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Robots and Choreography: a Contribution to Artificial Sentience Characterization

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Submitted version

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Abstract. The research work presented in this paper is at an early stage. While tests for artificial intelligence/consciousness/sentience continue to evolve, there still doesn't seem to be any consensus on what exactly we hope to capture with such tests. In this paper, we explore the possibility of an arts-based performative test for machine sentience. We analyzed a specific choreography, called Chemins à coulisses, through both the language and experience of the choreographer and a spectator, and we offer some additional theoretical lenses through which to tackle this problem, including phenomenology and distributed systems. We offer the beginnings of an approach to creating a performance-based test where the machine doesn't merely imitate steps but engages in a meaningful way with performers and spectators. There may be an under explored area for benchmarking machine sentience that sits at the intersection of phenomenology, choreography, and distributed systems.

Keywords: Machine Sentience, Choreography, Inter-subjectivity, Distributed Systems.

1 Introduction

We wanted to address Smart Life through the robots perspective. Robots will be part of our future to face incoming challenge of humanity. The new generation of robots will be smarter and able to interact accurately with human beings as we can see it in movies, novel or series. From our point of view robots will be enhanced through machine consciousness [1]. In the field of machine consciousness we are interested on a subfield called machine sentience, or artificial sentience.

Sentience is defined as an ability "of experiencing an affective state" [2]. It can define human-animal and human-human communications. Our belief is that sentience will be extended to human-robot communications in a close future [25]. We can imagine teamwork between humans and robots crafting complex building on a remote and dangerous planet far from the solar system.

As sentience is coming into play, we need to evaluate the ability of any robot to deliver it. Artificial Intelligence testing emerged from A. Turing works [3]. The idea of defining Sentience Testing has been introduced in [4]. This proposal was disruptive but needed a missing point of view: cognitive and philosophical sciences [4].

This paper describes a preliminary work on artificial testing. The second section describes robots as part of our culture and how they are imagined as part of our future. Section 3 provides an analysis of a choreography that could help to design artificial sentience testing. Section 4 regroups the point of view of the three authors about addressing artificial sentience testing through a dance performance. Section 5 provides some preliminary hints about artificial sentience testing. Section 6 concludes the paper.

2 Robots as part of an imagined future of humanity

Since the early 20th century, robots have played a prominent role in our images of the future. From books to movies, comics and TV series, there have been many robots that help us think about our future with them around us, from Maria of the Metropolis movie in 1927 by Fritz Lang, to the very popular R2D2 of the movie Star Wars in 1977 by G. Lucas, or the peaceful CHAPIE of the movie from N. Blomkamp and T. Tatchell in 2015. From HAL of the movie 2001: A space Odyssey in 1968 by Arthur C. Clarke, and S. Kubrik to HER of the movie by S. Jonze in 2013, robots have always challenged our mind and our way of thinking.

The movie A.I. Artificial Intelligence of S. Spielberg in 2001 shows how intelligence and emotions can help to get robots to be more human-like, and potentially to be the species that survives the future. One may notice that emotion and empathy are at the heart of various AI TV series: for example, we can watch Lost in Space, season 2 on Netflix, December 2019, where a teenager, Will Robinson, is tightly emotionally connected to an alien robot he saved. More unexpectedly, in Better than Us on Netflix, August 2019, episode 5, the robot of the family, Arisa, a very new generation of robots, explains to Safronov, the father, that she is able to sense emotional states from humans. This line of possibility from fiction mirrors V. Gal's real PhD thesis work in the same area [5]. Sometimes in fiction robots act together, as swarms or in collaborative teams, like Gorgonides vs Commando Elite in the movie Small Soldiers 1998 from J. Dante, or Autonomous Mobile Swords in the movie Screamers from C. Duguay 1995, and generally it turns bad, as the robots turn against their creators like Terminators do in the movie The Terminator, from J. Cameron, 1984. While our science fiction often shows us the limits and possibilities of our imaginations, robots, and especially swarms of robots, are part of our future and require careful attention.

Swarms of robots have also their own benchmarks. The RoboCup, where two teams of autonomous NAOs from SoftBank Robotics play soccer against each other, offers yet another benchmark for ongoing robotics research. The aim of this challenge is to defeat a professional world champion soccer team around 2050 [6]. Movies can again show a different perspective about how we can measure and test the possibility of robot intelligence and/or sentience. For example, biological androids, known as

replicants in the movie Blade Runner[1] from R. Scott, 1982, are detected by the Voight-Kampff test. The Voight-Kampff test evaluates the emotional response to an aggressive questionnaire and measures the empathy level of the tested. In the movie, it is supposed to be the dysfunctional emotional response that reveals the replicants to be different than the humans they resemble. The film challenges this very relevant capacity. It is also interesting to mention, the Baseline Test from the movie Blade Runner 2049 by D. Villeneuve, 2017, it is a "more advanced technology" that focuses on Replicant operational stability. Operational stability could be associated to some kind of alexithymia. Emotions, free will and consciousness are at the heart of the future of robots and humankind.

Humans have always been keen on comparing computers against human intelligence. Alan Turing defined the first AI test in 1950 [3]. Deep Blue defeated the chess world champion Garry Kasparov for the first time in 1997. It was one of the greatest benchmarks of AI research progress. Since then, benchmarking of AI has never stopped. Google's DeepMind AI won against Lee Sedol, one of the world top players of Go, in 2016. But AI has become affordable to developers. There is an AI based painter trained with Vincent Van Gogh paintings and landscape pictures known as VincentGanGogh [7]. It is able to transform a photo by adopting Van Gogh painting style and to post it on Instagram. VincentGanGogh writes hashtags, poems inspired by the painting it provided. It "like"s photos from other artists, and sometimes comments on them. Some people do not notice that it is not a human being. VincentGanGogh is a serverless program using Generative Adversarial Networks (a type of neural networks) based on AI Azure services. VincentGanGogh shows how Arts come into play with AI in a very convincing manner. It demonstrated that there can be compelling arts-based tests and benchmarks for AI, in addition to the usual text-based measures. Both AI and robots also mix to provide ultra-realistic robots like AI-DA the robot painter [8] [9].

These examples demonstrate how addressing the arts can be challenging for AI researchers, particularly when a robot is involved. It is challenging because arts summon emotions and reach the deepest and most intimate part of our humanity. In some ways, visual and performing arts can be challenging for humans to interpret, so we need to tread carefully when introducing algorithms and AI into this domain. But it seems as if the arts offer a particularly rich opportunity for understanding the possibility of artificial sentience. The aim of our ongoing project is to try and outline a test to evaluate the sentient intelligence of robots.

Our goal here is not to conclusively describe a detailed test, but instead to suggest a method of investigation that has not been robustly considered yet. For example, in a broad-reaching survey of tests of machine consciousness, Elemrani and Yampoulskiy [10] taxonomize such tests under a number of qualities they might possess. Importantly, while creativity appears relevant to a (small) number of tests [11] the most famous of these tests focused on jazz improvisation. The phenomenological experience of social interaction in such tests is largely absent. Granted, there are some func-

[1] BladeRunner is a movie related to the universe from the novel "Do Androids Dream of Electric Sheep?" from Philip K. Dick (1968).

tional correlates that appear occasionally in such tests, where looking at both the architecture of the system and its subsequent behaviour can stand in for an evaluation of an experiencing subject, but such correlates are themselves uncommon and poorly discussed within such literature. This is probably true for at least two reasons: first, we have yet to create a test even for humans and animals such that we could conclusively claim to have solved the problem of other minds, and therefore creating such a test for machines is clearly out of reach until the problem is clarified or redefined. Second, because the literature in phenomenology tends to begin at the felt, conscious experience of the experiencer, it might appear to be an odd starting point for such a test. While we cannot claim to have solved these problems at all, we believe there is something about the participation (by dancer and spectator) in certain kinds of performance that indicate underlying conscious experience, and that some version of this can be mapped on to the quest for machine sentience. Our motivation, then, is to bring together three perspectives not generally seen together (computer science, choreography, and phenomenology) and to suggest a methodology in practice that can be applied to tests of machine sentience. We recognize much is going unsaid here, including detailed descriptions of what prerequisites must be present to even participate in such a test, including something like humanoid embodiment and dynamic systems to interact with the unpredictable world in real time. We instead start here from a provocation that the work in machine sentience or consciousness has not looked to performance studies or choreography yet in ways that might reveal new and unique ways of approaching the problem.

3 Choreography analysis

We have tried to carefully study how the "Chemins à coulisses," a dance choreographed by Micheline Lelièvre, is played, more accurately implemented, and how parts of it work. The choreography is written for four performers. Each of them knows the overall partition. This dance is a quartet, performed in a square space. There is no music, except the sound of dancers' steps or their breathing. The video of the full performance can be seen at [12]. An explanation of the performance is provided on the following video [26].

Writing choreography means defining the steps to be executed, in which space and with which inner music. "Chemins à coulisses" is written using protocols like canon, repetition, and various changes of directions in space. This is quite common and easy to reproduce as required.

Each step of this dance is written, which means that the four dancers know exactly what they have to do. The choreography is built with different sequences and patterns, in which the performers slide and move in the choreographed space, but they also differ in the number of steps according to each dancer. They may dance all together the same steps at the same time, at the same pace, in different directions, or dance the same steps by pairs (in different spaces as well). But the core of the choreography remains elsewhere, and it is the most difficult part to explain, which plays into the ways this offers a mode of testing for sentience. Talking about the dance is extremely

challenging, and, like explaining the blue color to someone who was born without vision, we hope to point toward non-propositional knowledge as a source of valuable insight into human sentience.

In this choreography, certain items are not specified, like speed of execution. This means that the dancers have to rely on different skills, and not only on memory. Dancers know when and where the movement begins. They have to finish the sequence together, but they can't always see their partners, sometimes in the dance, they turn their back. How do they accomplish that? The ability to do this is the result of long practice and training. But there are also a certain number of parameters or skills that dancers use to achieve it.

In the performance, the dancers are hearing each other, but this is neither necessary nor sufficient for a successful performance of the dance. Mostly, they use a kinesthetic sense to feel how their partners behave. The dancers are all related to the others through feelings, including breathing, sound of movements, and perception of air moving around. And finally, the dancers finish the sequence in time and together. The whole dance has its own musicality, which means inner rhythm, inner music inside the movement itself. The dance is made of all these parameters together. Any attempt to analyze and make sense of the dance and the experience of the dance requires that the viewer differentiate imitation from interpretation.

If the dancers were only to imitate movements and just have to know in which space, at what time to perform them, and at which pace, it would not match with the design of Micheline's choreography. Something more subtle is required here. Dancers have to coordinate together without speaking, and without seeing each other sometimes. Their ability to interpret the choreography is very important. The heart of the creation is the choreography itself and not the performer individually. The four dancers create something that can only happen through the way they are related, each one to the others, beyond any personal desire.

This is the point where we are not sure that robots can be able to be as creative as dancers are! For sure they can imitate the choreography; it is not difficult. But would robots be able to act and make decisions allowing the dance to generate something unexpected that brings emotion for the audience and to the dancers as well? There are larger questions here related to autonomy that, we think, must be answered. But the possibility that a robot is being able to interact, as a person does in this dance, would indicate that, if some semblances of autonomy were already present, then perhaps the robot is engaging in the dance in a genuine way. As a counterexample, see any of the videos that Boston Dynamics has released of their robots dancing together. You can see the impressive range of movement each robot is capable of, but you can also see that there is nothing but pre-programmed imitation, without dynamic interaction and the ability to feel changes in the co-participants in the dance. Eric Whitman, one of the roboticists involved in teaching the Boston Dynamics robots to dance together, said, [13] "Everything had to be worked out in advance and scripted precisely. Robots have the advantage over humans in that they're very repeatable: Once you get it right, it stays right. But they have the disadvantage that you have to tell them every little detail. They don't improvise at all."

4 Levels of Description

4.1 Choreography (speaking as M. Lelièvre, Choreographer)

To choreograph is to create a situation that offers the possibility of a meeting. What is born from the encounter could not exist otherwise. This is what happens "between" the beings, the dancers, the public, and the places. What I would expect from a robot who would dance with us, would be that this object, (designed by humans) brings me (as the dancer) to a place of unexpected reflection and creation, by its specificity, as a different performer and in two-way exchange. So that it questions me-as-dancer, and simultaneously the encounter also modifies the robot.

It is undoubtedly a philosophical question and which questions what it means to be human living with other living beings and sharing an event with other living beings. To choreograph means to create a situation that offers the possibility of a meeting.

Objects and Subjects. The form of the robot is not important. I like to choreograph and perform with objects.

Once I helped a friend to create a dance with a cabbage. The cabbage in this case becomes a partner. It has its own way of being alive! It can be heavy, round or irregular in its form, fragile or not. All these parameters determine how one dances with this partner and how the choreographer constructs the dance according to the specificity of the two partners. Dancing with an object is to incorporate it, like a part of the moving body, an extension, or it can also create a space of interaction between the object and the dancer.

So, to dance with a robot, any form it would have would mean to know exactly what it is able to do and to construct the choreography according to these parameters. But to dance with a robot would not be like to dance with a human being. It is different because something is missing. And this missing something is what we're hoping can be captured and harnessed as a way to look for the presence of that missing something.

4.2 Social Cognition and Phenomenology (speaking as R. Zebrowski, Cognitive Scientist and Philosopher)

Traditionally, much work in social cognition has focused on the internal lives of the interactors, treating social cognition as traditional cognition facing outward. However, the theory of participatory sense-making, a theory with roots in enactivism, offers a richer story of social dynamics. This view focuses, instead of on the minds of individuals in a social situation, on the autonomous social system that arises from (and as) that social situation [14]. Rather than trying to make sense of social experiences just through the intentions of the individuals, participatory sense-making focuses on the myriad ways the interaction itself takes over, sometimes working against the interactors and their intentions. The classic example here is when two people walk down a hallway toward one another, and in attempting to move out of the way, both instead mirror the moves of the other, frustrating the intentions of everyone involved.

These kinds of dynamic systems can be measured and modeled, and there's a way in which the choreography that Micheline describes here can work in a very similar way. She describes the dancers and the spectators as engaged in an embodied, affective reaction rather than a cognitive one; we already know people lack the kind of privileged access to our own minds that has long been theorized, but thinking about choreographed dancers as part of a larger dynamic system offers a new way to consider machine sentience. What's more, we can measure and observe these systems from the top-down, through the autonomous dynamic system that arises in the interaction of the dance, and also from bottom-up, through what [15] have called mutual incorporation: the phenomenological level of description of the very same dynamic system.

4.3 Distributed Systems (speaking as E. Gressier Soudan, Computer Scientist)

Analysing the choreography Micheline designed and instantiated with performers sounds like watching the execution of a living distributed system, an unexpected kind of distributed system, but kind of. To start such an analysis, we need to provide a list of first criteria: control, coordination, order, determinism, and indeterminism also [16].

The design of the choreography first tells us that there is a set of behaviours expected from performers. The patterns that define the overall choreography invite the viewer to think that it is a deterministic execution. But, as the control belongs to each of the performers anytime, the result is not the same at each occurrence of the performance. Then, there is no total order [17] that drives the execution. Strictly speaking, the distributed execution can't be imitated and reproduced exactly the same each time.

Performers build their own synchronization all together, which is real time but not clock driven. They use an inner tempo, and their inner tempo self-synchronizes among the inner tempo of others. Self-Stabilizing algorithms are part of the distributed system domain [18]. The overall performance is self driven by messages the performers are exchanging breath, look around, noise from the movement of each other. What this means is that the execution self-stabilizes in the same way an autonomous system does. In a first approach, it is more a message-passing and event-driven distributed system. Except the knowledge of the full choreography before start, during performance no state information is explicitly or partially shared among dancers involving any information consistency management protocol [19].

Shared knowledge distributed systems are emerging through networked cyber physical systems paradigm [20]: enhanced crop growth control using robots and drones is an example of such an application. Do performers exchange knowledge when they execute the choreography? We can say yes. They build their own living map of the shared performance through the signals and events that their partners provide. It is not only signals and events, it is also the feeling of how the performance evolves, how their partners move to decide how they need to perform to be collectively right on the choreography purpose.

New research tries to enhance the responsiveness of Information and Communication Architectures. To deal with this goal, there have been attempts to model the evolving requirements of applications. Communication Networks evolves to be intent based [21] leading to intent mining using machine learning or federated machine learning techniques. Could we model the choreography using intention? Can we say that the choreography is an intent-based performance? A distributed system point of view is not enough to examine this last aspect. We need to address the performance with higher level tools that allow a better abstraction to take care of the inner semantic of performers' dance.

5 Analysis and Test of Machine Sentience

When Micheline describes the difference between dancing with objects and dancing with subjects, it's an illustration of what Fuchs and De Jaegher [15] terms mutual incorporation, which they define as, "a process in which the living bodies of both participants extend and form a common intercorporeality. [This kind of] intersubjectivity… is not a solitary task of deciphering of simulating the movements of others but means entering a process of embodied interaction and generating common meaning through it" [p. 465]. This is where we see these various levels of description overlapping to begin to offer us a way to approach a kind of test for machine sentience.

If we think about Micheline's description of the choreographed dance "chemins à coulisses", it is easy to see how this kind of interaction is not one of multiple mental states coming together to coordinate an interaction, but instead is a kind of embodied coordination that requires more than mere imitation. The performers in the dance know their movements, but must mesh with the others in the dance, giving up some of their autonomy for the sake of the larger system, in which each person embodies some part of the bodies of the others, and vice versa. As [15] put it, "In contrast to interactions with objects, which are only reactive- that is, they can change me but never because they intend to- in social interactions there is a certain way in which I am not in control… The other, while perceiving me and engaging with me, co-determines me in his gaze, touch, attitude, etc. I not only have limited control over the other, but also over myself in my encounter with him" [p. 477]. Think here of the difference between dancing with a cabbage (or an early 21st century robot) and dancing with another (or several other) human dancers. In the case of objects, there can be a kind of unidirectional incorporation, where I take up the body of the robot (or the cabbage) in my own embodied engagement with the world; but in the case of these reactive systems, there is no two-way intercorporeality. With another living body, we can understand the kinds of give and take required to perform such a dance, and the affective and embodied response that lets go of some amount of control for the sake of the interaction in general. We allow others in the choreography (and even among the spectators) to shape part of the dance, and in doing so we both recognize the subjectivity of the others, and also allow ourselves to be partially (and quite literally) determined by them in those moments. Will sentient robots be able to enter such behavior, and also this internal state perhaps?

6 Conclusion

We spoke earlier about how there are almost no tests of machine sentience that start at the creative or performative level. But there have been a number of robots used to stand in for human performers in plays, for example [22] [23] [24]. Yet by nearly universal account, those robots fail to do more than a set of mechanical pre-programmed responses, with no creativity or improvisation, and, more importantly, with no sense of genuine intersubjectivity or mutual incorporation. Thus far, robots have merely imitated, and not interpreted, these performances. No test of machine sentience is going to indicate anything interesting is happening in those performances. However, a dance, like the one we've been discussing here, offers an interesting moment for the emergence of genuine intersubjectivity.

The transversality of all this research opens the creativity and the subtlety of creation and interpretation. It makes concrete that art is a different way of thinking and the conversation between science, philosophy and choreography can be very inspiring.

Putting a robot in place of one of the dancers will offer a chance to see how dynamic the system is, but also to see how well attuned it is to the affect and embodiment of the dance partner. These are fine-tuned, sub-linguistic ways of interacting, and even people are not always successful at interpreting them. To that end, it probably matters more that a machine might pass this sort of test, and it means relatively little if it fails.

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