Cybernetic Interaction:

A Cybernetics-inspired exploration of audience participation

By Jun Li

A thesis exhibition presented to OCAD University in partial fulfillment of the requirements for the degree of Master of Design in Digital Futures

Toronto, Ontario, Canada, April 2021

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A Cybernetics-inspired exploration of audience participation

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Master of Design in Digital Futures, 2021

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Abstract

Cybernetic theory and interactivity have much in common, including human interrelationships between modern technology and how they define the whole interactive process. This thesis project explores the concepts of cybernetics and a possible way of engaging remote participants in interactive art. It leads to a contemplative future direction for cybernetics-inspired interactive artworks. By employing the methodology of Research Through Design (RTD), this thesis project develops a series of related supporting experiments and a social media-based interactive prototype that utilizes a machine learning model as a case study is developed to demonstrate the research and concludes with a discussion of identifying the interaction and the potential way of engaging participants. Overall this thesis describes an interactive tweeting experience not only focuses exclusively on the remote participants but also includes other audiences in a different site.

Keywords:

Cybernetics, Interactivity, Feedback, Audience participation.

Acknowledgements

Since the Covid-19 hit, 2020-2021 has been an extremely hard year for all of us. However, I'm super glad and grateful to those who helped and supported me during my graduate study in these two years. I could not have done it without all your support. From the bottom of my heart, I would like to express my sincere gratitude to you!

I would like to thank my supervisor, Associate Professor Adam Tindale, I attended your five graduate courses during my graduate study at OCAD University. You have inspired me a lot, not only on my thesis project but also on the other projects we collaborated with. It's been a wonderful, unforgettable and unique journey for all of us.

I would like to thank my co-supervisor, Associate Professor Nicholas Puckett and all of the Digital Futures graduate program faculty members for helping me think and give me inspiration. Thank you for your patience, enthusiasm, expertise and great suggestions.

I would like to thank all the Digital Futures cohort, especially Manisha Laroia, Sananda Dutta and Arshia Sobhan Sarbandi. We as a community helped and supported each other during the dark, lockdown time in Toronto, Canada. You guys helped me a lot during every stage of my thesis project.

I would like to thank my dear parents for providing me with unfailing support, understanding and continuous encouragement throughout my two years of study. This accomplishment would not have been possible without you. I know how hard this is for our family.

I would like to thank myself for my strength, persistence and hard work. It's been an extremely difficult challenge for me in my lifetime. I'm super grateful that I overcame these difficulties, still can keep hungry to continuously gain valuable knowledge and essential skills.

Finally, from the bottom of my heart, I really appreciate all your inspiration, help, and support again. This absolutely will be a precious wealth and wonderful experience in my life.

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Introduction

Thesis project overview

This thesis project is an experimental prototype that provides an interactive tweeting experience by exploring cybernetic theory. It is considering a different form of participant engagement and showing a remote experience of participants by getting a real-time response from the social media platform. In this project, audience participants and observers are able to observe the reaction chain and feedback while this tool aims to bridge remote participants and observers to engage in the feedback loop and create a distinct layer of interaction and conversation. Through this research, I explored the concept of connecting cybernetic theory to interactive art practice, mainly about the first-order cybernetic, the second-order cybernetic and interactivity based on my professional experience. (Figure 1) The core research of this project concentrates on the overlapping field of two main parts, cybernetic theory and interactive art which is discussed to explore the possibilities of interactive artworks by merging modern technology.

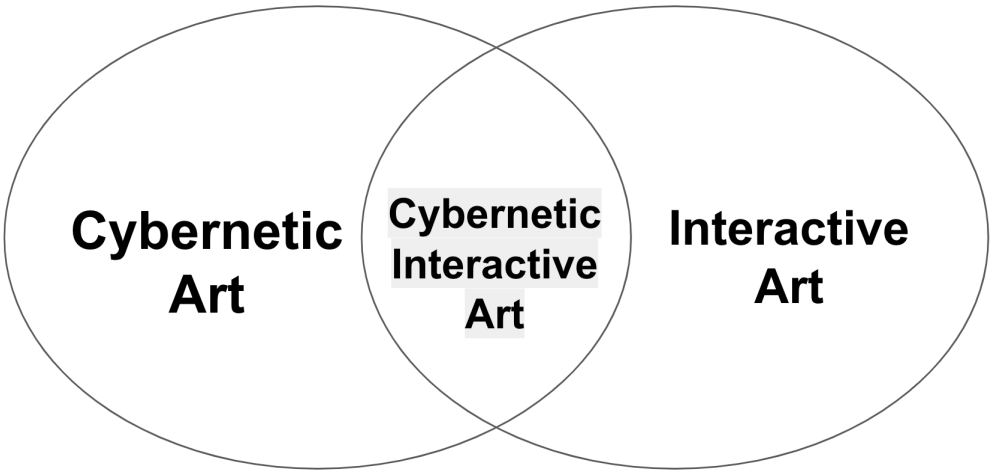

Fig 1. The investigating field of this thesis research

Cybernetic theory and interactivity have much in common. Most of the key notions in both of them can be described as the system in conversation that about the system talking to each other through the information passed back and forth between the particular relationship in audiences and artworks. These similar languages can be pointed out are feedback, control, conversation and system thinking in the field of cybernetic theory and interactive artworks. Some concepts of cybernetics are applicable to interactivity. The core field of my thesis project that I am paying attention to is cybernetics and interactivity in which intersections with the participants will be discussed to contribute to exploring communication, promoting the interaction and the relationship among the artworks, participants and observers. The purpose is to explore the interplay of cybernetics theory and interactivity and the connection between cybernetics/system thinking and technological/interactive artworks by illustrating the similarity of characteristics and comparing the conversation of two network systems. The goal is to deconstruct and reshape their relationships by thinking interactive artworks in the way of cybernetic thinking.

This major part of the project was set up on Twitter, which allows participants to have different artistic experiences. A different kind of interactive experience in observing art pieces is proposed to create cybernetic interactive artworks. In this research, I utilized research through design (RtD) as my methodology for thinking and contextualizing the cybernetics and experimenting with its concept in interactive art to see what those relationships are and what the possibilities might be. As the outcome of this thesis, it features a modified Tweeting experience with an embedded communication system to create a distinct opportunity. It utilizes the machine learning model to process the picture and immediately retweets the message back to social media almost in real-time after taking participants' inputs. It engages remote participants in a different way and allows them to share the interactive experience around the results of the artworks through this thesis project, which is giving me a new tool for enhancing my art practice.

In particular, this thesis seeks to address the following questions:

- **How to identify interactive systems/artworks in the way of cybernetic thinking?**
- **How to engage remote participants in a different way and share the interactive experience around the results of the artworks?**

Motivation

Over the past years, I have been passionately engaged with art production and the creative industries as an art and technology student, creative industries intern, new media art curator and artist-practitioner. I having seven years of experience with creative arts and technology, my main interest and enthusiasm is to create a more responsive and innovative experience for the audience and participants. My current Mdes research focuses on the development of art theory and technologies. My research interests in these areas, Audio-visual Immersive Installations, Performance Art, Wearable Device, Interactivity and Connectivity, Data Visualization and New Media Theory and Practice-Based Research. The concept and practice of developing my own speculations of 'Digital Futures' have been my passion since beginning my studies in art and technology at Roy Ascott Studios. At the same time, the past can be a rich source with which to inform contemporary practice.

I have focused on art and technology specifically by studying at Roy Ascott Studio, Shanghai Institute of Visual and Arts and OCAD University for the past years, where I have self-learned: TouchDesinger, Notch, P5.js, Arduino, Processing, Adobe Creative Suite and many more. Roy Ascott, the pioneer of Technoetic Arts, the former president of OCAD University, my dear professor in my undergraduate school, has inspired and influenced me a lot with his future vision. Ever since he taught us the basic idea of inputs, outputs, control and feedback in cybernetic theory, I often attempt to engage cybernetic theory as a guideline in the processing of creating artworks. This knowledge enables me to create immersive audiovisual installations and other creative technology products and outputs. Additionally, through experimenting with a theoretical foundation in art and technology at Roy Ascott Studios, I have been given new ways to understand, evaluate and present digital artworks. An experience that would profoundly deepen my understanding of the possible intersections between art, technology and enable me to produce unique and challenging experiences for audiences and participants. (Figure 2)

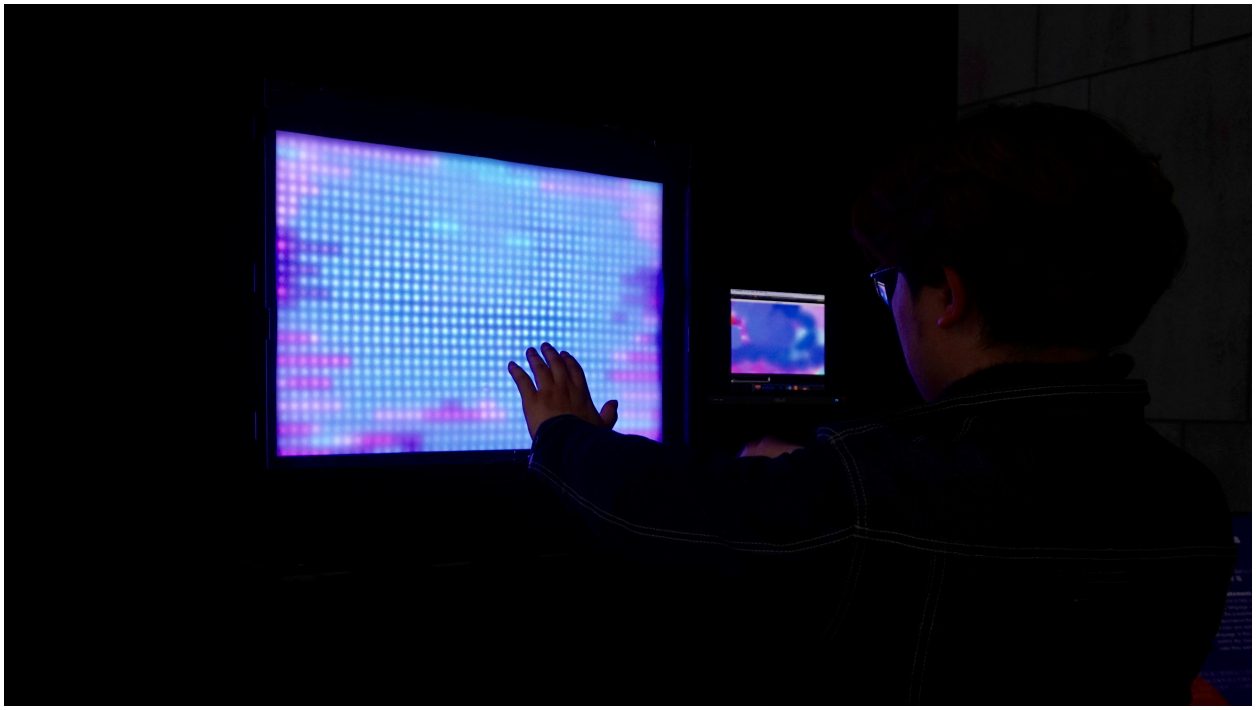

Fig 2. Digital Canvas, 2019, Interactive Installation-My undergraduate thesis project

Literature Review

This chapter will present an overview of the scholarly-literature related to my art practice as well as considered research devoted to this interdisciplinary subject. It focuses on cybernetic theory, which includes the introduction of it. Through exploring cybernetic concepts, it leads to a series of experiments and the final project. It gives me meaningful inspiration and helps me form my thesis argument that how I create my art projects and experiments in the domain of cybernetics and interactivity and figure out the connection and relationship between them.

Background knowledge of cybernetic theory

Artists work in the area of 'Art and Technology' to create collaborative artworks. We use technology-based new media art as a way out. However, technology is not the only method to create interactive artworks. The concept of interactive artworks is older than digital interactive artworks. The core of the interactive concept is built upon the relationship between audiences and artworks. Roy Ascott, one of the pioneers, a British artist, is the very first one in writing about the connections between art and cybernetics. He coined the term "Technoetic Arts" which utilizes computer science as one of the mediums to create art projects. He has developed the theory of audience participation and interaction with the artworks as early as 1966. (Schraffenberger and Van Der Heide 2012) The cybernetics system he described in the field of Telematic Arts can provide the capacity to engage and enhance the participants' interactions between themselves as much as with the art. His future vision has influenced and contributed to cybernetics a lot. It was transformed through his research and artistic practice from science into art.

Compared to the traditional art, the key and vital change of phenomenon are not on the method to create works rather than the increasing interconnection between audience and artworks. Many interactive works allow the view of audiences to participate

in the meaning of the work, but not until we realize that unless we understand the world in terms of the interactive system until we are in it. However, the core of this changing phenomenon can be demonstrated and explained as Cybernetics Theory, especially the first-order and the second-order Cybernetics that can contribute to symbiotic dialogues between art and technology.

A cybernetics artwork has the theory of interaction and cybernetics. The basic principles that overlap each other in the emergence areas, where both have are feedback, control and system thinking. These overlapping concepts were made rigorous by cybernetics. With the key concept and theory, it should have an observer (audience) participate in (interact with) the observed system (artworks), which means any interactive artworks are somehow incomplete without the observer and the observed system. All of the interactive artworks are designed and hoped to interact with the audience.

> *'This rich interplay derives from what is a self-organizing system in which there are two controlling factors: one, the spectator is a self-organizing sub-system, the other, the artwork is not usually at present homeostatic'*
> (Roy Ascott 1966).

The comparison of artistic methods and cybernetics is to understand how information and communication are passing by using a process to promote the active exchange of knowledge and competencies and to improve interaction and conversation in the context of producing interactive artworks.

Cybernetics brings an exciting perspective and provides theoretical support on how to apply system thinking to interactive artworks in this process. Through building the connection, it can better help to understand the interactive way and conversation with audiences and technological artworks by utilizing the cybernetic way to identify and compare the key terms, concepts and theory. In below, we will start by explaining the key concepts and how these two disparate systems work. Further, we will outline and reveal the common features of the cybernetic system, provide application examples of interactive art, and show how these can be applied to new media and interactive artworks.

In this way, the role of cybernetic theory will help and give us a better understanding of informing the function and processes of the interactive projects.

The first-order and second-order cybernetic

Cybernetics theory was first defined as the study of "control and communication in the animal and the machine" (Wiener 1948). In the 1940s American mathematician Norbert Wiener, who is generally acknowledged as the founder of the science of cybernetics, wrote that

> *'We have decided to call the entire field of control and communication theory, whether in the machine or in the animal, by the name of Cybernetics, which we form from the Greek word for steersman'*
> (Wiener 1948)

It means the inputs are constantly changed based on the feedback from the external environment to achieve the goals of continuous operation. The features of cybernetic systems are inputs, outputs, feedback, control and a perspective of systems. In general, Cybernetics is a subject, trying to explore the science of communications and automatic control systems in both machines and living things. 'Cybernetic reasoning can be applied to understand, model and design systems of any kind: physical, technological, biological, ecological, psychological, social, or any combination of those' (Heylighen and Joslyn 2001). Cybernetics as a process operating in nature has been a long time. From my understanding, basically, it can be summarized that everything we see, the society we live in, even our bodies are all cybernetic systems. The important concept about it is how to distinguish input, output, goal, control and feedback from different cybernetic systems.

The key theories in cybernetics are the first-order and the second-order cybernetics. (Figures 3 & 4)

> 'As Norbert Wiener was later to proclaim, "Cybernetics is nothing if it is not mathematical." Distinguishing the observer as a system separate from the organism was one way to make

reflexivity more manageable, for it reduced the problem of the observer to a problem of communication among systems.'

(N. Katherine Hayles 2008)

The first order is the cybernetics of systems that are observed from the outside as opposed to the cybernetics of systems involving their observers, where a feedback loop is observed from outside of the loop. The first-order cybernetics is concerned with circular causal processes. The second-order cybernetic loop is also known as the cybernetics of cybernetics, is the shift from the observed system to the cybernetics that considers observing, meaning the observer is observing from within the loop, the recursive application of cybernetics to itself and thus the Cybernetics that considers observing, rather than observed systems.

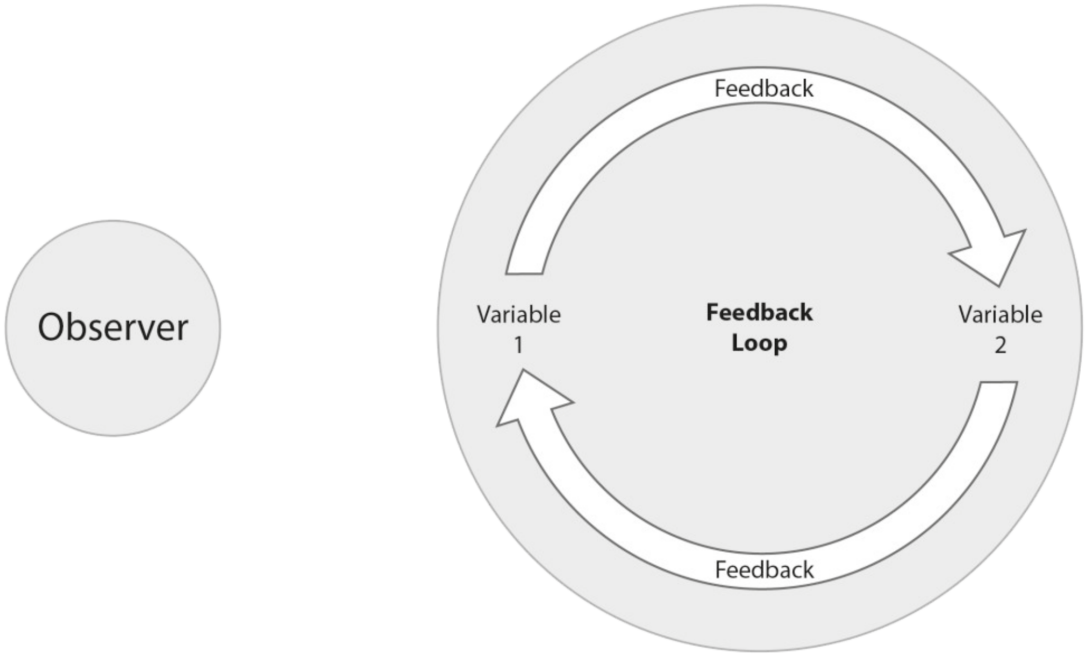

Fig 3. The first-order cybernetic (N. Katherine Hayles 2008)

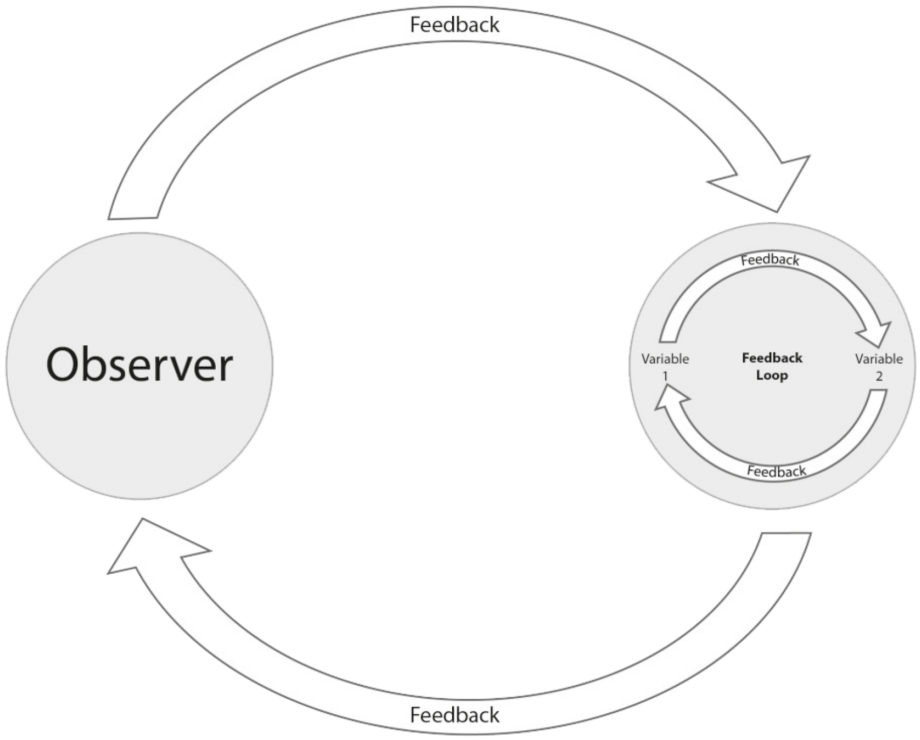

Fig 4. The second-order cybernetic (N. Katherine Hayles 2008)

The first-order and second-order cybernetics provide a basic and vital framework of the way we inspect and observe interactive artworks. The vital features in cybernetics are the feedback and the perspective of system thinking, interactive arts built upon the legacy of Cybernetics, where feedback is involved in the whole process of interacting with the artworks. However, Cybernetics isn't a brand new concept, a lot of cybernetic researchers, theorists and new media artists have been working on it for more than half a century. Cyberneticians have been researching it for figuring out how to define and utilize it in different scenarios. In terms of how I process it and what I'm arguing in this paper isn't the result and conclusion. Versus, it's just a start exclusively. As an interactive artist and creative technologist, I am interested in cybernetics and interactive art because it presents an appealing entry point among interactivity, control and feedback. The outcomes of system thinking in cybernetic thinking lead us to a way of reflection on what is more vital to creative, interactive artworks.

The third-order cybernetic

Currently, in 2020 - 2021, this is one of the best times for exploring and revealing the third-order cybernetic concepts to the public and pushing the boundaries of cybernetic theory further. Not only because of the tremendous research academic achievements cyberneticians made it possible, but also due to the global pandemic, interactive artworks are emerging increasingly on the internet by applying online technologies. Based on the solid theoretical of the first-order and the second-order cybernetic theory, the researchers have reached and worked on exploring the third-order cybernetic.

> 'They illustrate the concept by constructing the book as a circle, starting their discussion with unicellular organisms (first-order systems), progressing to multicellular organisms with nervous systems (second-order systems), and finally coming to cognitively aware humans who interact through language (third-order systems).'
>
> (N. Katherine Hayles 2008)

From what she described we can realize that the observer from different levels creates the system by drawing distinctions. It showed us with a new perspective and direction of how we are able to observe the system and think about which cybernetic system we are currently in.

> 'A composite unity's organization is the complex web of all possible relationships that can be realized by the autopoietic processes as they interact with one another...For example, a cell within my body may be considered as a system in itself, but it relies for its continued existence on its structural coupling to my body as a whole. Here again, the role of the observer becomes important…These are abstractions invented by the observer to explain what is seen; they exist in the observer's "domain of interactions" rather than in autopoiesis itself. '
>
> (N. Katherine Hayles 2008)

Based on my assumption of exploring cybernetics, depending on the location where we are observing and how we interact with the artworks and what is the role of the participants, it has developed the application of first-order and second-order cybernetic in

interactive artworks. Here is the unique experiment of cybernetic theory - The third-order cybernetic. It aims to those observers and participants who are not onsite, which offers a different kind of interactive experience with the art projects by exploring the third-order cybernetic. It has been considered an online remote interactive experience built upon the relationship of the first-order and the second-order cybernetic and emphasized the communication and how information has been sent back and forth in a different way. The combination and the cooperation of the first-order, the second-order and the third-order cybernetic theory provide us with a distinct perspective of how we interact with interactive artworks.

Interactivity and conversation

In recent years, interactive artworks are increasingly emerging at the intersection of art and technology, due to the rapid development and availability of accessible computer science. Interactivity is one of the characteristics of the new media art. The concept of it extends from 'Interaction', being a two-way communication system that involves a user's orders or responses. The foundational characteristics of interaction that have been defined included information exchange, feedback, control and interpretation processes. An interactive digital artwork consists of participants communicating and reacting with emerging technology, along with it came a new kind of art experience. Moreover, the relationship between them is different, and typically they will be divided into two categories, the roles of observers and the audience participants are distinct (Figure 5). Generally, the interaction involves engagement with the participants, during this process, the passed information and the peak class of it bring the conversation.

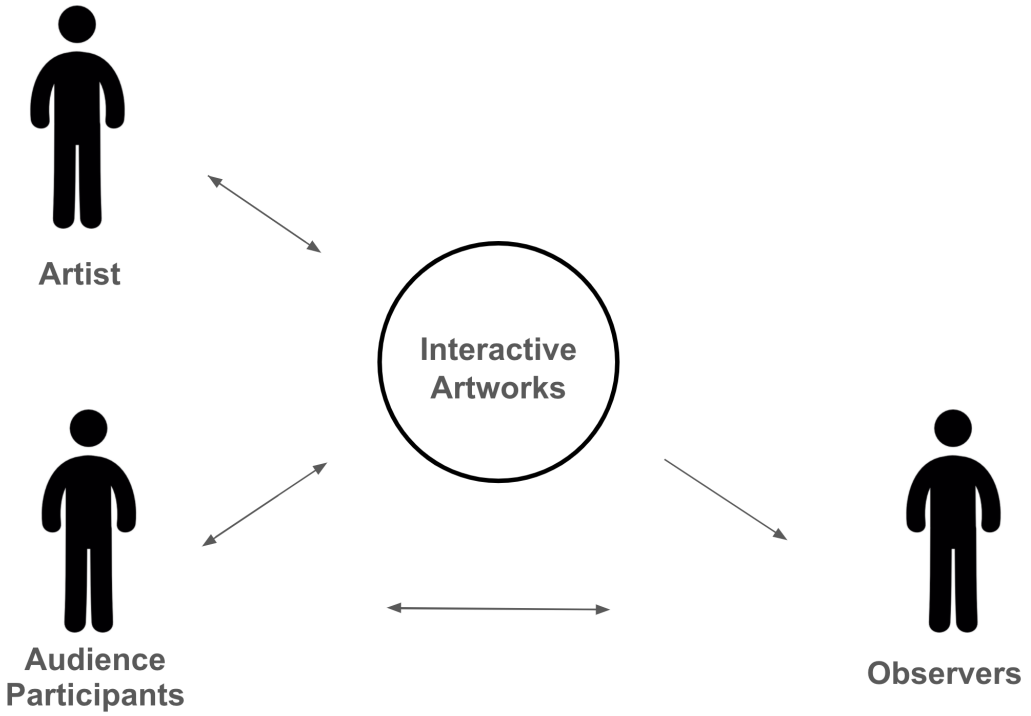

Fig 5. The relationship of interactive artworks.

Based on the relationship between artworks and observers, the traditional static artworks no longer do not change themselves with respect to their context because most of the interaction happened through internal personal psychology or emotions to the viewers. Compared to interactive art, the notion of interactivity and conversation is slowly becoming important. The conversation exists in the relationships among artworks, viewers and the environment, which is a similar notion 'feedback' in cybernetics. Therefore, it can be seen as potentially cybernetics on the basis of the definition that interactive digital artworks.

When an interactive artwork has been exhibited, participants are allowed to interact with the artworks, and they become both the interactors and audience at the same time. The particular type of behaviours clearly starts the conversation with artworks, the audience participants give the input to the physical installation and then quickly it gives you the reaction – the feedback. This kind of relationship exists only between the artworks and the audience participants who are interacting with them, which

the first-order cybernetic theory can explain. The whole process is carrying information in communications systems. It has a loop that includes both of them, the audience becomes an observer in the first layer of interaction, rather than an external observer.

Additionally, during the whole process of the context, it produces another extra external layer. The other audience is observing the dialogue between artworks and viewers. They are observing the feedback loop of the first-order cybernetics from the outside like a god's perspective. It can be compared and described with the notion of the second-order cybernetics loop. I believe the performance of the first-order loop is what artists want to show to the world in interactive arts, which indicates the relationship to the others with the conversation between audience participants and artworks. These participatory points are common to both modern cybernetics and interactive arts.

Feedback and control

Feedback and control are the first vital and basic characteristic terms that exist in both cybernetic and interactive art.

> *'In order to steer, you have to see where you're going; see whether that's towards the goal or off-course from the goal; then change your actions to head back toward the goal. I see the consequences. And I correct by acting again. That's the cybernetic loop.'*
> (Paul Pangaro 2016)

According to Paul Pangaro, a professor at Carnegie Mellon University, knowing whether you have reached or getting closer to your goal requires 'feedback and control'. He explains cybernetics is about having a goal and taking action to achieve that goal.

Prerequisites and the basis of establishing the conversation involve feedback and control. Through the interaction by the participants or artworks themselves and the responses are given mutually, the circle's continuous loop of feedback and control undergoes development as the conversation continues. From this perspective, interactive art shows many of the common points to a cybernetic framework. In 1967, the concept of

cybernetics was explored by Roy Ascott, after recognizing it, cybernetics art shows by building upon interactive art.

> *'The modern artist is primarily motivated to initiate a dialogue, to set feelings and ideas in motion, to enrich the artistic experience with the feedback from the spectator's response'* (Roy Ascott 1966).

Cybernetic art is able to recognize, interact and take into account some aspects of any information that is passed back to it from its outputs or behaviour. The feedback is necessarily constitutive of one form or another of interactive art. Moreover, the early practices of cybernetic art mostly consisted of interactive art. The artist usually shows two different perspectives of artworks: one is the audience interacting with it and the other is the rest of the audience observing the process of your processing. That brings the connection between cybernetics and interactive artworks.

Although Roy Ascott's concern with enabling audiences to participate in the process of artworks is before he awarded the cybernetic theory, his works still can be seen as an example. He created the first *Change Painting* in the 1960s (Figure 6), six pieces of glass with abstract shapes on them. He called these shapes 'Ultimate shapes' and they were sitting in various layers of a grooved frame that permitted each panel to slide horizontally along its length by moving these pieces by viewers. That particular way of interaction allows the viewers to make different possible compositional states. His initial thought was to let audiences engage with the process of creating according to their subjective aesthetic sensibilities at the moment of interacting with this artwork. So, the current output work depended on an exchange of information between viewers and artists in which feedback and control of the whole system could be explained the whole process based on their definition and his works also indicated that interactive artworks did not have to create by utilizing digital or technological way, the core of interactive arts should be focusing on the relationship and connection between the objects and viewers.

Fig 6. Roy Ascott, *Change Painting*, 1959, Five sliding painted glass panes in a wooden frame, 12 x 60 x 7.5 inches, Exhibited: Electronic Superhighway at the Whitechapel Gallery, London (2016).

System thinking

Cybernetics offers a theoretical model that starts with general concepts of feedback, control and goal. It helps solve the complex problems of system thinking. Cybernetics can be applied to complex technologies, organizations and even to the conversation itself. Not only that it provides the critical theory of the second-order cybernetics. I personally believe it is the key to system thinking. From the perspective of it, it affects us not only on how we see a particular artistic output but what will the system produce in the range of possible outputs.

The second-order cybernetics system can be regarded as a set of collaborating agencies. We could perhaps call the logic of system thinking 'Autonomy'. It is concerned with what kinds of behaviour can and cannot be output by different kinds of systems in principle. The elements of the system are fused through interaction so that they are influencing each other continually. Building upon the second-order cybernetics, within the relationship of participants and artworks, system thinking is a method of considering the overall behaviour of the whole system and its outputs. Summarizing from the concept of homeostasis – an ability to maintain a relatively stable internal state, coordination amongst the agencies in a system can be seen as oriented towards achieving a shared goal.

Apart from artists creating artworks in the form of machines, some artists create machines to create artworks instead. The high peak in the early development of cybernetic art was *Cybernetic Serendipity* which took place in London in 1968. The English cyberneticist Gordon Pask created *The Colloquy of Mobiles* for the exhibition (Figure 7). It was a reactive, computer-based system consisting of five mobiles. Through the way of light and sound, the rotating elements suspended from the ceiling communicated with each other, independent of external influences. The audience can participate in the conversation between machines by using flashlights and mirrors. He created a cybernetic model for the relationship between participants and artwork. According to Pask,

'Respond to a man, engage him in conversation, and adapt its characteristics to the prevailing mode of discourse'

(Gordon Pask 1968).

He emphasized good artworks to meet these demands and they even integrated the participants in the process of painting. The perception and behaviours of the participants begin an internal conversation with the artworks. By doing so, the conversation between the participants and the artworks becomes observable. Moreover, the participants can assume the role of the artists by interacting with the environment as well.

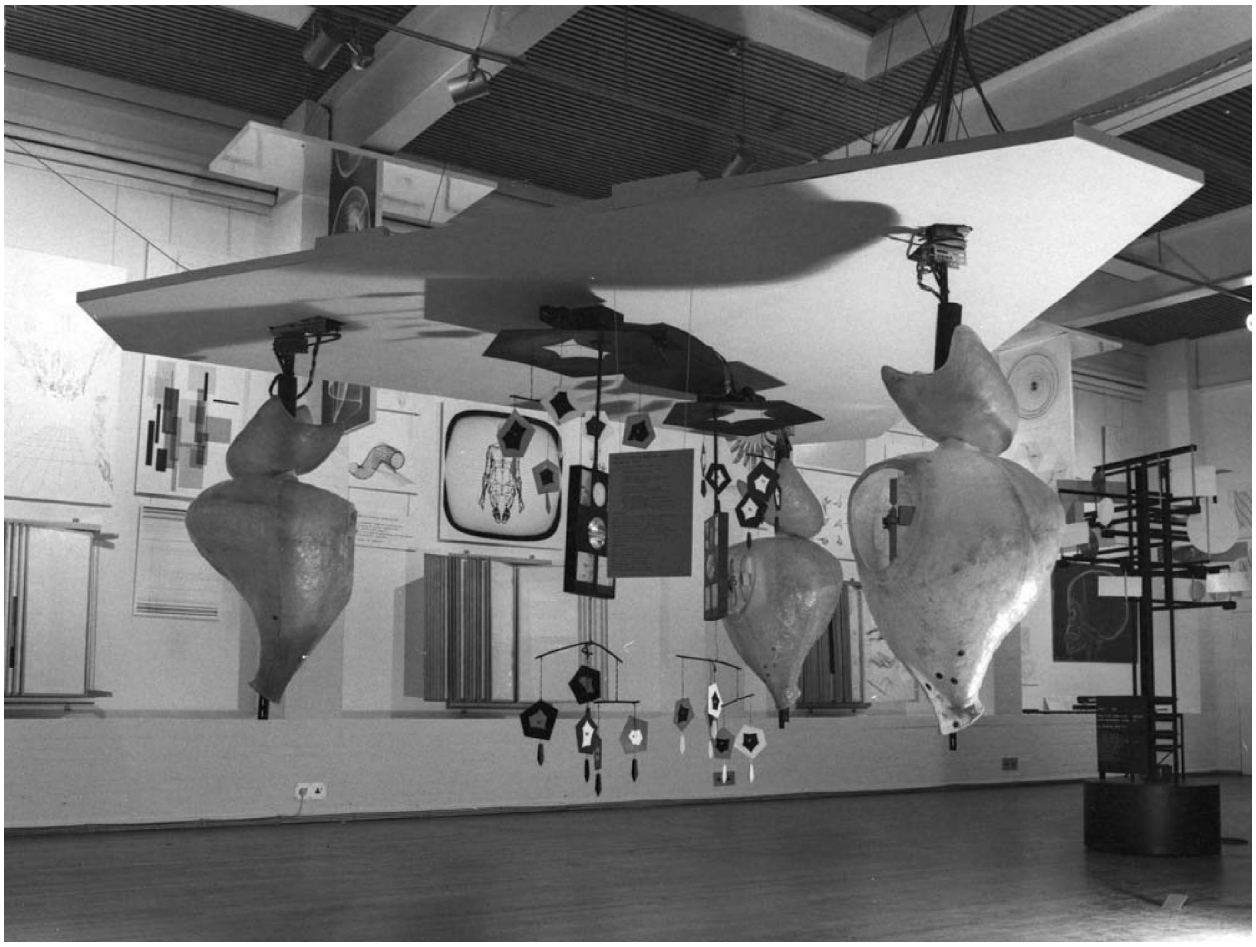

Fig 7. Gordon Pask, *The Colloquy of Mobiles*, 1968.

The connection between the cybernetics and final project

Cybernetics is demonstrating the relationship of technology. Since I'm making technological works, it helps me develop this thesis project and contextualizes how we can engage these cybernetic concepts in interactive art, what these relationships are and what the possibilities might be. By doing so, it gives me a different perspective for enhancing my art practice because it's revealing an exciting aspect of it and offering a much richer interactive experience when engaging with the participants. What's new about that relationship is it allows remote participants and the audience to have a different artistic experience, a distinct kind of cybernetic interactive experience that in observing art that is difficult to do in the past. These core concepts all lead to a contemplative future direction and guideline for cybernetic interactive artworks. This final project is set up on Twitter, it's a community-based and connection-based platform where they can think about how they relate to each other or process with each other.

Related art practice for supporting thesis research

This chapter starts by illustrating the relationships between participants with some artistic experiments I did in my thesis year. It is for first establishing a basic overview and better understanding of simply explaining the participants and observers in each order cybernetic relationship. It gives me inspiration and helps me think and connect some cybernetic theory in art practice and eventually comes up with the final thesis project. Since this thesis project mainly utilized the practice-based research method as the methodology for the thesis project and my core guideline that is often used for creating projects. Therefore, during the time I researching the cybernetic framework at OCAD U, I am also working on exploring the possible forms and outcomes of how to approach it with different methods. Especially, I have been working on exploring a unique form of art practice engaging an online interactive experience that bridges the participants and the artwork in a different space synchronously to create a remote interactive experience in real-time. All the following projects can be seen as cybernetic interactive artworks and experimented with the research framework that I'm researching.

Genesis-Remote laser-projection mapping performance

The following project as my side-project supporting my thesis concepts was one of the explorations and experiment projects that I collaborated with Associate professor Adam Tindale as the final project for the New Interface for Music Experience course in the fall semester, 2020, at OCAD University. (Figure 8 & 9) The visuals of this project are an attempt to abstractly explore and manifest concepts and mythological references in themes of cosmogony, through contemporary mediums and creative coding. Since the Covid hit, I have been working on exploring a new form of art practice engaging an online interactive experience that bridges the performers and the performance in a different space synchronously to create a remote laser-projection mapping show in real-time.

It's been a wonderful experience and an honour to collaborate with Associate professor Adam Tindale and such incredible teammates to push the boundaries of this project and grounded it successfully. Unfortunately, due to the Covid restriction in Toronto, Canada. we're not allowed to gather the audience to appreciate the full live performance onsite. However, This project has gone live and exhibited in the OCAD Digital Futures Open Show. It has provided a great example and demonstrated the relationship between cybernetics and interactivity. Furthermore, it has explained how we observe artworks through the internet in a different way.

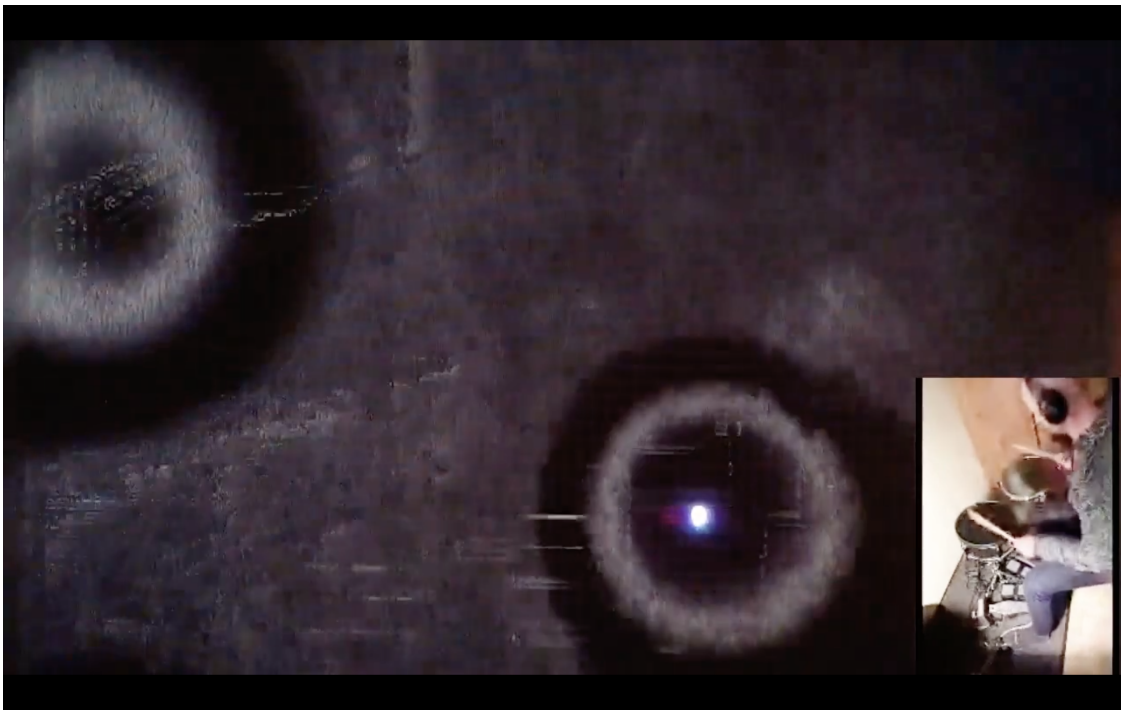

Fig 8. Genesis, 2020, Remote Live Laser-Projection Mapping Performance - Live screen, Zoom recordings

Fig 9. Genesis, 2020, Remote Live Laser-Projection Mapping Performance - Setup, Behind the scenes

It's a remote laser-projection mapping show. During the process, the exciting part was the participants weren't onsite but were able to interact with the system. Also, there were some participants on-site, so the combination of the relationship among artwork, online participants and onsite participants were brought different layers of interactive experiences for all of them when they enjoyed the show in different spaces. Therefore, it bridged the remote participants to the artwork according to the second-order cybernetic. Generally speaking, this project created an online interactive experience that allows the participants and remote artworks to have direct interaction with the artwork, receive feedback and watch the outcomes in a different place. What's more, since this project was set up online, it included another new level of the observers observing the whole system running, which has been identified as the three different order cybernetic in the thesis paper. Through this first experiment, I targeted to explore the gap between the interactive artworks and remote participants and created a rule in between to observe the information flow being sent back and forth. What I learn from it is that it helped the

audience participating into the reaction chain effectively. It contributed a lot to the final project by exploring and understanding the connection between cybernetic theory and interactivity.

Virtual Production

Another great example that represents the relationship and research is the virtual production workflow as a side thesis project that helps me demonstrate it. The following two projects were partly included in my exploration and experiment for my research as well while we were in the lockdown and having the remote course in 2020, Toronto, Canada.

Virtual production is an emerging method that uses creative tools or software to combine and connect live-action footage and computer graphics in real-time. Currently, it has been widely utilized in live broadcasting especially during this time Covid-19 situation because this is one of the best solutions for our creative industry still can keep running. Originally, It was first been used in the filmmaking industry, the concept of it is allowing the director to deliver the feedback across environments digitally or physically where cast members are physically working on sets across different locations. For many of it recently, Virtual Production has been pushing to happen online. Not only just partially due to Covid-19 but also because it provides a more accessible interactive experience for the participants worldwide.

The first experiment was in the Microsoft Teams 365 online meeting when I was having remote courses at OCAD U. (Figure 10) I grabbed my live camera video flow into my local system and then added some live real-time visual effects on the top of it, lastly fed it back to the online meeting video stream. As you can see from the picture, it can detect my sound volume and reflect with the soundbar on the screen in real-time. Furthermore, it can react with the other presented participants' sound inputs in real-time

as well. All participants located in a different place including myself can be regarded as involved in this art practice and observing how the information flow has been passed back and forth. Every individual participant can have their own inputs and outputs. So the video content itself can be regarded as an interactive system, all the participants were interacting with it remotely. According to my research framework, this experiment bridged the gaps between the artwork and the remote participants and offered a new possible way to experience the project.

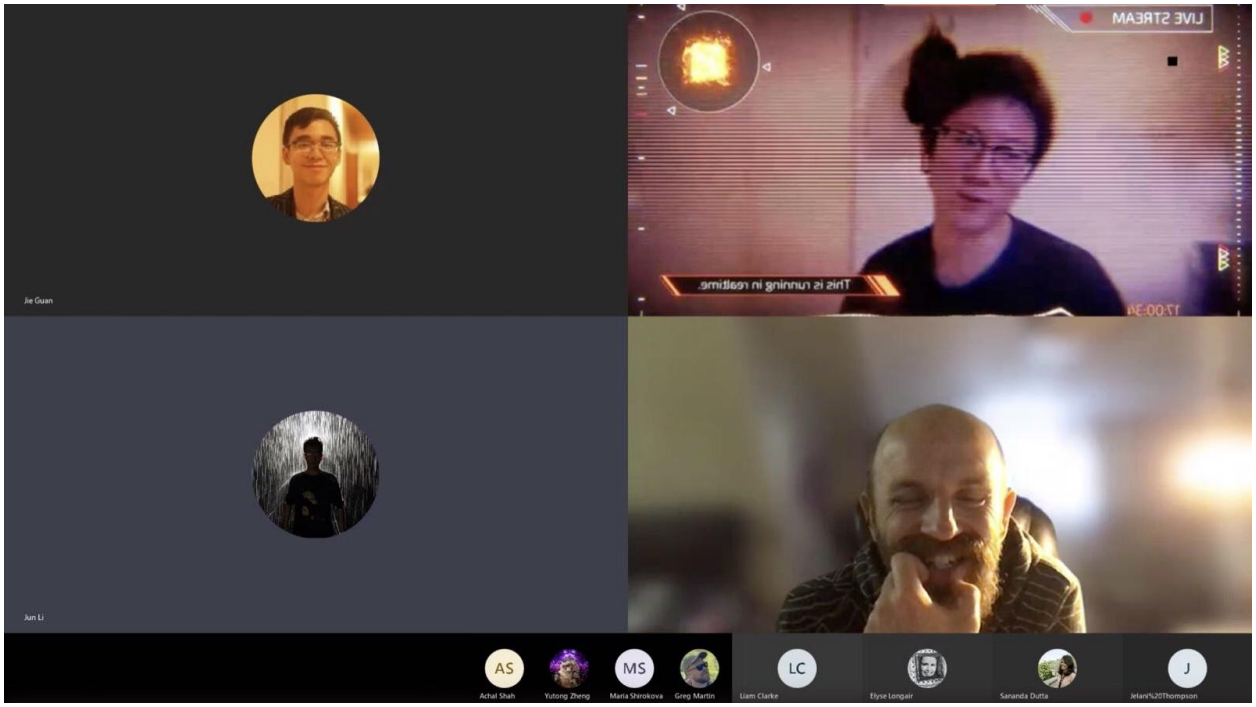

Fig 10. Virtual production experiment 1, 2020
- Live screen, Microsoft Teams 365 screenshot

The second experiment was an attempt to work on mapping myself in the virtual environment with my real body movement in the real world, in which I built a virtual space with my body inside it, floating particles and immersive ambient atmosphere. (Figure 11) This is exactly the same virtual production workflow in the creative industry, it created an online virtual experience that allows everyone to watch and interact with it in real-time. This experiment also explored a second-order cybernetic relationship that allows the

audience to observe the interacting reaction. These two virtual production examples reflected my idea and concept in how I regard the experiment projects works by bridging the gaps between the participants and the artworks on the basis of the first-order cybernetic and the second-order cybernetic theory.

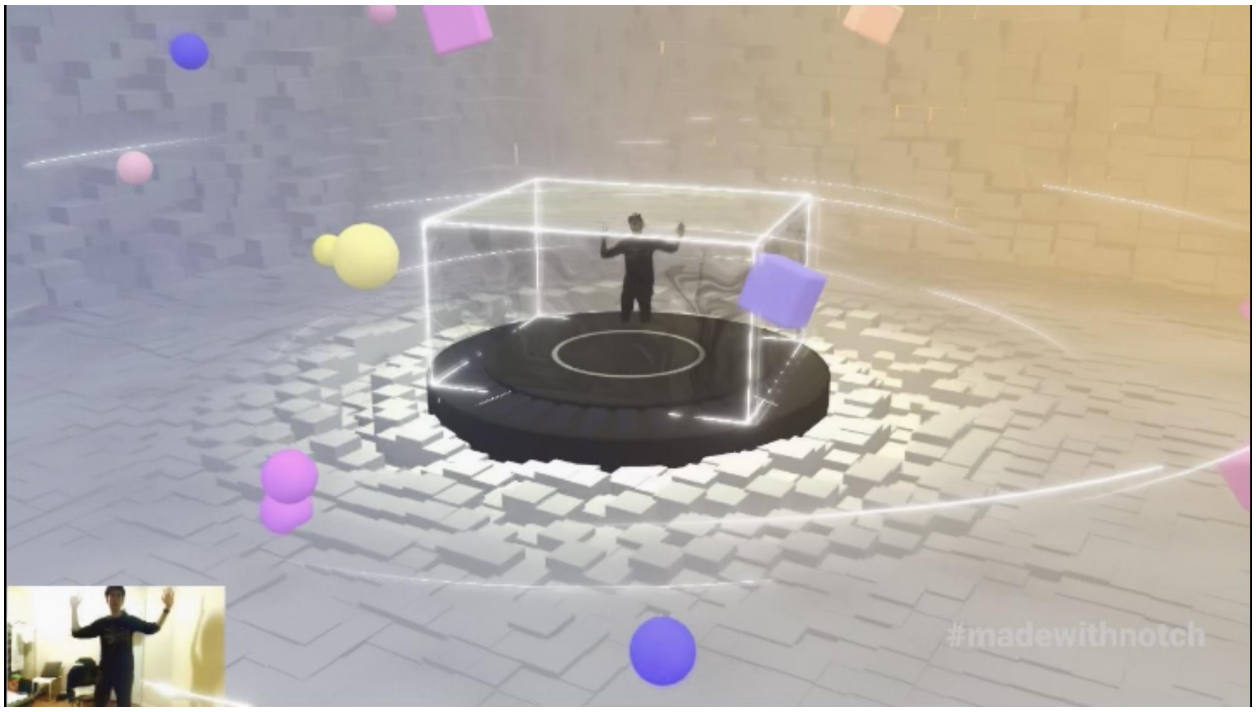

Fig 11. Virtual production experiment 2, 2020 - Notch screenshot

Through these two experiments, compared to the previous experiment, I shifted the orientation and was able to engage remote audiences in a different way. By experimenting and exploring the relationship of the participants-interactive artwork according to the cybernetics/interactivity research. It helped me a lot to create the final project and understand each order of cybernetic theory and what's their roles are in terms of the interactive artworks.

Summary

The importance of these three experiments is the relationship between the participants and the artworks which are separated in a different place and try to

experiment with different cybernetic order relationships. It is not similar to the traditional interactive artworks requiring the audience and the artworks in the same space. (Figure 12 & 13) The relationship between the observer and the observed system is changing as we move to telepresence and remote attendance. These art experiments firstly solved the problem of engaging remote participants by bridging the gap between the artworks and audiences. By doing so, it offered a model and perspective that allows us to create interactive artworks for remote participants and give them the opportunity to interact with the projects. Secondly, it provided an extra amount of audience participation that can interact with the system and create a richer interactive experience.

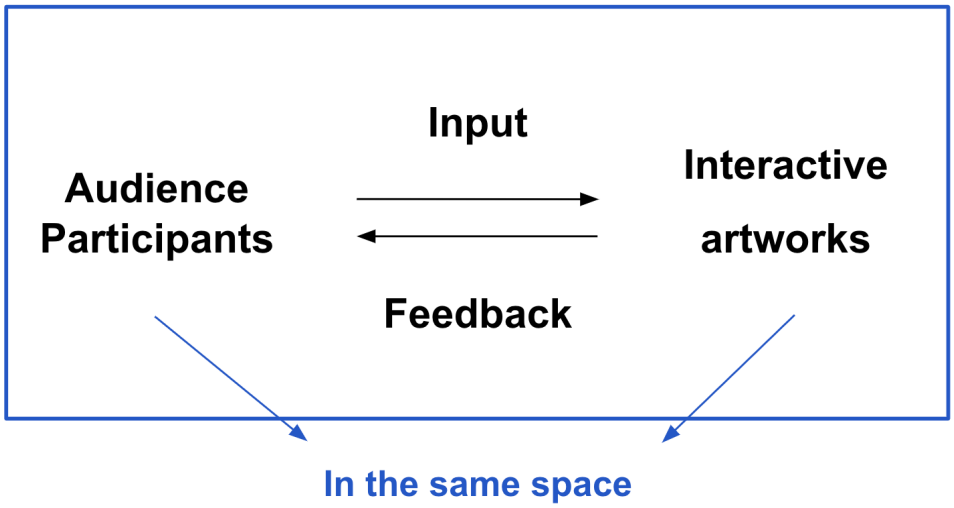

Fig 12. The relationship of audience participants and artwork in the same place.

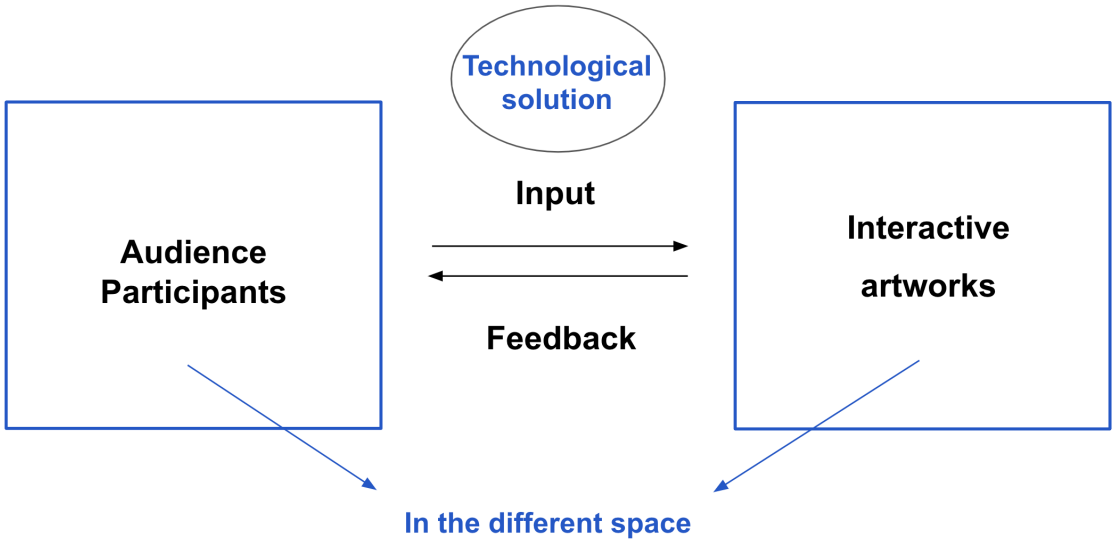

Fig 13. The relationship of audience participants and artwork in a different place.

Those typical examples all explored the relationship I covered in this thesis research framework. It all has been set up online and includes both the online and onsite interactive experience as well. To simply summarize, the cybernetic theory does play a critical role in the chain. It takes online participants' interaction as an input, processes it in real-time, then pushes it back to the online environment and makes it available for everyone who is in front of the screen as an outcome. From my experience and observation, the projects' Info flows around online and onsite at the same time. It does have completely different interactive experiences depending on your geographical location. Not everyone in a different location receives the same feedback, but it also provides multiple outcomes and different reactions, feedback, and inputs, which is making the interaction reaction chain continuously happen. For me, it is pretty interesting to clearly identify information from each individual channel. Furthermore, these art practices contribute a lot to creating the final art project.

Methodology

This thesis project uses Research Through Design (RTD) and practice-based research method by iteratively developing three prototypes. It is a research methodology where the prototyping process itself becomes a way to gain new knowledge. RTD focuses on practice-based research with an emphasis on developing design methods, artifact-led, conceptual frameworks, experiential, hands-on prototyping and theories, as well as products. (Gaver) Prototyping is a critical method in each stage of RTD. In terms of the nature of the final thesis project that is aimed to engage remote participants, exploring the cybernetics framework is an orientation of the three prototypes and art practice. By taking advantage of the practice-based research method, it provides a better understanding of complex and future-oriented issues. As John Zimmerman mentioned, Interaction design researchers integrate true knowledge (the models and theories from the behavioural scientist) with the how knowledge (the technical opportunities demonstrated by engineers). Design researchers ground their explorations in real knowledge produced by anthropologists and by design researchers performing the upfront research for a design project. (Zimmerman) RTD allows designers and researchers to learn from the real world and create projects intended to affect change. The progress documentation and evolution should cover the whole process from framing to the final outcome. (316) Also, it should pay attention to detail how theory from other disciplines has been met with the project and how the outcome helps to refine the general theory through reflection.

This thesis project followed these steps:

- This is a practice-based research thesis project, which means that the development of research questions comes from initiating an investigative process within artistic practice, in which the artistic methods within the creation of the project sought to answer the research questions and deliver new concrete forms of knowledge.
- The literature review of relevant articles, books, and other media that explore the relationship among cybernetic theory, Interactivity and Machine learning – as well

as research the work of other artists, theorists, and designers who are also working in this area.

- Consult experts and create new artistic communities
- Design plant/human interaction device-installation.
- Document the artistic/technical methods and production through sketches, images, and videos related to each prototype stage.
- Research relationships among cybernetic theory, Interactivity and Machine learning from the post-war period in art and technology to the present and relate my findings to this thesis project.
- Test the results and experiment further with art-technology practice methods to achieve the desired outcome and to understand interactions and make amends to the design if it is necessary.
- Analyze the above steps and make adjustments for the conclusion of the project and the thesis.

To explore the possible way of engaging remote participants and bringing interaction, I was experimenting and creating a lot of side-projects between research on cybernetics, interactivity and related art practice. Overall, my final project helps me to open the gateway from remote participants to interactive artworks that conceptualizes the idea of cybernetic art. All these experiments, art practice, theory serve as the bridge between the remote participants and the artworks. These three prototypes were all shared with my classmates and professors in a class critique environment where I received comments, feedback to reflect on each one. These art practices and prototypes contributed to developing my final project, which serves as a way to answer my research question of engaging remote participants in a different space and share the interactive experience around the results of the artworks.

Iterative Prototyping Stages

Overview

Following the methodological approach, the prototype-making has consisted of two early prototypes that aim to explore each order cybernetic theories and conducted one final prototype all based on mobile devices. This thesis project followed the practice-based research method, which means that the development of research questions comes from initiating an investigative process within artistic practice. Each prototype aims to provide and experiment with different order cybernetic theory in an interactive system step by step. The first prototype targets building the relationship of the first-order cybernetic and programming the main structural code of the interactive system. The second one targets exploring the machine learning models and building the relationship of the second-order and the third-order cybernetic. After explaining and exploring each level of cybernetic theory and applying the machine learning model into the reaction chain with two prototypes, the final prototype focuses on presenting the relationship of the research framework between cybernetics and interactivity, which is summarized in the previous literature review session.

*Due to the covid-19 restrictions in Toronto, Canada since March 2020, we have been experiencing lockdown and having a remote learning situation for the whole year, which means any specific tools or maker studios are not available for us. It is a severe hit for our creative industry and significantly changes the way we work on our projects we used to. We are not able to manufacture or produce any real physical outcomes. During this time, it's hard for us to build the prototypes in each step and evaluate them after it. However, because of it, it became a real challenge and motivation in the other way. We are doing our best to reach the goals of my projects. What's more, it's an excellent opportunity for me to explore online interactive artworks in this special year.

As explained above, I was negotiating with reality trying to seek a solution to build it virtually and avoid the physical making process as much as I can, but somehow still can express my art concept effectively and not lose too many essential details. Therefore, I chose and built my virtual installation eventually on the social media platform-Twitter as my prototype. As you can see with three prototypes down below, all of them have been built on the cloud but coded locally so I don't have to be bothered by the manufacturing problems and concentrated on the core part of my research project. This was the first priority I needed to solve before I got my hands on my thesis project. However, everything is a double-sided sword. Here came another difficult challenge immediately behind the scenes that I needed to hard code the whole program system from scratch with the way I am not good at.

As a creative technologist who came from an art background but has worked in the creative industry for roughly three years, the problems I always faced is I don't have enough knowledge and never been systematically taught about computer science so it is difficult for me to hard-code for interactive artworks. However, the creative industry always seeks to provide creative solutions to meet our requirements so that we can keep fulfilling and focusing on expressing the art concepts. Therefore, the next two paragraphs are the basic introduction of the creative tools and social media platform I choice for creating the prototypes and the final project in each step. It is playing a critical role and it's very handy for me, especially during this hard time in 2020.

The choice of creative software

TouchDesigner - This is one of the greatest creative software I often used for creating interactive projects during my graduate study. It is a developing platform for real-time projects ranging from visual effects to large-scale interactive installations or systems. Equipped with an interface for real-time feedback, this tool allows me to quickly go over the process of a continuous creative process from the initial idea over prototyping

to the final outcome. Generally speaking, TouchDesigner specialized in integration and rapid prototyping, which enables me to get the outcomes without spending too much time on the iteration process. Furthermore, it is a node-based coding language software platform. The learning curve is smooth and it's so much easier for new media artists to work on it. These great characteristics enable me to integrate and build this complex system and get the final results in real-time.

RunwayML - This is a machine learning library that is also a real-time creative platform that collects and offers different types of machine learning models, ranging from different tasks such as image synthesis, motion capture, text-based and so on. It offers two options depending on the performance of your computer and you can choose to run the machine learning models on the cloud GPU by paying five cents per minute or on your local CPU for free. What's more important, it doesn't need to have advanced computer science knowledge in the field of machine learning and it provides an entry-level introduction for anyone who wants to explore different targeted models. Technically, it is not just a machine learning PlayStation. It is allowing us to output the outcomes by bridging RunwayML to other creative software such as TouchDesigner to further process it through multiple protocols such as HTTP, OSC or Socket.io. With these great advantages, it enables me to utilize freely any machine learning models it offers, integrate them to the TouchDesigner system and similarly get the outcome in real-time.

Twitter- One of the biggest world-famous real-time social media platforms which users can interact and post with messages known as "tweets". As of 2019, Twitter had more than 330 million monthly active users. Twitter is a some-to-many microblogging online service so that it offers me great chances as a tool to interact with the participants worldwide to explore the third-order cybernetic. Also, Twitter provides the API sources for developers which enables us to publish and analyze Tweets and create unique customer interactive experiences with the account of Twitter Developer.

As you can see, the ability of real-time processing is the main principle of choosing tools and platforms in this thesis project. It is vital for the participants and the audiences to get quick feedback and obverse each level of the cybernetics relationship and the whole system. The specific workflow in detail of how each order cybernetic theory applies to interactive artworks and how the machine learning model works will be introduced and explained below in each prototype stage.

Prototype roadmap

The following sessions introduce a series of three iterative prototypes aimed to demonstrate each order cybernetic relationship and machine learning models, each one starts with a detailed description, process and technical explanations end with reflection and limitation. As the prototype roadmap table is shown in Figure 14. The three prototypes aim to solve different tasks and contribute a lot to the final thesis project from different aspects with difficult coding challenges. These prototype iterations served significantly to inform the development of the final thesis project with wonderful and valuable feedback from my professors and classmates.

	Twitter input & output	ML Model	Notch	Projector
Prototype 1	☑			
Prototype 2	☑	☑	☑	☑
Prototype 3	☑	☑		☑

Fig 14. The thesis project roadmap of each prototype stage

Prototype1

Description

This thesis project focuses on exploring the relationship of the research framework between cybernetics and interactivity. The goal of the first thesis prototype aims to demonstrate the relationship of the first-order cybernetic. It first starts with identity the input, output and feedback and maps it into an interactive artwork, which is the very basic and essential principle for any kind of interactive artwork. (Figure 15) Furthermore, it is working simultaneously on exploring the machine learning models that can work well with the system.

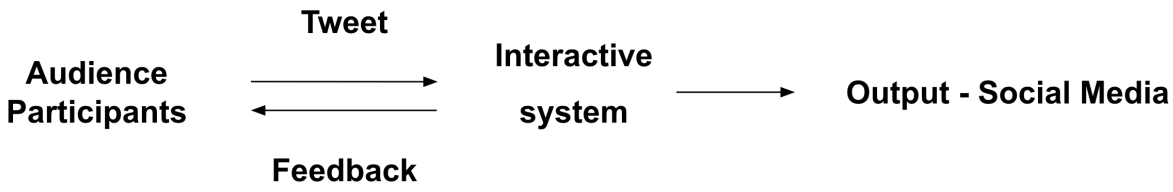

Fig 15. Mapping the first-order cybernetic concepts in first prototype

The design and Process

The specific workflow of this one is designing an embedded program but running outside individually of the social media platform-Twitter. (Figure 16) It can pull any tweet and its content information such as user name, user profile and image with a particular keyword uploaded by participants from Twitter to trigger the cybernetic reaction chain, then process it locally in the creative development platform-TouchDesigner. Ultimately, it automatically sends the content with images as Tweets back to Twitter with the pre-edited Tweet and a newly designed layout of the image. All these processes happen in real-time without any manual editing behind the scenes. Therefore, during this real-time

process, the Tweets uploaded by the participants have been identified as the inputs and the reuploaded Tweets sent by the system have been identified as the outputs and feedback from the cybernetic concepts we discussed before. it has set up a conversation between the participants and the interactive system since the moment users sent the Tweets.

Fig 16. The workflow of the first thesis prototype

Technically, first, I register for a Twitter developer account and apply for the consumer keys. This is like my username in my Twitter developer account and it is used to verify who I am to it. These consumer keys allowed me to manage and pull the data out of Twitter from the background, then import it by setting up a bridge into my local system and So, these consumer keys are vital and unique for my system and it's exclusively working for it. Second, as the imported data arrived in the local system-TouchDesigner, there's some data clearing process. For example, the coming data from Twitter is in the JSON format, it needs to be parsed and categorized into a different label for me to easily manipulate it later in the next step. Third, since the program needs to upload the processed data back to Twitter, I designed the layout of the final output in this step. I grabbed some of the user profile information and put these on the top of the green background. The green background is the substitute for exploring machine learning in the next prototype. So, the Tweets sent by the participants will attach to the green picture and reupload to Twitter with my customized message-'This is a testing message'. As you can see in Figure 17, the server is working for tracking, receiving, processing and sending the tweets.

For the machine learning part in the first prototype, I aim to explore some specific models that fit this kind of workflow. There are two types of models for me to choose from the table. One is the text-based models and the other is image-based models, corresponding to the Tweets and the images shared by the participants. During this stage, I haven't decided which one is right for my project so I keep experimenting and working on the design simultaneously. This is the technical reason I left the green background being uploaded with the users' profile information because it was purposed for the image-based machine learning model for the next prototype with the chosen one.

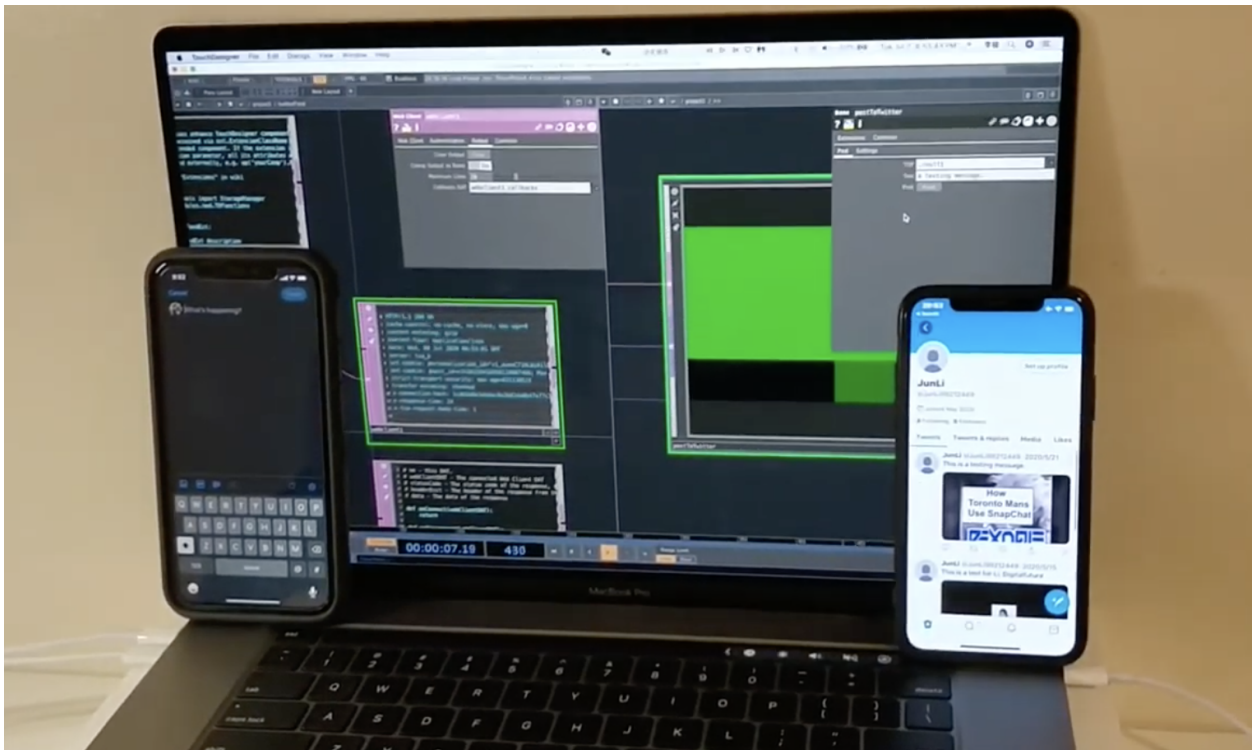

Fig 17. The first version of the thesis prototype.

Reflection and limitation

To my satisfaction, through this prototype, I achieved the goal of connecting the first-order concepts into the interactive system. I did the experiments with my classmates and professors to get the first thoughts after they experienced it. In this one, each of them

interacted with it through their account. Since the machine learning model hasn't been integrated into the system and the participants weren't interested in the Twitter experience due to the rough design. During this process, I still received positive feedback from them. They all felt and agreed that this prototype provided a cybernetic perspective to play with an interactive system, which they never thought of before. It is the first step of my project for showcasing first-order cybernetic theory.

I also achieved the goal of bridging Twitter to the program. I challenged myself in a majority of hardcoding ways to program the whole system which is an uncomfortable workflow I didn't get used to. It was an important foundation for the next steps. However, there were some problems when I tested by myself and asked my classmates to experience the project such as the design of the layout. But, the system didn't react in real-time. Here, for the real-time reaction I mean I hope the participants get the feedback from this prototype system as soon as possible, but this prototype has a couple of seconds delay due to the optimization process. Also, I tested and ran the different target machine learning models separately and I started to realize it is consuming a lot of graphics card power. I have to somehow find a powerful one for the next prototype during this hard time.

Prototype2

Description

The second prototype of this thesis project was built upon the foundation of the previous one and the feedback received from professors and classmates. It aims to explore the second-order cybernetic relationship by bringing the audience into the loop. (Figure 18) This is to present the combination of online and onsite interactive experience and add a machine learning model as an interactive method participating in the process, which is trying to offer them a richer interactive experience explained by cybernetic theory.

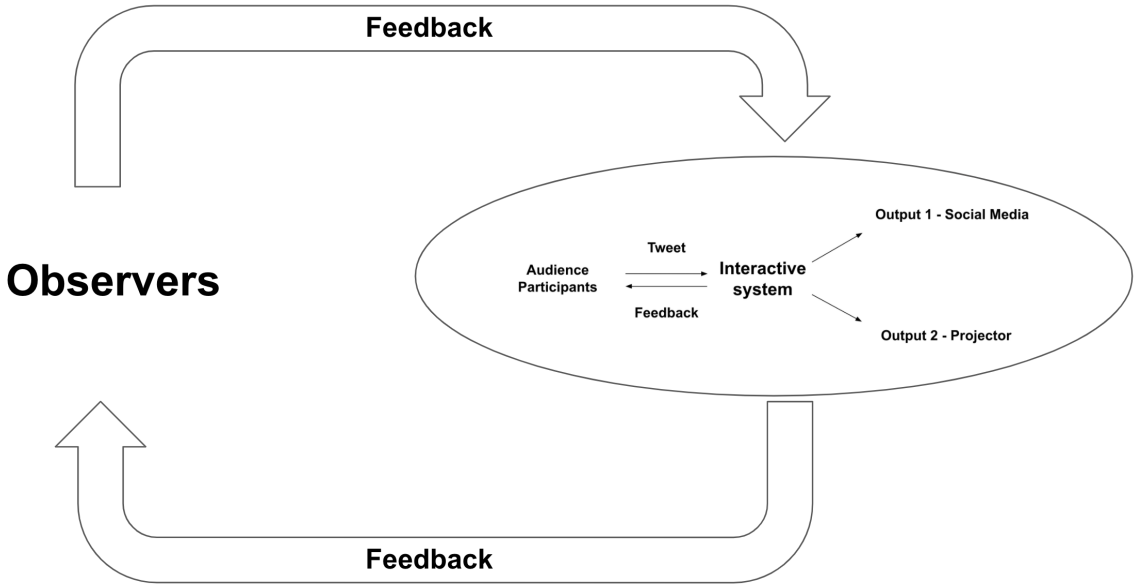

Fig 18. Mapping the second-order cybernetic concepts in the second prototype

The design and Process

The majority of the specific workflow is similar to the first prototype, but there are some differences compared to it. (Figure 19) First, the machine learning model is integrated into the system. Second, apart from sending the feedback back to the

participants' Twitter account, there is a second output through a projector showing a picture with a redesigned layout processed by the machine learning model. The purpose is to set up an online experience as feedback for the onsite observers, which is known as the second-order cybernetic theory. (In this thesis project, all of the concepts and behaviour have been simplified to the simplest model. In the real world, the relationship and the interaction could be much more complicated.) During this process, all of the onsite participants and observers will present the first-order and the second-order cybernetic relationships. What's more, since this interactive artwork is set up online and those participants who are not there in the exhibition can still interact with it remotely. It has added the core part of the third-order cybernetic relationship into this prototype. Not only they can receive the feedback from the system as onsite participants do, but also it will show the onsite output from the projector, which will be observed by the onsite observers who are in the second-order cybernetic relationship. Therefore, the combination of the onsite and online interaction experience indicated the multiple ongoing conversations across different levels of the relationship by the guideline of the first-order, the second-order and the third-order cybernetic theory.

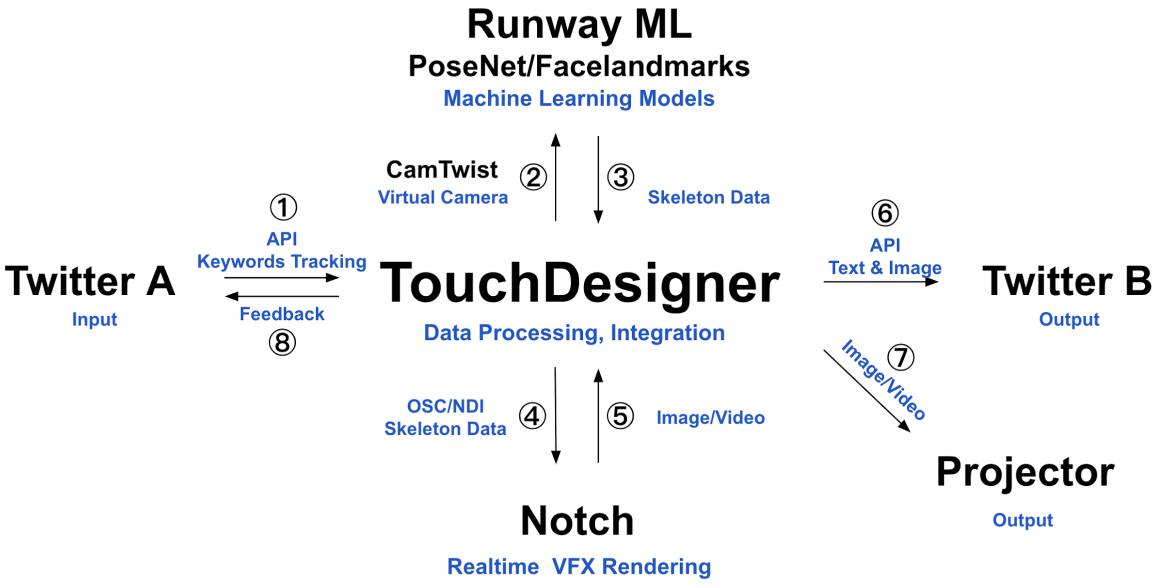

Fig 19. The workflow of the second thesis prototype

The technical update of the second prototype is that I integrated the machine learning model into the system. First, I was coding the program on the Mac system. It is supporting the protocol of Syphon Spout (a protocol that allows sharing its input texture with other applications that support the Spout framework) to share the image I got from the content of users' tweet to another creative software-RunwayML so that it can be processed by Posenet. After processing, it would send the skeleton data back to the system by OSC protocol (OSC stands for Open Sound Control. It is a standard that is used to exchange messages between applications). During this real-time process, the RunwayML has been embedded in my local system. However, there is a major issue. Although Posenet is running in real-time, it sent out the skeleton data after the system sent out the designed image. The speed of the machine learning process is slower than the speed of the system. It was because machine learning models need a powerful graphic card to process and the system workflow happening too quickly. There are two solutions that aim to solve this problem. One is to switch to a powerful computer with Nvidia GTX 1080Ti I got from the CFC media lab. Here, a big thank you to Joseph Ellsworth - The production manager in the CFC media lab. Not only I received valuable feedback when I had the course with you in the Summer semester, but also I can not program it without the hardware. The other is to slow down the process to send out the results until the data comes back from Posenet. The other major update is I set up another outcome by designing a picture with a new layout. It is through the projector to fully present the second-order and the third-order cybernetic relationship and form a common role for the onsite and online interactive experience. Finally, I'm working on exploring the possible outcomes through Notch (It is an interactive and motion graphic tool rendering in real-time.) to engage a more eye-catching and interesting onsite interactive experience. Also, it is very vital to keep an eye on optimization at this stage. Apparently, it involved tons of processes, updates and debugs so I have to keep cautious to keep the system working without any major problems.

The machine learning update in the second prototype is to explore and experiment with Text-based and image-based machine learning models. The technical goal of the

model choice is it is running in real-time and cooperating well with the whole system and creating interesting interactive experiences with the participants. Since I can manipulate and access the data that came from Twitter in many forms such as Text and images, Therefore, under this guidance, the text-based machine learning models are not as interesting as image-based ones. Among tons of the choice of image-based machine learning models, I finally decided to integrate Posenet into my local system. It refers to computer vision techniques that detect human figures in images or video so I programmed the system to attach circles in different sizes and colours on the top of the original images. During my machine learning testing process, there were many more interesting image-based machine learning algorithms and models on the table to choose from. It was so much fun to play with these, however, due to the performance of the computer, PoseNet is one of the few models that cost less computer power and is free to use. It also enables me to achieve the goal that always tries to push the system running in the real-time workflow.

Reflection and limitation

To my satisfaction, I achieved the goal listed for the second thesis prototype again. By bringing the audience and delivering various outputs to them in a different space, it has provided the first-order and second-order cybernetic relationship. Before I tested it with my friends, I deliberately didn't tell them who was in which order cybernetic relationship. I told them after they interacted with it, they started to realize and feel the interesting part of this project. However, I got some questions about the project itself whether it's focusing on the artworks. Yes, the project itself is meaningless, what I showed to the audience was the relationship among the project, participants and audiences. By clearly designing the outputs and following the research framework offered, I successfully demonstrated each order of cybernetic theory in this interactive system. Finally, I started to reflect on the possibility of using this interactive system for my research to decide whether it could be a better solution instead of it.

For the project itself, I have to admit that it is extremely difficult for me to push the boundaries of this project further in terms of the aspect of the production environment or the challenge of the coding difficulty. I experimented with a variety of machine learning models and successfully integrated them into my local system. So far, the majority of the thesis project, in terms of the coding and the exploration of the research framework has been done. What's left for the next prototype is the heavy debugging process and continuing to optimize the project workflow to ensure the project runs in real-time as quickly as possible. What's more, based on the feedback from the professors and my classmates in the round, I need to keep experimenting with each level of the cybernetic theory being presented in the interactive artworks and trying to demonstrate them as clearly as I can to better express the goal of the thesis project at the final stage.

Prototype3

Description

Based on the previous two prototypes I tested with valuable feedback and comments I collected from my professors, faculty from the CFC media centre and my friends and classmates. The third prototype focuses on experimenting with the third-order cybernetic theory and the verification of each order cybernetic, which is attempting to give clear information to the participants and observers. (Figure 20)

The third one is very close to the final thesis project major focuses on optimizing and bugging the process of the system workflow because it consists of the portal of Twitter and the machine learning integration. It is a super heavy workflow being designed and carried out as the goal is to push the system running and able to deliver the feedback to each order of cybernetic in real-time. At the same time, I'm exploring the potential way of showcasing the final project due to the current Covid-19 restrictions in Toronto. There are not many choices on the table left for me to decide, most probably will hold a virtual exhibition and present it online. Although my project is set up online, you can interact with it anywhere corresponding to the third-order cybernetic relationship. But vice versa, the participants will lose the onsite experience corresponding to the second-order cybernetic relationship.

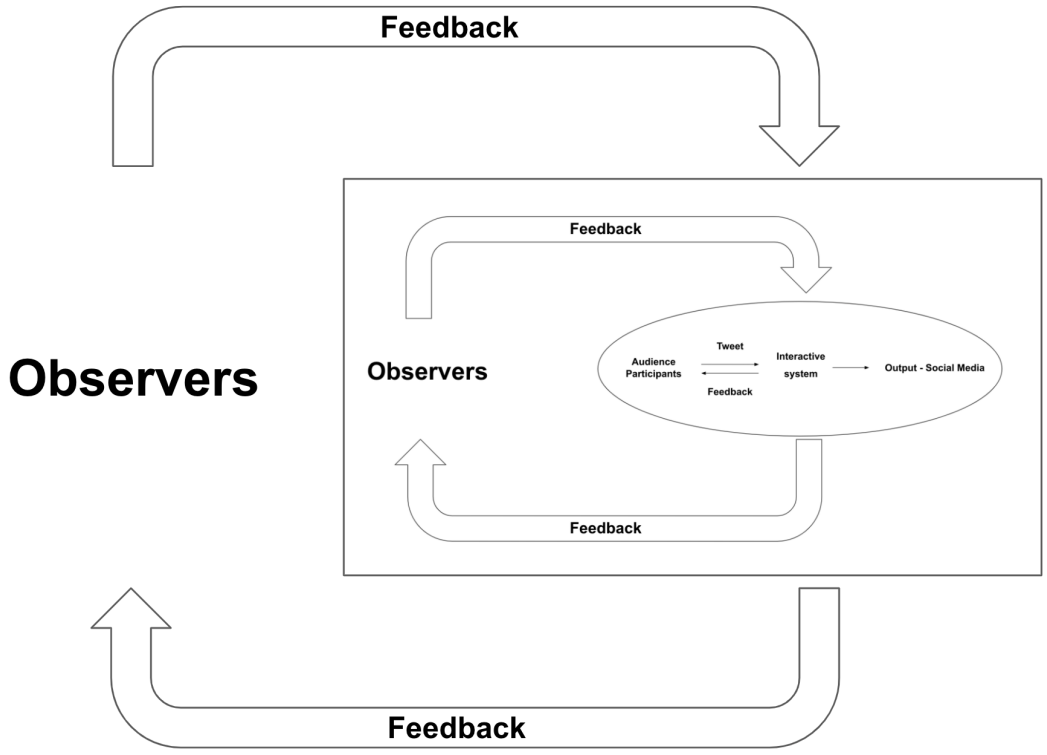

Fig 20. Mapping the third-order cybernetic concepts in the third prototype

The design and Process

From the technical aspect of the third prototype, I abandoned the plan of adding Notch into the workflow. (Figure 21) It is too risky because Notch is eating too much of my GPU resources and it's delaying the real-time workflow. Second, my plan for showcasing is not ready, I cannot guarantee to run my program on which computer. Third, I have achieved the goal of exploring and demonstrating each order of cybernetic theory with the current prototype. Less is more, it's not essential to add Notch into the workflow to process the image, which doesn't offer help to build my core research framework. Most of the time I spend on the third prototype is optimizing and debugging, it is a huge and heavy network since I decided to code it on the first day. Therefore, The third one includes a lot of improvement and debugging trying to reduce the system delay.

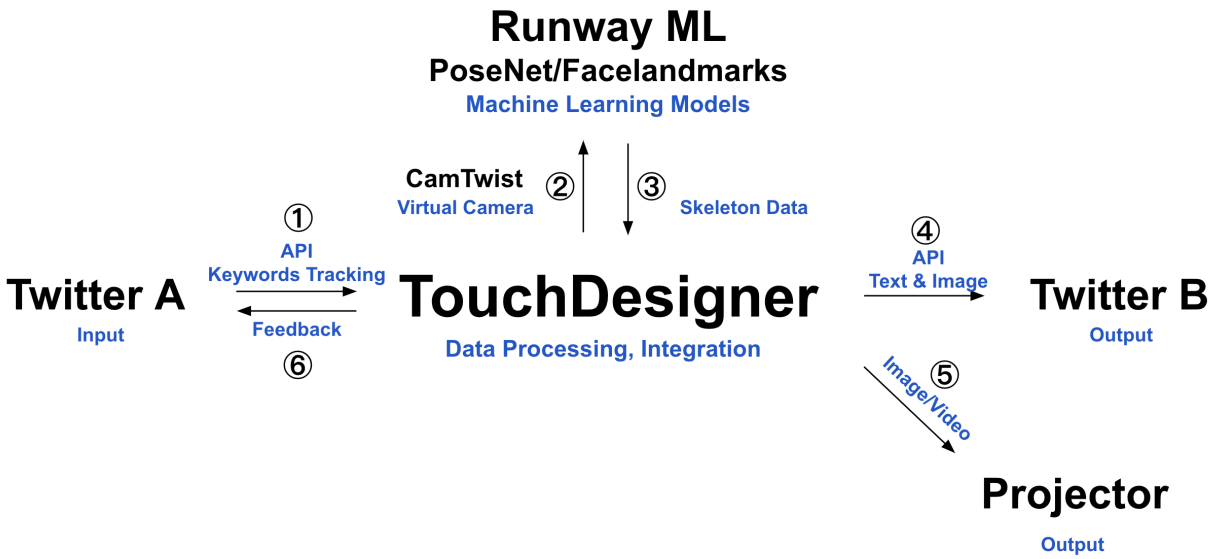

Fig 21. The workflow of the third thesis prototype

Reflection and limitation

I learned through art practising and making prototypes, I have a clear idea and I can clearly point out the first-order and the second-order cybernetic relationships in any interactive artworks. As the thesis investigation progresses, my main art concept shifts to focus on utilizing the cybernetic relationship as a guideline to create interactive artworks and explore the possible ways to express the third-order cybernetic in it. Meanwhile, by designing and experimenting with three prototypes, I have explored each order of cybernetic theory in my interactive artwork. I achieved the goal of establishing a relatively reliable interactive system that can express my art concept. It helps me build a clear sense of what role each person plays and what cybernetics they are in. The iterative of each prototyping process paves the way for my final project. Each prototype features the decisions that worked or not with new ideas from the feedback that was given by my professors. However, I also realized this project is probably not the best and the only way to present my research framework, it has more possibilities to play with this research

framework. For example, the interaction could be richer and more diversified so that participants can get more interactive functions as feedback with the project.

Final project

This final outcome is a platform built upon social media featuring a machine learning model that allows the result of interactive experience to be shared around the artworks. It firstly bridges the gap between remote participants and interactive artworks and secondly explores a distinct way of engaging remote audience participants and a creative form of interaction by exploring cybernetic theory.

System overview

The final thesis prototype is built based on the previous three prototypes. (Figure 22) It is a platform that has integrated with social media software and a machine learning model - Twitter and Posenet. It has developed a real-time, online and virtual installation that has the ability to process the Tweets and images shared by the participants. Derived from the early prototypes, it has explored and demonstrated each order of cybernetic theory. As shown in Fig 22, the system is real-time tracking the keywords as a trigger to interact with the system. In TouchDesigner, both Twitter application and machine learning model are embedded with different protocols called API and the virtual camera. As a result, this program is communicating with each other in the format of exchanging data in the JSON format. This program can take and process Tweets with a machine learning model and eventually send the redesigned picture back to Twitter in real-time. For the final version, the hardware projector has been taken out from the system since we have the virtual exhibition and it probably will mislead the audience.

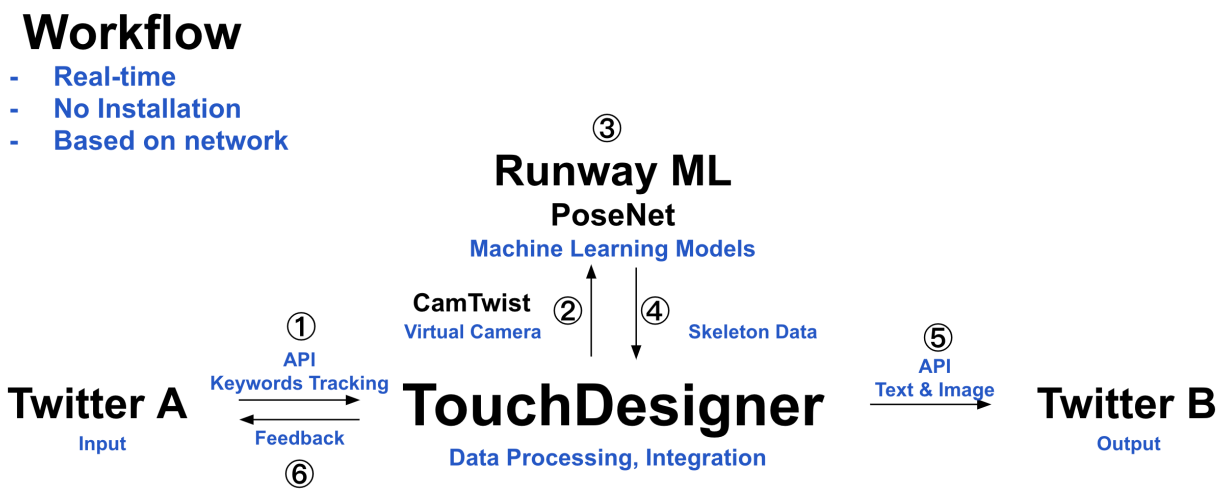

Fig 22. The workflow of the final thesis prototype

The design and process

Along with all three prototypes, the design challenge is how to solve the information flow and creatively engage with the audience. The technical issue is since this program is tracking the keywords in real-time, so it has to prevent the Tweets reuploaded by the program won't be detected the same keywords again, which means the content itself can't be placed in the Tweet. I programmed the system to have the layout and automatically sort all the user information into the right place. It solved the technical issue and helped participants better understand the workflow. What's more, this program can share this image with a custom Tweet to better engage the conversation between the audience and participants.

Reflection

According to the responses and feedback from the participants in the class critique environment, this prototype tool can be regarded to meet my research goals. To begin with, all participants and the audience thought it would be a promising prototype to

explain my cybernetic research framework, it has explored all essential elements of key concepts in it. Many of them believed it was a rare interactive experience, not only having fun with the physical Tweeting experience but also reflecting with the research question I focused on.

To simply summarize, as the audience participating in this interactive experience, the Tweets they shared firstly be considered as inputs to the system and the system responded with images and Tweets are considered secondly as outputs and feedback, which can be regarded as the first-order cybernetic relationship. While the second participant observing the system reaction, they can choose to participate and comment on the result of the interaction, thus, their role has shifted to the first-order cybernetic relationship. which can be regarded as the second-order cybernetic relationship. What's more, as this project provided a remote interactive experience, it gave the third participant a lot of possibilities to keep triggering the reaction going by keeping commenting on the conversation and result of the interaction, which is possibly defined by the third-order cybernetic relationship. During this process, the role of each group of audience and participants has been experimented by studying cybernetics. It has given the definition of the inputs, outputs, feedback, conversation and the first-order, the second-order and the third-order cybernetic relationship to summarize the interactive experience which is the goal and conclusion of this thesis research.

Additionally, this model of work being multifold and time-based interaction in this manner means that the audience participants can't observe everything at the same time. By default, each order in the cybernetic relationship presents a different viewing orientation from another. The first, second, and third-order relationships cannot be holistically observed. From the feedback of the participants, they probably won't realize that they are in which order relationship. Nevertheless, it's exciting to identify each participant and every interaction corresponding to the cybernetic concepts and provides a systemic framework for the interactive artworks. The positive feedback shows that the prototype can be effectively used to encourage participants and the audience to consider

the connection and relationships between any interactive system and cybernetic theory. Meanwhile, this research illustrates a method to create interactive artworks. By following this cybernetic guideline to create cybernetic interactive artworks, the artists can bring a richer experience for the audience and participants and engage them efficiently. From these processes, I received valuable and constructive feedback, which could be reflected in future work. I also have to admit that this final project is not the perfect case to represent the framework. As I discussed above, those other projects, there are many examples I have explained, that all show the framework relationships. After many explorations and experiments, I believe the final work so far is the best statement that I can find. It has approached my goal and fulfilled my intention for this project.

The journey of exploring cybernetic and creating project

In terms of this whole thesis journey, the enthusiasm and interests of playing with emerging technologies and the cybernetics knowledge I gained from Roy Ascott Technoetic studio drove me here to the intersection of art, interaction and cybernetics. As what I proposed about cybernetics above and how I created a wide range of different projects through exploring it. Cybernetics does play a very important role in between and helps me shape my ideas through creating projects. At the end of this thesis research, I realized that there are many ways of understanding different order cybernetic theory from various perspectives and cybernetic relationships don't exist exclusively in some particular interactive artworks, it's actually existing in any works. It's about how you approach and describe it from what kind of perspective. In this thesis paper, I discussed the way of cybernetic thinking and how I utilized it in interactive artworks. It's been an absolutely meaningful and successful journey for me.

The whole project heavily utilized the practice-based research method. I started by figuring out the relationship between the audience and artworks and thinking about how I bridge the remote participants to the artworks. So, I firstly created the 'Genesis - Remote Live Laser-Projection Mapping Performance'. It was my first experiment of exploring cybernetic concepts. I was experimenting with some of the concepts from cybernetics to the principle of interaction, in which I can see some common areas overlapped with each other. The outcome turned out very stunning and exciting. I was deeply diving in and looking for addressing my proposed cybernetic framework articulately by connecting some of the concepts to the artworks. Therefore, after the first experiment project, I immediately did the second experiment - Virtual Production to keep experimenting and exploring within the cybernetic framework. During these creating, I was able to understand the key notion such as inputs, outputs, feedback and control and more importantly, I learnt and summarized a lot from the cybernetics and projects and

eventually came with the final thesis project - An interactive tweeting experience built upon social media - Twitter, which is the project I believe has expressed all the key elements I listed and discussed above.

Conclusion

This project can be understood as a research project that explores and materializes the overlapping field of cybernetics and interactive art, where this project emphasized revealing and exploring the relationship of Cybernetic theory and Interactivity through an online interactive experience. Through the supporting experiment projects and the final work, I have presented and narrowed down some concepts from cybernetic theory. My ultimate goal was to see if it is possible to engage participants in different spaces and share the interactive experience around the results of the artworks. Based on the feedback and results of this project and related art practice, it clearly has addressed the research question. In this case, a social media-based interactive project has been developed to engage the audience and remote participants, which can be used as an effective means to represent my research between cybernetics and interactivity. They can interact with it and all of them can share or comment wherever they are.

Through this research, it built a bridge between cybernetics and interactive art and explored a fundamental relationship of the way of connecting cybernetics thinking to interactive works by comparing the common points, theory and art practices. By exploring cybernetic concepts into interactive artworks, it fused and widened their boundaries and contributed to critical concepts around the cybernetics nature of interactive art more widely. What is more, it not only assists but reminds and leads new media artists, especially those working in the field of interactive art to a new perspective of how to predesign the artworks and diagnoses it to understand how artists can make the artworks better by experimenting with the cybernetics concepts.

This research also has some limitations. First, it is only available on a small scale project and I need to guide the participants to engage the artwork. Second, the visual design and the user experience of the project could be designed more user-friendly. However, by focusing on the process of designing and building the prototype in each stage, the research methodology section of this thesis describes and evaluates the designation

and generative processes of this virtual interactive installation. l regard this project as a prototype and is not the only solution to the problem, but an auxiliary model helps me explain the framework and explore the possible way of creating interactive projects. These core concepts all provide a contemplative future direction and guideline for cybernetic interactive artworks.

Future work

Due to the Covid-19 restrictions, we are not able to present it in the art exhibition, it needs more opportunities to showcase and more close observation of the relationship that I discussed in this paper. Although the relationship in each level is clear enough for me to distinguish, I would like to clearly demonstrate it to every participant who gets involved in this project. Even though the possible outcomes built on this research framework could be significantly different, as I showcased in the related art practice I listed above, any interactive art projects that include this cybernetic behaviour can be identified and included in the field I discussed.

For the next step in the near future, I'd like to dive deeper and keep exploring the relationship between cybernetics and interactivity. Particularly in this project, it contained an onsite setup which was targeting to experiment with the second-order cybernetic relationship and demonstrate a full picture of the concept of how the online/offline participants working together to observe the information flow and how they affect each other to keep triggering the interaction. There could be various ways to fulfill the goal, which I learn from this research. Secondly, I can integrate and experiment with more exciting machine learning models to see what's the interesting outcomes and different reactions from the audience and participants. Furthermore, I would like to keep working on developing the user experience of this prototype. It could be designed more user-friendly to the remote participants. Lastly, through this whole thesis journey, I would like to keep exploring and experimenting in the interactive artwork with the framework relationship. This thesis research is just the very beginning of the combination of cybernetics and interactivity as a case study example. Beyond this prototype, I am super excited about the future direction of how this research topic leads me in the field of interactive art, especially resulting in a more diverse understanding and variety of possible outcomes in the near future.

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