenomenal aspects of our mental lives.The status of qualia is hotly debated in philosophy largely because it is central to a proper understanding of the nature of consciousness. Qualia are at the very heart of the mind-body problem."

(4) https://www.imdb.com/title/tt0113568/

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Chu-Yin Chen is an Artist and Professor in Digital Art at Paris 8 University. Since 2019, Chair Professor at National Tsing Hua University (Taiwan). Her creations, based on Artificial Life and complex systems develop interaction modes between audience and virtual creatures showing autonomous and evolving behaviors. Her digital artworks have been shown in numerous international exhibitions. Her research articulates on two overlapping areas: 1] Digital Creation using algorithms of complexity and emergence, and 2] Metacognition and Elicitation of the processes of creation, enaction and aesthetic reception, via psycho-phenomenology and mindfulness.