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Master's Thesis
Academic Year 2020

Light Choreographies: Giving Performative Expression to Moving Lights

Keio University
Graduate School of Media Design

Marcelo P Macieira

A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

Marcelo P Macieira

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Abstract of Master's Thesis of Academic Year 2020

Light Choreographies: Giving Performative Expression to Moving Lights

Category: Design

Summary

We are quickly heading towards a world where all objects will become machines. Nevertheless, machine ubiquitous presence has been causing stress and anxiety. According to Rudolf Laban, movement theorist, our wellbeing is related with how we express ourselves, we each have our own body language that if not expressed, makes our lives disfunctional. This research explores expressivity of abstract shaped machines with low degrees of freedom (DOF) in performance arts context. It uses Laban Movement Analysis, a system widely recognized of being able to analyze and create expressive movement for human bodies to design and analyze movement for such machines. We believe that this would make our co-existence with machines more meaningful, and, since machines are mediating almost all our communication and interactions, better express through them.

Keywords:

machine expressivity, laban movement analysis, human-computer interaction, human-machine interaction

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Chapter 1
Introduction

From the dawn of industrial revolution to current times, the relationship between humans and machines have become deeper and more complex. Machines came from industries to city life, then into our homes and personal lives. They have influence every aspect of our lives and affected our sense of time, distance, speed and even our sense of identity and self, radically changing the way we live, work and relate to one another [9]. This section will **(1)** briefly introduce this deepening of relationship, showing how the proximity between humans and machine has become a central aspect of modern live, **(2)** state the problem this research is concerned about, **(3)** reveal personal motivation on the subject, **(4)** define the objective of the research.

1.1. Background

1.1.1 From tools to mediums of expression

As defined on the dictionary, a tool is a piece of equipment that you use with your hands to make or repair something[1]. Using, modifying or adapting objects to extend our skills and transform our environment have been used a way to differ humans from other animals. Although animals also use objects surrounding them to improve their own bodies functions and accomplish tasks, for the German philosopher, sociologist, and anthropologist Arnold Gehlen, their use is vital on human relationship with his surroundings and, different from animals, only humans produces tools for specific future purposes, while animals, at best, use

1 From Cambridge Dictionary: `https://dictionary.cambridge.org/dictionary/english/tool`

the environment around them in a tool-like manner [10]. In effect, their complexity and use is deeply connected with human evolution, multiplication and diversification of tools marked the begin of the homo sapiens era [11] and play a very important role in anthropology, specially related to archaeology, it is through them and other artifacts that we study ancient communities and civilizations.

At first seen as tools, artifacts with embedded technique designed to amplify our skills, machines differ from them for having a certain degree of autonomy. Although limited, a small range of machines assisting in man's tasks, like the clock, measuring instruments and the telescope were already shaping man's relationship with the environment [12] but it was on industrial revolution that the presence of motors highlighted the autonomy aspect of machines, dramatically increasing the mechanical power of labor by imitating repetitive human gestures, allowing them not only to assist but also to amplify or even substitute people in what the activities had that required muscles, a semi-autonomous tool capable of increasing effectiveness, making work faster or more capable in a more than just ergonomic way.

Also around this time, machines that either imitated our senses started to be made. Photographic cameras, microphones, speakers, these sensory machines [12] changed not our capabilities to do physical work, by producing images and sounds instead of objects, they changed way of perceiving and experiencing the world. More than an extension of our senses, these machines opened new ways of communication by creating and reproducing signs, becoming mediums of expression capable of communicating ideas in its own language and that until today are used, remixed and remediated[2] in the most diverse ways. It is because they remediated music and painting that they had, since the beginning, their potential to deal with expression immediately acknowledged in areas that deal primarily with expression, such art and other creative fields, pioneering ways of expressing emotion through machines.

2 term used as in Bolter, David and Grusin, Richard. Remediation: Understanding new Media. MIT Press. 2000. [13]: Remediation is the process of how new media influence and are influenced by older ones they build upon, retaining some of its features while abandoning others, or, in the authors words "the formal logic by which new media refashion prior media forms".

1.1.2 Man Machine, Machine Man

"We become what we behold. We shape our tools, and thereafter our tools shape us." — Marshall McLuhan

Self propelled machines transitioned labor from muscle to mechanical power, marking the machine age [9] until transistors, programmable computers and digital technology changed our views on what is a machine and what it can do, shifting our conceptions of technology from the mechanical paradigm to that of cybernetics [10]. Gotthard Günther[3] distinction between 'first' (archimedean-classical) and 'second' (transclassical) machine further allow us to understand how these machines started to differ from previous ones. According to the philosopher, first machines are based on moving parts propelled by mechanical force while second machines not necessarily conduct a physical procedure, its parts does not necessarily move, instead, they are able to receive, process and use information to (some of them) conduct such procedures on classical ('first') machines, Günther analogize them as being like our arms ('first' machines) and our brain ('second' machines).

Analogies between human body and the mechanism of machines were present since before self propelled and processing information machines. Descartes's[4] thought of the human self as divided divided between body and mind, the first being an object like any other and the second an immaterial substance that controls how the body physically acts on the world. La Mettrie argued that there is nothing immaterial on thoughts and emotions, 'placing' the mind inside of the body, going from the idea of a body machine to that of a man machine[5]. These analogies would become inevitable as discoveries such as the DNA and advances on neuroscience approximated men from modern machines, specially computers [14], further questioning Descartes dualism and immateriality of the human self. With effect, the relationship with the machine is at the center of the modern subjectivity, centralized on the figure of the cyborg, as put by Donna Haraway:

3 German philosopher and logicist of the early 20th century. Some of his ideas builds Arnold Gehlen. Worked at the institute of Arnold Gehlen at the University of Leipzig.

4 French philosopher, mathematician, and scientist.

5 Name of the french philosopher and physician Julien Offray de La Mettrie most famous work.

> *"Late twentieth-century machines have made thoroughly ambiguous the difference between natural and artificial, mind and body, self-developing and externally designed, and many other distinctions that used to apply to organisms and machines. Our machines are disturbingly lively, and we ourselves frighteningly inert."* [15]

This ontological blur between man and machine would not only populate art, literature and be matter of theoretical debate but also influence how we design and build machines.

1.2. The Problem

Radio and Television defined the baby boomer generation and fundamentally changed their way of living and connection to the world, personal computer and instant communication did the same with generation X, while millennials had their lives influenced by mobile technology and social media. According to Michael Dimock, president of Pew Research Center Technology[6], the relationship with technology, and how it influence the way people communicate and interact is a generation-shaping aspect. Technology tendencies for the near future[7,8] such as internet of things, sensing and computer vision, virtual environments, artificial intelligence and social robotics, to name a few, make it clear that we are heading towards a world where virtually all objects will become machines. Connected and able to understand the world around them, including us, they represent a new step in the humanization of machines.

6 Dimock, Michael. Where Millennials end and generation Z begins. Pew Research. January, 2019. Accessed December 08, 2020. `https://www.pewresearch.org/fact-tank/2019/01/17/where-millennials-end-and-generation-z-begins/`

7 Marr, Bernard. These 25 technology trends will define the next decade. Forbes. September, 2019. Accessed December 09, 2020. `https://www.forbes.com/sites/bernardmarr/2020/04/20/these-25-technology-trends-will-define-the-next-decade/?sh=2fe587ae29e3`

8 Banino, Rob. 20 new technology trends we will see in the 2020s. Science Focus. May, 2020. Accessed December 09, 2020. `https://www.sciencefocus.com/future-technology/new-technology-trends-2020s/`

However, despite all benefits these machines can bring, like everything else, it has its down sides. Since the time of the 'first' machines and the mechanization of labor there was already discomfort about their presence. Not only related related to body injuries caused by repetitive movements and posture when operating machines but also to how they were changing other aspects of our lives such as social interaction[9]. Moreover, were heading towards a more automatized world with less interaction between people [10], self checkout, self driving cars, drone based delivery, technologies that decrease daily life human interaction and that have been accelerated by 2020's Covid 19 spread[11]. In a not so distant future, virtually all objects will become machines.

Today's machines are not only in our houses, but in our personal lives. Like us, they are not mere tools or 'workers', they are part of what we are, capable of doing many things that we do, they mediate most of our communication and interaction and as they get intelligent we are also able to communicate **with** them and as we interlace machines, virtuality, our bodies and minds, we are communicating **through** them, using their own ways of doing so, the medium is the message, would say Marshall McLuhan.

9 Hirsh-Pasek, Kathy, Schlesinger, Molly, Michnick G., Roberta and Mond, Esther Care. The New Humanism: Technology should enhance, not replace, human interactions. Brookings. June, 2018. Acessed December 6. https://www.brookings.edu/blog/education-plus-development/2018/06/11/the-new-humanism-technology-should-enhance-not-replace-human-interactions/

10 Byrne, David. Eliminating the Human. MIT Technology Review. August, 2017. Acessed December 6, 2020. https://www.technologyreview.com/2017/08/15/149854/eliminating-the-human/

11 Newman, Daniel. The Top 10 Digital Transformation Trends Of 2020: A Post Covid-19 Assessment. Forbes. August, 2020. Accessed December 6, 2020.https://www.forbes.com/sites/danielnewman/2020/08/11/the-top-10-digital-transformation-trends-of-2020-a-post-covid-19-assessment/?sh=7bf8f20d77b4

1.3. Personal Motivation

"Artists have to be interested in machines, have to abandon their romantic paintbrushes, their dusty palettes, their canvases and easels. They have to start understanding the anatomy of machines, the language of machines, their nature, and to re-route them into functioning in irregular ways to create works of art with the machines themselves, using their own means." — Bruno Munari[12]

Personally, I was always an enthusiast of new technologies. Since I was a kid I am always delight by technology advances. Nevertheless, I do also feel the downsides of over using it. Living abroad, my only contact with closer friends and family was, of course, video calls and text chat, and with Covid 19 spread, even my contact with friends here in Tokyo became like that and its simply not the same. But I believe that technology can advance in a direction where we feel more comfortable using it, and part of that would be to allow us to be more ourselves when using it, and not to feel limited by it.

Also, as an artist, it also excites me to think of the creative possibilities on our interaction with machines. On his documentary 'Cave of Forgotten Dreams', the director Werner Herzog questions why did the 'caveman' would go through all the trouble of drawing on the walls, why would he want to mark his hand on the wall when he should be hunting. And I believe that it has to do with a human necessity for self expression, using whatever you have available around you. This work is also largely influenced by Rudolf Laban thoughts that if we don't 'move our way' we have dysfunctional lives[13].

1.4. Objective

The objective of this research is to explore machines not as tools, but as an expressive medium, in order to make our interaction with them more meaningful and enable them to better communicate our feelings, towards expressive embodied experiences with machines. We want to explore their expressive language in

12 Artist from the Italian futurism movement.

13 Laban was referring literally to our movement and body language but I interpret it as being ourselves and expressing our identities in all ways.

scenarios where they are not necessarily functional and designed with a task in mind.

This was explored by using simple machines as elements of art performances, context chosen for this work because it is where where language and expression are used not because of its functionality, but as a mean of self expression, telling stories and for the creation of aesthetic experiences. I believe that this kind of exploration of machines expressivity could influence the way we design or use them, and make their presence less uncomfortable, and this research is a step in that direction.

Chapter 2

Literature Review and Related Work

On this section we reviewed works related to expression and affect in Human Computer Interaction (HCI) and Human Robot Interaction (HRI), focused but not limited to the use of Laban Movement Analysis (hereinafter referred to as LMA) within these fields. We will present how LMA has extrapolated dance and is being used in HCI and HRI to create expressive machine movement and expression based interactions. We will start by showing how LMA is used in therapy, showing the importance of human expression to wellbeing and mental health, to then show research that embed affect into machine design and how it does that, starting from affective computing and how it put affect and emotion as a design pillar, then showing how LMA has been used in HCI and HRI, by presenting works on segmentation and classification of movement according to LMA for gesture based interactions, followed by how LMA is being used to make expressive machine motion for both human-like and non-human like machines, and finally, research and artworks and performances that used robot expressiveness in performance art context.

2.1. From dance to HCI and HRI

2.1.1 Transcending Dance

LMA was started by Rudolf Von Laban at the beggining of the 20th century and is a method that observes movement qualities in order to describe and interpret it, to enhance communication and expression. It is a comprehensive structure for analyzing and representing expressive movement with a longstanding research within the dance community, but it has transcended the dance community to a diversity of other areas.

The system has been further developed, used and adapted by his pupils, more prominently Warren Lamb, vastly applying LMA analysis working with companies, not only to improve work efficiency but also for staff and executive hiring [16] [17]; Lisa Ullman, editor of one of Laban's most important books[1], and who's work is crucial in systematizing the theorist's thoughts after his death, allowing it to be better studied, understood and used in other fields; and Irmgard Bartenieff, for incorporating Laban's theory and physiotherapeutic principles into the Bartenieff Fundamentals [18], pioneering therapies not only related to physical rehabilitation and occupational therapy [19] but also somatic approaches that uses body and mind approaches to therapy [20] [21].

2.1.2 Expressiveness, Human Robot Interaction and Affective Computing

Established by MIT Professor Rosalind Picard in a publication of the same name [22], affective computing is, as described by Picard: computing that relates to, arises from, or deliberately influences emotion or other affective phenomena. More aware of the importance of emotion in interaction and communication, it influenced many research being done in both HCI and HRI, by putting affect if not in the center, in a much more important place on the design of interactive and robotic systems than before.

Relating to

In order to better co-exist with and assist humans, these systems should be able to sense and recognize the emotional state of the person its interacting with. Sensing physiological data in order to understand emotional state have not started at this time but researchers with interest in affective computing have been developing new wearables [23] and applications [24] [25]. Also, the increase of computer power and advances on computer vision allowed emotion recognition based on facial expressions and body language, and advance on artificial intelligence allowed

1 Laban, Rudolf von, and Lisa Ullmann. 1960. The mastery of movement. London: MacDonald and Evans.

for better interpretation of both sensoring and visual data [26] [27].

Arising from and deliberately influencing

Once recognized, the emotion is an input to which the system should react accordingly. This reaction might include an intervention that is deliberately designed to influence back the emotion of the interacting person. Generally used to improve wellbeing, this interventions can come in different forms such as actuators(Figure 2.1), or, like in social robots [28], related to the machine's social behavior through voice, text and body language, the last being the focus of this literature review.

Figure 2.1 KAN.KA: across-body directional haptic patterns for emotion regulation [1]

2.1.3 Automatic classification based on LMA and use for gesture interaction

The system's capacity classify movement based on its qualities called attention of the HCI (Human Computer Interaction) field and many researchers that started to explore capturing motion, automatically segmenting and classifying them using LMA, in order to interact with computers [29] [30] [31]. These works were mostly concerned with low level qualities of movement that could be recognized and trigger events on the machines the person is interacting with, or to get semantic classification of these gestures with the same goal.

2.1.4 Evaluating Interaction: Godspeed Questionnaire Series

When evaluating the behavior of robots, the Goodspeed Questionnaire Series (GQS), according to a meta analysis of its use [5] is one of the most used tools, with over 160 citations as of October 2014. The paper that originated the questionnaire [2] shows great concern about the likeability of the robots in social context. The items of the questionnaire(Figure 2.2) are designed to allow evaluation to if the robot has an acceptable social behavior that will make people feel comfortable and safe around them. In the context of performance arts, questionnaires based on GQS have been used [3] [4], that adds or modifies some of the items in order to evaluate aspects that are more relevant to the given context, as shown on (Figure 2.3). These modified questionnaires served as base for the one used on this research[2].

2.1.5 Anthropomorphism

The GQS meta analysis also shown that high rates of anthropomorphism are an indicator for social acceptability [5]. In fact, most of the research found uses human-like robots in their work. The vast majority of these works analyze how a robot, mimicking a human behavior known to be perceived in a given way, would be perceived by other people, in social conversational situations or in contexts where the robot is performing a task that in the real world it would be on a shared environment with people, as seen on tasks listed on the GQS meta analysis, that considered only works that used the human-like NAO robot(Figure 2.4).

Some of the works that deal with expressiveness in robot motion rely on LMA add expressivity to robotic motion [32] [33] and results positive, suggesting that motion design based on LMA can add expression to arbitrary movement. LMA is also used to analyze human-like robot's motion and compare to human motion [34] [6], as a way to understand the differences and how to improve robot motion towards more anthropomorphic like movement.

2 More about how it was modified can be found on the Study and Evaluation section of the thesis.

GODSPEED I: ANTHROPOMORPHISM

Please rate your impression of the robot on these scales:

以下のスケールに基づいてこのロボットの印象を評価してください。

Fake 偽物のような	1	2	3	4	5	Natural 自然な
Machinelike 機械的	1	2	3	4	5	Humanlike 人間的
Unconscious 意識を持たない	1	2	3	4	5	Conscious 意識を持っている
Artificial 人工的	1	2	3	4	5	Lifelike 生物的
Moving rigidly ぎこちない動き	1	2	3	4	5	Moving elegantly洗練された動き

GODSPEED II: ANIMACY

Please rate your impression of the robot on these scales:

以下のスケールに基づいてこのロボットの印象を評価してください。

Dead 死んでいる	1	2	3	4	5	Alive 生きている
Stagnant 活気のない	1	2	3	4	5	Lively 生き生きとした
Mechanical 機械的な	1	2	3	4	5	Organic 有機的な
Artificial 人工的な	1	2	3	4	5	Lifelike 生物的な
Inert 不活発な	1	2	3	4	5	Interactive 対話的な
Apathetic 無関心な	1	2	3	4	5	Responsive 反応のある

GODSPEED III: LIKEABILITY

Please rate your impression of the robot on these scales:

以下のスケールに基づいてこのロボットの印象を評価してください。

Dislike 嫌い	1	2	3	4	5	Like 好き
Unfriendly 親しみにくい	1	2	3	4	5	Friendly 親しみやすい
Unkind 不親切な	1	2	3	4	5	Kind 親切な
Unpleasant 不愉快な	1	2	3	4	5	Pleasant 愉快な
Awful ひどい	1	2	3	4	5	Nice 良い

GODSPEED IV: PERCEIVED INTELLIGENCE

Please rate your impression of the robot on these scales:

以下のスケールに基づいてこのロボットの印象を評価してください。

Incompetent 無能な	1	2	3	4	5	Competent 有能な
Ignorant 無知な	1	2	3	4	5	Knowledgeable 物知りな
Irresponsible 無責任な	1	2	3	4	5	Responsible 責任のある
Unintelligent 知的でない,	1	2	3	4	5	Intelligent 知的な
Foolish 愚かな	1	2	3	4	5	Sensible 賢明な

GODSPEED V: PERCEIVED SAFETY

Please rate your emotional state on these scales:

以下のスケールに基づいてあなたの心の状態を評価してください。

Anxious 不安な	1	2	3	4	5	Relaxed 落ち着いた
Agitated 動揺している	1	2	3	4	5	Calm 冷静な
Quiescent 平穏な	1	2	3	4	5	Surprised 驚いた

Figure 2.2 Godspeed Questionnaire from original publication [2]

(a)

Attribution	Attributes
Affective Capacity $\alpha = 0.82$ $M = 3.43$ $SD = 0.97$	Bland — Expressive Forgettable — Memorable Dull — Evocative Trivial — Meaningful Boring — Engaging
Perceived Intelligence $\alpha = 0.74$ $M = 3.06$ $SD = 1.14$	Incompetent — Competent Unintelligent — Intelligent Aimless — Deliberate Indifferent — Curious Scripted — Imaginative
Perceived Agency $\alpha = 0.70$ $M = 2.95$ $SD = 1.22$	Simple — Puzzling Predictable — Surprising Scripted — Imaginative Rehearsed — Spontaneous Rigid — Elastic
Intelligibility $\alpha = 0.75$ $M = 2.56$ $SD = 1.21$	Unintelligible — Intelligible Enigmatic — Understandable Opaque — Readable Ambiguous — Obvious Unconvincing — Believable
Anthropomorphism $\alpha = 0.84$ $M = 2.02$ $SD = 1.21$	Mechanical — Organic Machine-like — Human-like Non-human — Human Artificial — Natural Machine — Performer

(b)

Attribution	Attributes
Entertainment	Boring/engaging
Cronbach's alpha = 0.82	Unconvincing/believable
M = 3.93	Dull/expressive
SD = 0.93	Predictable/responsive
	Planned/spontaneous
Atmosphere	Unfriendly/friendly
Cronbach's alpha = 0.74	Distant/intimate
M = 3.85	Unrealistic/realistic
SD = 0.80	Shallow/affectionate
Robots on stage	Boring/entertaining
Cronbach's alpha = 0.81	Foolish/sensible
M = 4.20	Unrealistic/realistic
it SD = 0.77	Unconvincing/believable

Figure 2.3 **(a)** Questionnaire used on [3], when an 'Attribution' is highlighted, its not present on GQS and when an 'Attribute' is highlighted, it differs from the way its presented on GQS. **(b)** On [4] all original GQS items were kept and new ones are shown on the picture.

Application Context	Scenario
Elderly care	Approach Directions
No context	Casual conversartion (led by robot)
No context	Pervasive story-telling
No context	Robot as cleaner or guide
Robot bartender	Social engagement with customers
Care	Robot as care-giver
No context	Conversation
No context	Human-like motion copying
Elderly care	Conversation
No context	Turn taking
Social assistance	Solving mental rotation tasks
Elderly care	Robot in the smarthome
Elderly care	Robot as exercise coach
Elderly care	Robot in the smarthome
No context	Message retention
Elderly care	Robot attracting attention
No context	Antropomorphisation
No context	Play quiz with robot

Figure 2.4 Task performed by NAO robots on works analyzed on [5].

Figure 2.5 Social Robot Brian 2.0 [6]

2.1.6 Non Humanoid Bodies, Low Degrees of Freedom and the Correspondence Problem

Nevertheless, non verbal communication can also be performed by non anthropomorphic figures, even ones with low degrees of freedom (DOF). Heider and Simmel [35] early exploration of geometric shapes, by including questions such as "What kind of person is the triangle?" and "Why did the two triangles fight?" to be answered after watching an animation of geometric shapes on screen, already explored perception of character and emotion in abstract figures. On the same research, users were asked to tell the story of the movie in a few sentences, only one described it as actual geometric shapes[3], all other users described using terms related to emotion, intention and even describing the shapes as people[4].

The same applies to non humanoid robots with low DOF. While some works preserve some resemblance to humans or animals, keeping eyes, tail-like and ear-like parts that assist showing expressivity(Figure 2.6), others experimented with shapes or existing robots and machines that have no human or animal visual char-

3 The description starts with "A large solid triangle is shown entering a rectangle. It enters and comes out of this rectangle, and each time the corner and one-half of one of the sides of the rectangle form an opening.(...)"

4 An example: "(...)Then the two men have a fight, and the girl starts to go into the room to get out of the way and hesitates and finally goes in. She apparently does not want to be with the first man.(...)"

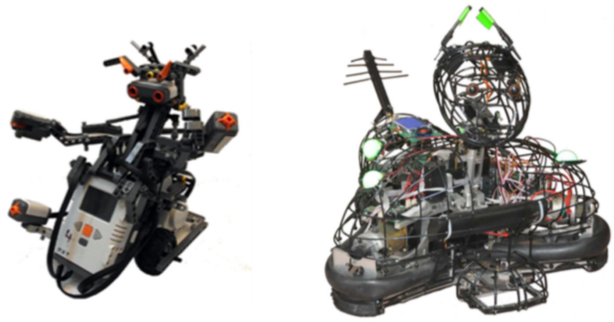

Figure 2.6 Robots used in [7] and [8], respectively.

acteristic [36] [37]. The more these machines differed from human-like appearance, more it became an issue to use what we know about human body language to create expressivity for them. This issue, known as the correspondence problem, was tackled by researchers in different ways.

Gemeinboeck and Saunders [3] proposed a method called Performative Body Mapping (PBM), that since demonstration learning is not fully possible because of the correspondence problem, builds on its core ideas and uses expertise of dancers to embody 'robot costumes', and have its motion captured as if they have the intended robot shape, from that data the actual robot would learn to move. It was vital to their research that the robot's shape had no analogies to living things, that it had no obvious head, face, front, back or limb-like structures, so that it did not relied on resemblance with human dance and that the shape didn't stand out for its novelty, and the resulting shape was a cube(Figure 2.9).

Cui et al [38] consulted specialists in the LMA system that helped designing and analyzing motion styles for drones, creating descriptions that would later be shown to lay observers together with the motion to validate if the perception would match the intention.

This thesis used a methodology based on Cui et al work, that had a similar process of an iterative step of motion generation and expert validation before lay user observation, but, instead of proposing perceptions prior to lay user observation, we used expert validation as a way to analyse what were the efforts present in the chosen equipment movement samples, to then relate to how they were perceived

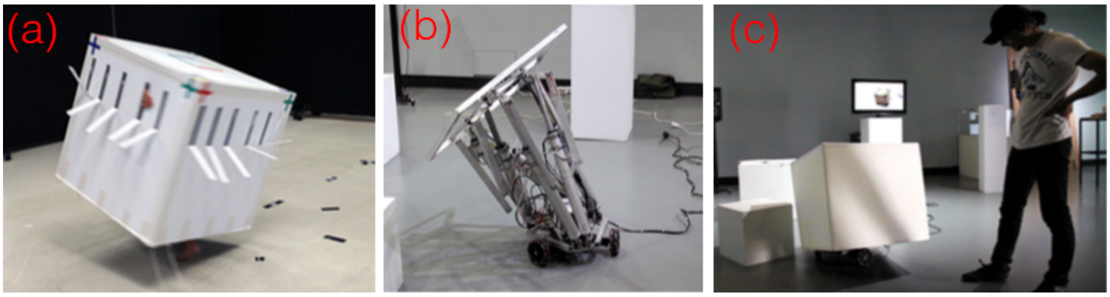

Figure 2.7 (a) Dancer wearing the robot's shape costume for motion capture. (b) Cube performer mechanism. (c) Cube performer covered by a box shape exterior, as is was exhibited and evaluated by audience. (Image source [3])

by lay observers[5].

2.1.7 Expressive Motion Design

Among the categories that Zhao [31] uses as different ways to generate expressive movement are:

- Adding expressiveness to neutral motions or providing tools to edit motion expressions: through signal processing, one can create tools that automatize or edit low level parameters of the movement making it more diverse and possibly expressive.
- Adding secondary movements: movements that are not the main focus but that its subtlety gives a richer and more varied set of movements.

Based on these, the motion for the moving heads after the first prototype were designed, better described on the Concept section of this thesis.

5 Further explanation about how how the process was adapted can be found on the Concept section of this thesis.

2.2. Machines, Art and Performance

Machines have been used by artists since the early industrial revolution. On this works, the machine as a medium, that is, its capacity to communicate and convey feeling is the focus of its use, without functional intention.

The Italian Futurism, art movements from the early 20th century is notorious for having explored how the machine could enhance their artistic expression, or exploring an expression of their own [39]. Luigi Russolo composed music with machines that were not designed to be instruments. Futurist poetry, from Italy and abroad, used resources from printing machines, such as bold letters, different typefaces and font sizes, and geometrical composition of words on paper to express their ideas. Around 1930, Bruno Munari, Italian futurist, questioning the understanding of technology and its function in the modern age, built machines without an obvious utilitarian function, but not completely useless, similar to other work present on this literature review, the artist was concerned with how the machine presence can affect the environment and people around them and what it communicated to people, but explored it without a context.

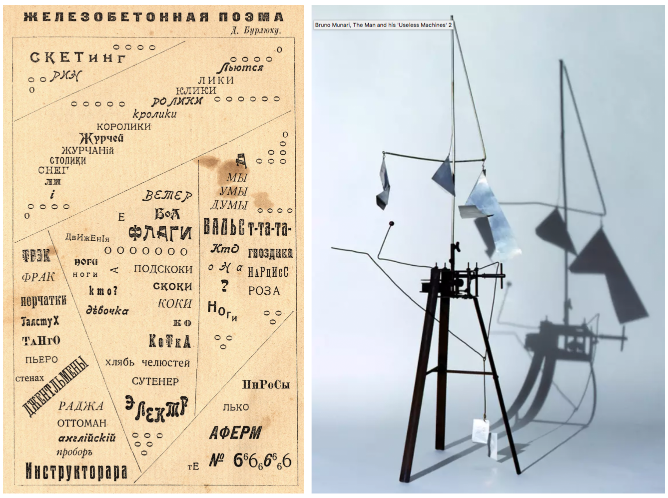

Figure 2.8 Futurist poetry bt Vasily Kamensky and 'Useless Machines' by Bruno Murnari. (Images source: `https://i.pinimg.com/originals/9d/08/9a/9d089abf33712e4efda03a73271aa642.jpg` and `https://i.pinimg.com/originals/47/69/26/47692651ada39f468b4bf610bbdd156b.jpg`)

Later on the century, Jean Tinguely would also explore similar concepts but would use machines in even more active roles on his works, using them as performers. On 2016, an exhibition about Tinguely, on the Stedelijk museum was named "Machine Spectacle", highlighting his use of machines in performance context. Stelarc is another artist that famously used machines on his performances to enhance his expression. His works not only talked about machines and technology, but used it on the performances as main elements of the performance and his work is largely influential on the field of art and technology. These half man half machine performers became more present within dance performances, and performances that used prosthetic machines or machine support such as wheelchairs to enhance their bodies and expression started to appear.

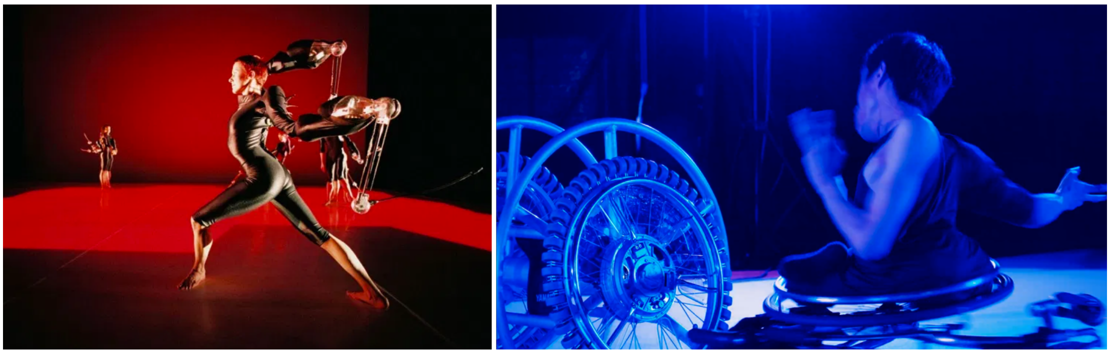

Figure 2.9 Performances Nemesis (2002), by Random Dance Company and ORIGIN (2020) by Kanbara Kenta, Music by TOMC. (Images source: `http://scannerdot.com/2002/12/random-dance-nemesis-2002-score-by-scanner/` and `https://youtu.be/CNYuF629Elw`)

Dividual Plays, a dance piece performed on the Yamaguchi Center for Arts and Media (YCAM) in 2015, used motion capture of the dancers on stage that resulted in different behavior of several different kinds of machines, that was called "small laboratories", placed by the stage that would react to or express the dancers movements in their way. The machines output would influence back the stage, affecting the dancers(Figure 2.10).

Conventional equipment used in live performances such as light equipment, laser beams and projections are an usual way of enhancing the performance in music,

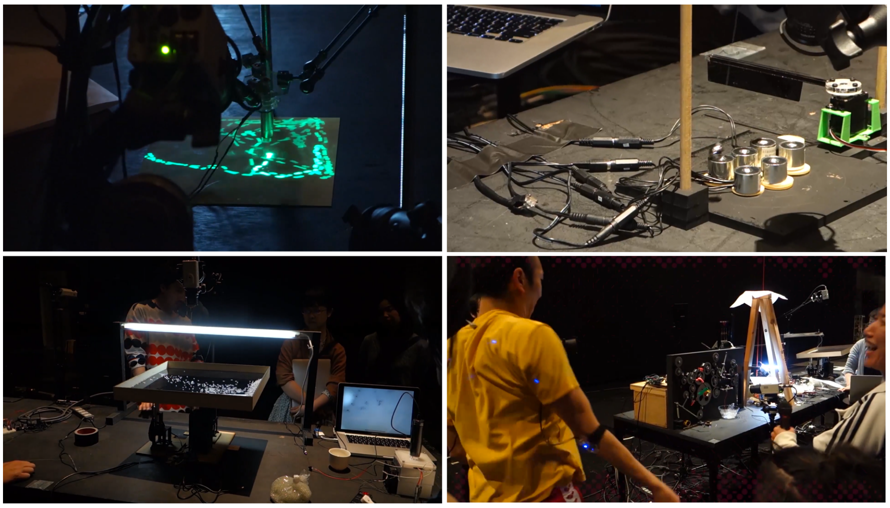

Figure 2.10 Examples of 'small laboratories' of Dividual Plays performance by Yoko Ando, performed at YCAM in 2015. (Images source: `https://vimeo.com/116310859`)

dance, sports and all kinds of events. However, for this thesis works that used them with active roles on the performance were more relevant because they explored the communication between performer and machine on stage, and for that, had to find the expressive qualities for that context, that machine can afford(Figure 2.11).

2.2.1 Contributions of this research

Related research on movement expressivity and machines are in its vast majority referring to expression as internal emotional states that can be useful for utilitarian interaction, or for giving character to machines, that, although close to an actor performance, differs from performances such as dance and others. Geimeinboeck and Saunders [3] was the closes work to this, that looked for expressivity in non-organic abstract forms, unique to its body, that is, with no relationship with human body movement, and evaluated the perception in performance arts context. On the other hand, the mentioned artistic work design process was not published, neither could it be found detailed description such as it would be done in a publication.

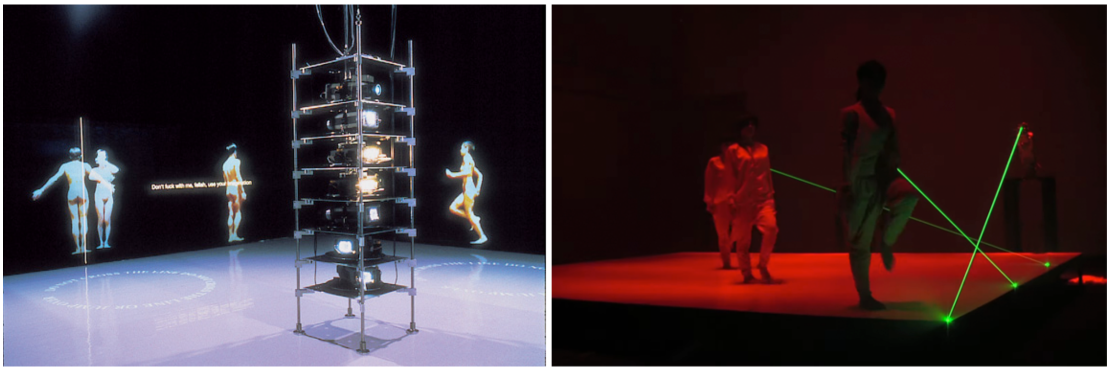

Figure 2.11 Teiji Furuhashi "Tableau Morant" (1994), and ELEVENPLAY + Rhizomatiks "Laser" (2014). (Images source https://epidemic.net/en/photos/dumbtype/lovers/photo1.html and https://www.youtube.com/watch?v=0FH_TvSdzaA)

Therefore, this work is a contribution to researchers that are interested in an approach to performance arts based on fields and methodologies from fields such as HCI and HRI. Another contribution is towards the use of low DOF machines with no aspect resembling human or animal bodies, in research related to non verbal communication, which also proved to be relatively uncommon.

On this work, two ways of using such machines to express feeling in performance art context was designed and tested. The first relied on the connection with human body data to be used by the machines in their own language, and the second was an exploration of the machine's body language alone, where segments of movement and light variation were designed and evaluated by audience in an experimental setup.

Chapter 3
Concept and Implementation

3.1. Pilot Study: Boiling Mind

A pilot study was made during my participation on Boiling Mind project: a dance performance that used the audience physiological signals to control stage elements such as music, projections and lighting. Every performance is unique and audience reacts in different ways and during it a connection is made between performers and audience through sharing of feelings. The project's goal was to enhance this connection by using these stage elements as an audience presence, affecting dancers movements.

3.1.1 Designing Boilind Mind

Boiling Mind was the result of a cooperation between the choreographer, dancers, researchers in human computer interaction, sound designer and media artists during the course of one year. My participation started after a proof of concept performance, which I was present as audience. On this performance data was gathered from only a few of the audience participants and showed in form of projections on stage. After conducting interviews with the audience the team decided that to realize the concept it would be needed to get data from more member of the audience, and more importantly, the way this data was shown during this first performance acted more as a way of showing back the audience their data than to influence the dancers during the performance (Figure 3.1), a more multi-modal approach was needed [40]. So more people, including me, joined the team to make the music and the stage lighting also connected to the audience data.

For the performances following the proof of concept of the project, it was de-

Figure 3.1 Proof of concept performance stage setup

cided that heart and electrodermal activities (EDA)[1] from all members of the audience would be collected and used during the performance (Figure 3.2), and that this data should be used more intuitively, better blended into the stage design, involving more of the elements used on stage.

My part on the project was to use this data to make the audience present on stage through the lighting equipment. The design should give the dancers information about how the audience was reacting to the performance, as a way of participating on the act, and also show how it relates with their own reactions. Two designs were presented on how to achieve this through stage lights, on both, audience heartbeat and electrodermal activities would be represented in intuitive ways.

The first design proposal used two projectors located on each side of the stage. One based on audience data and another one based on the dancers data, they would project a simple line that vibrated according to each group average heartbeat rate and with brightness controlled according to the electrodermal activity arousal. The angle of the projected line in relationship with the projector changes according to the relationship between the average of audience and dancers heart

1 Electrodermal Activity is a property of human skin, in particular, changes in the skin conductance level and its associated with emotion or stress, often used to assess emotional arousal [40]

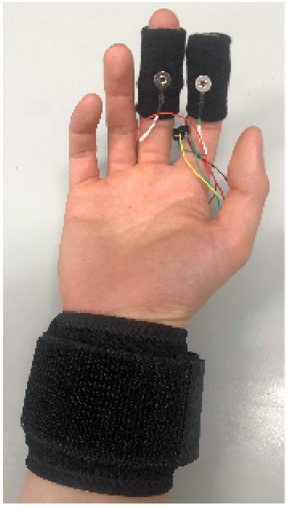 

Figure 3.2 **Left:** Wristband with electrodermal, heart activity, acceleration and gyro sensors, used by the audience during the performance. **Right:** Boiling mind audience seats before performance, each seat had a wristband ready to be used during the performance.

rate, the closer the values, the closer to 0 degrees both angles would be, and the more different they are, they would move away from each other, going opposite ways, as shown in (Figure 3.3).

The second proposed design was based on moving light fixtures called moving heads. Moving heads are lights standing on a base that is able to move in two axis (Figure 3.4) and that can be controlled through DMX protocol. There are different styles of light effect for moving heads and the chosen one was the beam light, because it allows the desired effect of having lights pointing to each other, forming a single beam. They would be positioned in groups on opposite sides of the stage, one group representing audience and the other representing the dancers. Each moving head is linked to a person of that given group and its light blink together with that person's heart, while brightness is linked to the EDA. All moving heads have an initial position that changes in case a dancer and someone from the audience had their hearts beating in the same rate. When that happened, they would move and look at each other, forming a single bright beam that symbolizes the connection between performer and audience, key concept of the piece. When the rates became too far apart, the lights would go back to their initial position

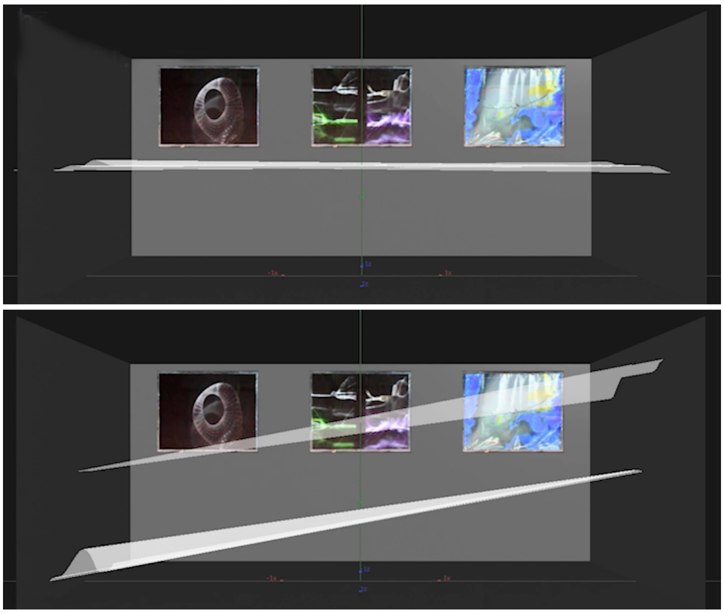

Figure 3.3 Illustration of first design proposal, A video demonstrating the first proposal can be seen at `https://youtu.be/bf59VuylyVg`

(Figure 3.5).

3.1.2 Limitations and Adaptations

After discussing with the team, we decided to go for the second proposal, projections were already being used on the performance and moving heads would add to the stage composition a new element that also allowed that single person data could be more explicitly used and perceived. Both designs relied on possibility of using not only the audience data but also dancers data. Getting the data from the dancers while they perform has proven to be a challenge due to the amount of movement performed during a dance piece and we decided to use only the audience data. Also, positioning the equipment on the floor could cause accidents during the performance, dancers felt that it would be better to place them somewhere they would not have to worry about while they dance. Considering all that, a redesign of the lighting system was necessary, described below.

1. Lights were repositioned on high locations around the stage (Figure 3.6),

Figure 3.4 Moving head. (Image source: https://www.megamusicrs.com.br/MLB-1605817236-par-2-moving-head-lighting-high-power-100w-spot-dmx-led-_JM)

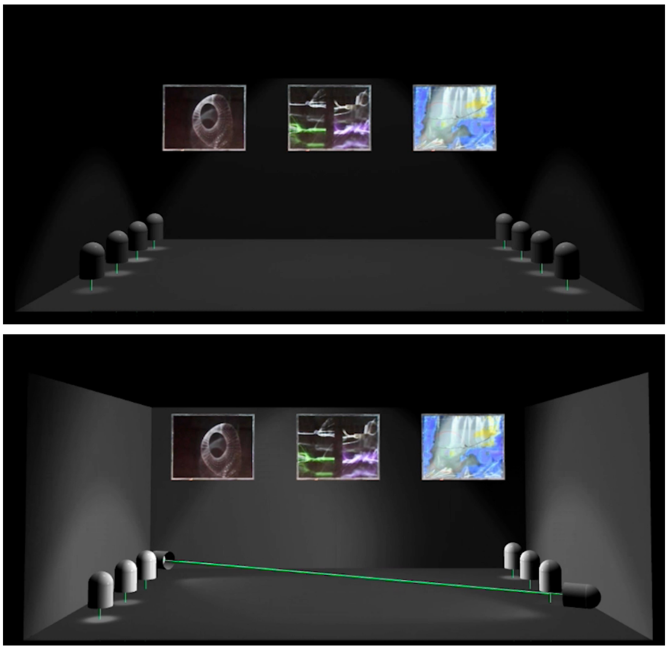

Figure 3.5 Illustration of second design proposal showing all lights on their initial position on the top and on the bottom showing 2 lights positioned looking at each other, event triggered by the synchronization of a dancer and a person from the audience's heartbeat. A video demonstrating the second proposal can be seen at https://youtu.be/4PeL2KTyDzg

using tripods and the ceiling structure of the venue.

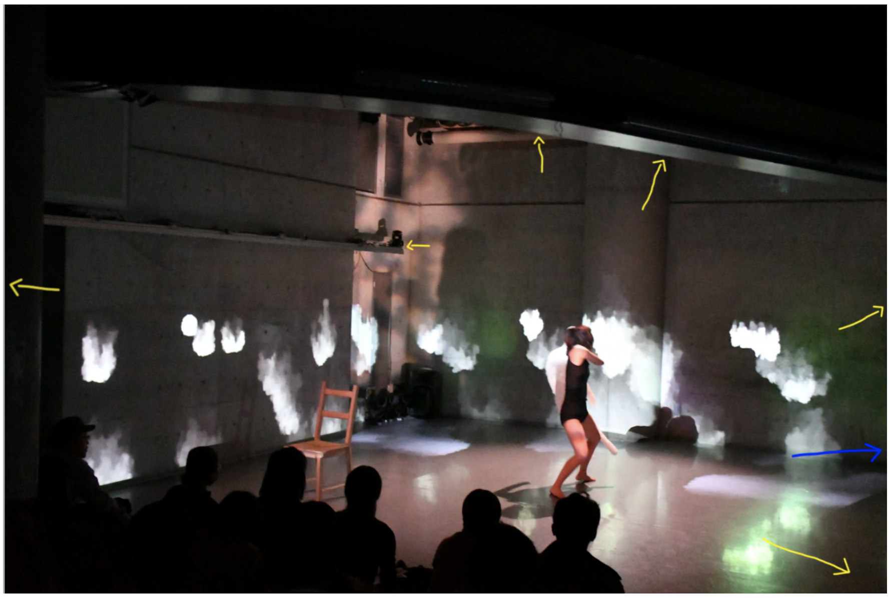

Figure 3.6 Positioning of moving heads on stage as used during performances. Blue arrow indicates position of haze machine.

2. Since only audience data could be used, all moving heads were linked to only audience data. The system had two modes, that were activated depending on the performance current scene.

a. On mode A, six audience members were randomly selected and had each one of them their heart rate data mapped to a corresponding moving head, blinking according to the heart signal. Whereas on the proposal the lights could only form doubles between a dancer and someone from the audience, now when more than one person from the audience had similar beats per minute (BPM) rate, it would form a group, the lights would move and create a chain, that is, more than 2 people with the same heart rate would have their related moving heads looking at one another in sequence(Figure 3.7). When a group member BPM value differed from the rest of the group, the corresponding moving head light moved back to its initial position and was randomly reassigned to a different audience member.

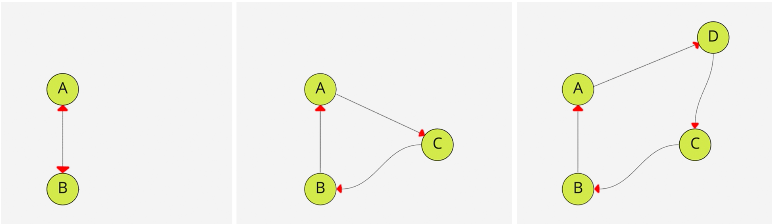

Figure 3.7 Group behavior of the lights, from left to right it shows group growing and from right to left shows group shrinking behavior. Arrows indicate where the light are pointing at.

b. On mode B, a single member of the audience would be linked to all moving heads on stage. This was used on one specific scene of the performance when dancers invited one member of the audience to go on stage and interacted with that person (Figure 3.8). The scene was strongly focused on the invited person, that seated on a chair on the center of the stage, and on that moment of the performance, the whole stage interaction was focused on the invited person.

Figure 3.8 Dancer invite audience member during performance

3.1.3 Performing Boiling Mind

The whole piece has approximately 1 hour and was performed in 3 full sessions in Tokyo. The moving head light system was present in selected scenes of the piece, decided together with the art director and choreographer. It was developed in Touch Designer [2] and received the data from the wearable wristband through system developed by other project members. When modes were activated they functioned automatically until turned off or switched to another mode and during the performance, the operation consisted in toggling modes on and off during the selected scenes. Monitoring the signals being used was also necessary during the performance so that, if needed, the connection between a given audience member and its correspondent light could be changed to another member, in case the signal was not usable for some reason. Before the performance started there was a brief introduction about the piece concept and the integration of audience data into the stage design and after the performance they were asked to answer to a questionnaire.

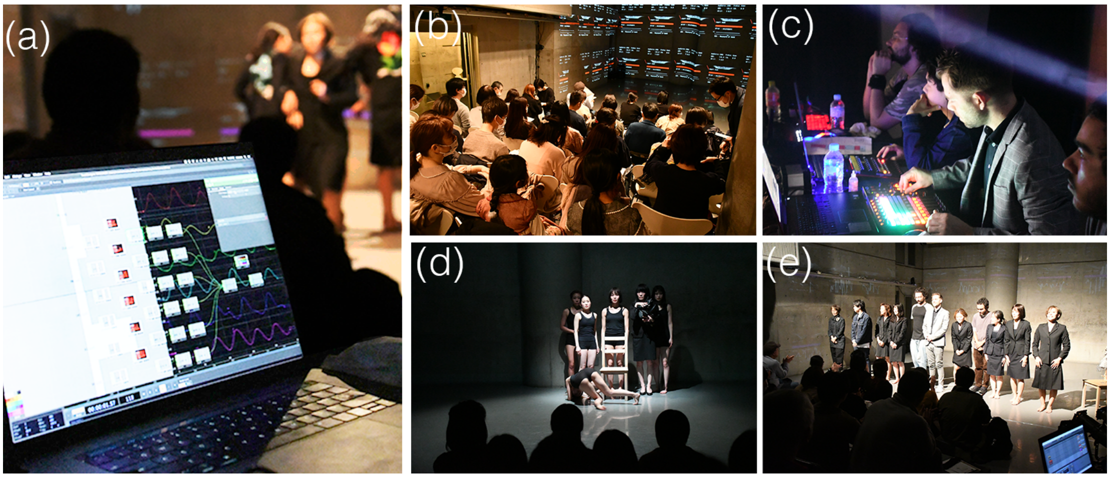

Figure 3.9 (a) Monitoring heart signals during performance. (b) Overview of audience before performance start. (c) Keio Media Design technical/artist team on the control table during performance. (d) Mademoiselle Cinema dance company dancers performing the piece. (e) Whole team thanking audience.

2 Node based visual programming environment for real time interactive multimedia content. https://derivative.ca/

3.1.4 Learnings and Moving Forward

Boiling Mind's light system explored how can audience body data be used by moving lights to, in their own ways, represent aspects of audience reaction to the performance. It was an experiment of embodiment in low DOF machines that faced the correspondence problem by directly connecting audience data to the lights in an intuitive, comprehensible way and also using their capacity to move and the beam style of the lights to convey the concept of connection. The experiment explored the equipment 'body language' to represent another body's emotions and the concept was very well received by the audience [40], that enjoyed the fact that their data was being used as part of the performance, but from the questionnaires answered by the audience, the stage elements were not so impactful, as 86% answered that the dance itself was more of their interest than the interaction and novelty of the stage design [40]. Therefore, next step was to further explore the equipment's expressive features, including more complex and continuous movement, in order to enable the moving heads to have a more active role on a performance.

3.2. Light Choreographies

"Something is said to have presence when it demands that the beholder take it into account, that he take it seriously, and when the fulfillment of that demand consist simply in being aware of it and, so to speak, in acting accordingly" - Michael Fried (as cited in [39])

3.2.1 Design Methodology

Focusing on the moving head's movement, the primary material of dance expression, related research and personal interest in dance performances lead us to use LMA(Figure 3.11), as mentioned, a system capable of describing movement that has been widely used on HCI and HRI research to deal with machine motion expressivity. In order to apply LMA to non human-like low DOF machines, and approaching the correspondence problem, we based our methodology on previous work.

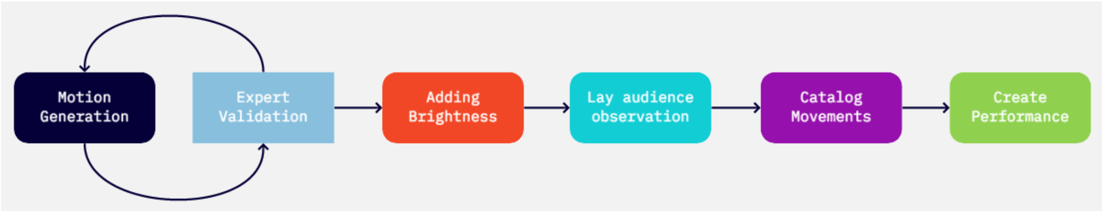

Figure 3.10 Methodology used.

Cui et al [38] consulted specialists in the LMA system, that analyzed the machine's movements and developed descriptions to be validated by lay viewers, one of the specialists helped creating and other analyzed the 10 motion styles for drones in in-home context, to then describe then using terms such as ”clear” and “puffy”, and also giving descriptive context to those styles, related to the in-home context, such as ”Monotonously patrolling an empty backyard.” or ”Efficiently picking up a messy bedroom.”. They were then shown to lay viewers to see if the perception would match the intention and validate the styles.

This thesis also relied on the help from LMA specialists for analyzing the motion created for the moving heads. However, the analysis was used in order to classify the motion according to LMA Efforts, to be shown later to lay observers without suggesting context or terms that had an intended emotional reaction. In our case, they were used to allow a common language to be used for both dancers and moving heads, a choreographic frame that would allow a composition to be made and performed by both. Lay user observation was used to evaluate if the perception of audience would be positive in terms of emotional response, entertainment, and others(Figure 3.10).

3.2.2 Motion Generation and Expert Validation

LMA's Effort component is the part of the system that is recognized to deal with expressivity of movement [32] [6] [38]. The Effort component has 4 sub components, called motion factors, each having 2 two opposing extremes, they are the smallest units needed in describing movement [31]. Effort's motion factors are:

- Time: from sustained to quick, the time factor is not only about speed but about urgency.
- Weight: from light to heavy, weight is the apparent physical effort and relationship to gravity.
- Space: from indirect to direct, its the attention to surroundings and path of movement in relationship with the space.
- Flow: from free to bound, its the amount of muscular tension and control over movement.

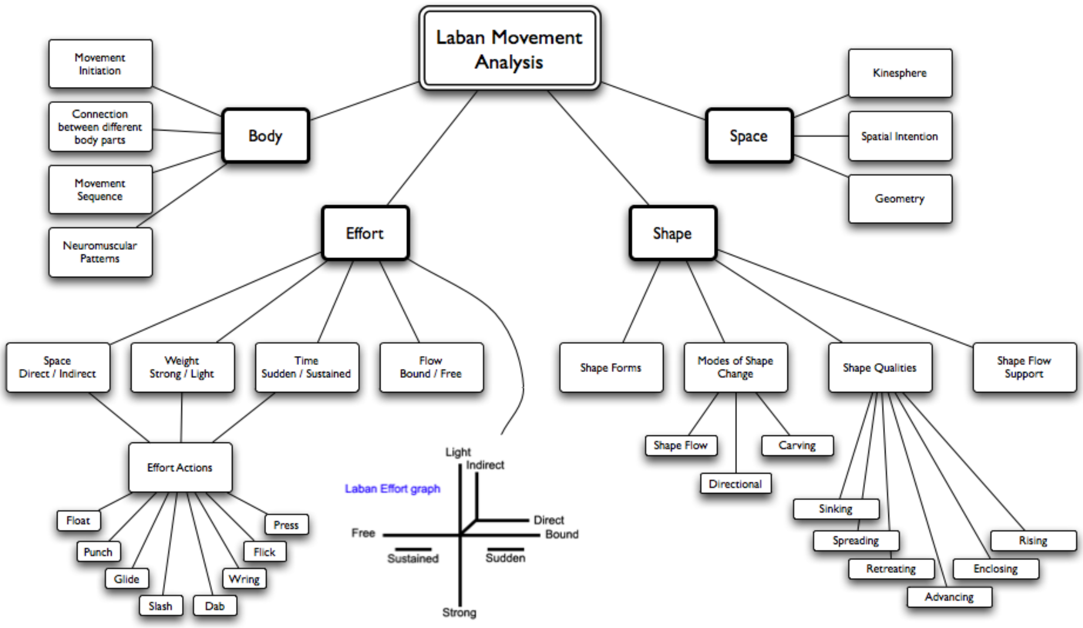

Figure 3.11 Illustration of whole LMA system. For this research only the Effort component was analyzed, for being the one that deals with qualitative aspects of movement. Image from `https://labanotationandlma.weebly.com/lma.html`

Two experts(Figure 3.13) in Laban's theory assisted on this moment, Carol

Vilela[3] and Leandro Souza[4]. After initial meetings and discussions on Effort, correspondence problem, limitations of the equipment and general subjects related to the research, we decided to proceed with the research by having them analysing small samples of motion of 3d virtual moving heads shown in different angles, that they would, per sequence, classify their motion factos on a scale from 1 to 5. The set used had 29 sequences, and both were asked how diverse they felt the set was, to assure it contained several motion styles, and from 1 to 5, answer were 4 for Carol and 3 for Leandro. We considered the set satisfactory to move to the next step.

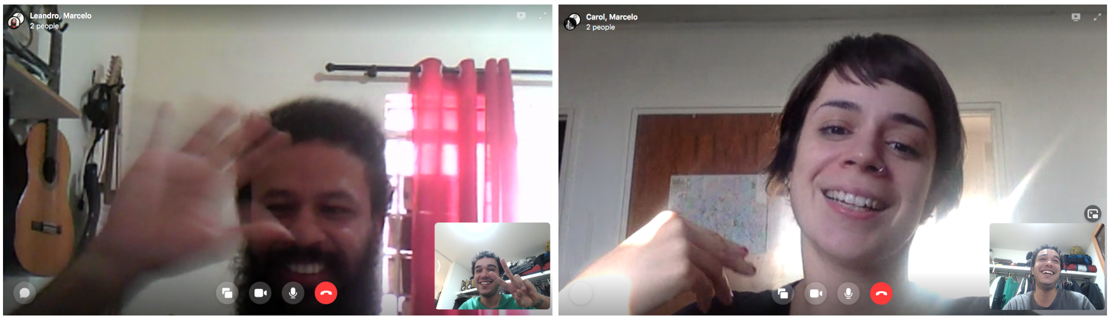

Figure 3.12 Meeting with experts in Laban's theory that helped this research. My thanks to Leandro (on the left) and Carol (on the right).

3.2.3 Adding Brightness and Preparing Set for Lay Observation

Light brightness variation was added to extended versions of video sequences. Similarly to the sequences shown to expert, Touch Designer was used and controlling movement and brightness was done either by keyframe animation (Figure 3.14) or wave patterns and modifications (Figure 3.15).

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3 Graduated in Dance by the Université Paris 8, certified in Labanotation (Laban's notation system for recording and analyzing human movement) by the Conservatoire National Supérieur de Musique et de Danse de Paris (CNSMDP)

4 Researcher with Doctor Degree by the Federal University of Minas Gerais (UFMG) related to interactive systems in dance, and music creation based on gesture interaction using LMA.

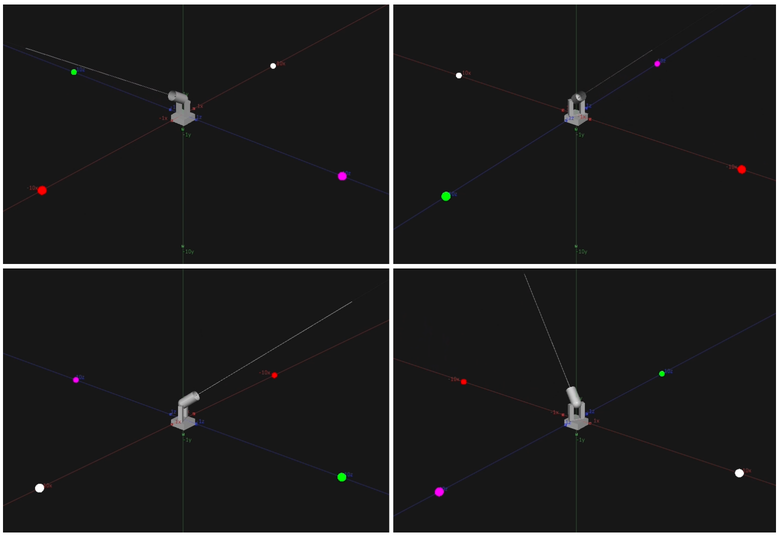
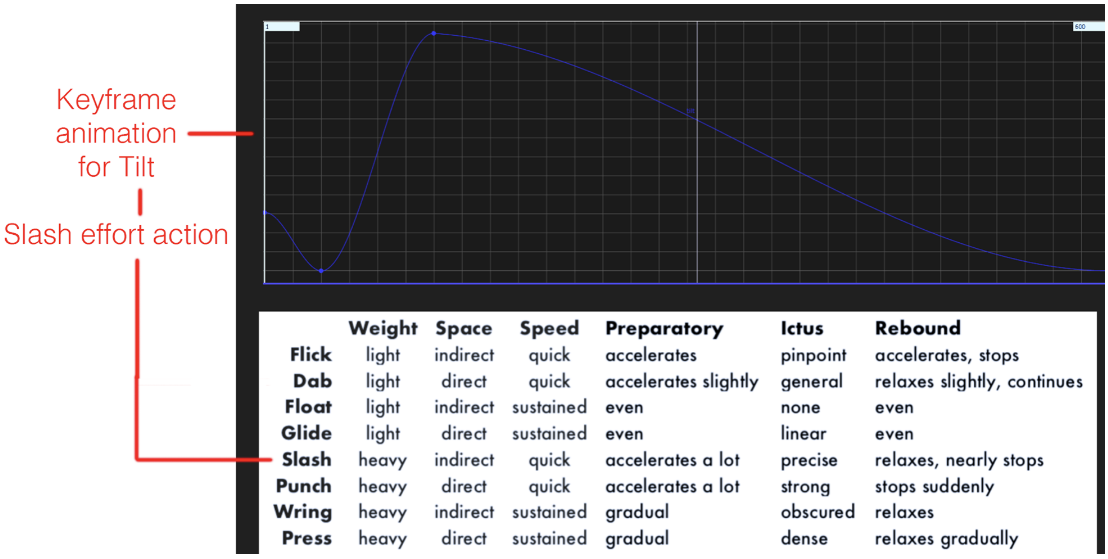


Figure 3.13 Sample of video shown to experts, the image shows one part of the same sequence being shown in 4 different angles, on the videos they would be shown sequentially, not at the same time as on the image. Full set of videos are available on `https://www.dropbox.com/sh/2twbmszb6ym3d7s/AADZv_AEgHdP1mYqUmE4jv2ka?dl=0`



	Weight	Space	Speed	Preparatory	Ictus	Rebound
Flick	light	indirect	quick	accelerates	pinpoint	accelerates, stops
Dab	light	direct	quick	accelerates slightly	general	relaxes slightly, continues
Float	light	indirect	sustained	even	none	even
Glide	light	direct	sustained	even	linear	even
Slash	heavy	indirect	quick	accelerates a lot	precise	relaxes, nearly stops
Punch	heavy	direct	quick	accelerates a lot	strong	stops suddenly
Wring	heavy	indirect	sustained	gradual	obscured	relaxes
Press	heavy	direct	sustained	gradual	dense	relaxes gradually

Figure 3.14 Keyframe animation for Tilt based on Slash effort action. (Effort Table image source: The Conductor's Reference `https://www.conductorsreference.com/laban`)

Figure 3.15 Touch Designer nodes for creating and modifying a triangle wave, making resulted movement indirect.

The approach of adding brightness was based on (1) secondary animation, cited in [31] as a way of generating expressive movement and also consistently used in animation [41] to make the motion more appealing and (2) movement anticipation: showing the animated figure build energy for its next movement. Both principles are illustrated on (Figure 3.16). These principles were implemented in the motion sequences prepared for lay observation, creating variations that would allow later evaluation on its effectiveness, based on lay observers answers.

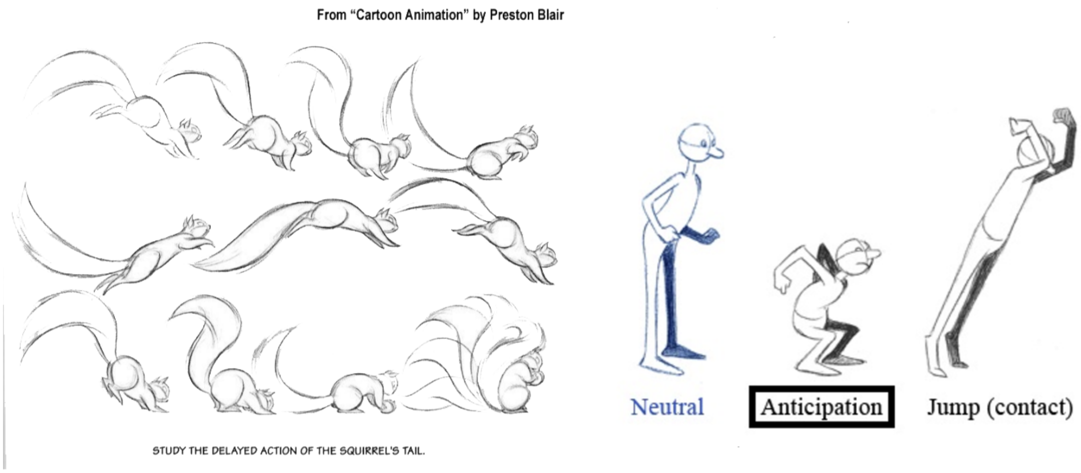


Figure 3.16 Secondary animation of tail during jump and jump anticipation. (Images source: `https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQg1B5iNAtqSCBIt339ecJVYAgvE0weC8NI3g&usqp=CAU` and `https://steamuserimages-a.akamaihd.net/ugc/949809582031385 59/E2687EB3B16DF0F808AD8B68F9F173776DDB1C0F/`)

The selected sequences for user study were designed to represent a diverse range of effort combinations, made based on LMA 8 Effort Actions, designed intended to represent their qualities(Figure 3.17). The 'Flow' motion factor was not taken in consideration on this design, its definitions and, according to the experts consulted, the way they are normally evaluated requires a more complex body as it seem to require a relationship between the parts that are moving, requiring a more complex body language.

				Cues for LMA Effort Based Motion Design		
	Weight	**Space**	**Speed**	**Preparatory**	**Ictus**	**Rebound**
Flick	light	indirect	quick	accelerates	pinpoint	accelerates, stops
Dab	light	direct	quick	accelerates slightly	general	relaxes slightly, continues
Float	light	indirect	sustained	even	none	even
Glide	light	direct	sustained	even	linear	even
Slash	heavy	indirect	quick	accelerates a lot	precise	relaxes, nearly stops
Punch	heavy	direct	quick	accelerates a lot	strong	stops suddenly
Wring	heavy	indirect	sustained	gradual	obscured	relaxes
Press	heavy	direct	sustained	gradual	dense	relaxes gradually

Figure 3.17 Description of LMA 8 Effort Actions. (Image source: The Conductor's Reference - Laban Library available at `https://www.conductorsreference.com/laban`)

Chapter 4
Study and Evaluation

4.1. Experimental Setup

In order to evaluate the perception of lay audience, we conducted a study where each person would see the sequences of movement and bright variation being performed by 6 moving heads. For each sequence they were asked to answer a questionnaire(Figure 4.1) based on Godspeed Questionnaire Series (GQS)] and variations from it used in related research that evaluated audience reaction to machine performers [3] [4]. A total of 9 people participated on the experiment (6 male, 3 female). We wanted to evaluate the overall perception of lay observers to the sequences designed for the experiment, if they were capable of causing emotional response, if they were entertaining, and explore possible correlations that can provide insights for the performance design. Questionnaire item description could be accessed by observers by clicking the '?' icon on the control tablet, items were:

- Scripted/Improvised: Was this pre programmed or done improvising live?
- Organic/Mechanic: Did it felt mechanic or organic?
- Evident/Subtle: Was it evident everything that happened?
- Familiar/Unfamiliar: How familiar are you with what you just saw?
- Apathetic/Emotional: Did it had/convey any emotion?
- Quiet/Tempestuous: Did it felt quiet or tempestuous?
- Dull/Entertaining: How entertaining was it?

- Dead?Alive: Did it looked dead or alive?

The total number of sequences shown was 26[1], order were randomized for each user.

- 6 designed sequences shown 3 times each, (1) using all moving heads with secondary animation, (2) using all moving heads without secondary animation, (3) randomly chosen from showing sequence using only 2 central or 4 peripheral moving heads, also randomizing with our without secondary animation. Total of designed sequences shown per session were 18.
- 2 bigger and more complex sequences were displayed once with all moving heads and secondary animation.
- 3 dummy sequences, shown with and without secondary animation.

After they finished observing the sequences, there would be a small conversation session where they would be asked about their general impressions, what were they paying attention to on the sequences (the equipment moving? the beam of light? the reflections on the walls?), they were also asked if they felt the set was diverse or repetitive.

The first user was shown more sequences, that would show more variations of each sequence, including secondary animation variation, but, after the final conversation, user's feedback was very clear about the overall experience having been very repetitive, variations could not be perceived [2], and this would make him lose interest and his answers became biased. Nevertheless, this user's session displayed all sequences seen by others, so his answers were considered on the evaluation.

Another important note is that during one observation session the system showed issues and only 18 sequences were displayed, and had their results considered on evaluation.

1 Demonstration recording of the sequences can be seen at `https://www.dropbox.com/sh/fb5wa27s20qpuen/AADuRDjzbi42gDrrWKt8fGrSa?dl=0`

2 Mostly because the equipment used is a low end moving head light that does not allow subtle brightness and acceleration variation.

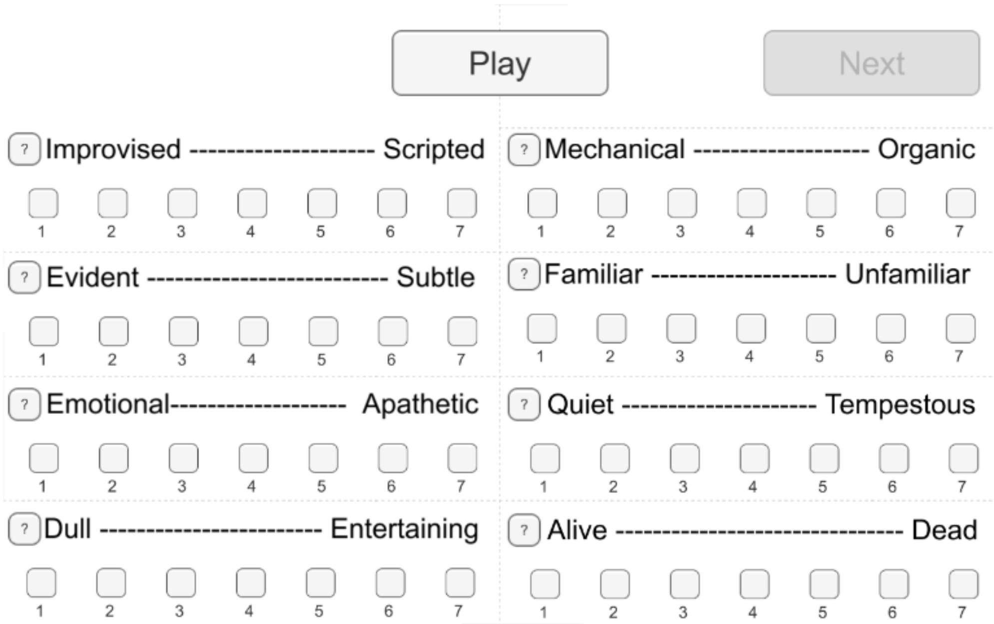


Figure 4.1 Tablet screen showing interface control and questionnaire items.

4.1.1 Dummy vs Designed

A small portion of the sequences shown to lay observers was not designed according to the process described previously. These sequences were made based on typical stage design lighting control and shown to users for comparison with the sequences designed for expression. The results (table 4.1) shown a high contrast between dummy and designed motion answers, with the later having higher rates of emotional response and also more entertaining.

Category	Dummy(m)	Designed(m)
Apathetic/Emotional	2	5
Dull/Entertaining	2	6

Table 4.1 Dummy and Designed motion means

4.1.2 Overall Perception of Designed Motion

Overall, answers were positive in terms of emotional response, having 5 as an average response from users. Entertaining answers was also positive, with an answer average of 6. After the test, conversation with observers about their general impressions having answers like 'I have never been in a dark room looking at lights moving before', and 'I had never seen equipment like this so close and had to pay so much attention to it", also considering answers to Familiar/Unfamiliar question suggest that the unfamiliarity of the experience atmosphere could have biased the answers in terms of entertainment.

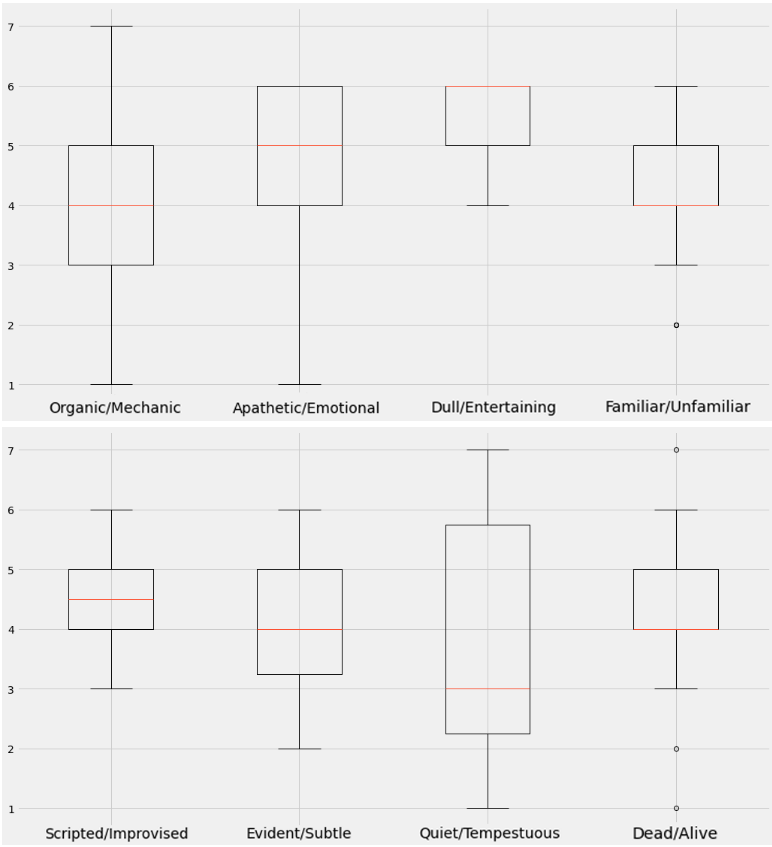


Figure 4.2 Box plots using mean values of answers to designed motion for all questionnaire items, refer to table 4.2 for standard deviation

.

Category	Standard Deviation
Organic/Mechanic	1.6
Apathetic/Emotional	1.5
Dull/Entertaining	0.65
Familiar/Unfamiliar	1.17
Scripted/Improvised	0.87
Evident/Subtle	1.22
Quiet/Tempestuous	1.79
Dead/Alive	1.39

Table 4.2 Standard deviation of questionnaire categories.

The use of secondary animation was sucessfull to make the sequences be perceived as more alive (as its the goal when used in traditional animation) and emotional. Sequences with secondary animation had a higher rate on both item's answers, as shown in table 4.3.

Category	Without Secondary(m)	With Secondary(m)
Dead/Alive	3.1	3.7
Apathetic/Emotional	3.8	4.3

Table 4.3 Table2

4.1.3 Discussion

This study allowed an initial investigation of reception of the movements designed following the proposed methodology. Results indicate that a system used to analyze and create expressive movement, and that is widely used for dance performances can be used on a similar context with low DOF machines, and the evaluation was based on related research that was also concerned with the perception in context of artistic performance, related to emotion, subtlety and entertainment. Correlations between questionnaire items such as if the movement looks improvised and its relationship with emotional response or quiet/tempestuous related to evident/suble can be further investigated as they represent an interest within the performance art field, and can provide useful insights on the performance design.

Chapter 5
Conclusion

This research explored the use of low DOF machines to express emotion in the context of performance arts. It started by giving a philosophical and historical background that shows how machines and humans are connected, to argue that for that reason, the human need for expression is also important when interacting with and embodying machines. We showed related research that consider emotion, expressiveness and affect as crucial in wellbeing and an important aspect that should be considered in HCI and HRI, and also reviewed how LMA is used on these works, and how the interaction is evaluated. We then reviewed works that deal with affect and abstract shaped machines, how they approached the correspondence problem, to then show related art work. We described our approach and process, and how we experimented with the concept in 2 different ways, the first was evaluated and it will be available as it will be published on 2021 ACM International Conference on Tangible, Embedded and Embodied Interaction (TEI) [40], and evaluation of the second approach was done as part of this work. Future work includes better analysis of the data gathered on the user study of the second approach. It is necessary to understand the relation between LMA's qualities and how they were perceived, in order to have a choreographic frame, that is, in order to be able to compose a choreography with intended expression that can be used to make people and moving heads dance together. This would allow for study of how the dancer perceived the equipment as another presence on stage, and also by the choreographer to analyse if the equipment performed as expected. Beyond that, it can be used as a mediator for embodiment between humans and abstract shaped machines.

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