Robot Ludens: Inducing the Semblance of Life in Machines

Julia Ghorayeb Zamboni

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By: Julia Ghorayeb Zamboni

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______________________________ External Examiner
Dr. Jana Horáková

______________________________ External to Program
Dr. Jonathan Lessard

______________________________ Examiner
Dr. Luis Rodrigues

______________________________ Examiner
Dr. Mia Consalvo

______________________________ Thesis Supervisor
Dr. Bill Vorn

Approved by ______________________________
Dr. Rachel Berger, Graduate Program Director

December 3, 2020

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Dr. Effrosyni Diamantoudi, Dean
School of Graduate Studies

Abstract

Robot Ludens: Inducing the Semblance of Life in Machines

Julia Ghorayeb Zamboni, Ph.D. candidate
Concordia University, 2020

As culture and technology move forward, researchers from various fields have continuously developed new ways to create lifelike machines that evoke empathy and engagement with humans. This shared goal drives an enormous effort in the realms of arts, games, and social machines, among others. The present study's core research problem revolves around understanding how non-living devices gain a semblance of life and intelligence. The goal is to identify and examine the expressive components that induce the attribution of life into machines. The research follows the methodological framework of research-creation, integrating theory with creative processes. The theoretical framework's key findings establish the following four design elements for creating lifelike machines: Body, Behavior, Context, and Name. It examines how the articulation of those elements can assign different meanings to devices. In association with the theoretical framework, this study also involves producing two examples of lifelike machines within the realms of art and game design. The first is a robotic art installation called Robot Ludens, exploring possibilities and challenges for creating robots playing alive and playing dead. The other is a drawing game called Pict.io, which tries to simulate camaraderie dynamics between humans and computational players.

Keywords: lifelike machines, agency, sign-system, robotic art, game characters, social machines

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Introduction

For centuries, humans have been fascinated with the idea of creating life through non-living apparatuses. Devices with lifelike properties permeate different aspects of society and culture, such as the arts, mythology, literature, and the sciences. For instance, the fields of Artificial Intelligence (AI) and robotics are ultimately trying to create artificial agents with physical and intellectual capacities equivalent to or better than their biological counterparts. At the same time, cognitive theorists and philosophers continually engage in determining at what point the phenomena of life or intelligence would come into being in mechanisms. Even though today the distinction between the living and non-living is evident, and it is common sense that machines are not equivalent to living organisms, some devices can blur this distinction and are perceived as if they were alive.

Therefore, although machines are not living organisms, they can often be seen as if they were. They appear to have a will, thoughts, and emotions. For instance, during single-player video games, humans play with their computational opponents as if they were playing with conscious and competitive entities that, such as ourselves, care about the outcome of the game. Why is it that some machines are perceived as simple tools or appliances, while others can challenge the boundaries of the non-living and are seen as lifelike?

Questions about generating the semblance of life are shared among machine creators in many areas. Most often, the expressivity shift from non-living objects into seemingly living entities is pursued by artists, game designers, and social roboticists. For instance, game designers frequently require designing AI opponents that can convincingly assume the roles of human players in all kinds of computational games. Social roboticists hope to create socially intelligent machines that communicate and interact with humans in a personal way. Artists often seek to explore the aesthetic ambiguity of machines and devise autonomous behavior for generating the semblance of life. While those creators pursue different aesthetic outcomes, they usually hope to generate a sense of agency capable of convincing humans that such devices are somewhat different from other inanimate objects.

Every time a creator develops a lifelike machine, she makes a set of design choices regarding the type, behavior, and presentation of the device. While lifelike machines often have anthropomorphic inclinations, they do not have to imitate the human form or movements to be believable for the observer. The present research investigates the main elements of design that a creator should consider when attempting to generate the semblance of life in machines. It hopes to identify a structural relationship between the various components that one associates with the presence of life, and how a change in those elements affect the meanings generated in human perception. At the same time, this research aims to create practical experimentations in the fields of arts and game design, with the production of two different instances of lifelike machines.

The first section of this dissertation is the Literature Review, divided into four parts, three focused on the machines, and one directed at the human that perceives life in the device. The sections dedicated to machines present several approaches used for describing and creating lifelike machines in different epochs in the fields of arts, games, and social robotics. The section on human participants focuses on the cognitive process that the viewer undergoes when they perceive machines as if they were alive. Prior studies of lifelike machines are centered on specific niches. They lack a comprehensive theory for analyzing the elements that are at play for machines of different kinds and contexts to take the semblance of life and their relationship with each other. For this reason, the present research aims to look at machines from an interdisciplinary point of view, which includes multiple strategies for creating lifelike apparatuses.

Chapter 2 presents the methodology. The methodological framework implemented in this study is research-creation, which involves two simultaneous segments, a theoretical investigation and practical experimentation, where the two phases indirectly support each other. The theoretical phase of this research uses methodological procedures borrowed from the field of the semiotics of puppetry, consisting of the classification and analysis of the sign-systems that allow non-living materials to take on the semblance of life. The motivation for this choice is that both machines and puppets are inanimate objects that can acquire a semblance of life depending on how they are designed, and the predicaments that they share have been extensively studied by puppeteers. In addition to the theoretical study, the practical phase of this research is an opportunity for testing elements of design for creating lifelike machines. The creative production of lifelike machines is framed on a method of iterative design where machines are created, exhibited, evaluated, adjusted, and exhibited again. Thus, the design decisions were based on the successive phases of experimentation and evaluation.

As a result of the theoretical research, Chapter 3 exposes a structure comprising identification, description and exemplification of the sign-systems that allow non-living materials to take on the semblance of life. Signs might include, but are not limited to, movements, music, material composition, verbal and body language, tone of voice, stage settings, and other elements used to fulfill the communicative function of generating the semblance of life. The sections in this chapter present a systematization of four main items: the body, the behavior, the context, and the name of the machine. Moreover, the phase of practical creation involved experimentation with the design elements studied in this chapter to produce machines within two different applications, one in art and the other in game design. As a result, two projects were developed: the artistic installation Robot Ludens and the game Pict.io.

While this dissertation focuses on the communication of the notion of life in machines, the art installation Robot Ludens, presented in Chapter 4, investigates not only the appearance of life but also how to create the semblance of death in devices. This subject's significance arises from the conceptual boundaries established between life, death, and inanimate matter. Death concerns life by marking its end. While a dead entity and an inanimate object bear the shared feature of not being alive, they are still antagonistic concepts. Therefore, this notion brings to the project an extended artistic challenge of depicting death on something that has never been alive. The art installation consists of a diptych with two scenes, one with a spider-like robot taking on the appearance of being alive (playing alive), the other with a similar robot taking the appearance of being dead (playing dead). The scenes hope to explore the transformation of the resembled status of the robots from the inanimate, to the living and the dead.

The artistic work occurred in two versions, between 2017 and 2019. It was executed, exhibited, and evaluated twice, first in 2017, at the Zentrum für Kunst und Medientechnologie (ZKM), in Karlsruhe, and then in 2019, at the festival Printemps Numérique, in Montreal. The survey methods used for evaluating the artwork were direct observation in the first exhibition and design and implementation of a questionnaire in the second. The evaluation aimed to estimate what was the general feeling that the work provoked in the viewers. Moreover, it hoped to access the design choices' effectiveness for communicating the notion of death in an immobile robot, and if the audience could understand the device's immobility as a sign that the machine is dead and not broken or turned off.

Chapter 5 presents the development of Pict.io, a drawing game played by humans and machines. This game was inspired by Pictionary, and adapts from Google's program Quick, Draw!. It is performed by an AI player that can guess what their human teammates are drawing. In this game, each team is composed of two humans and one machine, communicating through drawings and speech as they work together to solve challenges. Different than most examples of AI players, in this game, humans and machines must collaborate to succeed in the game. The project aims to create a situation in which the AI creates a sense of camaraderie, and humans perceive the machine as fellow players.

This game was presented in several venues, and at each demonstration, we evaluated and tweaked the game based on the player's responses for it to become more engaging. This research-creation was a collaborative project developed with the doctorate colleagues Luciano Frizzera and Julia Salles, in the study group Machine Agencies at Milieux institute and Technoculture, Arts, and Games (TAG) at Concordia University.

The present investigations on the expressive elements of machines hope to contribute to creators in various fields who wish to generate a semblance of life in devices. It considers the different design components of a machine and how their articulations can produce different aesthetic outcomes. Depending on its expressive elements, lifelike machines can generate different emotional responses in the viewers, such as identification and empathy, creepiness, and distress. Therefore, by understanding how design decisions may impact the observer's experience, researchers can choose what components provide the best vehicle for the idea they want to communicate and the emotional response they hope to provoke. This way, they can direct their productions towards the desired effect.

Chapter 1: Literature Review

This literature review draws on the historical and contemporary theory of machines, considering how lifelike devices are produced, discussed, and dismissed. The review departs from the principle that every lifelike mechanism involves at least one device and one human to perceive it. Thus, this section has two main components: one focusing on machines in the fields of performing arts, games, and social machines, and one about the human participant, considering how individuals perceive life's attributes in mechanisms.

1.1 Performing Machines

In the performing arts, scholars have different views of what makes machines legitimate artistic performers. For instance, regarding musical performances, the philosopher Stanley Godlovitch (2002 [1998]) proposed that devices cannot be considered real music players, like humans. In his view, a player must have both technical and interpretative musical abilities, and machines are only capable of technical performances since they cannot emotionally interpret the music and experience aesthetic experiences as humans do. In Godlovitch's words:

> No program could sensibly be said to perform artistically. Why not? Because the program did not, in any convoluted sense, learn what it performs. Because programs do not overcome difficulties. Because programs do not choose the repertoire they perform for any personal reasons. Because programs never decide to scuttle a performance in defiance of the rules of the contest, or make people laugh. Because programs neither envy their fellow programs, nor alter their performance in an attempt to emulate what they regard as better, more sensitive, more insightful artistic reflections than their own. Because programs do not get

nervous before they generate their output, nor do they worry about what their teachers, friends, and lovers will think of them if they fail. Because programs have no life plans, no personal histories. 'Because no [program] would act tired.' (Godlovitch, 2002 [1998], p. 143)

However, in 1908, almost a century before Godlovitch made this proposal, the theatre practitioner, director, actor, and scenic designer Edward Gordon Craig argued the opposite regarding the device's ability to perform artistically. In Craig's view, non-living performers are superior to human performers precisely because they do not have a mind to interfere in their performances. He asserted that the movements of the actor's body, facial expression, and sounds of his voice are subjected to his emotions. Even though it should not disturb their acts, emotions possess actors; it affects how they move their heads, arms, and feet, such that humans are unable to stand against their "torrent of his passions" (Craig, 1908, p.3).

Craig suggested that the actor must abandon the theatre, and the inanimate figure—which he called the uber-marionette, should take its place. This figure would not exhibit the weakness of the living performers. Similarly, the German poet Heinrich von Kleist wrote a paper in 1972, describing a conversation that he had with an opera dancer, whom he calls Mr. C. The opera dancer proposed that there is more grace in the performance of a jointed mechanical doll than in the structure of the human body because marionettes have no egos or emotional weaknesses and, thus, their movements are wholly mechanized and precise, with no flaws. Kleist describes the dialog with the dancer about puppetry performances in the following words:

I replied that a puppeteer's work had been suggested as something rather dull: somewhat grinding the handle of a hurdy-gurdy. Not at all, he replied. Rather the movement of his fingers has a somewhat artificial relationship to those of the attached puppets, somewhat like the relationship of numbers to logarithms or the asymptote to the hyperbola. Furthermore he stated the belief that this final trace of the intellect could eventually be removed from the marionettes, so that their dance could pass entirely over into the world of the mechanical and be operated by means of a handle, such as I had suggested. (Kleist, 1972, p. 23)

In 2006, the performance theorist Philip Auslander wrote the paper "Human Boogie" analyzing a robotic artwork called *Abacus*, by Sergey Shutov. In this paper, Auslander legitimized machine participation in art shows and refuted Godlovitch's idea that those devices are not real performers. To address this class of artificial performers, Auslander coined the term "robotic performance", derived from Michael Kirby's notion of "nonmatrixed performing," which refers to art performers that do not play roles other than themselves and are not part of some fictionalized world. Auslander asserted that robotic performances should be characterized within the context of performance art (in contrast to the traditional dramatic theater) because these machines refuse the conventional forms of theatre illusionism and do not pretend to be anything else. However, there are examples of robotic performances that employ imitative machines that his theory does not consider.

Representational approaches to machines have existed since ancient times. For instance, it can be seen in the automaton from the 18th century, which are mechanical toys that reproduce the appearances and movement of animal and human beings. This approach also remains current today, for example, in the famous hyperrealistic robots created by David Henson. Nevertheless, the degree of imitation from reality is a choice that varies widely among creators, and numerous robotic artists have been prioritizing the role of autonomous behavior for generating the semblance of life, other than illusionism and visual representation. For instance, the robotic artist Bill Vorn proposes that:

> Animated metal parts in a robot or dots on a computer screen can be seen as being alive if they move and react in a non-repetitive and unforseeable way, giving a strong impression of self-decision and autonomy. Do Artificial Life creatures have to be figurative representations (anthropomorphic or zoomorphic) to be convincing? The premise of our hypothesis is that, as long as they manifest autonomous behaviors in the interaction process, agents could bear any abstract visual form. (Vorn, 2015, p. 183 and 184)

1.2 Game Playing Machines

Another field that often pursues the creation of a semblance of life in machines is gaming. Numerous game designers seek to produce AI-controlled opponents that can play against humans by evoking empathy and resemble living entities. Game playing machines, like machines in art performances, can acquire a continued level of engagement when human players ascribe them with motivations such as desires, hostility, and pursuit. Thus, when humans play against or with devices, they often perceive them as if they were making conscious and intentional choices within the game.

Moreover, the association between intelligence and the ability to play games is remarkably relevant to AI. This field regularly applies theories and structures of games to design and test new levels of machine intelligence. The game structure is recurrent in AI because it involves qualities that are usually associated with the presence of intelligence, such as goal-seeking, interactive behavior, perception, communication, learning, and other skills. Since the foundations of AI to the current date, numerous researchers such as Claude Shannon (Shannon, 1950 and 1955), Alan Turing (Turing 2004 [1950]), Stephen Coles (Coles, 1994), Hubert Dreyfus and Daniel Dennet

(Dreyfus & Dennet, 2005), and Stefano Franchi (Franchi, 2005) have been investigating computer games implications to AI development and for understanding human intelligence.

The influential mathematician and electrical engineer, Claude Shannon, was one of the precursors of game structure application to produce AI. Proposing an association between intelligence and the ability to play games, Shannon stated that even though it would be naive to assume that the brain operates analogously to a machine, research in the design of game playing machines will lead to insights toward the understanding of the operation of the human brain (Shannon 1955, p. 448).

The first experiment created to test the level of machine intelligence was designed in the form of a game, by the English pioneering computer scientist and mathematician Alan Turing in 1950. The Turing test, named the imitation game**,** was developed to examine a machine's level of intelligence compared to human-level intelligence. The test was published in his 1950 paper, "Computing Machinery and Intelligence". In this game, a machine, competing against a human, should convince a jury of people that the device was a person. The device would use natural language limited to a text channeled through a computer keyboard and screen. If the human judge could not tell the machine from the human, the device is assumed to have passed the test. Turing claimed that if a computer were able to do that, it would simulate human mental phenomena (Turing, 2004 [1950]).

Also in 1950, Claude Shannon classified three main types of devices that play games. The most straightforward machine could play games that have been thoroughly analyzed and had strategies developed for each situation in the game, for example, in tic-tac-toe. The second class of game-playing machines refers to games for which a complete analysis is unknown, but certain general principles of play strategy are available. This class included games such as checkers, chess, and bridge. In this kind of play, a machine would investigate, in each position, the different moves it could make, the diverse responses available to its opponent on two or three steps ahead, and choose a move that leads to the position of the highest winning probabilities. The third type of game playing machine presented by Shannon would be one that learns during play. In this case, the game's rules and goals are introduced into the program, with some principles of how to improve, and the machine gradually develops its playing skills through experience (Shannon, 1950).

In the 1950s, when Shannon wrote his papers, the sophisticated levels of gameplaying he proposed for machines were not technically possible. Today, these three levels have been implemented. For instance, DeepMind, a team of scientists, engineers, machine learning experts, in collaboration with Google, developed the programs AlphaGo and AlphaGo Zero. AlphaGo was the first program to defeat a world champion in the game of Go, in 2016. It selected its moves using deep neural networks trained by supervised learning from human players, and by reinforcement learning from self-play. In 2017, AlphaGo Zero introduced an algorithm that used only reinforcement learning without adding human data, supervision, or any knowledge beyond game rules. The new program, AlphaGo Zero, won 100-0, defeating AlphaGo, after forty days of self-play, and became the best Go player in the world. As declared by the computer scientists affiliated with DeepMind company, Silver et al.:

> Humankind has accumulated Go knowledge from millions of games played over thousands of years, collectively distilled into patterns, proverbs and books. In the space of a few days, starting tabula rasa, AlphaGo Zero was able to rediscover much of this Go knowledge, as well as novel strategies that provide new insights into the oldest of games. (Silver, et al., 2017, p. 358)

On the other hand, while AI has exceeded in board games such as Chess and Go, which involves formal structures and rules, and they can engage in natural language and dialog, other problems remain. For example, the creation of compelling narrative and story-telling. While computer programs can create narrative structures and possible plotlines, they are still not considered successful in producing literary creation. Various researchers, such as Juul (2000) and Gervás (2018), believe that human-level literary production is not achievable for computers because it requires some kind of embodiment. Cognitive capacities such as the ability to contextual knowledge, to relive experiences of all kinds, feel empathy, and emotions that are out of the reach of AI. The game designer Jesper Juul, for instance, stated the following:

> games belong to a formal/algorithmic domain, whereas stories belong in the interpretative domain. Games have to have formally defined rules to be games, and stories, being based on interpretation, are not formally defined. The definitive proof of this is the fact you can create a world-beating computer chess program. And this has already been done. But you cannot create a world-beating computer program that writes stories. (Juul, 2000, p. 4)

As an alternative to the field of AI, which frequently uses games to measure levels of intelligence in machines, from the game studies perspective, computers do not need to be intelligent entities to be considered as real players. Various game researchers, such as Björk and Juul (2012), Lenhart (2012), and Simon (2006), have observed that in games played by AI, more important than having actual intentional behavior is the appearance of having it. "It can seem counter-intuitive when intentional stance theory implies that players do not need to have actual intentionality, but only to appear to others as having that" (Björk and Juul, 2012). Game designers propose that in games such as Chess, Go, and videogames, operated by non-playable characters (NPCs), where the computer assumes the roles of human players, the main problem of design is creating convincing AI opponents. For instance, game researcher Lenhart asserted:

If a situation is a game, we expect a certain kind of behavior pattern. We assume a play attitude on all participating entities. We cannot truly get inside the head of our fellow entities, but we naturally assume a kind of human play attitude, a “playful profile” that is coherent with our own understanding. We then watch the behaviors and actions of the entity and if the action appears be accomplishing and pursuing the goals and beliefs that we ourselves would hold, we then believe the actions of the entity to be intentional. If the entity appears to act in a way that makes us believe it is intentionally playing, we say that the entity is a player, i.e. that it is performing the social role of player. (Lenhart, 2012, p. 37-38)

1.3 Social Machines

In addition to the fields of arts and games, lifelike machines have become part of our social interactions in different spheres of our lives. Social devices communicate and cooperate with people within the domestic environment for health-related applications, including eldercare (Vandemeulebroucke et al., 2018), autism intervention (Scassellati et al., 2012) (Wood et al., 2019) and rehabilitation (Mohammed et al.,2017). Some machines work as museum guides (Nourbakhsh et al.,2003), in education (Belpaeme et al., 2018), entertainment (Morris et al., 2019), and numerous toys (Raffle et al., 2006), and pets (Weiss et al., 2009).

Human-Robot Interaction (HRI) is possibly the most significant area of social machines. This field is dedicated to designing, understanding, and evaluating robots' employment by or with humans. HRI has vast realms of applicability that seek to respond to society's needs, in which robots assume various roles, such as supervisors, operators, mentors, and others. This area is generating growing social implications through its constant development (Goodrich, 2007). One of the main applications of HRI is in providing assistance and companionship. For instance, robots are increasingly developed to assist the elderly by providing support for emotional well-being and physical needs, including mobility support. Moreover, in complement to robots that provide hands-on assistance to users, Socially Assistive Robotics (SAR) concentrates on the development of socially intelligent machines that monitor, coach, and motivate users to engage in health and wellness-promoting activities (Matarić, 2017).

Even though current machines are not self-conscious, or have anything like a human level intelligence, they can engage in human-like interactions. Cynthia Breazeal, a remarkable explorer of social robotics and HRI from the Massachusetts Institute of Technology, has highlighted that the success of these social machines depends on more than their efficiency in their functions but on their capacity to interact with people naturally and intuitively (Breazeal, 2003 and 2004). Breazeal is a leading researcher settling the path toward creating sociable robots, and she developed the robot Kismet, which she uses as a case study. She proposes that the critical components of social intelligence in machines are derived from characteristics of human social intelligence. For instance, facial expressions, gestures, body movement, speech, language, and gaze direction are essential factors to facilitate human-robot interactions.

Breazeal explains that the readability of the device's modes of expression helps humans to understand social robots. She advises that for the robot's behavior, including facial expressions, gaze, posture, and gestures, to be an effective strategy for inferring its "mental states," it must match with its underlying computational processes, and to the person's expectations within given social situations. If this match is appropriately constructed, the human can intuitively understand how to interact with the robot. Moreover, she also explains that sociable robots must perceive and interpret human social behavior to interact with people in a human-like manner. This inference means not only to understand humans' gestures, expressions, and language but also to combine them with knowledge of the individual's personality, culture, and context. Having the ability to identify those elements is significant for machines to infer the humans' mental states with whom they communicate (Breazeal, 2004).

Even though socially contextualized machines are not usually recognized as carriers of real intelligence, devices have been increasingly accepted as social agents. A remarkable case is the humanoid robot Sophia, developed by the company Hanson Robotics. Through vast publicity exploitation, Sophia received Saudi Arabian citizenship in October 2017. She became the first machine to be granted nationality, even though the device is not exceptionally intelligent or socially aware. While granting citizenship to Sophia is arguable a loss in common sense, this machine's social status remains a relevant subject, and allusive to its capacity to be perceived, in some degree, as lifelike.

The study of the impact that machines have as participants in human societies and the issues that arise by assigning them with companionship roles are equally increasing. In this realm, ensuring human safety is considered one of the most critical factors in social machines. This issue goes beyond the mitigation of physical injuries generated by collisions between humans and robots; it reflects on the various ways in which a device could harm a person, such as generating adverse psychological effects that occur from distressing or dangerous interaction. Thus, this area goes beyond creating socially integrated machines and approaches the means of how to ensure they are also ethical and trustworthy (Lasota, 2017).

1.4 Human perception of life in inanimate objects

In all fields, the human participant is a fundamental component in the definition of a lifelike machine. The notion of lifelikeness is correlated with the human ability to perceive an inanimate object as something else, a living entity. This process of perception is similar to what occurs in the field of puppetry. As remarkably described by the Canadian puppeteer Ronnie Burkett, the breath of life in the device is also the breath of the human:

> I need an audience in front of me. Not for their noise, what I need is their quality of listening and their quality of breath, because when an audience is listening, especially in my work, and when an audience will hold their breath when a character is about to say something or reveal something, that breath is what makes my work literally come alive. That is the breath of the puppet (Gary Friedman Productions, 2013).

The process of human perception of life in inanimate matter has been extensively studied in the field of puppetry semiotics, and it serves as a reference to the present research. For instance, Czech researcher Jiří Veltrusky, coined the term 'vivification,' to refer to the puppet's becoming lifelike. He described vivification as the phenomenon akin to personification, where the spectators are induced to perceive the inanimate puppets as live beings acting on their own initiative. (Veltrusky, 1983, p.88). Veltrusky proposed that the process of vivification results from the articulation of three main expressive elements: an inanimate figure (the puppet), the motion imparted to it, and its voice. The author explains that the puppet's aesthetic results from the way that these signs are combined. Similarly, Henryk Judorowsky, in his paper entitled Transcodification of the sign-systems of puppetry, proposes that the puppet is formed of separate units that act together to stress their expressive functions. (Jurkowski, 1983).

The cognitive capacity to represent objects as something else (that is, a living organism), is at the core of the concept of human play. The sociologist Gregory Bateson (1987 [1972]) proposed that play comes into being when individuals are capable of understanding "as if" situations. For example, during a play-fight, an animal knows that a bite does not mean a real bite. Thus, they recognize that the bites emitted by themselves and by others are merely signs and are not necessarily true to reality. Therefore, the act of play involves recognizing the difference between “something” and “something that stands for something”. Bateson explains this idea as follows:

> If we speculate about the evolution of communication, it is evident that a very important stage in this evolution occurs when the organism gradually ceases to respond quite "automatically" to the mood-signs of another and becomes able to recognize the sign as a signal: that is, to recognize that the other individual's and its own signals are only signals, which can be trusted, distrusted, falsified, denied, amplified, corrected, and so forth. (Bateson, 1972, p. 184)

While it is evident that play is separate from the basic notion of reality, Bateson clarifies that play also differs from the processes of fantasy, delusion, and dreaming. In his words: "Within the dream, the dreamer is usually unaware that he is dreaming, and within "play" he must often be reminded that "This is play" (Bateson, 1972, p.190). Therefore, while a delusional or dreaming person is usually unaware that she/he is dreaming or fantasizing, the player is always aware of both realms of reality and fantasy — the player deals, necessarily, with two frames of interpretation.

Lifelike machines generate in the observers this ambiguous effect, which Bateson relates to playing. Robotic artists and theorists often refer to the ambiguity present in devices, which lies in the fact that lifelike robots never seem to renounce to either frame of reality or fantasy entirely, so they are often described as existing between the living and the non-living. Two terms are frequently associated with lifelike machines' perceptive experience: suspension of disbelief and double vision. The term "suspension of disbelief" refers to the ability to suspend their judgments regarding the implausibility of fictional narratives, such as a machine coming to life. This term was first used by the poet Samuel Taylor Coleridge in the context of literature and spread to other areas such as theater and cinema (Coleridge,1817). Moreover, various authors use it to refer to the perception of machines, such as (Vorn, 2000 and 2015), (Duffy, 2012), (Demers, 2006, 2014 and 2010), (Velonaki & Rye, 2010 and 2016), (Horáková & Kelemen, 2006 and 2010), (Demers & Horáková, 2008), (Sussman,1999) (Ghedini & Bergamasco, 2010) and (Penny, 2008). For instance, by comparing puppets and robots, the researchers Ghedini and Bergamasco declared that:

> Specifically, robots, puppets, and "things" crossing category boundaries, question what we perceive as "life". They suggest that there is no such a thing as a discrete gap in our perception between animate creatures and inanimate objects, rather a continuous category. Moreover, in their paradoxical status of quasi-living entities, they are agents of cognitive dissonance, addressing the ambiguities of our perceptions and confronting us with stimuli that we "know" are deceptive or fictional, but accept as "true" or "real", operating a "suspension of disbelief". (Fiammetta Ghedini, Massimo Bergamasco, 2010, p. 736)

In the same line, the term *double vision* was coined in the field of puppet theatre by the researcher Steve Tillis. It refers to the way the spectator sees the puppets in two different ways at once: as a perceived object and as imagined life (Tillis, 1992). The robotic artist LP Demers proposed that the same effect occurs in performing machines (Demers, 2010 and 2014). The experiences of "double vision" and "suspension of disbelief" are associated with an individual's mental capacity to represent particular objects as if another. These theorizations about the processes of double-vision and suspension of disbelief, referent to robots, show that, most of the time, when viewers perceive machines as living and conscious entities, they are simultaneously aware that these lifelike features are not real, and that the machines are only seeming to be alive.

Chapter 2: Methodology

Machines are inanimate objects that can, under appropriate conditions, be perceived as lifelike. Many professionals, such as artists, game designers, and social roboticists, attempt to create the appearance of life in machines, facilitating interaction with humans for functional, artistic, and entertainment purposes. The literature review shows that across disciplines, different strategies have been used to make machines appear alive. Some researchers are engaged in stimulating emotional responses; others in creating devices that can solve logical problems; that can sense and respond to the physical world, and so on. On the other hand, each researcher directs her focus to particular aspects and approaches to this end, and individual theories do not account for the systematization of the different methods at hand or how they are related.

For this reason, the present research looks at machines from an interdisciplinary point of view by appointing diverse approaches that can be employed and combined to generate the semblance of life while establishing relationships among them. This study aims to provide a system that operates across fields to assess different approaches and locate an extensive set of data regarding their shared predicament of creating lifelike machines.

Often, machine creators such as artists and social roboticists aspire to produce devices that evoke empathy and have a strong sense of presence in the world. Still, the ultimate aesthetic effect desired by each professional can vary greatly. While some creators aim to produce realistic devices and trick the viewers into believing that the machines are humans, others want to show their mechanical aspects as part of their identity. Some creators want to produce artifacts that seem intelligent and capable of reasoning, and others want them to seem sensitive to pain or have a sense of humor.

The pursuit of generating lifelike machines involves the articulation of multiple expressive components, and as a result, devices may not always induce the effect aspired by its creator. For instance, the signs of life might not be enough for the observer to perceive agency in the machines, by portraying mechanical and unconvincing behavior. Alternatively, other than creating empathy, the device may become creepy and frightening to the observers, as indicated in the theory of Uncanny Valley (Mori, 2012), which will be detailed below. Thus, the core problem in this research project is to understand how the semblance of life is produced for human participants. By understanding how design decisions may impact the observer's experience of machines, designers can have more control over their productions and public reception. This exploratory study answers two main questions: 1) What are the design elements that generate the semblance of life in machines? 2) how can the chosen design decisions and their articulation impact the people's perception and appreciation of machines?

The goal of this research is to outline a definition and analysis of the main dramatic components that induce the attribution of life into machines employed by artists, game designers, and social roboticists alike. Moreover, the study also aims to create two practical cases of lifelike machines in which we could experiment with the articulation of the elements examined in the theoretical framework within two different applications: art, and game design. The hands-on process also explores the expressive potential of two distinct kinds of devices: robotic and computational. The first project is a robotic art installation about machines playing alive and playing dead, that is, taking on the appearance of being alive and being dead. The other is a game-playing AI algorithm that simulates camaraderie's dynamics between humans and machines.

The present research follows the methodological framework of research-creation, defined by (Chapman and Sawchuk, 2012) as an outline for projects that integrate theory with creative processes and experimental components. The authors explain that research-creation is not a fixed methodological approach, and it supports different procedures for structuring works with creative components. The two main sections of theory and practice feed on each other, even though both can be presented separately. The two practical activities involving the creation of lifelike machines allowed new insights into the theory through experimentation, refinement, and additional data generation. On the other hand, the theoretical section provided a systematization of the expressive elements available for the design of the lifelike machines, which could be tested, and combined in different ways, throughout the creative process.

2.1 Theoretical Research

The theoretical section of this research has its foundations on the method of semiotics of puppetry. A semiotics framework refers to the study of signs and their interpretation. While semiotic approaches often constitute the study of languages, signs may take many other forms, including gestures, images, sounds, and so on. This study applies the methods developed in the semiotic field of puppetry because puppets and lifelike machines have much in common. Both are inanimate objects that acquire the semblance of life through a set of expressive elements and design choices. While the field of the semiotics of puppetry is dedicated to the investigation of signs that transform the non-living puppets into lifelike characters, this research focuses on the elements that induce humans to perceive machines as living entities.

The present investigation adapts the methodological procedures of classification and analysis of sign-systems of puppetry, as proposed by Jurkowski, (1983), Veltrusky, (1983), and Tillis, (1992); and machines, as indicated by Demers & Horakova, (2008), for defining the components that provide the semblance of life to machines. The proposed sign-system of lifelike machines refers to an organized collection of signs and their relations to the perception of life.

During this process, the first procedure is the identification of primary units of meaning and then break them into smaller parts, which can then be analyzed more precisely and in detail within multiple examples of lifelike machines.

In this study, the theoretical framework emerges from the examination of several examples of living machines, encompassing different kinds of devices, and in different domains, such as robotic arts, computational games, and social machines. It examines the strategies used by several creators for bringing machines to life and finds patterns that help to understand how a change of design components in the machines might affect the connotations they generate for the human participant. The theory is formulated following an iterative process of design where the research phases, including data collection, data analysis, and conclusion, are undertaken more than once (Given, 2008). This procedure enables the assimilation of new ideas to the project, as the work develops, and stimulates unexpected results.

2.2 Practical Research

The second segment of this research consists of an experimental process of creating lifelike machines. It is conducted by considering the expressive components described in the theoretical section to facilitate the design choices throughout the production of the two projects. The first experiment is a robotic art installation called Robot Ludens; the second is Pict.io, a game playing machine.

Robot Ludens (2017- 2019) is an artistic investigation of robots as role-players, and the transformation of the meanings attributed to them, ranging from the non-living to the living. This installation consists of a diptych with two monitors and two spider-like robots. In one of the panels, the robot is playing alive, and in the other, the robot is playing dead. This work aims to investigate how to extrapolate the semblance of life in machines and to communicate three opposed, and yet, associated notions of life, death, and inanimate objects.

Pict.io (2018- 2019) is a collaborative game for humans and machines based on the drawing game Pictionary. This game builds on Google's' experiment Quick, Draw, which uses a neural network to guess what humans are drawing. The project aims to create a situation in which the AI creates a sense of camaraderie, and humans perceive the machine as a fellow player.

Both projects were grounded on an iterative process of design, which emphasizes playtesting and prototyping. "Iterative design is a cyclic process that alternates between prototyping, playtesting, evaluation, and refinement" (Salen & Zimmerman, 2003). In this method of iterative design, the two examples of lifelike machines were created, experimented, evaluated, adjusted, and experimented again, so that the design decisions are based on the successive versions of the devices. The processes of creation and evaluation of the two projects are detailed in chapters 4 and 5.

Chapter 3: The Sign-Systems of Lifelike Machines

For investigating the set of expressive elements that support machines to acquire the semblance of life, this study identifies the main design components used by artists, social roboticists, and game designers, in their productions of lifelike machines. As a departure point, this research was grounded in the artist L.P. Demers' proposition that robotic performances have three inter-related constituents, the robot's Body, Behavior, and Context. In Demers' words:

> In order to unfold the investigation of machine performers, the analysis is broken down into the inter-related constituents of a robot: its body (representation), its movements or behaviors (body in action) and its context (environment at large, from the stage to culture). (Demers, 2010, p. 35)

This research also builds on the investigation conducted in my master's degree in artistic robotic performances (Zamboni, 2013). Unlike the previous approaches, the current study takes into account robots and other kinds of machines, such as computers. The motivation for examining other kinds of devices is to provide a comprehensive assessment of the expressive elements available for the creation of lifelike machines and an understanding of their different aesthetic outcomes. Moreover, a fourth item was added, which is the name of the machine. This element can also provide extra clues for the observer's interpretation of a machine. Thus, the resulting classification of sign-systems has four primary elements: body, behavior, context, and name. It is displayed in table 1, shown below, analyzed separately, and subcategorized in smaller units in the following sections.

Body	*Types of Machines*	disembodied devices	
		embodied machines	
	Physical Appearance	realism	size & materials
		stylization	
		abstraction	
Behavior	*Activity*	bio-inspired processes	
		socio-cultural actions	
	Expressive Means	motion	
		speech and sound effects	
		screen display	
	Level of Control	direct human operation	
		explicitly scripted	
		self-governing and learning	
Context	setting		
	scenery & lighting		
	ambient sound & music		
Name of the machine			

Table 1 Sign-system of lifelike machines

3.1 The Body

In every example of lifelike machines, the definition of its body is an essential factor for outlining its expressive potential and limitations. Thus, our concern here is to describe the main variables of the machine's body and how they are used for creating the semblance of life in the devices. The category of the body has two main classes: the types of machines and their appearance.

3.1.1 Types of Machines: From Computers to Robots

The choice of different types of machines provides diverse modes of expression for generating the semblance of life. When artists, social roboticists, and game designers, hoping to create lifelike devices, select a specific kind of mechanism, they rely on what each instrument can offer as an expressive medium. Technical factors, such as the sensory system, locomotion, processing power, memory, among others, set boundaries on the kinds of behavior that machines can adopt. In this section, we propose two categories of devices, embodied and disembodied machines. Computers and robots offer different visual features and interactive skills. Disembodied and computational systems are often interfaced with screens and set towards solving logical problems, understanding natural language, planning, learning, and playing strategy games. Embodied devices, on the other hand, are physically present before the viewers, they can act in the world through movement, embodied actions, and object manipulation.

3.1.1.1 Disembodied Devices

In its origins, computers were not conceived with the intention to bear correspondence to living organisms and human reasoning. Differently, computation originated as a mathematical problem when, in the XVII century, the French mathematician Blaise Pascal invented the first calculator for solving sum and subtraction (Goldstine, 1993). However, what started as a mathematical device, soon evolved to become a protagonist to the problem of creating artificial intelligence (AI) or thinking machines.

The turning point for the conception of thinking machines was Turing's proposal of "the imitation game", in which a machine must pass as a human before a judge, as previously mentioned. While reflecting on the nature of the human mind and the limits of computation, Turing suggested that, if while answering the questions, the computer could be programmed so that the judges do not know whether they were talking to a computer or a person, it would indicate that machines can think (Turing, 2004 [1950]).

One of the first programs able to play the Turing Test and pretend to have human-level intelligence was ELIZA, an early system that could chat with its user through text. Eliza was created at MIT by Joseph Weizenbaum in the 1960s. This program could process natural language by using a process of scripts, which followed specific rules on how to reply to the user's inputs. Weizenbaum argued that ELIZA scripts respond roughly as psychotherapists by asking the interlocutor to talk more about each subject they mention. Admittedly, many psychotherapists could disagree with his comparison. Weizenbaum affirmed that during the interaction with ELIZA, the speaker had the impression of being heard and understood by the program (Weizenbaum, 1966). Even though ELIZA does not have human-level intelligence and this machine could not contextualize the conversation and understand the meaning of what was discussed in the same way that the human participant, this program offered the users an illusion that the machine could do it. Take, for example, the following conversation:

ELIZA: Tell me more about your family

Human: My mother takes care of me

ELIZA: Who else in your family takes care of you

Human: My father.

ELIZA: Your father

Human: You are like my father in some ways.

ELIZA: What resemblance do you see

Human: You are not very aggressive but I think you don't want me to notice that.

ELIZA: What makes you think I am not very aggressive

Human: You don't argue with me.

ELIZA: Why do you think I don't argue with you

Human: You are afraid of me.

ELIZA: Does it please you to believe I am afraid of you

Human: My father is afraid of everybody.

ELIZA: What else comes to your mind when you think of your father

Human: Bullies.

(Weizenbaum, 1966)

The susceptibility of users to interpret the machine's behavior as if it is intentional, even when they are aware that they are interacting with a computer program, became known as the ELIZA effect. About this effect, Weizenbaum wrote: "I had not realized that extremely short exposures to a relatively simple computer program could induce powerful delusional thinking in quite normal people." (Weizenbaum, 1976).

In addition to being able to process natural language, the skills of computational agents are extensive, including the ability to compete in strategic games such as Chess and Go, reasoning, planning, computer vision, learning, and composing paintings, and music. There are diverse ways for computers to perform a dialog or to play a game, which are defined depending on their input-output (I/O) system. The I/O system of a machine is the structure responsible for receiving data and sending it to the outside world, and it is central to the expressivity of devices. The inputs are the information collected by the system, and the outputs are the data sent from it. In the program ELIZA, for example, users communicate through the keyboard as input and the monitor as the output. Other examples of inputs are the mouse, joystick, microphones, camera, and touchscreen.

Likewise, other typical examples of outputs are the speakers, which produce an audio output; and printers, which produce graphical or text output.

The I/O system of a device generates a different set of components to its behavior. It establishes the interactions between humans and the machine, which can be similar or distinct from human-human interaction. Different from ELIZA, many of the chatbots and virtual assistants produced today contain a microphone & speaker for communication. For instance, Siri, Apple Inc.'s virtual assistant, which communicates through a natural-language interface and sounds like a woman with a slightly synthetic tone. On the other hand, Siri, like other chatbots, cannot maintain a long and meaningful conversation with its users. Its conversational skills are limited to the device's programmed functions, such as setting alarms, timers, and reminders, get directions and preview one's calendar, which, different from ELIZA, does not provide the speaker with the impression of being heard and understood by the device on a personal level.

Moreover, since the interaction with computational agents happens at the software level, the personification of machines is not attached to its hardware. The program becomes a sort of immaterial conscience, that can be transferred among devices, and even be present in more than one device at the same time. The lack of physicality in computational agents make it possible that, as long as these programs behave appropriately, the user may not be able to know if they are communicating with a machine or if there is another human behind the computer, controlling the interaction.

On the other hand, there are computational devices whose behavior may be perceived as intelligent or lifelike, but not humanlike. For instance, the Go player Lee Sedol, who lost to the program AlphaGo, in 2016, did not describe his opponent as humanlike. In the post-match press conference (DeepMind, 2016), Lee Sedol claimed that playing with the program was completely different from his experience of playing with humans. He stated that the style of AlphaGo was different from that of human players and that, more than the technique, the difference also lies in the psychological aspects and the machine's ability to maintain its focus that is no match for humans.

4.1.1.2 Embodied Devices

Even though the computation domain was more influential than the field of robotics until the mid-1980s, in the following years, increasing attention was dedicated to the creation of embodied, behavior-based, and biologically inspired machines. The MIT roboticist Rodney Brooks had a central position in this transformation (Brooks, 1991a). Unlike computational systems, robots have a physical presence in the world; they can sense their environment and modify it by moving around and manipulating objects. Their physical body produces constraints to their speed range, shape, and size. The machine's form and articulation define their postures, movements, and gestures.

Thus, robots are unlike computational machines, whose agency is not necessarily associated with the device's hardware, and the same software can be attached to multiple devices. In robots, the body is situated in the real world and directly affects its behavior through sensorimotor systems and physical interactions. Embodied mechanisms are generally recognized as situated machines, in which their functions are best explained by the association and interactions between the device and the environment. They stand in contradistinction to the traditional AI approach that characterizes machines' functions as conceptually separated from the environment, interacting with them through computational representations.

Brook's pioneer approach to machine intelligence involves a bottom-up process where cognition emerges from the sensorimotor experiences of the device within the real world. This path has been followed by numerous researchers that develop embodied devices with contextualized perception and action in the environment. The entire body of robots, their motor and perceptual system, shapes their manifestation of intelligent behavior (Anderson, 2003). This new approach to AI is considered more robust than traditional computation methods because the decision-making processes are physically grounded. Thus, these embodied machines can adapt to their ever-changing environmental conditions so that their behavior does not collapse at the minor deviations in the exterior world (Brooks, 1991b). The essential feature that affects robot expressivity is the connection between their sensitivity, processing systems, and effectors. Robotic systems employ receptors (sensor), a control station (processor), and effectors to adapt to the world and behave autonomously, for example, by moving around without bumping. Receptors detect changes in defined variables, such as the presence or absence of walls. Control stations integrate the sensor with the effector by analyzing the variable's state and signaling to the effectors to generate a response, such as changing direction.

Robots rely on sensors to provide information about their environment and, consequently, enable appropriate behavior. There are many examples of bioinspired sensors, such as vision, hearing, and touch, which permit machines to interact with the world with similar capacities to living beings. Sensors can provide information about the internal and external condition of the devices — for example, the location of the machine, the position of its effectors, and the machine's level of battery — also, sensors inform devices about the external conditions of the world, such as the existence and location of walls, the ambient temperature, the size, color and shape of objects; and the intensity of light and sounds (Matarić, 2007).

The main component of the robot's expressivity as a living entity is usually its effectors, which are the mechanical parts of the system that act on the environment and enable a robot to take action. They are mainly used for locomotion (moving around) and manipulation (handling objects)

(Matarić, 2007). For instance, robotic arms permit machines to manipulate objects, and robotic legs provide locomotion to devices. The means of movement of a robot has a significant impact on how humans perceive the device, and their effectors frequently establish representational associations with arms and legs. There are numerous examples of robots with bioinspired locomotion; for instance, some robots have legs (two, four, six, or more limbs), wings, and flaps so that those machines can walk, crawl, swim, fly, climb and jump like various animals.

One significant example of bioinspired locomotion can be observed in the creations of the Dutch artist Theo Jansen, called Strandbeesten (Dutch for "beach beasts"). This series of moving devices include various species of machines with six or more legs. Although they do not represent any existing animal, the locomotion system of these machines makes them appear incredibly lifelike. Other than their animated movements, the artist aspires to develop these machines further, providing some degree of autonomous behavior to maintain them functioning in their environment. For example, he has theorized features such as water detectors, for the machines to be able to move away from the sea, anchoring system for fixing themselves to the ground if they sense an approaching storm, and air pressure store to propel themselves in the absence of wind (Jansen, 2007). These machines' endurance relies on their motor capabilities and not on a processing center, different from the computational devices.

On the other hand, the robot’s locomotion can also be non-biologically inspired, for example, wheeled devices, which are a usual design choice for terrestrial robots. The motion of wheeled machines tends to be less lifelike than the movement of bioinspired devices. For example, we can do a thought experiment where we have two similar unmanned vehicles walking side-by-side in a straight line from point A to point B with constant velocity. One is a motorized mechanism with wheels, and the other is the same device, but instead of wheels, it has articulated legs to propel it forward. In this hypothetical situation, it is reasonable to presuppose that the legged machine will look more lifelike than the wheeled one.

3.1.2 Physical Appearance of Machines

Another essential expressive aspect of a machine's body is the appearance of the device. The visual appearance of a mechanism can be anywhere inside a continuum that varies from realistic representation to stylization, to the creation of abstract forms that do not resemble living entities. The features of a machine's body can provide the observer with clues regarding its behavior. For example, if we are talking about a humanoid robot, such as Nao, manufactured by the company SoftBank, and describing its ability to locomote, one may expect the device to do it using its legs, instead of crawling on the floor. Similarly, if we say that the same robot can communicate vocally, we would not expect it to bark. These two hypothesized behaviors that may come as a surprise for a humanoid robot such as Nao would not be unexpected if we were describing a snake-shaped or a dog-shaped device. On the other hand, it is essential to notice that the machines' behavior may either support or contradict the expectation set by the visual appearance of the device. These contradictions that subvert people's expectations are likely to occur, especially in the arts.

3.1.2.1 Realism

The idea of producing devices that look like humans is a phenomenon that permeated the premises of mythology and literature since ancient times. In the 18th century, automatons became well-known devices that imitated the human form. They looked like elaborate dolls that could do a set of movements, such as playing the piano or drawing an image. For example, the automaton called "The musician", created by Pierre Jaquet-Droz looks like a young woman and plays its miniature piano by pressing its keys with her fingers. However, only in recent years, devices were able to achieve higher levels of visual illusionism that emulate humans. One famous example of a humanoid robot that visually imitates the human being is Hanson Robotics' latest robot, Sophia.

Sofia has quickly become adored by the media, giving multiple interviews, such as for *The Tonight Show*, with Jimmy Fallon (04/25/2017). The machine can interact face-to-face with human beings, talking and making facial expressions and gazing. On the other hand, Sofia's behavior does not seem as natural and realistic as its appearance is. Her timing of reaction is a bit off, and her expressions and gestures look mechanical and stiff. Thus, even though contemporary machines, such as Sofia, can have a highly realistic appearance in comparison to human beings, they cannot have nearly the same high-level set of skills regarding their behavior. Their collection of skills cannot live up to that same degree of development, and their appearance and behavior become mismatched to each other.

Realistic machines have often been correlated with the generation of a feeling of repulsion, which was called the uncanny valley. The Japanese roboticist Masahiro Mori first described the uncanny valley in 1970, when he proposed that the relationship between the degree of anthropomorphism of the robots and the degree of empathy of the observer is not continuously ascending. According to Mori, some degree of anthropomorphism is vital to generate human affinity towards robots. The roboticist believes that industrial robots do not create empathy precisely because they do not look like humans. However, the author emphasizes that at higher levels of realism, when robots look almost like humans, the machines generate the feeling of aversion in the viewers, which he called the uncanny valley. The word "valley" refers to the abrupt shift in the observer's perception from empathy to repulsion in anthropomorphic devices. At a certain degree of resemblance to humans, robots enter a valley of non-familiar, where, for example, zombies and corpses are also located. To avoid this repugnance, Mori proposed that roboticists should aim for stylization, not realism, in machine appearance (Mori, 2012 [1970]).

Nevertheless, this theory is polemical, and there is an ongoing debate regarding whether robots can be realistic without being frightful. For instance, roboticist David Hanson, Sofia's creator, implemented a survey that challenges this claim (Hanson, 2005) & (Hanson, 2006). He conducted web-surveys with human participants showing videos and pictures of his robots. The results showed that viewers' reactions never dipped into the negative region of repulsion defined by the "valley." Yet, his survey would have been more significant if participants could interact directly with the robots, instead of watching videos. On the other hand, even though he questioned the theory of Uncanny Valley, Hansom acknowledges that people are more sensitive to realistic faces than to stylized ones. He suggests that other than focusing on the feeling of repulsion, roboticists should look for a "Path of Engagement.". This path would provide realistic robots with social responsivity and aesthetic refinement through the integration of AI, mechanical engineering, and art.

The effect of the Uncanny Valley is not restricted to robots' applications. For instance, it has also been reported to occur in video game non-playable characters (NPC). As technology allows for computational characters with increased graphical fidelity, expressive faces, body models, and movements, these realistic virtual agents have also been accused of generating the feeling of repulsion in human players. For example, the Computational Media researcher, Noah Wardrip-Fruin argued that modeling visually realistic characters is not a practical approach to generate empathy towards virtual creatures (Wardrip-Fruin, 2009). The author claims that this strategy creates an inconsistency between the appearance of the response of the character and the actual ability to respond, thus, reducing the emotional engagement of the human player. Like Mori, he proposes that game designers should strive for simpler graphics that do not attempt to hide what goes on in the computational processes. As an example, the author cites games such as The Sims, where the graphical representations are relatively simple but which appear genuinely responsive to the game.

Typically, the more imitative the design of the device is, the more significant is the discrepancy between the machine's appearance and its behavior, which can induce the feeling of uncanniness. On the other hand, the sense of uncanniness is not always unwelcome. For instance, the artist LP Demers proposes that the art world is more prepared to accept the perceptual ambivalences of machines than the scientific fields, and this characteristic is often part of aesthetic values chosen by artists (Demers, 2014). Similarly, in the realm of computer games, the eerie sensations associated with the uncanny valley might be used to the advantage of game design, especially in the horror genre of computer games, as suggested by game sound researcher Mark Grimshaw (Grimshaw, 2009).

3.1.2.2 Stylization

While some machines, such as the robot Sophia, have a realistic depiction of the natural world (except for her skull), a more usual approach taken by artists, roboticists, and game designers is stylization. The process of stylization involves varying the quality and quantity of anatomical details, including augmentation and weakening certain visual features, or the simplification or exaggeration of the shapes, colors, proportions, and textures of the machine. Roboticists frequently use the strategy of stylization in the creation of social robotics, either because it is more straightforward to achieve than realism, or to avoid the effect of the uncanny valley. The reduction of forms to basic shapes conveys a sense of simplicity for the machine, so they look nonthreatening. For instance, the robot Kismet, created by Cynthia Breazeal, has an animal-like morphology, with two eyes, ears, and mouth, but it is made in a simple toy-like aesthetics. Kismet can communicate orally, and through facial expression, gaze direction, body posture, gesture, and voice, and its appearance is aligned with its behavioral skills (Breazeal, 2003).

The aesthetic consequence of this approach to stylization has been discussed, for example, by the puppet theorist Steve Tillis. The author explains that when designers create puppets without a detailed visual representation, the pieces of missing information in the puppet become subject to the spectator's interpretation (Tillis,1992). The same process occurs in a machine's viewers. While very realistic devices do not leave much space for the imagination, simplified devices leave the appearance without resolution, which makes them open to interpretations. Depending on the machine's movements, speech, and environment, this space is filled by the viewer's projections of the expressions that are relevant to the context, such as happiness, fear, annoyance, or sadness. For example, let us take SpotMini, an agile dog-like robot from Boston Dynamics that climbs stairs, handles objects, and operates indoors and outdoors. Like most robots from Boston Dynamics, it is not visually realistic but looks exceptionally lifelike and purposeful. Depending on the way it interacts with its environment, the robot may appear to be curious, playful, or threatening even though there is no visual information to infer those emotional states other than the machine's movements.

3.1.2.3 Abstraction and Functional Machines

Even though within the context of science-fiction, machines have been persistently created with human forms, the advent of cybernetics, robotics, and autonomous machines in the middle of the twentieth century introduced a new realm of abstract looking devices that convey a sense of independence from visual references to the human figure (Burnham, 1982). Other than the human shape, those machines could manifest characteristics of life through self-organization, balance, reactivity, and interactivity.

An excellent example of the lifelike and yet, entirely visually abstract robot is Petit Mal, from Simon Penny. Petit Mal is an autonomous device that senses and explores space and pursues and reacts to people. This device is made of two wheels connected by one articulation with a vertical bar without visually representing any living being (Penny, 2013). The robot invites the audience to play a catch game by dynamically walking away and then advancing in a rhythmic back and forth movement. Different from highly bioinspired machines, Petit Mal, when turned off, does not resemble life at all. However, when in motion, this machine may be interpreted as a living entity. The robot is not representative of another organism, and its body is designed to be functional to its behavior, with no unnecessary visual elements.

The same effect of appearing lifelike could occur with home appliances and other equipment that are made for specific tasks, such as cooking, sewing, and washing machines. These machines are usually perceived as simple tools because their activities are strictly functional and mechanical, as is the case of industrial robotic arms in assembly operation lines. Through repetitive task sequencers, the observer will not have a strong sense of liveness from the machine. However, depending on their behavior and their environment, these functional devices may also assume lifelike appearance. For instance, in the artwork Fish-Bird, by artist Mari Velonaki, robots are two wheelchairs that communicate with each other and with the audience through movements and written texts (Rye, & Velonaki et al., 2005). The chairs exchange love notes and address the impossibility of being together. Any abstract shape, when acting in a meaningful way, can be seen as alive, just like devices with human or animal forms.

3.1.2.4 Physical Appearance of Machines: Scale & Material

Additional factors that impart meaning to lifelike machines are their size and material. In embodied devices, the device's dimension is often confronted with the human scale and the environment in which the mechanism is situated. The bigger the machine is, the more powerful and potentially violent it may look. Differently, smaller sized devices are less threatening and toy-like. See, for instance, Theo Jansen's creation's Strandbeesten, which exists in two scales. The original machines are majestic and breathtaking creatures that are close to three-meter high. However, the artist fabricates thirty-centimeter commercial miniatures, that while still fascinating, are toy-like mechanisms that are clearly under control. They do not look as powerful and autonomous as their big siblings. Moreover, the machine size can be presented not only in relation to the human scale but its surroundings, including other machines, settings, and props. This provides the device with a "relative size," which is discussed later in this dissertation, in the section about the machine's environment.

The last variable we will analyze under the body is the machine's materials. Other than the traditional metallic robots, we can find a great variety of soft and deformable materials in robotic systems. The substance that a device is made from may offer more than functional proprieties, and they are chosen due to their aesthetic expressivity. The materiality can also be described inside a continuum, varying from imitative to self-evident (Tillis, 1992), where self-evident materials call attention to themselves, such as metal, plastic, and wood. For example, Breazeal's robot Kismet, which is visibly inorganic, is made of plastic and metal. On the other hand, imitative materials are substances that have a representational role and pretend to be something else — for example, frubber, a rubber-like material created by Hanson robotics (Hanson, 2005) used for creating the skin of his hyperrealist robots, such as the robot Sophia.

Moreover, different materials, such as metal, rubber, and fur, create tactile impressions that look confronting, comfortable, cold, or hard (Tillis, 1992). For example, while robots made of apparent metal and wire structure look cold and inorganic, stuffed robots, such as PARO, which is made of fur, looks soft and warm. PARO is a therapeutic robot developed by AIST that looks like a baby seal. It can perceive people's presence, senses when it is being stroked, and responds by moving its head and legs, making baby seal sounds. Thus, apart from the material's degree of realism, which can make machines look more or less alive, it can also induce the idea of temperament, making devices look either friendly or hostile to their users.

3.2 The Behavior

Following the description of the body, the goal of this section is to analyze the role of the behavior in making machines look lifelike. Multiple artists, such as Simon Penny (Penny,1997), Bill Vorn (Vorn, 2015), and Louis-Philippe Demers (Demers, 2006), create machine performances where the semblance of life results primarily from the device's actions rather than their appearance. The argument for the predominance of the behavior over the body is that even if the machine's design is visually abstract and does not resemble a living being, biologically inspired action still can induce a robust and long-lasting sense of liveness.

On the other hand, it is essential to keep in mind that the behavior of a machine extensively depends on its ontology, including body construction, hardware, and software. The way that a system is built has a direct consequence in determining the behavioral possibilities of the machine. The body design of an apparatus, including its sets of sensors, actuators, and other gadgets, set the limits for what is or is not possible for the machine to do. Depending on the machine's construction, its embodiment, and computational capabilities, devices may be mobile or immobile, agile, or slow, sensitive, and responsive to the human presence or not, and so on.

For studying the element of behavior, we arranged this section into three main categories: activity, to refer to what the machine is doing; expressive means, referring to the modes of transmission that the device uses for acting; and lastly, the level of autonomy of the machine, concerning how self-sufficient and adaptative the machine is.

3.2.1 Activity of Machines

As we can see in countless examples of lifelike devices, machines can be set to do, or pretend to do, many of the same activity that humans and animals do, including to assume physiological functions, psychological states, and participating in sociocultural instances, such as playing games and music.

3.2.1.1 Bioinspired Processes

There are many examples of living organisms that do not possess intellectual abilities but display some more primitive indications of life. As it has been stated by the robotic artist Bill Vorn, the illusion of intelligence in machines inevitably generates the semblance of life, but not the opposite. The perception of intelligence is not necessary to generate the illusion of life (Vorn, 2010). Some machines are built with underlying control mechanisms that generate similar processes to the living organisms, such as responding to stimuli and adapting to their environment.

One of the primary processes generated by living bodies is the ability to maintain a homeostatic process, which is the regulation of physiological processes to keep organisms in a stable state while adapting to different external and internal conditions. This phenomenon was developed in many cybernetics systems, created in the first half of the 20th century, to investigate the processes of communications and control of both machines and living organisms (Wiener, 2019 [1948]). The classic example of homeostatic devices is the robots Elmer and Elsie, created by the Cybernetics precursor Grey Walter (1950). The two robots had self-regulatory sensorimotor systems and were able to find their way around obstacles to discover sources of energy through a phototropic shell. These two machines became known as the Tortoises due to their shape and slow movement.

Artificial life (A-Life), a field named by American biologist Christopher Langton in the 1980s, is possibly the most significant area of bio-inspired processes in machines. This interdisciplinary field studies the fundamental processes of living systems in artificial conditions, aiming to gain a deeper understanding of natural life and mimic its properties into artificial systems. American philosopher *Mark A. Bedau* suggested that the field can be subdivided into three mediums: *soft,* for software, which includes computer models and simulations; *hard*, from hardware, focusing on robotics; and *wet*, from biochemistry. This field explores a vast range of phenomena, ranging from single cells, whole organisms, social groups, and evolving ecologies (Bedau, 2003).

For instance, computational systems of a-life can go through processes of mutation, self-replication (take computer viruses), and evolution, that stand at the core of the developments of life. Some computer programs are taken as a parallel to DNA, as they go through a process inspired by natural selection. One example is Tierra, a computer simulation developed by ecologist Thomas Ray (Ray, 1992) in which programs compete for time (central processing unit (CPU) time) and space (access to main memory). This computer simulation was the precursor of programs that generate ecological and evolutionary dynamics such as symbiosis and host/parasite regulations.

Following the creation of the field, artists started using techniques of a-life to create artworks. One example of this application in the arts is the installation Propagaciones, by Argentinian artist Leo Nuñez. This artwork takes inspiration from the Game of Life, a class of mathematical a-life model, called cellular automata. A cellular automaton is a group of cells on a grid that evolves through discrete steps by following a set of simple rules based on neighboring cells states. The rules are applied iteratively for exhibiting remarkable patterned behaviors. In the artwork Propagaciones, individual cells are composed of 50 low-tech robots that trigger each other through light signals, creating propagating patterns across the occupied area (Penny, 2010).

Nevertheless, in many cases, this kind of bioinspired action might not look lifelike at all. While forms of visualization of the process are usually provided, for example, through graphics display in Tierra and other similar computer simulations, if the information is not explicit, the connotation to the processes of life might be unclear to the user. Furthermore, witnessing bioinspired processes in the system might take a very long time, and the observer might need to visit the machine over a window-period, to see the transformation occurring in the device. Thus, the timing of the behavior can also create difficulties for the perception of life in machines. In those cases, information about the machine's functions and its connection to life's principles are frequently provided with the support of an explanatory text. Consequently, the association with life tends to become more intellectual than emotional for the participant.

3.2.1.2 Socio-cultural Actions

A more direct form of depicting life in machines is by portraying social skills. Machines that can engage in interpersonal interactions, follow social norms, and respond to stimuli across multiple contexts have remarked success in generating personification and empathy. Some of the factors that come to play in the device's demonstrations of social skills are their ability to imitate and respond to different emotions, communicate nonverbally, such as with body language, gaze, facial expressions, and intonation, and to use movements to express themselves. These communicative interactions add powerful expressive cues to their actions and can provide machines with the semblance of mental states, desires, intentions, personality, and emotion.

For instance, the robot Kismet, developed by Cynthia Breazeal, engages with people in face-to-face interaction and can carry social signals through gaze direction, facial expression, body posture, and vocal sounds that facilitate communication with humans. Kismet can also recognize the facial expressions of the humans that interact with the machine (Breazeal, 2004). Other functions introduced in similar social robots are providing them with the ability to respond to their name, and a memory for the names and faces of people, and their previous interactions. Those features add an extra level of intimacy to the user's perception of the device as if they held emotional attachments to their human caretakers.

Machines are often recognized as genuine participants in various cultural activities, such as gameplay and artistic performance. While at social and cultural events, machine behavior is carried out following rules and conventions that are intrinsic to the activity in which they are taking part. Such activity creates a frame that contextualizes the machines and brings a set of expectations for their behavior. Consequently, even though devices do not experience social situations in the same ways as humans, they can, to a certain degree, prompt participants to infer machines with temper, such as competitiveness, cheerfulness and irritability.

A notable sphere where this can be observed is in games. Adding game structure to a machine, such as goal-seeking, coordination, collaborating, or competition, make the machine agency compelling and engaging. During games, they may display visual and auditory skills, sensorimotor responses, the ability to make choices, following goals, and learning with their experience, which are things that we associate with human levels of intelligence. While they do not need to have human-level proficiency, devices must have some degree of ability in the activity that they are engaging. If the machine cannot have a minimal ability to carry on the action, they might be funny at first, but they will become boring after a while.

Exceptionally monotonous game-playing machines can be seen, for example, in some instances of FIRA Robot World Cup. The robotic soccer competition features multi-robots divided into two teams that can cooperate to adapt to the game in real-time. The robots exhibit sensorimotor responses to control themselves, keep track and control of the ball, and react while other robots affect the environment in unpredictable ways (Kitano, 1997). Their physical abilities (e.g., coordination, speed, strength) are deeply connected to their construction. In this game, there are two categories of robotic players, the humanoids and the cubic wheeled machines. While the cubic robots can play fairly engaging, dynamic matches, the humanoid robot can barely stand up and move on the field. Players spend half of the game lying on the ground and thus lose the dynamics of a football game for their lack of an essential ability to stand up and hit the ball.

On the other hand, even though machines suffer a high demand to be efficient players, intentional mistakes in their behavior have been considered a formula for humanizing machines and generating empathy. For example, in the paper Computing Machinery and Intelligence, written by Alan Turing in 1950, he examines the imitation game, where the computer tries to imitate a human while answering a questionnaire. Turing proposed that the device should be programmed in a way that it occasionally provided wrong answers. Otherwise, the interrogator would distinguish the computer from the human for its accuracy. Turing argued that this kind of deliberate mistake, which he calls "errors of conclusion", would confuse the human participants on whether they are interacting with a machine or a human (Turing, 2004 [1950])

Moreover, providing the machine with the possibility of abandoning or subverting the rules of its ongoing activity, such as inadvertently leaving or cheating on a game, can also make the device surprisingly lifelike. For instance, Douglas Hofstadter, an American scholar of cognitive science and AI, proposes that it is an inherent property of intelligence to be able to jump out of the task that it is doing. He recounts a computer chess tournament held in Canada in the 1970s, where one of the programs was the weakest of the contestants. This program, however, had the capacity of spotting its helpless position and quitting much before the game was over. So, even though it was not a proficient chess player and lost every match, this program was capable of leaving the game in a distinct manner. Hofstadter comments that this ability to exit the system made many of the local chess experts impressed (Hofstadter, 1999 [1979]).

3.2.2 Expressive Means

There are many different ways machines could perform the same activity. For example, playing chess. Usually, this game is played by computational machines through a graphic interface. Nevertheless, the same game could also be played by a robot moving physical pawns on a board, or it could even be performed through text or voice commands. It is up to the machine designer to choose which way is adequate, depending on the experience she wants to portray to the human participant. The three most frequent means of expression for a machine's behavior are movement, sound, and graphics interface. Yet, less conventional methods could also be added to a device to make them increasingly lifelike, including warmth and smell.

3.2.2.1 Motion

Motion can create a compelling and direct sense of life in machines, and it is often the most significant expressive factor for robotic artists. A simple straight walk might be enough to make them incredibly lifelike. For instance, devices that have a bioinspired structure, even if they have uncomplicated articulated joints, may induce association with the movements of living creatures, such as a dog, a fish, or a fly, depending on how the body is constructed. Moreover, even though they have anthropomorphic and zoomorphic characteristics, they do not have to imitate the human or animal movement to be credible. Non-bioinspired bodies, such as wheeled devices, can also generate lifelike behaviors through movement. However, for some creatures, a simple straight walk might not be enough to create this animation effect. On the other hand, when their movement is coupled with rhythm, speed, strength, balance, and coordination, even a wheeled and abstract-looking machine such as Petit Mal becomes animated.

Moreover, non-bioinspired devices can also generate a lifelike effect even through simple movements when they interact with other agents. This outcome can be observed in a set of simple devices with sensorimotor control features such as collision avoidance, changing position, orientation, velocity, and acceleration or working toward achieving a goal. While the motion of the individual robots is not particularly lifelike, their combined behavior may cause the machine's behavior to appear organic and intentional. For instance, the possibility of creating a semblance of life with simple wheeled robots was theorized by the cyberneticist Valentino Braitenberg in his book Vehicles (Braitenberg, 1986).

Braitenberg proposed a series of thought experiments for the design of simple devices that could produce animal-like behaviors. The first set of robots would have a single motor and light sensor for simple reactive responses, such as changing direction, following each other, or fleeing.

Their components would gradually progress to include more motors, sensors, and more complicated links between the machines so that they eventually could develop memory and learning. Braitenberg suggested that the relationships between those devices could lead to the attribution of emotional states and intentions for these mechanisms. Those simple objects' motions became expressive through speed, acceleration, and direction, combined with their relationship with one another. The ways they walk past or across each other, withdrawing or approaching, stopping, and starting a movement, and changing direction, lead observers to ascribe meanings such as desires, fear, aggression, and pursuit.

Another feature that promotes the appearance of life in devices is their ability to not only move around reacting to their environment but also manipulating objects and modifying things in the world, such as pushing, pulling, constructing, and destroying artifacts. Machines may use different kinds of apparatuses for manipulating objects, such as pressure sensors, actuators such as arms and grips. Nevertheless, handling objects is not always enough to generate lifelike behavior in devices, especially if the machine is not bioinspired. For example, many machines manipulate objects as part of their functional routine, such as industrial robots, without looking as if they were alive. Thus, for an abstract looking mechanism to circumvent this practical sphere of the functional device and occupy an imaginary domain of living entity in the viewer’s mind, other elements may be employed. For instance, this effect can be attained if machines are handling allusive tools and weapons, like swords, and conducting culturally meaningful actions, such as combat, game playing, or religious activities.

3.2.2.2 Speech and Sound Effects

In machines, speech is often used as a manner for facilitating interaction with humans. More than text communication, speech helps the participants to build an image of the speaker and draw conclusions about features such as sex, age, mood, and attitude toward the object of conversation. As proposed by the theater theorist Erika Fischer-Lichte (1992), vocalization allows not only for the use of linguistic signs but also paralinguistic, including varying volume, rhythm, pitch, pace, and intonation, which serves for regulating communication. Paralinguistic signs give nuances to the communication, and they can even alter the meaning of the linguistic message. For instance, if someone says they are happy, but their voice sounds annoyed, we will not believe that this person is content.

Most often, the machine's peculiar way of speaking, and sound characteristics, calls for the perception of the speaker as human-like but not entirely human. For instance, personal assistants, such as Alexa, Siri, and Cortana, are capable of voice interaction. These devices most often sound like a woman, but not quite, as they usually have a synthetic tone and minimal paralinguistic capability of intonation. On the other hand, in 2018, Google announced its new virtual assistant, powered by Google Duplex, that uses a natural speech pattern to mimic a human voice. This agent is state of the art in the use of paralinguistic signs, and it can perfectly imitate human-sounding speech, including pauses, interjections such as "uhum" and intonation. Google presented an entire call for a haircut appointment, where the speaker on the line was unaware that she was talking to a machine (Leviathan & Matias, 2018). On the other hand, there is a limitation to this kind of demos where we only have access to the call that went well, so that we do not know how many trials the machine needed to do before successfully completing a call. Yet, it is clear that advances are being made on machine voice interaction.

On a different approach to the creation of oral communication, the robotic mouth from Kagawa University, in Japan, is mechanically inspired by the physiology of human vocal organs. This machine speaks through an air pump, with artificial vocal cords, a resonance tube, a nasal cavity, and a microphone. The robot can vocalize human-like nasal sounds through the control of the mechanical parts (Kitani, Hayashi, & Sawada, 2008). While this is not a conversational device such as a chat robot, the machine's guttural sounds of simple syllables are enough to bring life to the machine. However, it may also be uncanny.

Another fascinating strategy used by a machine for generating sound is the art installation The Well-tempered Robot, created by the group Robotlab, based in Karlsruhe, Germany. This artwork features an industrial robotic arm tempered like a musical instrument, which produces classical melodies, such as Mozart's Serenade No. 13 in G major, through its movements. In this installation, the sounds generated are the typical noises of the robot's motors, joints, axis, and gears. When the machine moves, it creates music without trying to hide the mechanical appearance and sound characteristics of an industrial robot. Nevertheless, even with mechanical components evident, the rhythmic sequences of the robot's motion, associated with its sounds, lead the observer to interpret an attitude of self-expression into the machine. This relationship established between the synchronized movements of its limbs and musical production attains a spontaneous dance-like quality of expressing joyfulness.

3.2.2.3 Screen Display

Various machines, and especially computational devices, often use screen displays as a form of expression to generate the semblance of life. The screen display provides a platform of images and texts for the simulation of virtually any activity, including playing games, having dialogs, and simulating life. For instance, visual graphics are often used in video games to depict virtual worlds with fictional characters, representing monsters and warriors. When AI is created as a convincing character, its agency might be apprehended at two levels of fantasy, first as the character displayed on the screen, and, at the same time, it may pass itself as a human player controlling the characters.

On the other hand, visual graphics on a screen can also create embodiment effects, depending on how it connects to the hardware of the machine. In association with the body of a device, the screen display can be perceived at the same level of interpretation as the hardware, in opposition to the computational approach to a virtual world attained in videogames. One example where this can be observed is the personal assistant, Tapia, produced by the Japanese company MJI Inc. Tapia is an oval white object with two big moving eyes displayed on a screen and a synthetic female voice. The device's eyes can move towards people, providing the machine with a sense of facial expression to its little oval body, which looks like a toy. The eyes do not conduct the user's attention to a virtual world; it becomes part of the physical object, the body of the machine. However, different from its hardware, the graphic features can undergo all kinds of transformation, and characters can assume different sizes, multiply and become fuzzy, while it still seems connected to the body of the machine.

3.2.3 Levels of Control

Different forms of control can be employed to generate a machine's behavior. There are devices that are highly autonomous, sensible to their internal and external conditions, adaptive, and capable of learning with experience through bottom-up processes. Some machines act employing top-down programmed behavior, in a more scripted and repetitive manner, without any regard to its environment. Other machines are teleoperated. Those modes of control can, of course, be combined and have nuances in each device.

3.2.3.1 Direct Human Operation

Despite current progress in robot techniques, fully autonomous solutions are still complex to obtain. Thus, the direct human operation is a form of allowing machines to perform complex tasks with reliability. When humans directly operate machines, this is the closest that they get to puppetry. However, unlike puppets, the human controller of machines does not have to be physically present at the same place as the object. Machines can be teleoperated (operation at a distance) via different interfaces, such as joysticks or by writing commands so that humans can have complete or partial control over the device's behavior.

One early example of a human-operated mechanism is the Chess Player, built by Hungarian inventor Wolfgang von Kempelen in 1769. This device looked like a Turkish sorcerer automaton and played chess against volunteers during demonstrations. This device operated with a small man hiding inside a secret drawer who controlled the machine. von Kempelen did not allege that the device was really an intelligent machine that could play the game. However, while the machine was presented openly as a trick, von Kempelen maintained how the machine worked as a secret, prompting the illusion of intelligence in the mechanism (Sussman, 2001).

There are, however, cases where the human operator of the machine is exposed to the observer’s eyes. Nevertheless, even when the observer sees the human manipulating the device, it does not prevent the attribution of life from occurring. The reason for that is that the phenomenon of make-believe does not rely on tricking the human into thinking the machines are behaving autonomously. The observer can ascribe intentions and motivations to the devices as long as its behavior is compelling enough to redirect the viewer's attention to the machine and stimulate their imagination.

A different approach to human control of devices is the integration of human and machine agencies. This framework is present, for instance, in various pieces of work from the robotic artist Stelarc dealing with human-machine symbiosis. One example is his exoskeleton, a six-legged walking machine that has been constructed to work in association with the human body. The human controller is positioned on top of a six-legged mechanism, wearing the exoskeleton on its upper body and arms. This person actuates the mechanism by moving its arms, such that different gestures control the motion of the device forward, backward, sideways, and turns on the spot. In this kind of approach, the human and the machine are perceived as one entity.

3.2.3.2 Explicitly Scripted

Behavior explicitly scripted in machines by top-down processes provides them with response templates so that they act by directly following a sequence of operations and responding to predetermined instructions. This strategy for self-operating behavior by direct orchestration has existed since the creation of early automata and mechanical toys with the objective of creating the illusion of autonomous behavior in machines. The existence of mechanical toys precedes the electronic era. It is traced back to the Hellenistic period, with the work developed by Hero of Alexandria, involving hydraulics, pneumatics, and mechanics techniques for the creation of theatrical spectacles. One of his famous automatons is a statue that poured wine. Automatons became very popular in Europe during the 18th century, with famous inventors, including the French Jacques de Vaucanson, and the Swiss Pierre Jaquet-Droz. Vaucanson constructed the famous digesting duck, a mechanical duck that could pretend to eat and defecate. Jaquet-Droz created, among many others, the Writer, a mechanical toy that writes letters on a paper with real ink (Foulkes, 2017). Other related mechanisms are the Karakuri puppets, traditional Japanese mechanized creatures that were established in the 17th century to the 19th century. The Karakuri also looked like dolls and could perform tasks, such as tea-serving or dancing (Shea, 2015).

The direct scripted strategy for controlling behavior is frequently used in most interactive, state of the art machines. For instance, the robot Sofia, developed by Hanson robotics, has a pre-defined and fixed script-based speech that is chosen from a palette of responses template. While Sofia's interactive behavior adds an extra level of possibilities for generating life associations, the effect of make-believe does not last for a long time in most devices that use scripted responses during free interactions with the user. After a while, the communication may become tedious and mechanical, if the observer identifies a repetitive pattern of responses.

On the other hand, during free interactions, while the device's explicitly scripted behavior is usually perceived as unlifelike, there are ways for designers to mitigate this effect. For instance, adding a cultural frame to their pre-programmed behavior, such as a game structure, has the potential to contextualize repetitive action and to increase the expressivity of devices. For example, the artwork Abacus, by Sergey Shutov. This art installation consists of 40 mechanical humanlike figures that are kneeled and bowing using black robes and producing sounds of prayers from different religions in more than 40 different languages. Even though the device's behavior is exceptionally straightforward and repetitive, the reference to religious rites makes that behavior extremely expressive in the audience's eyes because rites are repetitive themselves.

3.2.3.3 Self-governance and Learning

Self-governing, autonomous machines perform without direct human control, or with minimal assistance. They can perceive their environment and their internal condition, and change their behavior in real-time, based on information from their sensorial system (Matarić, 2007). For example, through self-organization, a robotic swarm can generate arrangements formed by multiple simple robots, interacting locally to produce complex coordinate behaviors. This technique is inspired by insect societies that perform tasks beyond the capabilities of individuals through decentralized and collaborative strategies. Thus, these robots can solve problems such as locating and transporting an object, following trails, communicating the location of energy supply, and the presence of danger without being explicitly programmed to do so (Beni, 2004). However, it does not mean that the robots' behavior is unexpected to their designer. Emergent behavior is indirectly programmed, but still, designed. A group of swarm robots can seem lifelike by acting autonomously in a coordinated manner, making joint maneuvers without bumping to each other, and building things.

Moreover, some machines can learn and gradually improve their behavior through experience. For instance, in 1950, the first examples of gameplaying machines would make the same moves over and over, without having learned new skills and improving its form of play. Today, however, gameplaying programs such as Go, learn from previous games, and change their strategy accordingly, enhancing their abilities and acquiring knowledge from experience. While in its first game, the machine may play only with the knowledge about the rules of the game and the possibilities of movements, as it begins to score and lose, it starts to play in a more sophisticated way to learn and improve in the game (Silver et al., 2017).

Throughout history, just like the ongoing aspiration for making machines increasingly human-like, the inverse proposition has also been considered. Many times, the conception of living entities as machines have served as both a metaphor and a scientific approach for understanding the phenomenon of life. The recognition of living organisms as physical matter composed of inanimate elements, undergoing simple rules of physics and chemistry, bears connection with different scientific disciplines such as AI and robotics, biology, neuroscience, and psychology. While the recent approaches to these fields support the notion that intelligent behavior in living organisms and machines emerges from a bottom-up process, there is no consensus on what the limit for the advancement and refinement of those processes in mechanisms is, and whether they will ever become equivalent to the phenomenon of life. Nevertheless, the advances of bottom-up approaches and situated sensorimotor functions allow machines to become increasingly self-sufficient, moving away from simple imitation of life, to run closer from exhibiting patterns similar to those found in living organisms.

3.3 Context

In addition to the attributes of body and behavior, customizing the environment in which a machine performs can also be a strategy to intensify lifelikeness. Artists often use audiovisual elements as dramaturgical tools to build the intended meaning in the scene, for revealing or hiding aspects of the devices, and directing their attention to the features of the machine that makes them more expressive (Demers, 2014). Remarkably, even if the body and behavior of a mechanism are not enough to make it lifelike, the introduction of dramatic environmental elements can induce the human participants to imagine life traits in the devices. In this section, we investigate how space can function as a system that imparts meaning to the machines. It includes three aspects, setting, scenery, and sound, the last two, mostly employed by artists.

3.3.1 Setting

Spaces with different social functions have implications on how individuals interpret specific situations. Each environment, such as a temple, stage, art gallery, domestic spaces, public/ institutional spaces, and game playfield, provides a structure for the comprehension of what is going on. The sociologist Erving Goffman called this sort of structure "frames" (Goffman,1974). The author explains that in ordinary circumstances, actions are framed in terms of a primary framework, where things are assumed to be really happening. For example, a couple kissing on the streets is taken as just a kiss. On the other hand, the keying of actions, for example, the same kiss happening onstage, provides us with the notion that, on some level, the kiss is not to be taken literally. The same process occurs in machines. The theatre space generates a frame that offers internal rules, codes, and assumptions for how the audience imparts meaning to devices and accommodates distinctive spatial, temporal, and conceptual expectations for their behavior. Thus, if a machine performs within a theatre, individuals acknowledge that make-believe is going on, and the viewer knows that she should not use the same sort of thinking as for the same device functionally actuating in a factory.

Therefore, by circumscribing the setting in which the machine's activity takes place, a creator also defines a range of conventions that influence people's expectations. Even though make-believe also takes place when machines are inserted in public spaces and other everyday environments, such as a plaza or a store, in those spaces, devices usually overtake a social role in people's life. Within those spaces, machines are seen with increasing levels of social legitimacy as pets, friends, and lovers that are relevant beyond the fictitious worlds of art and play. Consequently, in public and domestic environments, humans regularly take part as more than observers to the machines; they usually become active participants who act in the same social enterprise with the devices. The occurrence of machines in social and domestic spaces for companionship and friendship are increasing every day. For example, Aibo, a robotic dog toy, designed and manufactured by Sony, is a popular robotic pet. It can react to human touch, move around, see its environment, recognize spoken commands, play with a ball, and sit. Another growing field of domestic robots is the expression of sexual functionality and displaying affection to their human holder.

3.3.2 Scenery and Lighting

Scenery and lighting are resources often used by artists for absorbing the machines in a world of fantasy. These, however, are hardly used outside the realm of the arts. Within these elements, devices such as industrial robots, initially created for functional applications in real life, can be resignified and take another level of dramatic meaning. These dramatic components, either realistic or stylized, can connote many other fictional spaces to contextualize the machine's actions, such as for portraying a forest, a war zone, or a celestial setting. Objects such as scenery, props, and audiovisual equipment, provide social, historical, and cultural symbols to the machines' behaviors.

The use of scenery and props can also be employed to change the apparent size of a device (Tillis, 1992). While the size of the machine is often compared to the size of the human body, when inside a dedicated setting, they may rely on other references available in their surroundings, such as scenery, props, and other machines. A robot and scenery may be proportioned to each other in such a way that the whole scene is scaled down or up to be assumed as if it was life-size. Therefore, the relative size of two identical machines may be seen as bigger or smaller, depending on the scale provided by surrounding objects.

However, when the devices are associated with more traditional techniques of staging, such as a proscenium stage arc, it is difficult for the audience to interact with the machines due to the physical separation between the spectators and the performers. Most robot performances are separated from the audience, not only because of the constraints of the physical space but generally because it is safer for the public. For instance, the show Sparked, created in 2014 by Cirque du Soleil in collaboration with Verity Studios and ETH Zurich. In this play, ten drones representing lamps came into life and danced alongside a human performer playing the lamp repairman. (Dubois, 2015). In this show, the audience can only passively watch the robots' performances while a human actor interacts with the devices onstage.

On the other hand, theatrical machines are often presented inside immersive environments that can be directly sensed and acted upon not only by other performers but also by the viewers. In this form of immersive staging, the participant is not bound to passive observation, and viewers have a chance to participate in the scene. For instance, the work La Cour des Miracles, from artists Bill Vorn and LP Demers, is an interactive robotic installation with an immersive environment populated with numerous machines reacting to the viewer's presence. The machines in this work are articulated metallic structures that, through movement, sound, and light, generate the sensation of being afflicted by pain and suffering. While in this artwork the fictitious space allows humans to occupy the same subjective framework as the population of machines, the environment is not friendly. Instead, the atmosphere is hostile for the human participant who walks around among the devices.

Effects created by lighting, lasers, and fog machines can also be used for enclosing and creating the atmosphere of a scene in robotic performances, as can be seen in several artworks created by the artists Bill Vorn and LP Demers. These types of equipment are used for selecting visibility and directing the viewer's attention to the artist's intent. For example, in La Cour des Miracles, light and darkness are a significant factor in creating the scene and regulating the audience's perception of what is happening. In this work, the artists used cold shaded light, with spatial distribution and movement to create an uneasy mood that aggravates the feelings of anxiety and sadness into the scene.

Another factor that can impact the perception of a machine's behavior is the number of devices acting together. Engaging multiple machines in the same area may serve to create an ambiance where machines relate to each other. Group-dynamics can generate aesthetic and vitality to the scene, whether the devices are synchronized or not. Numerous devices acting together may create a chorus effect or formation such that their routines are perceived as a unity. Moreover, when various machines work towards a common purpose and engage in teamwork, they may appear to have a perception of themselves and their role in the group. Their sequences of motion relating to one another, moving towards a collective goal, can ascribe intentions and motivations to their behavior.

3.3.3 Ambient Sound & Music

Sounds and music can also be used to evoke emotion and reflect the mood of the machine's actions. They may be either recorded or live. The volume and rhythm of music and sounds are usually associated with the device's movements to make them more expressive. Different styles of music, including popular songs, traditional ballads, religious, ceremonial, and work songs, may highlight distinct feelings and invoke cultural references and specific cultural connotations to the machines. It may be used to imply social situations and emotional states, such as sadness, happiness, aggression.

One significative example of the use of music to transform robot's impressions is the artwork The Tiller Girls, from Louis-Philippe Demers. In this piece, the artist took a group of 32 metallic jointed robots developed at the AI Lab Zurich called Stumpy. These machines do not have lifelike features, either visual or behavior, and they can jump by balancing their upper and bottom body parts. In The Tiller Girls, music completely transforms these machine's expressions when synchronized with their movements, and the jumping robots are then perceived as if they were dancing. Demers also demonstrated that when these machines operate to the sound of cabaret music, this element induced a cultural reference into the machines that also provokes a perception of gender. The Tiller Girls was a dance troupe from the early 20th century in which rows of dancers performed in synchrony, kicking their legs up in the air to the theme of upbeat music. The artist explains that the mechanic-looking robots become lifelike and gendered because they display a direct reference to the Tiller Girls by appropriating social, historical, and cultural features into performance (Demers, 2014). The human participant projects a transformation on the device's body and behavior, adapting its traits to the music's emotions.

Moreover, the use of sound can have similar functions to light and scenery by setting the tone and referring to different fictional spaces where a device may find itself. For instance, sound effects and music can project social situations to contextualize a machine as if it was in a variety of circumstances, such as a crowd, a party, or, why not, a funeral. Thus, sounds and music may be employed not only as indications for a machine's activities and emotional states but also as clues for identifying the fictional environments in which they may find themselves.

3.4 Name of the Machine

In addition to the body, behavior, and environment that are always present in a lifelike machine, carrying a name can also function as a sign for conjuring up meaning to a device. Nevertheless, the name is a sporadic sign since not every machine is given a name, and even when they have one, it may not always be evident for the people that interact with the device. On the other hand, providing a name for a device is a form to personify it and make it more relatable, that is why most machines with social functions have names. Some examples are Alexa, Cortana, Eliza, Aibo, Kismet, Siri, Tapia, Sofia, among others. The name given to a machine offers an additional communicative tool for the machine's creator, seeking to provide users with information that affect the attribution of features such as gender (or gender neutrality), and nationality. Moreover, names can also have increased symbolic meaning and induce further interpretation of their social roles and personality traits.

Many machine creators understand naming as a communicative tool that can be chosen for various purposes. Often, when they are sold as market products, their names also function as a form of branding, while artists tend to create names that have extra levels of symbolic meanings and historical references. For instance, the robotic artist Simon Penny explains that he named his famous machine, Petit Mal, as an emblem for its mechanical structure that makes it unpredictable and a little out of control. A Petit Mal is an epileptic condition, characterized by a short lapse of consciousness. The artist also emphasizes that this name provokes a humorous tension because it is contrary to the conventional idea of ’control’ in robotics (Penny, 1997).

In the context of the arts, however, there are many examples where the machines do not have a name, but the artwork does. The title of the artwork has a related function as the name of a device. It can also evoke a particular frame of reference for the machine and the creation of symbolic meanings for its behaviors. Title meanings can be very explicit or less obvious, but this component of an artwork often provides extra clues and associations to direct the interpretation of a piece.

One example of a title contributing to the creation of meaning is the robot installation DSM-VI, from Canadian artist Bill Vorn. This artwork presents multiple robots in an immersive environment populated with abstract metal creatures. They are arranged in an intricate space, some of them are responsive to the viewers, and others are apathetic. These machines generate a set of erratic and absurd behavior that, in conjunction with sound, light, and fog, gives them a lifelike and distressing aspect. The artwork's title, however, brings an extra layer of significance to the experience. DSM refers to the Diagnostic and Statistical Manual of Mental Disorders, a polemic manual issued by the American Psychiatric Association that describes a series of human mental disorders, such as neurosis, psychosis, paranoia, schizophrenia, delirium, among others. This manual was published until version V, and the work proposes version number VI. The title of this artwork, combined with the other construction elements of the installation, contributes to the creation of an allegorical world of robotic systems expressing acute dysfunctional behaviors (Vorn, 2012).

3.5 Final Considerations

As we have seen in the previous sections, at least three components are always present in lifelike machines: they have a body, a set of behaviors, and an environment. Not every device possesses a name; however, they often do. Since each sign can be treated differently, machines' lifelike expression can occur through non-representational and contradictory components. The articulation of these elements may be combined to support or contradict each other, inducing different aesthetic outcomes to the machines. Features support each other, for example, when a machine's body matches its behavior, and the action fits its social situation. A supportive association of signs reinforce the intended purpose and create more explicit meaning. In such configuration, signs may become redundant and sometimes produce a dull effect. On the other hand, the association of contrasting elements tends to generate tension, surprise, and confusion, that may be intended or not by the machine creator. Machines' signs of life can be manipulated and combined to communicate not only the notion of life in a device but also introduce symbolic meanings established with references from things in the world, literature, art, politics, etc.

In the proposed sign-system of lifelike machines, some components can directly reshape or overcome others (see table 2). For instance, the kind of machine, including its sensors, actuators, and i.o systems, automatically define limits for its behavior, including expressive means and autonomy levels (arrow a). Moreover, some signs appear more effective than others to convey life. For example, bioinspired behavior often remains more direct and expressive than realistic looking bodies. As we have seen in many examples above, lifelike behavior can be so convincing that it makes abstract machines appear more lifelike and natural than devices with super realistic bodies (arrow b). Furthermore, even though lifelikeness tends to originate mainly from bioinspired body or behavior, in some cases, context can be the turning factor to bring a device to life, even when body and behavior are not particularly convincing on their own. For instance, light and music may transform a lifeless looking machine, with an abstract body and repetitive behavior, into an animated agent, by establishing cultural and emotional content into the machine's performance (arrows c).

Types of Machines	disembodied devices
	embodied machines

Body	*Physical Appearance*	realism	size & materials
		stylization	
		abstraction	
a) b)	*Activity*	bio-inspired processes	
		socio-cultural actions	
	Expressive Means	motion	
		speech and sound effects	
		screen display	
Behavior	*Level of Control*	direct human operation	
		explicitly scripted	
		self-governing and learning	
Context	setting		
	scenery & lighting		
	ambient sound & music		
Name of the machine			

Table 2: Relation among signs

In addition to the proposed sign-system, other aspects should also be considered for understanding how humans understand lifelike machines. For instance, historical, socio-cultural contexts, and paradigm sets. The expectation about what a machine can or cannot do and how they do it change depending on circumstances outside of the device. Each period has its paradigm regarding what skills are taken as ordinary and what should indicate the presence of human-level intelligence in machines, and when researchers successfully solve an AI problem, this achievement quickly becomes disconnected from the concept of "real" intelligence. As the American author on the history and philosophical implication of AI, Pamela McCorduck, puts it: "it's part of the history of the field of artificial intelligence that every time somebody figured out how to make a computer do something—play good checkers, solve simple but relatively informal problems—there was a chorus of critics to say, but that's not thinking" (McCorduck 2004, p.204). For example, the ability to play chess was hugely pursued in the field of AI throughout most of the 20th century. However, after 1997, when the chess-playing computer Deep Blue defeated the world champion, Garry Kasparov, chess was no longer considered a validation of machines' cognition.

Likewise, a person from the 15th century would be stunned by a chatbot, but today these devices are familiar and unimpressive. A naive observer that is not familiar with a particular machine is more inclined to be impressed by its behavior than an informed observer that understands in detail the machine's functioning. Thus, what defines the same device as extraordinary or ordinary highly depends on the subjective expectations of the observer. Another crucial factor to bear in mind when thinking about lifelike machines is the discourse and lures behind them (Demers, 2014). What are the claims made by the machine's creator and by the media about the machine? Are they telling the truth?

Furthermore, broadcasting forms also affect how machines are seen. A substantial part of the population does not have the chance to see or interact with many lifelike machines. Thus, dissemination of those machines is often made by recorded format, typically via video content. While the broadcasting of machine behaviors provides an exceptional opportunity for showing them to a broad public, its format affects the way they are perceived. Not only does the video format provoke different emotional responses from the viewers, but it also allows tricks to promote a better presentation of the device's behaviors, such as editing.

An example of the power of editing is Google Duplex, the virtual assistant capable of realistically mimicking a human voice. As previously mentioned, in their demonstrations of its features, Google presented the assistant successfully booking a hairdresser appointment by phone, such that the person on the line does not know she is talking to a machine. However, Google Duplex is not on the market yet, and we only have access to the audio recordings released by Google. That means that while the result is impressive, we do not know how many failed calls there were before the successful one. So, by watching a broadcasted version of the machine, the observer becomes subjected to editing, correction, and condensation, which do not always accurately represent what happened live.

To conclude, while previous sections showed that the meaning of the machine as lifelike depends on the articulation of sign-systems, other factors also play a role in their outcome. For instance, the epoch that the machine is shown, and the degree of familiarity people have with its technology; the socio-cultural paradigms in which it is contextualized; the claims made about the machine, and how observers have access to it, either by live interaction or broadcasting.

Chapter 4: Robot Ludens

In this chapter, we propose a change of focus from the theoretical to the artistic approach. While the previous chapter outlines the main dramatic components that provoke the semblance of life into machines, this chapter presents a creative investigation of the same subject. This artistic exploration articulates some of the semiotics principles described above for building a scene with a lifelike machine. However, while the theoretical phase aimed to generalize and classify devices, the art creation operated within its margins, exploring the limits of machine representation and looking for their potential for polysemy and ambiguity.

The exploration started by looking into the well-known space "between the living and non-living" in machines. It examined the machines' ability to pretend to be something other than themselves while being recognized simultaneously for what they really are (inanimate objects). Through the exploration of the notion of life, we stretched it to an extreme and arrived at the idea of death. At that point, the machine seemed to flip back into the realm of the nonliving. Yet, this flip did not settle the previous living, non-living duality. It prompted two contradictory forms of "not living": being dead (having been alive) and being inanimate (having never been alive). The installation aims to refer to the three states of life, death, and inanimate objects. The artistic challenge is to articulate design elements for the audience to understand the three different concepts, including the connotation of death, rather than 'broken artwork' in a machine. The aim of portraying death brings an artistic and conceptual issue to the project. To depict death in an inanimate matter, one must still, to a degree, display a disrupted notion of life.

This installation consists of a diptych with two monitors in the horizontal, each hosting a spider-robot, playing alive and playing dead, as seen in figure 1. The spiderlike robot brings with it not only the reference to life but also an extra meaning of the animal's typical behavior of “playing dead”. The two panels below the devices provide scenery representing the interior of a room. They also depict virtual companions for the robots. In the first panel (playing alive), the robot plays with a virtual character by following it and being followed by it. In the second panel (playing dead), the robot is turned off and lies upside down, while a virtual shadow is slowly changing its outline around the inert machine.

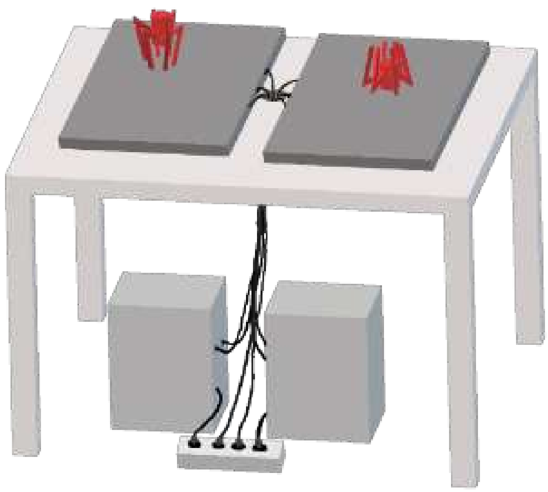

Figure 1: Design for Robot Ludens installation

While the body, behavior, and context are used to communicate the notions of life and death, the artwork's title "Robot Ludens" hopes to go in the opposite way and refer to their inanimate nature. The title refers to the book *Homo Ludens, A Study of the Play-Element in Culture*, the first comprehensive study of human play, from the Dutch philosopher Johan Huizinga. The book shows that play occurs in an alternative world, spatially-temporally delimited from everyday reality and has its own set of conditions, rules, and meaning (Huizinga, 1955). The function of the name is to pose a reminder that the two robots are not really alive or dead and that they are "just playing” to be those things.

The work was presented in two versions. In these situations, we could evaluate if the audience understood the scenes' intended meaning and estimate the emotional associations these choices stimulate, such as anxiety, surprise, or delight, through observation and questionnaire. The first version of the project was presented in the show "Open Codes' exhibition at ZKM, Karlsruhe, in 2017. The second was presented at the *Printemps Numérique* exhibition, in Montreal, in 2019.

4.1 Technical Details

The robots used in this project are adaptations of the robotic toy Hexabug Spider, shown in figure 2, which are controlled using an infrared (IR) remote controller. The robot can receive four commands via the IR remote, move forward, move backward, rotate clockwise, and rotate counter-clockwise. The robots have been painted and modified by adding stylus pen tips to their feet and the top of the robot’s heads. The stylus pen tips are connected by wires to allow a flow of current between them; this permits for capacitive touchscreens to detect touches by each leg of the robot and any touch made by the head of the robot when it is upside down. As the robot walks on the screen, the multi-touch interface written in Java recognizes the position of its legs and estimates the robot’s central position and the robot's heading. Two PCs run a Java program using Processing libraries, which provide the interactive behavior between the robot and the virtual shadow. The desired robot commands are communicated via a USB cable from the Java program to an Arduino Nano, which is, in turn, connected to the robot’s original IR remote controller. The robot is powered by three 1.5-volt coin cell batteries, which provide a lifetime of approximately 45 minutes if the robot is in constant motion.

Figure 2: Robot Hexabug modified by Michael Di Perna (photo by Natasha Vesper)

The battery time frame requires regular care for battery changes. For decreasing the number of times that someone would have to change the batteries, we added a "go to sleep" function every time there was no one around the work. In the beginning, the two monitors and robots are immobile, and the screens display a noisy image, with the message "touch to restart". The interactions start when the audience touches any of the screens. With this input, the system runs for one minute and goes back to a state of repose. After 45 repetitions, the monitor of the living robot shuts again, this time with the message "change batteries". When the robot's batteries are charged, the cycle restarts. This sleep function drastically reduced the amount of attention needed, but it still requires a few daily battery changes, which need to be conceded by the gallery or festival. Otherwise, the work would have to run with pre-programmed schedules, like many performances (Figures 3a and 3b).

Figure 3a and 3b: Diptych in the state of repose I (Photographer Natasha Vesper, 2017)

The virtual figures that interact with the robot (spider shadows and the fly, in the second version of the work) are constructed as sprites, which are 2D characters, integrated into a larger scene. Sprites are composed of cycles of images, in which the position of the character changes frame by frame and gives the illusion of continuous and animated movement (see figures 4a, 4b, and 5).

Figure 4a and 4b: Spider sprites of living and dead shadows, by Stephen Menzies

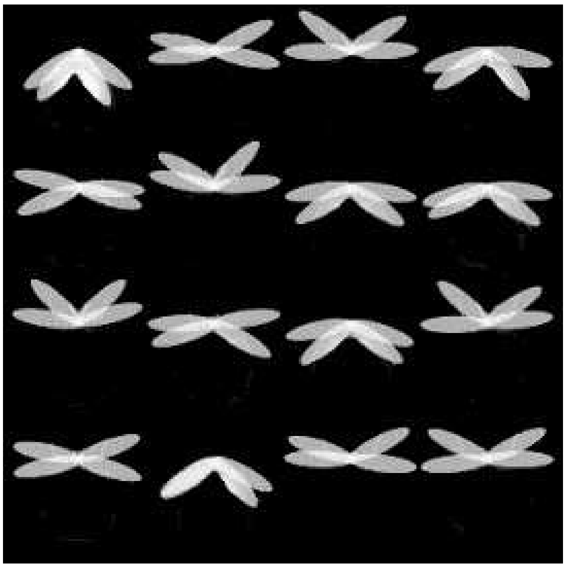

Figure 5: Sprites of the fly

4.2 Robot Ludens (2017)

In the first panel, the robot engages with the virtual shadow, which moves around playfully while the robot unsuccessfully tries to catch it. In the second panel, the monitor displays the same virtual environment as in the first, except that it is rotated in 180 degrees (figure 6). The second robot is turned off and lies on its back, while its shadow is slowly changing its outline around the inert machine (figure 7) — the two screens display visually minimalist images, which consists of the interior of empty rooms with a window. The two rooms of the scenes are consistent when seen independently, but they generate an impossible geometry when taken together. The resulting artwork was created considering the sign-system of machines provided in chapter 3. The selected aspects of design are presented in table 3.

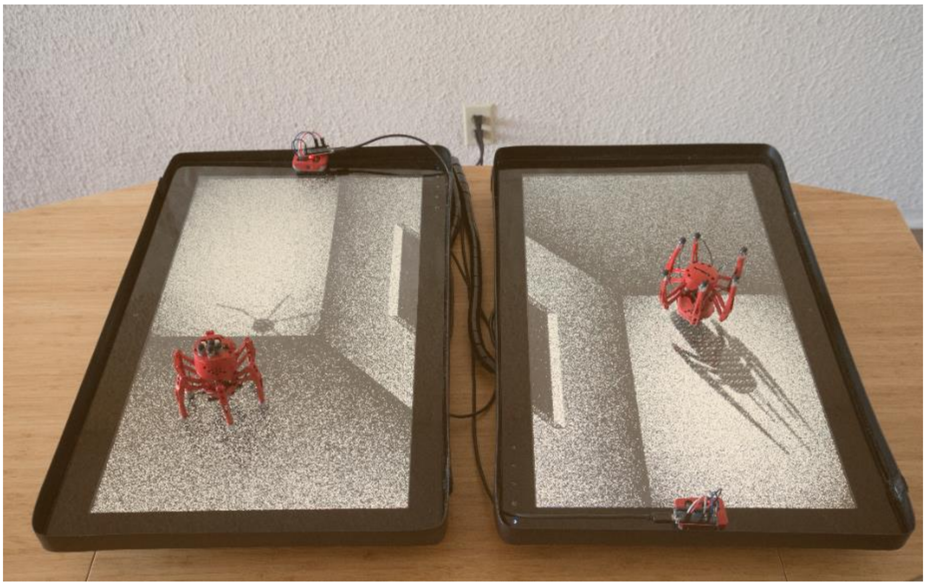

Figure 6: Installation Robot Ludens (Photographer Natasha Vesper, 2017)

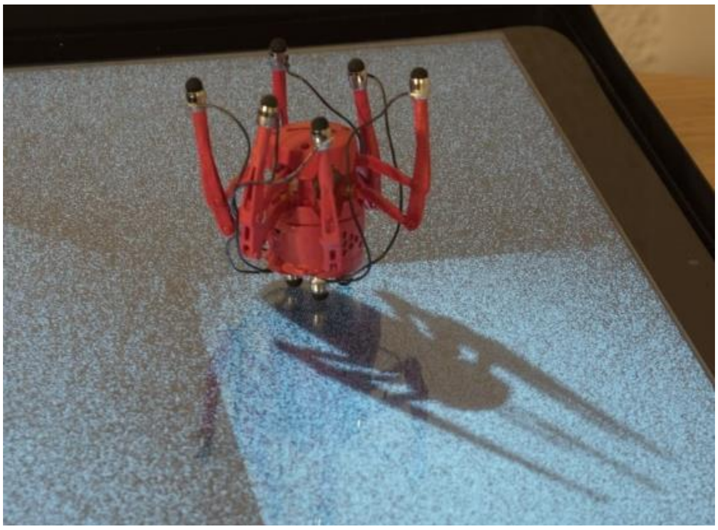

Figure 7: Robot playing dead (Photographer Natasha Vesper, 2017)

PANEL		playing alive	playing dead
Body	*Types of Machines*	Hexapod toy robot *Hexabug*	Idem
	Physical Appearance	Stylized spider Mechanical looking Made of plastic Apparent electronic components and wires 7cm tall Red	Idem
Behavior	*Activity*	Playing tag with a virtual spider	The robot is turned off and lies on its back
	Expressive Means	Movement	No movement
	Level of Control	Scripted-based behavior, Reactive to the screen	—
Context	*Setting*	Art show	
	Audio-visual Elements	A touchscreen monitor is placed below the robot, providing a graphic virtual world for it.	Same monitor-robot configuration, with a virtual shadow of the spider-like machine slowly changing its outline around the inert robot
Name of the Artwork		Robot Ludens	

Table 3: Sign-system of Robot Ludens

4.2.1 Exhibition and Evaluation

The artwork Robot Ludens was shown at the “Open Codes” exhibition, at ZKM, Karlsruhe, from 20 October 2017 to 20 August 2018. During the first three days of the exhibition, I was at ZKM and had the chance to discreetly observe the audience’s interaction with the work. It was evident from the first day that the two robots were not understood at the same level of interpretation as I intended with the piece. While the robot ‘playing alive’ caused an immediate and usually joyful response from the audience, most of the viewers looked disappointed or confused towards the 'dead' robot. Moreover, whereas most of the audience did not touch the living robot, roughly 80% of the participants either touched, held, turned it downside up (in opposition to upside down, as I envisioned the work), or hit the dead robot, as if to see if it would start working. During this observation period, I concluded that the audience did not perceive the association between the articulated notions of life, death, and inanimate objects. The dead robot could not break out of its manifestation of inanimate machine. Thus, it took the appearance of a broken artwork, and not as a dramatization of death.

4.3 Robot Ludens: It is not alive; it has never been alive (2019)

In the second version of the installation, the goal was to make the idea of death more visible in the second robot. In this piece, the robot's body is the same as the first version of the work, but the screens display different images, establishing a different setting for the scenes. While in the first version of the piece, the two scenes were visually minimalistic, the second version attempts to create additional meaning to the scenes by displaying a bright domestic environment, with windows and fruit on display (see figure 8). In the second panel, where the "dead" robot is turned off, the screen shows the image of a needle, similar to those that pierce dead insects on display. Below the needle, the robot's virtual shadow slowly changes its outline around the inert spider-robot (see figure 9). Moreover, the behavior of the 'living' robot is slightly different from the first version. In the new 'playing alive' scene, the robot is trying to catch a fly but can never get it because the fly is on the other side of the virtual window.

The representation of the fruit and the fly, in this second version of the work, hopes to introduce an iconic element to symbolize the idea of death. It refers to the 17th century still-life tradition of celebrating the pleasures of life while warning about its brevity through decomposition and mortality (Sneddon, 2014). Fruits, skulls, and flowers became an iconic depiction of memento mori, which means ‘remember you must die’.

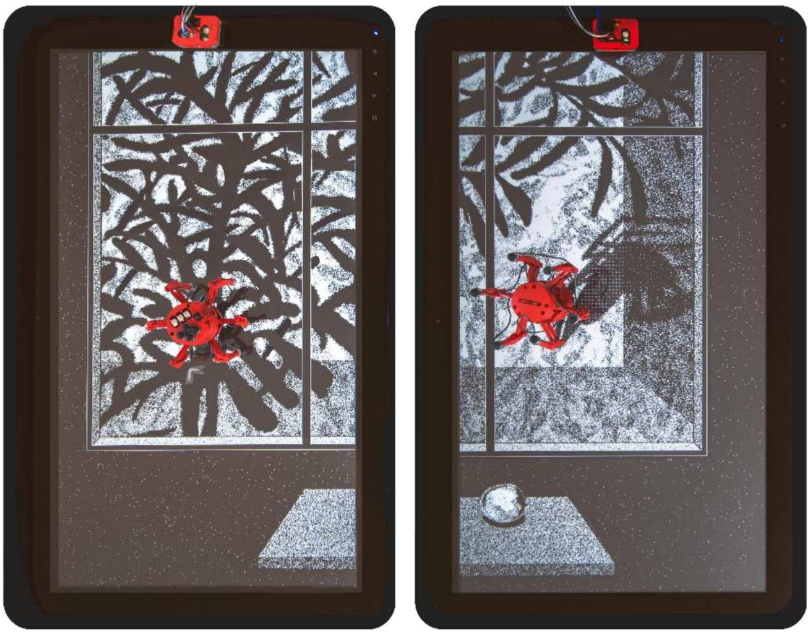

Figure 8: Robot Ludens: it is not alive, it has never been alive (Photographer Natasha Vesper, 2019)

Figure 9: Robot playing dead II (Photograph by Disrael Camargo, 2019)

The second version of this work also had the addition of a subtitle to the name, resulting in Robot Ludens: It's not alive, it has never been alive. The function of this caption is to contrapose the narratives of life and death presented at the fantasy level of the artwork and highlight the machine's condition as inanimate objects. Thus, the outcome of the installation was shaped by the reconsideration of the design elements delineated in table 3. The modifications applied to the work are presented in table 4.

PANEL		**playing alive**	**playing dead**
Design	*Type of Machine*	Same as before	Idem
	Machine's Appearance	Same as before	Idem
Behavior	*Activity*	Same as before	Idem
	Expressive Means	Same as before	
	Level of Control	Same as before	
Context	*Setting*	Art show	
	Audio-visual Elements	A touchscreen monitor is placed below each robot, providing a virtual world for them. This virtual world depicts the interior of a room with a window, vegetation, and a fly moving in this window as if it were on the other side of the glass, across the spider robot.	Same monitor-robot configuration. However, in this scene, there is a virtual shadow of the spider-like machine, which is slowly changing its outline around the inert robot, and the image of fruit on top of a counter.
Name of the Artwork		Robot Ludens. It is not alive, it has never been alive	

Table 4: Sign-system of Robot Ludens, second version

4.3.1 Exhibition and Evaluation

The artwork Robot Ludens: It's not alive, it has never been alive, was shown at the *Printemps Numérique* exhibition, in Montreal, on May 31, 2019. During the exhibition, I invited the audience to participate in the research by filling out a questionnaire. Since this exhibition lasted only one day, our priority was to reach as many observers as possible in that time frame. For that reason, we selected the method of questionnaire application to access people's responses, instead of interviews. The questionnaire provided a quick and practical way of obtaining information from several observers at the same time. Moreover, it allowed the use of both open and closed questions, so both quantitative and qualitative data could be obtained to assess how the audience experienced the installation.

The questionnaire (appendix A) hopes to verify if the concept of death was communicated more clearly this time and if the audience could understand that the theme of the work is not only the notions of life and death but machines identity as inanimate objects that can take the semblance of both living and non-living entities. Furthermore, it assessed what feelings the work generated. Did it generate a feeling of uncanny? Was the audience confused with the meaning of the work, and, in case yes, did they felt stimulated or uninterested in looking at it closely?

4.3.1.1 Closed-ended Questions

The closed-ended questions were inspired by (Bartneck et al., 2009) questionnaire, which proposes a measurement tool for HRI that includes the notions of anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety. Based on Bartneck's categories, the closed-ended questions aim to investigate what kind of feelings the work generates, such as repulsion, curiosity, engagement, or confusion. It also aims to gauge which of the three notions was communicated more efficiently, the notion of life, death, or inanimate objects.

This part of the survey was measured on a Five-Point Likert scale which is used to rate the degree to which the audience agree or disagree with statements about their perceptions of the work (Sullivan et al. 2013). The mean value is computed to measure the average answer for each question, and the standard deviation will be used to measure the spread of answers around the mean value. The data is displayed in a bar chart to facilitate its visualization. The values vary from 1 to 5, with 1 being "strongly disagree," and 5 beings "strongly agree". The gray dot on the chart represents the mean value, while the horizontal lines show the standard deviation for each response.

4.3.1.2 Audience's Responses to the Closed Questions

Twenty-five participants responded to the closed questions. As we can see in figure 10, the work does not create the feeling of repulse in most of the audience, since the trend of responses for repulse lies in between one and two. The audience considered the artwork moderately engaging, with a mean value of almost 4 out of 5. For the feeling of confusion, the medium value was 3, meaning "neither agree or disagree". However, this item had a notable variance between 2 and 4, meaning that the audience had different opinions on this item. On the other hand, even though the work seemed confusing for various participants, it almost unanimously created curiosity, with mean value of almost 5, and insignificant variance.

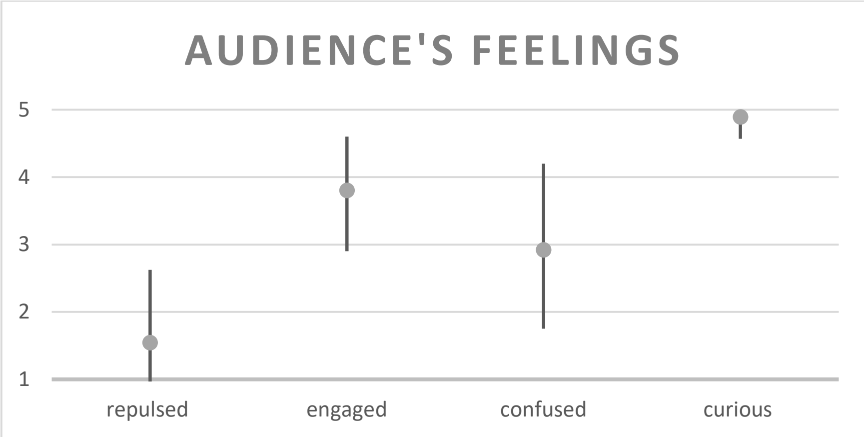

Figure 10: Audience's feelings

The following graph, figure 11, exhibits the audience's perception of scene one (playing alive), comparing the audience's interpretation of the robot as alive, broken, and inanimate. As we can see in the graph, the participants found that the robot in this scene looked moderately lifelike, with a mean value close to 4 (moderately agree). This value is just slightly higher than the perception of the same robot as inanimate. Nevertheless, this robot was not perceived to be broken, with a mean value between 1 and 2.

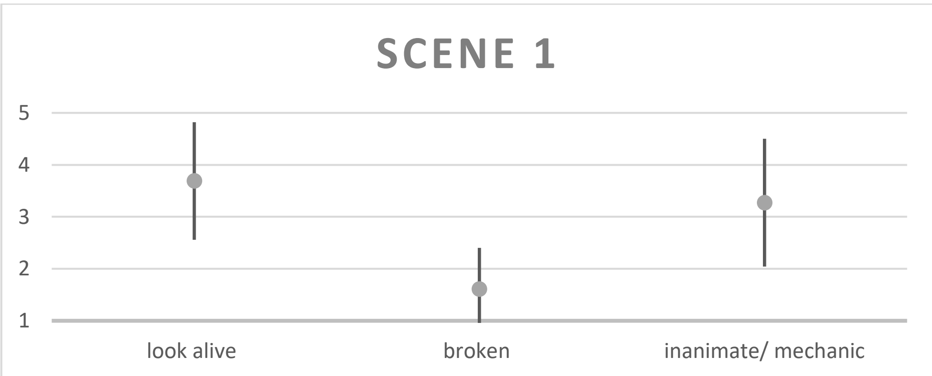

Figure 11: Perception of scene 1

Regarding the second scene (playing dead), figure 12 shows that the participants thought that the robot in this scene looked moderately dead, with a mean value close to 4, just like the perception of liveness in scene one. On the other hand, while in scene one, the perception of the robot as inanimate was close to 3, in the second scene, it was close to 4. Thus, overall, the robot seemed more inanimate than it seemed dead, just like in the previous version of the work. Furthermore, while in the first scene, the participants did not think that the machine seemed broken, in this scene, the mean value is higher than 3, and the deviation varies widely between 1 to 5. This indicates that some people still might have thought that this robot was immobile due to malfunction and not to denote death.

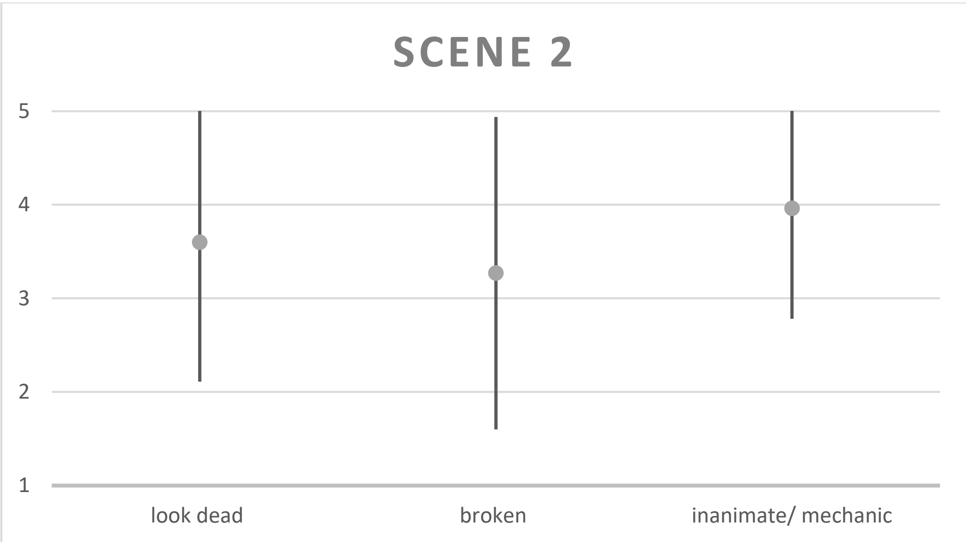

Figure 12: Perception of scene 2

4.3.1.3 Open-ended Questions

The open-ended questions were inspired by the questionnaire posed by Art Curator Cindy Ingram (Ingram, 2017), which offers a form of art reflection and appreciation in art history. The questions aim to elaborate on the audience answers and to offer new insights into issues not captured in the close-ended survey. Twenty-five participants responded to the open questions. However, some respondents left a few items unanswered. The exact number of answers is provided for each question below. The responses were examined through content analysis to investigate the patterns and subjects that appeared in the replies. We applied an inductive approach based on Kondracki & Wellman's depiction, by examining the answers without preconceived categories, to detect the themes that emerged from the data (Kondracki & Wellman, 2002). First, we read the responses for each answer a few times and identified the main topics that appeared in the text. Then, reread the answer, selecting sections and terms corresponding to each topic. After, we displayed the selected segments in tables under these topics (appendix B), to analyze the responses. To complement the display of the analysis, we created "word cloud" images with TagCrowd (https://tagcrowd.com/), developed by Daniel Steinbock, to provide a visual representation of the responses.

4.3.1.4 Audience's Responses to the Open Questions

Twenty-four people answered the first question: "What came to your mind when you first saw the artwork?", and five topics emerged: Technology, Nature, Arts, Emotional Reactions, and Qualifiers to the artwork. The emphasis on the responses was associated with the technological aspect of the project and the spider. The topics related to the arts emerged in two shares, one oriented to the design choices of the artwork, including the terms "color", "painting", and "illustration"; and the other turned towards performative actions of the robot, including the words "dancing" and "making art". Participants also wrote about their first reaction to the artwork, focusing on feelings of incomprehension and engagement. One participant reported being scared. Finally, some of the qualifiers attributed to the exhibition were funny, attractive, and ludic. The frequency of appearance of terms can be seen in figure 13, a tag crowd of the audience's first impressions.

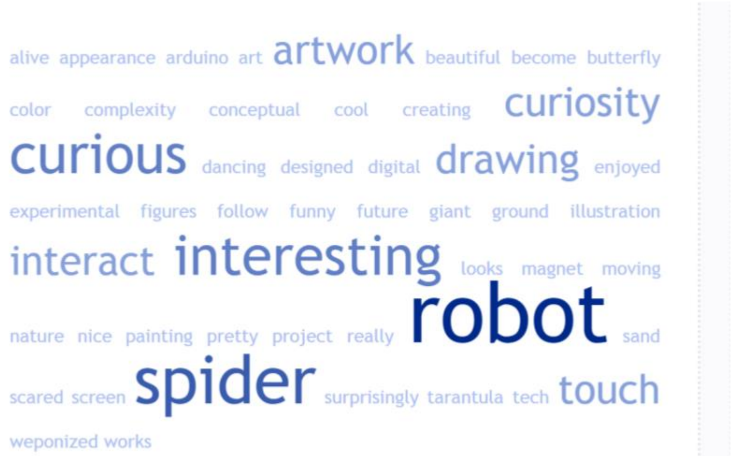

Figure 13: Audience's first impressions (Tag Crowd)

Twenty-two people answered the second question, "Did your opinion about the installation change the longer you looked at it? How?". Thirteen of them responded positively, seven said it did not change, and three answered neither yes nor no. While most participants who said "yes" did not elaborate on how their opinion changed, some mentioned that the perception of movement in the first robot and the shadow of the dead robot influenced their change of viewpoint, as shown in figure 14.

Figure 14: Audience's opinion (Tag Crowd)

Twenty-two people answered the third question, "How does the title contribute, or not, to your interpretation of the artwork?". Twelve participants said that the title contributed to their interpretation of the artwork; two said it did not; three did not know the title. The other five did not answer this question with either yes or no**.** In addition to the “yes or no” answers, one respondent replied that even though the first part of the title contributes to his comprehension of the artwork, the subtitle is redundant and does not add to the piece. Two participants mentioned that the title instigates them to learn more about the work.

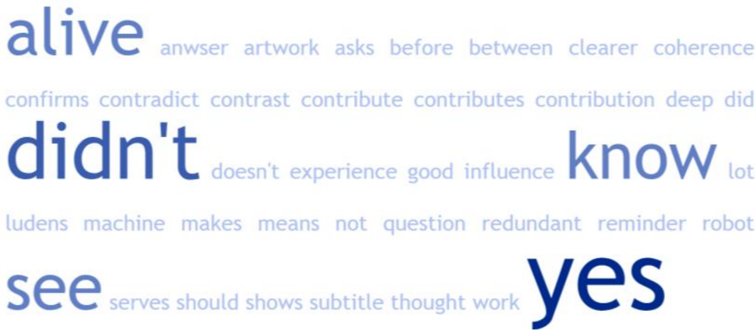

Figure 15: Title’s impact on the work

Twenty-two people answered the fourth question, "What do you think that the theme of this installation is?", and six primary themes emerged. As seen in figure 16, the most common subjects presented were robots and life. Some of the participants proposed questions such as "are robots alive?" and "How do we define "alive"?". Another topic that emerged refers to the contrast between paired concepts, including Biological vs. Artificial, and Life vs. Death. The other topic that arose is Technology, including questions about the future of robotics. Three participants said that they did not know what the theme of the installation was.

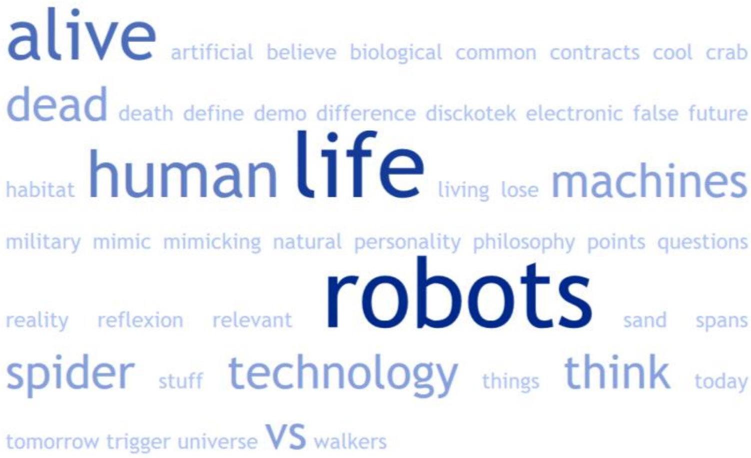

Figure 16: Theme of the installation (Tag Crowd)

Thirteen participants responded to the fifth question, "Do you have any other comment?", and the most common responses were suggestions on how to make the project more engaging and easier to understand. Some of the ideas were: adding interactivity to the audience's movements, using color on the screens, adding a poster with the project explanation, and adding "involuntary" motion to the dead spider, for it to look like it just died. Lastly, I computed how many times words associated with the notions of life and death, such as "alive", "living", "dead", and "died", appeared in all the answers. Words associated with the concept of life appeared 16 times, and death appeared only three times.

4.3.1.5 Results

Twenty-five people agreed to answer the questions. Even though this result does not represent a large sample, it indicated a pattern in viewer responses. The close-ended questions showed that among participants, the perception of the two robots as inanimate objects was relatively high. While the "living robot" induced the notion of life more strongly than inanimate matter, the "dead robot" resembled more an inanimate object than the representation of death. This survey shows that even though the notion of death could be moderately understood among participants, it was not presented strongly enough to overcome the robot's inanimate nature or the appearance of being a broken machine or simply switched off. The survey also shows that the artwork does not generate a sense of uncanny, as it did not cause repulsion in the vast majority of the audience. This made me wonder if the work would have generated this feeling of repulsion if the notion of death was more evident.

In agreement with the findings from the close-ended questions, in the second part of the questionnaire, it is possible to observe that while the notion of life was cited many times, the idea of death was rarely mentioned. Moreover, while it is shown that the title contributed to impart meaning to the artwork, for most of the audience, it was not clear that the theme of the installation is not only the representations of life and death in machines but also the notion of the machine as an inanimate object that can assume multiple meanings through "role-play". Finally, even though this intended self-reference was not apparent for most of the participants, and the feeling of confusion was mentioned often, most of the audience reported feeling curiosity and engagement.

Chapter 5: Pict.io_ A collaborative game for humans and machines

The development of the game Pict.io constituted a complementary component to the artistic process. While the installation Robot Ludens employed embodied and bio-inspired (spider-like) machines, in Pict.io, we shifted towards the application of disembodied devices with no visual representation to create a resemblance of life. Our task in Pict.io was to rely mainly on the expressive components of behavior to build AI agents that induce human-machine socialization and stimulate empathy**.** This practice was an opportunity to understand and test how the design of a game structure creates conditions for supporting the expression of life in devices.

As discussed in previous chapters, games offer an excellent setting for the sense of life to emerge in machines. Their goal-seeking, interactive behaviors may appear to be motivated by emotions, such as a will to win the game. Moreover, the structure of games provides a framework where repetitive behavior does not seem mechanical, as the game rules contextualize them. Therefore, designing the game mechanics becomes a determining factor in the process of creating the AI player. The objective of this practice is to modulate the game mechanics and AI behavior to convey motivations, such as desires and hostility, and personality traits, like a sense of humor or annoyance to the AI player.

Pict.io was inspired by Pictionary, a popular multiplayer game where players attempt to draw a selected concept while their teammates strive to guess what the drawing means. Pictionary provokes a positive and cheerful social dynamic that we aimed to extend to the AI players. In Pict.io, two humans and one AI player work together to communicate simple concepts, like duck, feet, or castle, using limited resources. A human player must provide visual or verbal information about a given object to another human, who must draw the item for the machine to guess. The experience aims to facilitate socialization through easy fun, camaraderie, and laughter with the AI.

Moreover, within this framework of visual communication established by Pict.io, the AI's ability to recognize doodles also impacts its semblance of life and intelligence. The ability to identify linear sketches indicates that AI can make visual abstractions and linear representation. Moreover, it inserts the AI agent in a cultural framework since the process of representing things in the world is not arbitrary. For instance, depending on the human participant's age, nationality, and sense of humor, the representation of objects like "oven," "television," or "telephone" may change. Likewise, depending on how the AI gathered its data, its cultural contextualization can also vary. This contextualization allows for a more intricate human-machine experience, where humans can play around with how the AI recognizes objects that change shape within different generations, nations, etc. The game has three AI characters options, and their expressive elements are detailed in the section "Design of AI Players" (see figure 17).

Figure 17: Playing pict.io (Felipe Carrelli, 2017)

Pict.io was created in collaboration with the communication scientists Luciano Frizzera and Julia Salles. During the development of the game Pict.io, Frizzera was the leading member of the game's technological development. I led the creation of the drawing challenges, and Salles led the definition of the AI characters and personality traits. However, we made the most critical decisions collectively, and each one contributed to all the design phases. This project was produced as an exercise in research-creation inside the study group Machine Agencies, led by Professor Bart Simon, and hosted by the Milieux Institute at Concordia University. The group is composed of an interdisciplinary crowd of researchers working on topics associated with AI. It investigates the incorporation of technology in various contexts, including sociology, games, arts, and politics, while addressing the social implications of using these technologies. Figure 18 shows the initial page of the game URL.

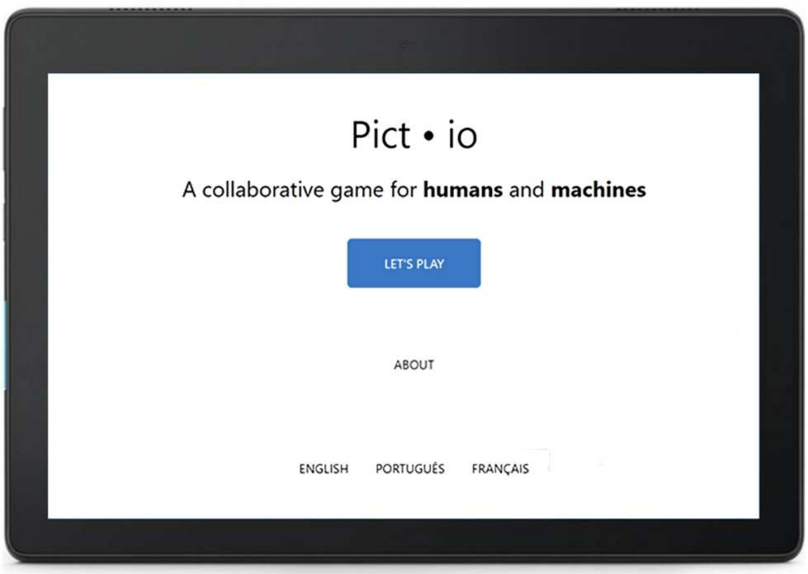

Figure 18: Pict.io, initial game page

5.1 Technical Details

Pict.io builds on Quick, Draw!, an online game where participants are given 30 seconds to make linear drawings on a white canvas on the screen, while the computer tries to guess what is being drawn. Quick, Draw! is one of the experiments created at Google's Magenta, an open-source research project that explores the application of machine learning, where a program can change as it learns, for creating art and music. Quick, Draw! uses a Machine Learning to guess what human players are drawing. This application learns by experience using neural networks, an example of machine learning inspired by biological neurons. Neural networks are made of cells that work together to produce the desired result, although each cell is only responsible for solving a small part of the problem. More specifically, Quick, Draw! employs a recurrent neural network (RNN) model to learn to interpret drawings. Unlike previous models, RNN is a class of neural networks that can learn to recognize context-sensitive inputs because the memory of previous inputs remains in the network's internal state (Graves et al., 2008).

Quick, Draw! uses an RNN model called sketch-RNN, and based on the data collected, it can find patterns within drawing categories (Ha & Eck, 2017). The system was trained with a dataset of 50 million drawings from 15 million people worldwide, and it can recognize up to 345 different categories of linear pictures, including flowers, cows, The Great Wall of China, and much more. Each group contains around 200.000 to 500.000 illustrations from online participants. Pict.io was constructed using the data collected from Quick, Draw!, and Magenta's Application Programming Interface (API), the software that intermediates the pre-trained Magenta's models in the browser.

At the initial stage of the game development, we investigated Quick, Draw! 's strengths as a drawing game with an AI player. As we interacted with Quick, Draw!, we realized that while this game is entertaining to play, part of its appeal comes from the surprise of having a computer understand our doodles. For this reason, after a while, the interaction becomes less impactful, and participants lost interest in engaging with the machine. In Pict.io, we applied the structure of Quick, Draw!, but made it more elaborate and difficult to win. We designed three drawing challenges to add barriers in the communication between teammates, aiming to purposefully impair control and create disability so that players would have to put more effort toward succeeding in the game.

5.2 Iterative Design

The research-creation followed the iterative process of design, which emphasizes playtesting and prototyping (Salen & Zimmerman, 2003). Through this method, decisions were based on a continuous cycle of prototyping, playtesting, and refinement, as shown in figure 19. This process occurred in the course of one year, from 2018 to 2019. While the productions of both Robot Ludens and Pict.io used the creative process of iterative design, the methods for evaluating the results varied within the two practices. Within Robot Ludes, the evaluation of iterations was first carried out through the observation of the audience's interaction with the robots, in the first version of the work, and then through a structured questionnaire in the second and last version of the installation. In Pict.io, however, the method for assessing the AI player and game playability was realized by playtesting the application ourselves, and by the observation of other people playing.

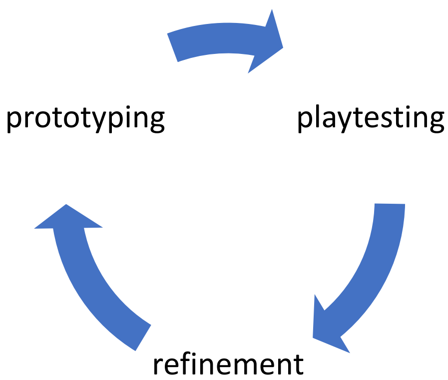

Figure 19: Iterative design

Playtest is the core method of evaluation in the field of game design. In this process, game designers expose their unfinished game to a group of users for identifying design flaws to ensure that the game mechanics are balanced and that the game progresses smoothly during play. During the playtesting phase, we played the game repeatedly, and we also observed and interacted with a broad group of users from different ages and cultural backgrounds playing the game. User reactions during playtesting and their feedback gathered from their opinions lead to adjustments and alterations. They helped us strengthen the design framework and improve engagement with the game and AI player. During this practice, creative work exceeded the design of the lifelike machine. Instead, this experiment involved three fronts of design: game mechanics, game interface, and the design of AI-controlled players.

5.2.1 Game Mechanics: How to Play Pict.io

The game is online and can be played on devices with a touchscreen and speaker, such as tablets and smartphones. There are two modes of playing the game, one is with two humans and the machine, and the other with a single human player, for when the user is alone. The motivation for creating a multiplayer alternative was establishing a set for a social experience and connection among humans, hoping to facilitate a mood for their feeling of sociability and camaraderie with the machine. In the challenges with two human players, the team collaborates to pass a message around, from player 1 (human) to player 3 (machine), using player 2 (human) as a proxy. Player 1 must provide visual or verbal information about a given object to the proxy, who must draw the object for the machine to guess it. There are two challenges for this mode of play, Drawing on the wall and Verbal description, and one challenge for the single-player option, called Blind drawing with the non-dominant hand, as shown in figure 20.

Figure 20: Pict.io challenges

5.2.1.1 Challenge 1: Drawing on the Wall

Player 1 draws the given object on a wall, using just their fingers, without leaving any visible mark. Player 2 follows player 1 gestures and reproduces the finger trajectory on the screen. The machine has 30 seconds to guess what is being drawn (see figure 21)

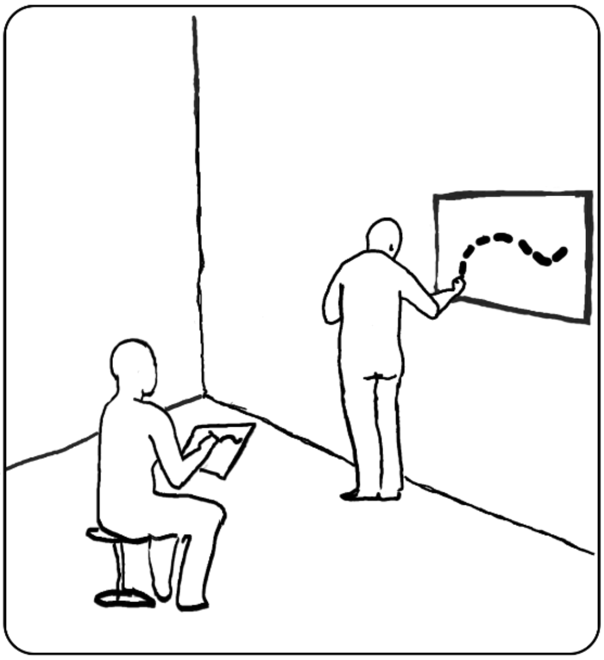

Figure 21:Pict.io, drawing on the wall

5.2.1.2 Challenge 2: Verbal Description

Player 1 must verbally describe the given object using only geometrical figures and spatial orientation. Player 2 follows Player 1's instructions and reproduces it on the tablet. The machine has 60 seconds to guess what is being drawn (see figure 22).

Figure 22: Pict.io, verbal description

5.2.1.3 Challenge 3: Blind Drawing with Non-dominant Hand

In this mode of the challenge, there is only one human player. The player must draw the given object without looking at the screen and using their non-dominant hand. While the human player draws, the machine has 45 seconds to guess what is being drawn (see figure 23).

Figure 23: Pict.io, drawing with closed eyes, and non-dominant hand

The focus of the game mechanics was to create engaging playability for the human players. Thus, the goal of each challenge is to impose a limited resource for communication among participants, aiming to defy the player's performances continually during the game. The idea for the challenges originates in a set of traditional drawing exercises that involves coordination, timing, motor skills, abilities to make a visual synthesis, and encourages ambidexterity of thinking (McKim,1980).

The first challenge, called "Drawing on the wall", was initially inspired by the children's game where someone draws on the back of another person, who must translate the linear shape onto a paper. We tried this game with a tablet, but it was virtually impossible to transmit any of the word categories available in Quick, Draw! through touch. We experimented with touching other parts of the body, such as the hands, but could not communicate the word categories through this sense. We then decided to make it into a challenge of visual awareness and concentration. Thus, in

"Drawing on the wall", the first player draws on a wall surface with his fingers (without leaving marks), and the second player must follow the finger's trajectory by drawing it on the tablet.

The second challenge, "verbal description", was based on the remarkable drawing exercise of verbalization. In this exercise, one person receives an object, and this person must describe this object in terms of geometrical forms, for the other person to draw and guess what the object is. Dissecting images into geometrical shapes and giving instruction to construct an image is an exercise that involves ambidextrous thinking— where individuals move from one operation to another, from seeing into analyzing, and verbalization. This process involves the capability of receiving information of one kind and transferring it into another type.

The third challenge is blind drawing, in which participants draw with their eyes closed. This exercise deprives the human player of their sight, forcing people to process spatial information using other sensory systems. For instance, the sense of touch, to estimate the finger's movement and position concerning the rest of the drawing in order to compensate for the loss of visual input. We coupled this sight limitation with another similar exercise of drawing with the non-dominant hand. This activity can be extrapolated into other parts of the body, such as drawing using the feet, mouth, and so on. Those two exercises were combined to create the challenge "Blind drawing with the non-dominant hand", developed for one human and the machine, as an option for when the human player is alone or does not want to play with another human.

One essential feature of the design of Pict.io was to find the ideal number of seconds for players to solve each challenge. The definition of timing was conducted by trial and error, based on observations of other players' interactions with the game, and our own playtests. We realized that when the time was too extended, the game became less thrilling and challenging, but when it was too short, it became too hard to play and generated more frustration than enjoyment. Finally, we determined that the optimal time for challenges was 30 seconds for Drawing on the wall, 60 seconds for Verbal description, and 45 seconds for Blind drawing with the non-dominant hand.

5.2.2 Game Interface

During the interface design process, we created several different interfaces for the game to make it simple to interact with and increase game flow (see figure 24). One of the most critical features of the design was the introduction of a "clear" button so that the players could erase their drawings in the middle of a challenge, as shown in figure 25. This feature was essential in the interface, because, during play, the screen quickly becomes filled with sketches, and gets in a state of confusion where the game must be interrupted. With this button, every time players want to restart, they can go back to the white screen. Other main changes in the interface included improving the form of presentation of each challenge and providing three options of language choice, French, English, and Portuguese. Figures 26 and 27 show the screens after winning and losing a match.

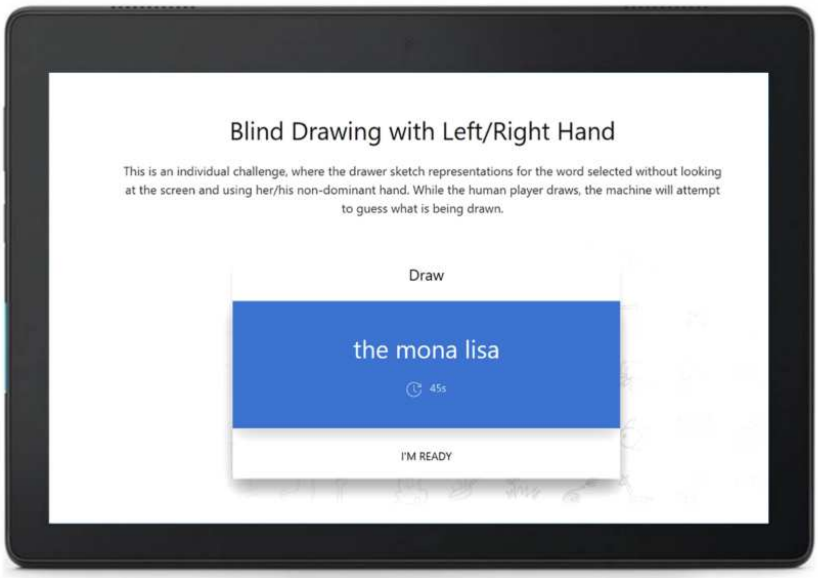

Figure 24: Pict.io, card selection

Figure 25: Pict.io, drawing board

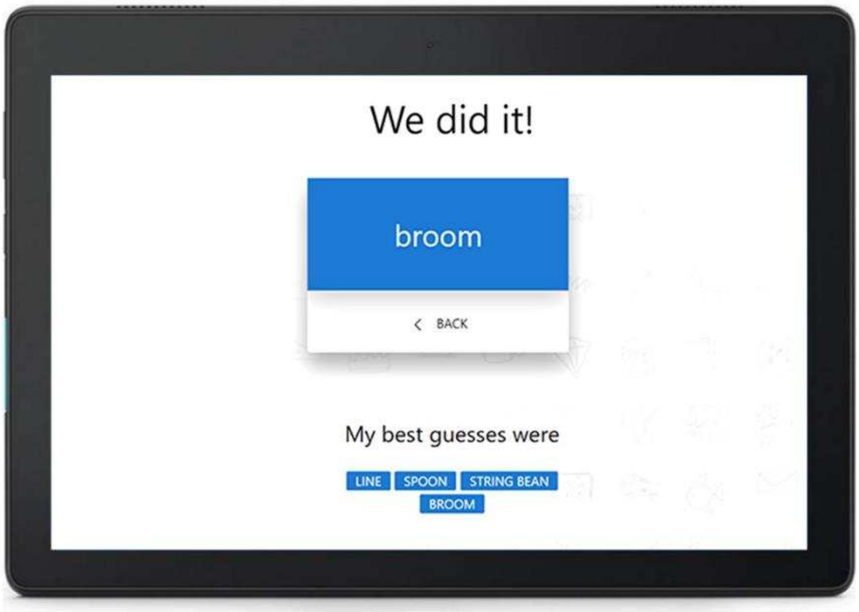

Figure 26: Pict.io, winning a challenge

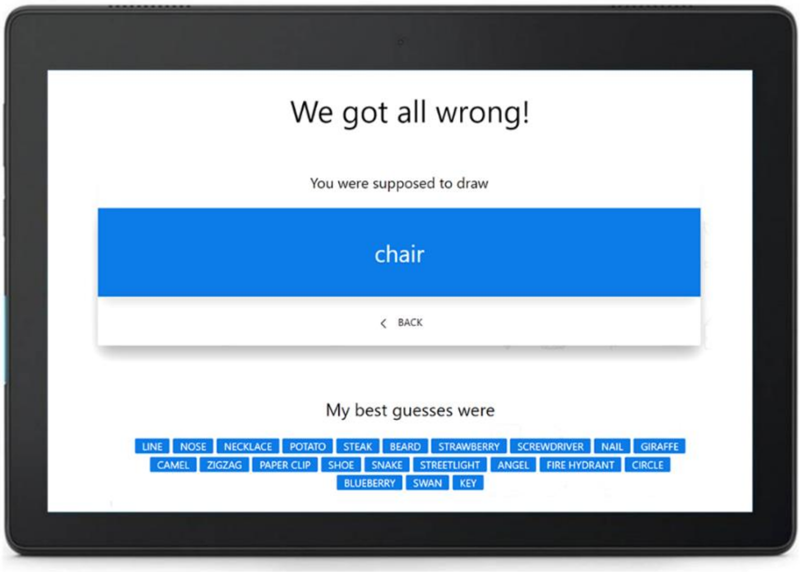

Figure 27: Pict.io, losing a challenge

5.2.3 Design of AI Players

As we worked on the design of the AI players, we thought of them as characters. The last version of Pict.io holds three AI characters for speaking in English, French, and Portuguese. We named them Sam, Alex, and Duda, respectively. We choose names that are gender-neutral, short, and sound "fun". These are disembodied players that exist within the user's tablets and cellphones. Thus, like in video games, their presence is not necessarily attached to any particular machine used in the game. The sense of embodiment of these agents comes entirely from their interaction within the game.

Even though the AI is a disembodied agent, the selection of a physical device for playing Pict.io still influences the personification of the AI player. Each operating system, such as Android and Windows, offers a distinct voice agent installed in their systems. Thus, depending on the user's device, the AI personifies different gender, nationality, pitch, tone, and timber. Moreover, in Pict.io, there is no visual representation of the AI player. Not only the physical instantiation of the device does not function as part of the embodiment of the characters; neither does the graphics display. The graphical design features uniquely as an interface for the game. Thus, we worked mainly on one expressive element, the machine behavior, to generate the semblance of life. Through the observations of user interaction with the AI, we focused on tweaking and perfecting its behavior (table 4).

Body	*Type of Machine*	Computational devices with touchscreen and speakers, such as tablets and cellphones.
	Machine's Appearance	The graphic display serves as the interface of the game. There is no graphic representation for the AI players' bodies.
Behavior	*Activity*	AI agents are playing the drawing game, where they try to guess what humans are drawing.
	Expressive Means	Voice interaction. It speaks English, French, and Portuguese, with different genders and accents, depending on the device. Their pitch sounds mechanical. AI greets human players and introduces themselves. They start each guess with "I see…". The agent also makes interjections about the game and the quality of the drawings of their human teammates and uses paralinguistic signs, such as "Hahaha", "Ummmmmm ...", and "Ugh".
	Level of control	Initially, the system learned to understand drawings by experience using a recurrent neural network (RNN) based on data collected around the world. At the time of the match, the AI uses its knowledge to determine possible answers, but it does not always play its best guess. The algorithm randomly assigns the AI player's interjections.
Context	*Settings*	This game is portable and was created to be played online on individuals' devices anywhere they would like.
	Audio-visual Elements	--
Name of AI Players		Sam (English speaking AI) Alex (French speaking AI) Duda (Portuguese speaking AI)

Table 5: Sign-system of game Pict.io

Pict.io's AI players sound mechanical, which clearly distinguishes these characters as a machine. On the other hand, the AI-controlled player's speech capability is an essential component used to generate a sense of embodiment in the players. We used the same tricks that Eliza and other chatbots apply, and it is through the voice synthesizer that the machine communicates with human players. For instance, at the beginning of each match, the AI player introduces itself by its name, greets human players, and invites them to play. During the game, the AI player starts each of its guesses with "I see…", such as "I see a bird". Besides, AI players can also make interjections about the game and the qualities of the drawing of their human teammates. Those comments can be either warm and uplifting or annoying and judgmental such as "draw faster", or "what a beautiful drawing!". Moreover, the voice provides not only linguistic content but also paralinguistic signs, such as "Hahaha", "Ummmmmm ...", and "Ugh".

A critical point of the design of the AI characters was tuning the content and frequency of their interjections according to what we observed from their interaction with humans. For instance, when we presented the work at the Makers Fair at Concordia, in 2019, the AI made many negative comments to human players, such as "what a bad drawing", which seemed to make some participants upset. Many users got frustrated with this remark from the AI player and began reiterating that they were, in fact, lousy drawers and unskilled for the activity. We took that user response as both positive and negative indications for the game's intention. On the one hand, it suggested that we had attained some level of personification in the machine. The users were validating the device's "opinion" and accepting that the AI player could pass this kind of judgment on them. On the other hand, that outcome did not comply with the emotion that we were hoping to generate. We did not want the game to produce feelings of resentment and inadequacy in humans but a more joyful attitude. After this event, we toned those comments down and included more uplifting quotations.

During the game development, we also realized that the most relevant aspect of designing the AI player's behavior was finding the right amount of proficiency and making mistakes. In the first playtesting sections, the AI played with its best guesses, so that it would understand the drawings very frequently and quickly. This skill of the machine made the game experience monotonous because there was no tension or challenge. On the other hand, we also noticed that the drawings were sometimes unfinished or remarkably deformed, unrecognizable from the human perspective, but the AI still identified them. Situations like this appeared to generate much fun if they were unexpected. Thus, we did not eliminate those situations where machines play exceptionally well, but made it rarer in the game, increasing the probability of mistakes to occur.

Moreover, another circumstance that generates laughter and enjoyment in participants is when the human players had created "perfect" drawings, and the AI could not understand them. The human willingness to accept the AI's mistakes became a form of encouraging cooperation between team players and take away the negative connotations from the human player's errors. This situation seemed to transform the mistakes into fun experiences and support the emergence of friendly interactions for the human with the machine. Nevertheless, like the precedent, this situation is only enjoyable while it is rare in the game. So, finding the balance of making mistakes and accurate guesses was critical in designing the AI characters.

5.3 Results

In Pict.io, we experimented with the creation of an AI agency within the context of a drawing game. We employed some of the sign-systems discussed in the theoretical section, especially voice interaction, for creating an AI-controlled device that could engage with human players, supporting the game's outcome as a leisure activity. This AI character aimed to play in collaboration with humans, evoke empathy, and maintain a continuous level of engagement throughout the game.

Throughout the years 2018 and 2019, Pict.io was presented in South and North Americas, within events about education, scientific outreach, and maker fairs. The venues of playtesting include Montréal Maker Faire, at Concordia University (Montreal, Quebec, Canada), November 2018; Camp Serrapilheira de divulgação científica, Museu do Amanhã (Rio de Janeiro, Brazil), September 2018; Conversations citoyennes sur l'IA, Université de Montréal (Montreal, Quebec, Canada), June 2018; Hackathon AI, Concordia University, November 2018; ConcordAI, Concordia University, November 2018; Concordia 4th Space, April 2019. Semaine du NumériQC, Musée de la Civilisation de la ville de Québec (Quebec City, Quebec, Canada), April 2019. In these events, we had the chance to examine how the human players reacted to each version of the game and the different AI personalities.

This experience, established through continuous playtesting and prototyping, showed that for the user interaction with the AI to be engaging is not enough to generate a believable character but to have a balanced game design to contextualize the AI. The mechanics of the game provides a framework for AI and humans to engage in shared goal-oriented behavior inside the game rules. The underlying game provides humans and machines with a common problem to solve. The engagement with the AI arises from the desire for effective communication as an initial condition for the attribution of agency.

Throughout the playtests, we understood that unless the game had elements that continually created tension and challenged players, participants would not engage with the AI for more than a few moments. For this reason, we modified the game structure from "Quick, Draw!" and designed a set of drawing challenges aiming to restrict the means of communication among players, and continually defy their abilities during the game. The visual challenges were formulated based on a set of drawing exercises that involves coordination, timing, motor skills, and abilities to make visual synthesis and analysis. Other than creating tension in the game, these constraints enforced by the drawing challenges also serve to induce errors in the human-machine communication. Having participants communicating with limited resources amplified the circumstances in which the messages transmitted would take unexpected paths; thus, inducing nonlinearity and unpredictability to their interaction errors.

The characters guessing errors prompted moments of deviation from expectations, which were frequently proceeded by a laugh from the human players. The choice of shifting the paradigms of AI as competitive and perfect performers to collaborative and flawed characters also hoped to induce feelings of empathy and identification towards machines. This way, characters would not be seen as antagonists to the humans but as collaborators that have their own limitations. So, in Pict.io, AI's mistakes are inevitable and desirable. Although the objective of the game is for the AI to guess given words, a big part of the enjoyment came from the errors that occur during the challenges.

In their first minutes of interaction with Pict.io, participants expressed feelings of wonder and surprise about the unlikelihood of communicating with a machine that recognizes their drawings, including the most imprecise sketches. These results were significantly stronger in younger players. However, this impression of the lifelike machine does not last long among most adults. On the other hand, participants were still engaged in working with the machine and overcoming the game obstacles. The game was still able to create a situation of constant tension that engages the human-machine interaction, increasing the feeling of agency and identification towards the AI.

Conclusion

There are various sorts of machines, and while some are recognized merely for what they are, that is, non-living objects and appliances, others can challenge the boundaries of perception between the living and the non-living. Since the advent of the first examples of lifelike machines, they have become increasingly real-looking, skilled, sensitive, and interactive. Today's devices can look amazingly real, detect human language, respond to multiple stimuli, adapt to their environment, and learn.

Moreover, the presence of lifelike machines in both public and private spaces has increased significantly. Today they are recurrent in diverse spheres and hugely employed in the arts, social robotics, and gaming. However, previous studies of this subject attended specific niches, focusing on particular features, and the issue of the semblance of life missed a more comprehensive theory for analyzing the common elements at play for lifelike machines of different kinds and contexts. Thus, the present research looked at devices from a broader perspective, analyzing diverse strategies and their correlation to the investigation of lifelike apparatuses.

While the subject of lifelike machines is shared in different fields, the intended meaning of a lifelike machine can vary greatly. Social roboticists typically want to create empathy and identification through familiar experiences to the users, and artists often wish to disrupt expectations and explore the unfamiliar realms. Nevertheless, in both cases, designers may fail to create the meaning that they expect. Thus, this exploratory research hopes to contribute to those who want to produce machines with a sense of agency. This study hopes to encourage researchers to avoid applying expressive elements arbitrarily but instead identify their design choices, consider possible alternatives, and the potential outcomes from their combination, so that they can have more control over their productions and viewer reception.

This exploratory study intended to identify the main elements of design that a creator should consider when attempting to generate the semblance of life in machines. The research pursued two main questions: What are the design elements that create the semblance of life in devices? How does the articulation of these components impact individuals' perception and appreciation of machines as lifelike? The outcome of this study aimed to create an operational outline of the sign-system of lifelike machines.

The methodology implemented in this study is framed as a research-creation, which involves two simultaneous segments, a theoretical investigation, and creative, practical experimentation, where the two phases indirectly support each other. The theoretical phase of this research applied the methodological procedures and tools from the field of the semiotics of puppetry, consisting of the classification and analysis of the elements that generate the semblance of life into non-living objects. As a result, it provides the outline of lifelike machine components, drawing from the examination of several examples of devices that seem alive.

In summary, the project suggested a structural relationship between the various design elements at hand for the creation of lifelike mechanisms and how they might affect the observer's perception of these devices. It identified and analyzed four primary components: body, behavior, context, and name of the machine. These variables were broken into smaller parts and examined in more depth. Nevertheless, the study shows that the meanings deriving from any of the presented signs are not provided in isolation, and each element reflects on the others and may change their separate meaning. More specifically, the selected set of sign-systems in a machine may work with or against each other to construct meaning. Thus, depending on how those elements are combined, they may promote empathy and identification, generate an aura of authenticity, or be perceived as fake and artificial. When the signs of the body, behavior, context, and name are mutually supportive and employed for the same purpose, they can reinforce the intended meaning. For instance, this happens when a robot's visual appearance matches its locomotion mode, and the robot's behavior fits its social situation. On the other hand, when signs are combined in contrast to each other, this often creates surprise and tension, which can also be an intended effect for many machine designers.

Moreover, the signs of life in machines operate by presenting a set of elements associated with living entities. Thus, their aesthetic outcomes also vary depending on how each element relates to reality. Each sign-system may have different relations to the things that they represent. They may be designed as mimesis of reality or intended as more abstract or symbolic representations of a concept. While mimesis focuses on imitation, abstraction approaches presuppose a conceptual process that communicates meaning in a non-literal manner.

Even though machines regularly undergo a demand to have a technically precise operation, the numerous examples analyzed have shown that lifelike expression is not conditioned to realistic approaches. Their signs for representing life can be restrained and simple, yet effective, such as in robots that move by changing trajectory to interact with the environment, avoiding obstacles. Observers can accept the machine's proposed meaning by focusing on their relevant aspects of functioning and abstracting the parts that are not helpful for the construction of meaning. Thus, even when their mechanical characteristics are evident, a machine can still be accepted as if it was a living entity. As shown in many of the provided examples, this process of generalization is a frequent asset in the viewer's suspension of disbelief.

On the other hand, symbolic approaches go past the visual resemblance to the thing being represented and introduce another level of meanings that are contextualized by cultural conventions. For instance, a robotic hand can refer to life simply by its resemblance to a human hand, and its convincing movements. However, the same robot can convey extra meaning if it makes hand gestures that symbolize defiance, freedom, or authoritarianism. Through the vast array of associations that the signs carry with them, their articulation can offer the generation of metaphors, indicate support for an idea or allegory, show sarcasm, as well as other assets.

The research also demonstrated that the articulation of signs hardly produces machines that are taken to be genuinely alive. Despite some creators' attempts to reproduce an exact representation of life, machines usually fail to resemble life exactly. Even though in sporadic circumstances, the viewers can potentially believe that the mechanisms are alive, most often, they can also distinguish the device as the inanimate object that they are. Thus, their design's outcome invariably shapes the human participant's interpretation of machines to be somewhere between the living and the non-living. This inherent ambiguity to the perception of lifelike machines involves the ongoing duality between the signs and things that they represent, which are associated with the processes of double-vision and suspension of disbelief.

This study's comprehensive nature, which included machines in the fields of arts, games, and social robotics, produced benefits but also presented limitations. While it was a useful means to assess the generalizability of strategies and findings across fields through abundant data, it did not allow space for an in-depth study of each specific variable, or of its application in each discipline. Furthermore, this classification of sign-systems of machines converges toward the most frequently used means, and it cannot provide an ultimate representation that covers all available forms of lifelike machines. Also, while the proposed systematization of sign-systems appears rather rigid, in the real world, there can be a continuous transition between categories, such as types of machines, from embodied to disembodied, and machine appearance, from realism to abstract, with many possibilities in between.

Moreover, this analytical method of studying the sign-system in lifelike machines cannot offer a definitive answer to how people interpret machines. The study demonstrated that the circumstances external to the devices, and not always controlled by the machine designer, also influence the machine's interpretation. For instance, signs are built inside socio-cultural conventions that regulate their expectations of the machines. When conventions change, a sign may attain a different outcome than what is expected by the machine designer. Furthermore, analyses cannot include the individual's highly variable and subjective emotional nuances.

This research also presented the development of two practical investigations of lifelike machines, with the artwork Robot Ludens and the game Pict.io. The art installation Robot Ludens consisted of a diptych with two scenes, one with a spider-like robot 'playing alive', and the other with a similar robot 'playing dead'. This project aimed to explore how to create the semblance of life in a robot and then extrapolate it to communicate the associated and yet opposed notions of death and inanimate object. This installation was iterated and presented in two different versions. The data collected during its evaluation demonstrated that the concept of death in the machine was not effectively communicated. It became apparent that to imply the concept of death is significantly harder than the idea of life in machines because the viewers tend to understand the device's immobility as a sign that the machine is either broken or turned off.

The other practical development of this research was Pict.io, a drawing game played by humans and machines. In this game, we aimed to generate the feelings of empathy and camaraderie between humans and machines through an artificial player that can guess what their human teammates are drawing. This experience showed that for designing an engaging situation in which the AI creates a sense of camaraderie, the AI player should not be a perfect player, but rather be able to commit mistakes. This feature increased humans' acceptance of the AI as a fellow teammate. We also realized that adding interjections about the human's drawings, both uplifting and sometimes offensive, could transform user experiences by triggering a series of emotional responses, from frustration to enjoyment. The experience also revealed that people's perceptions of the device were influenced not only by the credibility of the player construction but also by the quality of game design, which had to be improved continuously towards the project development. Finally, the observation of an extensive number of players showed that player's age had an inverse relationship to the machine's acceptance and attribution of life characteristics to their AI teammates.

The two main sections of theory and practice influenced each other during the research. On the one hand, the practical activities stimulated new insights into the theory. For instance, the name of a machine was introduced as a category in the theory while I was considering the title of the installation Robot Ludens, and the name of the AI players for Pict.io. On the other hand, the theoretical section also affected the two creative productions by granting a systematization for the design of the lifelike machines. The categories defined in the theoretical phase provided a direction in the process of experimentation, evaluation, and refinement of both Robot Ludens and Pict.io.

A recognized weakness of the two practical projects was in the evaluation processes. In the final stages of the research, we realized that it would have been beneficial to maintain a pattern for gathering and analyzing data among the two projects, such as the application of questionnaires, to compare the results of the two. Moreover, for the evaluation of the artwork Robot Ludens, it would have been helpful to exhibit this piece a second time for each iteration, without disclaiming its name, to assess how much the absence of the title would have influenced people's understanding of the work.

The creative projects allowed me to experiment with the creation of lifelike machines in two fields of study considered in the theoretical section: arts and games. It also enabled me to investigate the semblance of life using two different machines, embodied and disembodied, so that distinct sets of expressive elements could be tested. On the other hand, the two projects had a small format, delineated to explore the possible applications and feasibility of the proposed concepts, and to observe people's responses within short development cycles. Therefore, future research in the two realms of art production and game design should be taken to another level. In pict.io, we hope to create a full version of the game with a more complex and complete character. We plan on adding to pict.io a robotic arm so that the machine can take other roles in the game, not only guessing what is being drawn but also creating drawings and giving instructions for the human players on how to draw selected objects in the game. I also look forward to developing further artistic projects refacing the challenge of depicting death in machines, which still yields an instigating realm to explore.

Based on this research, pending questions on the sign-systems of lifelike machines become focused on how the four primary elements of body, behavior, context, and the name could be, if not isolated, emphasized, and studied in more depth. Moreover, going forward, it would be helpful to retreat to a less interdisciplinary approach, applying and extending this outline within separate fields. This way, future researchers could investigate the effect on those sign-systems toward their specific needs, exploring different pathways to express and explore the semblance of life in machines.

This research's scope does not raise questions regarding the set of ethical values associated with design choices. In upcoming artistic practices, I hope to contemplate design choices more deeply by paying attention to their potential implications. With this awareness, I hope to avoid taking an involuntary part in the perpetuation of stereotypes about both humans and machines and challenge the general simplistic dichotomous ideas of machines being intrinsically good or evil to humankind.

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Appendix A

Questionnaire

Robot Ludens: It is not alive, it has never been alive

<u>Section 1</u>

Please mark on the sheet where you situate yourself regarding the following statements:

	Strongly disagree	Moderately disagree	Neither agree nor	Moderately agree	Strongly agree
When I saw the work, I felt repulsed	O	O	O	O	O
When I saw the work, I felt engaged	O	O	O	O	O
When I saw the work, I felt confused	O	O	O	O	O
When I saw the work, I felt curious	O	O	O	O	O
			Regarding the scene 1		
I felt that the robot in this scene looks alive	O	O	O	O	O
I felt that the robot in this scene is broken	O	O	O	O	O
I felt that the robot in this scene looks mechanic/inanimate	O	O	O	O	O
			Regarding the scene 2		
I felt that the robot in this scene looks dead	O	O	O	O	O
I felt that the robot in this scene is broken	O	O	O	O	O
I felt that the robot in this scene looks mechanic/inanimate	O	O	O	O	O

Table A1: Closed questions

Section 2

Please answer in a few lines the following questions:

What came to your mind when you first saw the artwork?

Did your opinion about the installation change the longer you looked at it? How?

How does the title contribute, or not, to your interpretation of the artwork?

What do you think that the theme of this installation is?

Do you have any other comment?

Appendix B

Content classification of the open-ended questions of the questionnaire

Question 1: What came to your mind when you first saw the artwork?		
Technological Attributes		Robot Robot Arduino project Follow the robot Complexity to make robots Spider robot- screen interaction Weponized giant robot Robot Designed to interact with the user Future Experimental tech
Biological Attributes		Moving spider Spiders Tarantula Nature Butterfly Mutation Spider Alive
Art-related	Visually oriented	Color of the ground and figures Appearance Sand drawing Illustration Digital painting
	Performance oriented	Dancing Touch creating artwork Robot making the art Spider drawing with a magnet
Audience's reaction	Incomprehension	Don't know what it is I didn't know it was an artwork What is it trying to achieve?
	Engagement	Curious to how it works Curiosity I felt curiosity I was curious I was really curious Surprisingly, I was interested It felt interesting

		Enjoyed Want to touch it
	Uncanny	Scared about what it can become
Qualifiers		Funny Ludic Attractive Beautiful Nice Pretty cool Interesting Conceptual
Number of responses		Twenty-four

Table 6: Content examination, question 1

Question 2: Did your opinion about the installation change the longer you looked at it? How?		
Yes	Perception of movment	Catching the fly Shadow moving Spider following the bug Spider moves Interaction Reactive and passive Shadow moves Understand the movements
	Others	See more details Understood how it works Explication has more sense Feel more engaged More attached
No	The original feeling increased I was more amazed I really enjoyed more	
Neyther yes or no	Technology is not alweys equal to reality Don't really know Growing confusion More curiosity	
Number of responses	Twenty- two	

Table 7: Content examination, question 2

Question 3: How does the title contribute, or not, to your interpretation of the artwork?		
Yes	Simple awnsers	It was a reminder Deep Confirms my anwser Yes it contributes Good contribution Makes it all clearer Yes Robot Ludens- coherence with the work
	Life in machines	It asks the question of what it means to be alive Yes. “should machine be alive?
	Contrast relashionships	Yes. Contrast between the two It serves to contradict what it shows
No	Subtitle did not contribute. I thought it was redundant Doesn’t really influence the experience	
Don’t know the title	Didn’t see any title I didn’t know the title before to see I didn’t know about the title of the artwork	
Neyther yes or no	Reflection	It makes me curious to learn more about it It requests to think further
	Others	“Kind of” The title is abstract and interprets artist’s sentiments Interesting. Fair point of view. Very conceptual
Number of responses		Twenty-two

Table 8: Content examination, question 3

Question 4: What do you think that the theme of this installation is?		
Life and machines	Questions about life	Are robots alive? How do we define "alive”? Robots are not alive even if they move? Spider in their natural habitat
	Mimic life	Mimic life with machines Believe stuff like robots are more human than electronic when they are still robots Mimicking life
Contrast Relationships	Biological vs artificial	Biological life/ artificial life Reality x tech Being human/ alive/robot
	Life vs death	Life and death Robotization, living, and dead things
Technological Outcomes		Tomorrow's machines may take our personality Future military contracts Demo of technology Today's questions about robots
Uncertainty		No idea I don't know I am not sure
Qualifiers		Relevant It's simple and efficient Cool spider walkers Amazing It's good Philosophy
Number of responses		Twenty-two

Table 9: Content examination, question 4

Question 5: Do you have any other comment?	
Suggestions	Change movement with gestures could have made it interactive and fun I wonder if the black and white color is intentional (art) or a limitation (tech). Color (e.g., green) would render the scene more authentic/ natural/ easier to understand Adding a poster or a banner to explain the concept Second spider "involuntary" movements, so that it looks like it just died
Questions about life	It brings life Is conscience proof of life?
Cumpliments	Nice piece! Compelling and almost self-explanatory I like it! Great piece of art! Great work. Enjoyed very much Congratulations! It's really cool
Number of responses	Thirteen

Table 10: Content examination, question 5